ELEBOR®

ΕΛΕΒΟΡ Α.Ε.Β.Ε.

ΕΛΛΗΝΙΚΟΣ ΓΕΩΤΕΧΝΙΚΟΣ ΕΞΟΠΛΙΣΜΟΣ

Αγκύρια προεντάσεως TTM

Post-tensioned TTM ground anchors

Ground Support

Boring – Drilling – Tunnelling – Mining – Construction – Geotechnical

Company profile

1968 > > > > > > > > 2013 >

Η **ΕΛΕΒΟΡ ΑΕΒΕ** είναι ενδεχομένως ο αρχαιότερος και πρωτοπόρος προμηθευτής ειδικού γεωτεχνικού εξοπλισμού στην Ελληνική αγορά, με δραστηριότητα που ξεκινά από το 1968. Η εταιρεία διαθέτει πολύ μεγάλη εμπειρία στην προμήθεια εξοπλισμού για γεωτρήσεις, έργα σηραγγοποιίας, μεταλλείων και γενικά υπογείων και γεωτεχνικών έργων.

Η **ΕΛΕΒΟΡ ΑΕΒΕ** παρακολουθεί διαρκώς τις εξελίξεις της τεχνολογίας του γεωτεχνικού εξοπλισμού και διαθέτει στην αγορά πρωτοποριακά προϊόντα σύγχρονης τεχνολογίας. Οι επιλογές στηρίζονται σε μεγάλο βαθμό στη μεγάλη εμπειρία καθώς και στην εξειδικευμένη επιστημονική κατάρτιση των στελεχών της εταιρείας που κατέχουν ανώτερους και ανώτατους επιστημονικούς τίτλους. Έτσι η εταιρεία σήμερα απολαμβάνει τη φήμη των «εξειδικευμένων – τεχνοκρατών» και με ικανοποίηση διαπιστώνει ότι οι πελάτες της απευθύνονται στην εταιρεία, όχι μόνο για την αγορά εξοπλισμού, αλλά και στην αναζήτηση προτάσεων και πιθανών λύσεων σε τεχνικά θέματα καθώς και συμβουλών για εξοικονόμηση του κόστους κατασκευής των έργων.

Η **ΕΛΕΒΟΡ ΑΕΒΕ** διαθέτει ευρεία γκάμα προϊόντων αγκύρωσης/ηλώσεων μεταξύ των οποίων και τη πλήρη σειρά των εργοστασιακά προ-συναρμολογημένων προσωρινών και μόνιμων αγκυρίων προεντάσεως TTM.

Το 2010 η **ΕΛΕΒΟΡ ΑΕΒΕ** εντάχθηκε στην κοινότητα των ισχυρότερων Ελληνικών επιχειρήσεων που αξιολογούνται από την ICAP.

ELEBOR S.A. is possibly the oldest and pioneer supplier of specialized geotechnical equipment in the Greek market, with activity being traced back to 1968. Company's expertise is the supply of equipment for drilling, tunnelling, mining and generally for underground and geotechnical works.

ELEBOR S.A. is constantly monitoring the developments of the geotechnical equipment technology and offers to the market advanced products of the latest know-how. Product selections as well as related choices are primarily based on the long experience as well as on the specialized scientific skills of key members of the company. Thus, the company today has a reputation in the market as "specialized – technocrats" and with great satisfaction realizes that customers are contacting the company not only for purchasing products but also to receive support and suggestions to technical problems as well as to proposals for project cost-cutting solutions.

ELEBOR offers a wide range of rock bolting and soil nailing products including the complete range of factory pre-assembled post-tensioned TTM ground anchors.

In 2010, **ELEBOR S.A.** was assessed by ICAP and awarded with the ICAP Strongest Companies in Greece Certificate.

STRONGEST COMPANIES IN GREECE ICAP certificate 2010

Awarded to: ELEBOR S.A.

CRFP130927

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49.00	***TESTING METHODS FOR PERMANENT AND TEMPORARY GROUND ANCHORS*** *(Abstract from "**EURO NORM EN 1537-2002** Annex E)*	
50.00	***SITES***	

All materials comply with the Standard EN-1537 - 2002 "Execution of special geotechnical work: Ground Anchors"

Catalogue revision: ***E***
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1.6 Italian and European Standard EN 1537

1.6.1 – Italian and European Standard EN 1537 "Execution of special geotechnical work: Ground anchors". Scope.

This Standard is the official version of the ***European Standard EN 1537*** *edition 1999, which is therefore given the status of a national regulation.*
The Standard establishes and defines principles with regard to anchor technology. This Standard is applicable to the installation, testing and monitoring of permanent and temporary ground anchors where the load capacity is tested. An anchor consists of an anchor head, a free anchor length and a fixed anchor length which is bonded to the ground by grout. The term "ground" is taken to encompass both soil and rock.
The installation and testing phases require skilled and qualified labour and supervision. This Standard cannot replace the knowledge of specialist personnel and the expertise of experienced contractors required to apply the Standard.
This Standard does not address alternative systems of anchoring such as tension piles, screw anchors, mechanical anchors, soil nails, expander anchors or deadman anchors.
The Standard establishes and defines principles with regard to anchor technology. Where anchor systems do not comply with the principles defined in the text, flexibility in the use of these systems is offered by written acceptance of the ***"Client's Technical Responsible".***
The Standard ***EN 1537*** *introduces a new responsible figure, the* ***" Client's Technical Representative"*** *who is delegated to: accept and approve materials, approve the type of anchor used, check documents of the product supporting tests as well as the quality of the materials used.*

1.6.2 - Abstract from "EURO NORM EN 1537-2002 paragraph 6.1."

Anchor systems shall be used for which successful experience with respect to performance and durability *has been documented.*
All anchor systems shall have been subjected to at least one system test to verify the competence of the system.
The results of all tests shall be documented in detail.
The documented system test shall be approved by the ***Client's Technical Responsible*** *in accordance with the principles stated in this Standard.*
All materials used must be mutually compatible. This applies in particular to adjacent materials with a common interface. Material properties shall not change during the design life of the ground anchor in such a way that the anchor loses its serviceability. Anchors involving the use of newly developed materials or methods of execution are permitted subject to the performance of the anchor and durability of the materials used being proven by system tests and approved by the ***Client's Technical Responsible*** *to ensure that the serviceability of the anchor system is maintained for the design life of the anchored structure.*

1.6.3 - Abstract from "EURO NORM EN 1537-2002 paragraph 6.3."

The anchor head shall allow the tendon to be stressed, *proof loaded and locked-off and, if required, released, distressed and restressed. It shall be able to carry the characteristic tensile load of the tendon of 100% Ptk.*
The anchor head shall comply with ENV 1992-1: Eurocode 2, unless the required deviation is justified.
The anchor head shall be designed to tolerate angular deviations of the tendon from the direction normal to the head, up to a maximum of 3° at 97% Ptk. of the tendon.
The anchor head shall distribute the tendon load to the main structure or to the ground in accordance with the overall design of the structure through designed or tested components.
The anchor head (i.e. the connection between the anchor tendon and the structure) shall be able to adjust to deformations which may be expected during the design life of the structure.

1.6.4 - Abstract from "EURO NORM EN 1537-2002 paragraph 6.4."

Couplers *shall comply with ENV 1992-1-1: Eurocode 2, and shall not compromise the required tensile strength of the tendon. The tendon shall not be coupled inside the bond length.*
The free extension of a steel tendon shall not be compromised by restraint of the coupler.
The corrosion protection of the coupler shall be compatible with the corrosion protection provided to the tendon.

1.6.5 - Abstract from "EURO NORM EN 1537-2002 paragraph 6.5."

In order to anchor the tendon in the bond length*, profiled or ribbed tendons, strands or compression tubes shall be used in this section.*
As a guide the following types of steel tendon may be may be anchored by bond action:
- *cold drawn wires profiled after drawing;*
- *quenched and tempered wires ribbed during hot rolling;*
- *ribbed bars;*
- *7 wire strands.*

The relative area fr of the ribs of ribbed or profiled wires and bars shall be in accordance with ENV 1992-1: Eurocode 2.
Prestressing steels with a smooth surface with or without special proven anchoring devices may only be used with temporary anchors when approved by the ***Client's Technical Representative****.*

1.6.6 - Abstract from "EURO NORM EN 1537-2002 paragraph 6.6."

Spacers and other components in the borehole. *All installed tendons and encapsulations shall be provided with a minimum of 10 mm grout cover to the borehole wall. This may be achieved by the use of spacers or centralizers.*
Any component installed and remaining in the borehole should be spaced and located so that it does not reduce the bond capacity of the anchor. To ensure correct positioning of the tendon(s), the tendon components, the corrosion protection components and any other component in the borehole, spacers should be located such that minimum grout cover requirements and complete filling of open volume by grout are provided.
Spacers and centralizers shall not impede grout flow. When used outside an encapsulation in a permanent anchor, spacers should be manufactured from corrosion resistant materials.
The design of centralizers shall take into account the shape of the hole, e.g. the presence of underreamed bells, the weight of the tendon and the susceptibility of the ground to disturbance during insertion of the tendon.

1.6.7 - Abstract from "EURO NORM EN 1537-2002 paragraph 6.9.2."

Temporary ground anchor. *The steel components of a temporary ground anchor shall be provided with protection which will inhibit or prevent corrosion over a minimum design life of two years.*
If there is a possibility that the design life of a temporary ground anchor is to be extended on a temporary basis, or if the ground anchor is installed in soil conditions known to be corrosive, then measures approved by the Client's Technical Representative shall be taken to protect all parts of the anchor from corrosion.

1.6.8 - Abstract from "EURO NORM EN 1537-2002 paragraph 6.9.3"

Permanent ground anchor. *The minimum corrosion protection surrounding the tendon(s) of the anchor shall be a single continuous layer of corrosion preventive material which does not degrade during the design life of the anchor.*
The tendon(s) of a permanent ground anchor shall be provided with either:
a) *two protective barriers to corrosion such that if one barrier is damaged during the installation or anchor loading, the second remains intact; or,*

b) a single protective barrier to corrosion, the integrity of which shall be proven by testing each anchor insitu,
c) a corrosion protection system provided by a steel duct tube-a-manchette type anchor,
d) a corrosion protection system provided by a corrugated plastic duct tube-a-manchette type anchor,
e) a corrosion protection system provided by a steel duct compression tube type anchor

1.6.9 - Abstract from "EURO NORM EN 1537-2002 paragraph 6.11.3"

Anchor head. *Where the environment is aggressive, early protection of the anchor head shall be applied to both temporary and permanent anchors.*
The purpose of the inner head protection is to provide an effective overlap with the free length protection, to protect the short exposed length of tendon below and passing through the bearing plate.
Where injection techniques are employed, a lower injection pipe and upper vent pipe should be used to ensure complete filling of the void. Where no access for injection of the inner head is provided, a pre-packed corrosion protection compound may be used.
Where restressability or load checking is not required, reins, grouts and other setting sealants may be used within the anchor cap.
Where restressability or load checking is required the outer head protection including the anchor head cap and its contents shall be removable. It shall be possible to refill the cap with corrosion protection compound.
A suitable seal and mechanical coupling shall be provided between the cap and the bearing plate.
Where applied to permanent anchors the bearing plate and the other exposed steel components at the anchor head shall be protected in accordance with the relevant EN for the coating of steel structures prior to being brought onto site.
*Steel caps for permanent anchors shall have a minimum wall thickness of 3 mm. Reinforced plastic caps having a minimum wall thickness of 5 mm may be used, where approved by the **Client's Technical Representative.***
The protection system applied to the inner and outer anchor head shall be subjected to a system test.

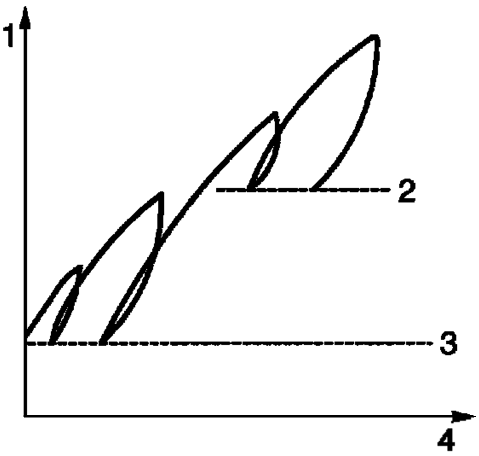
1.6.10 - Abstract from "EURO NORM EN 1537-2002 paragraph 8.4.2"

Stressing equipment and dynamometers *Stressing equipment and load cells in regular use shall be calibrated at intervals not exceeding 6 months, and the calibration certificate shall be made available for inspection on site at all times. Stressing equipment for bar and strand tendon should tension the complete tendon as a single unit. Stressing equipment which tensions individual strands not simultaneously should be provided with or be supplemented by measuring devices which establish the total load in the multiple strands at any time during testing. Alternatively accurate lift-off checks should be undertaken.*

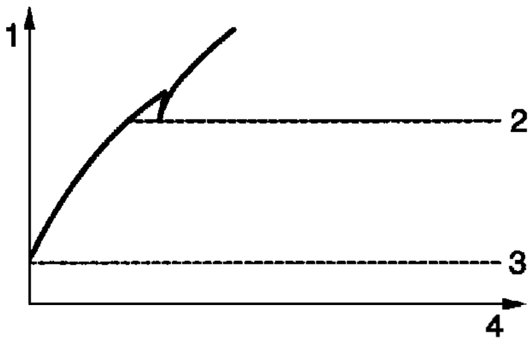
1.6.11 - Abstract from "EURO NORM EN 1537-2002 paragraph 9.3"

The datum load Pa adopted from which measurement commences, is normally about 10% of the proof load.
Higher datum loads are permitted in cycling loading tests after load cycles where unusually high tendon extensions occur.

1 *Anchor load*
2 *Optional higher datum load*
3 *Datum load Pa*
4 *Anchor displacement*



a) With load cycling



b) Without load cycling

1.6.12 - Abstract from "EURO NORM EN 1537-2002 paragraph 9.4"

Test methods. The Client's Technical Representative *shall approve the test method and the associated interpretation system which shall be used in each test class. For each test class the ground anchor shall be loaded in stages in accordance with any procedure required for that test class.*
Three examples of test methods applicable to each test class are given in annex E - these are:
a) ***test Method 1****: The anchor is loaded incrementally in one or more cycles from a datum load to a proof load. Displacement of the anchor head is measured over a time period at the maximum load in each cycle;*
b) ***test Method 2:*** *The anchor is loaded incrementally in cycles from a datum load to a proof load or to failure. The loss of load at the anchor head is measured over a time period at the maximum load in each cycle;*
c) ***test Method 3:*** *The anchor is loaded in incremental steps from a datum load to a maximum load. The displacement of the anchor head is measured under maintained load at each loading step.*
During all testing the load shall be applied and released smoothly so that the anchor is not subjected to any shock or dynamic loads.

1.6.13 - Abstract from "EURO NORM EN 1537-2002 paragraph 9.6"

Investigation tests *may be required to establish for the designer, in advance of the installation of the working ground anchors, the ultimate load resistance in relation to the ground conditions and materials used, to prove the competence of the contractor and/or to prove a new type of ground anchor by inducing a failure at the grout/ground interface.*
Investigation tests should be carried out where anchors are used in ground conditions not yet tested by previous investigation tests or with higher working loads than those already adopted in similar ground conditions.
Anchors used for investigation tests are loaded more rigorously than anchors in acceptance tests so it may be necessary to increase the size of the tendon to accommodate this. Anchors subjected to investigation tests shall not be used in permanent works if they have been loaded to failure.
The diameter of the borehole and dimensions of other components, apart from the tendon, should be

kept the same as the working anchor.
Where an increase in capacity of the tendon is not possible then a shorter fixed length may be tested in order to induce a grout/ground failure.
Where failure of a test anchor with a reduced fixed anchor length is attained an increase in load resistance directly proportional to the increase in fixed length should not be expected for anchors of longer fixed lengths.
If the diameter of the borehole is increased the behaviour of an anchor in an investigation test may not be compared directly to the behaviour of working anchors. The anchor shall be loaded to failure (Ra) or to a proof load (Pp) which shall be limited to 0.80 Ptk or 0.95 Pt0.1K.

1.6.14 - Abstract from "EURO NORM EN 1537-2002 paragraph 9.8"

Maximum lock-off load. *If a creep or load loss limit is not exceeded, the maximum lock-off load (P0) shall be limited to 0.60 Ptk.*
If, in the case of either a suitability test or an acceptance test, the creep or load loss limit is exceeded, the lock-off load shall be reduced to a level where the creep or load loss criterion is satisfied.

Characteristics of the strands:

Diameter	Standard	Type of strand	Nominal diameter	Nominal area	Mass	f_{tk}	Yield point (Ptk)	Elastic limit at 0.1% (Pt0,1k)	Relaxation after 1000 h.0.7 - 0.8 f_{pk}	
			mm.	mm^2	gr./m	N/mm^2	KN	KN	%	%
T15 T15S	EN 10138	normal super	15.2 15.7	140 150	1095 1170	1860 1860	260 279	224 240	2.5 2.5	4.5 4.5
T15C	EN 10138	Compact	15.2	165	1290	1860	300	258	2.5	4.5

Elastic modulus = 196 +/- 10 KN / mm²

2.0 - GROUND ANCHORS

*An anchor **EURO NORM EN 1537-2002** Paragraph 1 page 1 consists of an anchor head, a free anchor length and a fixed anchor length which is bonded to the ground by grout. The term "ground" is taken to encompass both soil and rock. This Standard does not address alternative systems of anchoring such as tension piles, screw anchors, mechanical anchors, soil nails, and expander anchors or deadman anchors.*

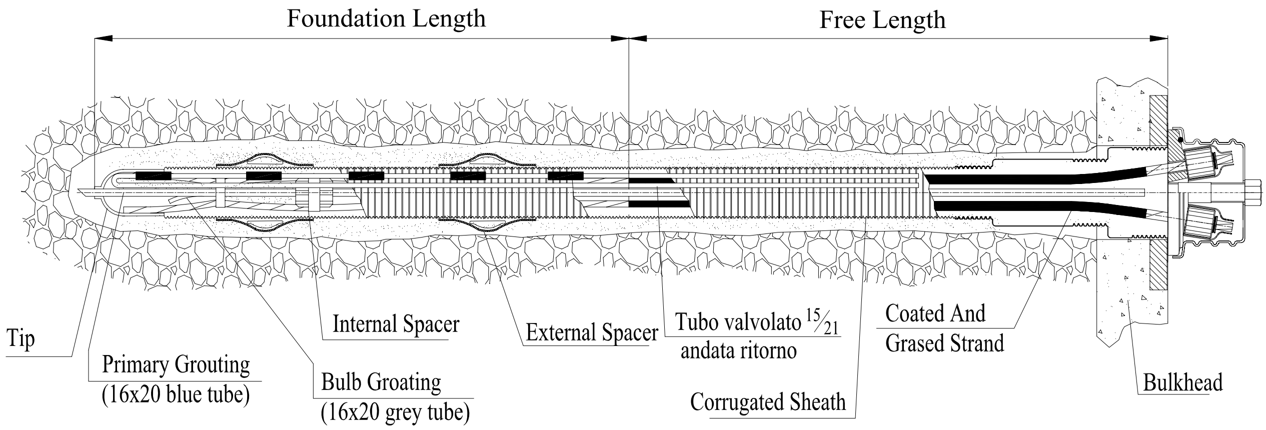
2.1 - Ground anchor functional parts:

- *head: group of terminal elements that transmit tensile load of the anchor to the anchored structure or directly to the rock;*
- *free length: group of elements that transmit the tensile load from the head to the foundation;*
- *foundation length: group of elements that transmit the tensile load of the anchor to the ground.*

2.2 - Ground anchor elements

With reference to the functional parts these are:

- *blocking device and head distribution plate;*
- *tendon and sheath;*
- *foundation anchoring device.*



The types of elementary ground anchors on sale according to the several load categories are:

- ***TPR-00** (temporary ground anchor with free length singularly protected with grease);*
- ***TPR-01**(temporary ground anchor with free length further protected with grease);*
- ***TPE-02** (permanent ground anchor);*
- ***TPE-03** (double protection permanent ground anchor with two encapsulated concentric sheaths);*
- ***TPE-02SP** (permanent ground anchor with selectively re-grout valves on the **I.R.S** bulb);*
- ***TPR-04** (temporary ground anchor with central valvate part for **I.R.S** selective re-grout);*
- ***TPE-05** (permanent ground anchor with **RRM** selectively re-grout valves on the **I.R.S** bulb);*
- ***TPE 07** (encapsulated permanent ground anchors);*
- ***TPE-08** (permanent ground anchor with external valvate part – U shaped for **I.R. non-selective re-grout**);*
- ***TPD-09** (dielectric permanent ground anchor);*
- ***TPS-10** (partially removable temporary ground anchor);*
- ***TPS-11** (partially removable permanent ground anchor);*
- ***TPF-12** (totally removable permanent ground anchor);*
- ***TPE-15** (increased adherence permanent ground anchor);*
- ***TPE-16** (increased adherence permanent ground anchor with **RRM I.R.S** valves);*
- ***TPE-17** (multi-bulb permanent ground anchor)*
- ***TPE-18** (multi-bulb permanent ground anchor)*
- ***TPE-19** (avalanche protection permanent ground anchor)*
- ***TPR-20** (temporary ground anchor with preventer for the installation into strata under pressure)*

*Other types of ground anchors may be produced. They are variations with respect to the types indicated above and they are made on the customer's request and then approved by the **Client's Technical Representative.***

3.0 - GROUND ANCHORS TYPES

EURO NORM EN 1537-2002 paragraph 6.9 *classifies the ground anchors according to their resistance to their static function. Temporary ground anchors end their static function within two years since their installation, while the static function of permanent anchors lasts over two years.*

3.1 – "TPR" temporary ground anchors

(***EURO NORM EN 1537-2002*** *Paragraph 6.9.2)*

The steel components of a temporary ground anchor shall be provided with protection which will inhibit or prevent corrosion over a minimum design life of two years. If there is a possibility that the design life of a temporary ground anchor is to be extended on a temporary basis, or if the ground anchor is installed in soil conditions known to be corrosive, then measures approved by the Client's Technical Representative shall be taken to protect all parts of the anchor from corrosion. They are used in temporary structures to contain bulkheads or for structures that at the end of the work will no longer require the static function of the anchor.

Temporary ground anchors are divided into the following types:

- *Removable* ***"TPS";***
- *Monitored with cell;*
- *Re-grout* ***"I.R.*** *and* ***I.R.S.".***

TPR temporary ground anchors

Examples of corrosion protection are described in Table 2 of the ***EURO NORM EN 1537-2002.***

3.2 - “TPE” permanent ground anchors
*(**EURO NORM EN 1537-2002** paragraph 6.9.3)*

Permanent ground anchors are defined as those which are to have a design life of more than two years. The minimum corrosion protection surrounding the tendon(s) of the anchor shall be a single continuous layer of corrosion preventive material which does not degrade during the design life of the anchor. The tendons of a permanent ground anchor shall be provided with either:

- *two protective barriers to corrosion such that if one barrier is damaged during the installation or anchor loading, the second remains intact,*
- *a single protective barrier to corrosion , the integrity of which shall be proven by testing each anchor on site,*
- *a corrosion protection system provided by a steel duct tube-a-manchette type anchor,*
- *a corrosion protection system provided by a corrugated plastic duct tube-a-manchette type anchor,*
- *a corrosion protection system provided by a steel duct compression tube type anchor,*

They are used in structures where the action of the anchor is required for a long period.

Permanent ground anchors are divided into the following types:

- *Removable **“TPS”;***
- *Re-grout **“I.R.** and **I.R.S.”;***
- *Dielectric **“TPD”;***
- *Monitored with cell.*

Re-grout TPE permanent ground anchors

*Examples of corrosion protection for permanent anchors are described in Table 3 of the **EURO NORM EN 1537-2002***

*<u>At paragraphs 6.9.2 and 6.9.3, the Standard allows the **Client's Technical Representative** to change the protections and making of the product.</u>*

4.0 - GROUTING
*(**EURO NORM EN 1537-2002** paragraph 8.3)*

***General** (**EURO NORM EN 1537-2002** paragraph 8.3.1)*
Grouting meets one or more of the following functions:

***a)** to form the fixed anchor length in order that the applied load may be transferred from the tendon to the surrounding ground;*
***b)** to protect the tendon against corrosion;*
***c)** to strengthen the ground immediately adjacent to the fixed anchor length in order to enhance ground anchor capacity;*
***d)** to seal the ground immediately adjacent to the fixed anchor length in order to limit the loss of grout.*

***Note:** If a grout volume injected is in excess of three times the borehole volume at pressures not exceeding total overburden pressure, then general void filling is indicated which is beyond routine anchor construction. In such cases general void filling may be necessary before grouting the anchor. For functions c) and d) above only nominal grout consumptions should be expected.*

In order to form the fixed anchor length without an uncontrolled loss of grout over this length, the following operations may be considered:

- *borehole testing;*
- *Pregrouting;*
- *anchor grouting.*

4.1 - Technical specification for grouting with valvate tubes

Filling of the casing with grouting mixture having a ratio water/dry mixture < 0.40
After 12 hours since the insertion of the anchor, grouting can be carried out via the valves of the foundation bulb by 75 l per valve.

For a successful grout we recommend:

- *an accurate cleaning after each phase of operation of the 27x34 mm T 001 tube;*
- *use of XG 27-600 double pistons only;*
- *for a better handling: of re-grouts, tube cleaning, re-insertion of 27x34 mm. T 001 tubes full of mixture or water, double pistons with XG 27-900 non-return valve on the tip;*
- *for primary grouting use 325 cement, 425 for the next ones;*
- *replace grouting caps on the double piston when worn out;*
- *carefully wash the double piston by disassembling it after each use.*

4.2 - Borehole testing (EURO NORM EN 1537-2002 paragraph 8.3.2.)*

On completion of the borehole or during the grouting of the anchor measures shall be taken to ensure that the fixed anchor length is fully grouted after the grout has set. This may be done for example, by water testing, falling head grout tests or by pressure grouting.

***Note 1:** Water testing - The likelihood of cement grout loss can be assessed in rock from an analysis of a water injection test. Routinely a falling head test is applied to the borehole or the fixed anchor length via a packer. Pregrouting is not usually required if leakage or water loss in the hole or fixed anchor length is less than 5 l/min at an excess head of 0.1 MPa measured over a period of 10 min.*

***Note 2:** Falling head grout test - When pressure grouting of the fixed anchor length is not carried out as part of the routine anchor construction, the borehole may be pre-filled with grout and the grout level observed until it becomes steady. If the level continues to fall it should be topped up and after sufficient stiffening of the grout, the borehole should be redrilled and retested. The test may be applied to the entire borehole or restricted to the fixed anchor length by packer or casing over the free anchor length.*

Note 3: *Pressure grouting - For anchor types where grouting of the free anchor length is done under pressure, this activity is generally isolated during controlled withdrawal of the lining tube or by the use of a packer or tube á manchette system. During injection a controlled flow rate at a measured pressure indicates a satisfactory grouting operation. On completion of grouting of the free anchor length the efficiency of this phase can be checked by monitoring the response of the ground to further grout injection when the back pressure should be quickly restored.*

4.3 - Pregrouting (EURO NORM EN 1537-2002 paragraph 8.3.3.)

Pregrouting should be carried out by filling the borehole with cement based grout. Sand/cement grout is commonly employed in rock and very stiff to hard cohesive deposits with partially filled or open fissures and in permeable cohesionless soils to reduce grout consumption.
On completion of Pregrouting the borehole should be retested and if necessary, the grouting process should be repeated after redrilling.

4.4 - Pregrouting of rock (EURO NORM EN 1537-2002 paragraph 8.3.4.)

In soft rocks, the time of redrilling in relation to grout strength gain is critical to avoid problems of drilling alignment.
Chemical grouting should not be necessary in normal practice but, if employed, it should be established that the chemical will have no deleterious effect on the anchor or on the environment (i.e. contamination of soil and groundwater).
Where a water test indicates a hydraulic connection to an adjacent unstressed anchor, then stressing of that anchor should not be carried out before the grout has set.

4.5 - Pregrouting of soil (EURO NORM EN 1537-2002 paragraph 8.3.5.)

Where borehole testing has identified that the soil is highly permeable or that the grout may be injected at a high flow rate without generating back pressure, pregrouting may be required. This may not be a routine procedure but a prudent precautionary measure if the above soil conditions are suspected to prevail.
In exceptional circumstances it may be necessary to carry out general void filling for overall ground strengthening. In this case such work should not be considered part of routine ground anchor construction.

4.6 - Anchor grouting (EURO NORM EN 1537-2002 paragraph 8.3.6.)

Placement of grout should be carried out as soon as possible after completion of drilling. When grouting by the tremie method, the end of the tremie pipe shall remain submerged in grout within the fixed anchor length and grouting shall continue until the consistency of the grout emerging is the same as that of the injected grout.
The grouting process should always start at the lower end of the section to be grouted. For horizontal and upward inclined holes, a seal or packer is required to prevent loss of grout from either the fixed anchor length or the entire hole.
Air and water shall be able to escape to permit complete grout filling. When installing nearly horizontal anchors, special measures, such as multi-stage pressure grouting should be used to prevent any voids being left in the section to be grouted. When multi-sequence grouting along the fixed anchor length or regrouting is envisaged, a sleeve pipe (valve á manchette) system should be incorporated in the anchor assembly.
In certain ground conditions where the grout column is adequately confined in the free length, some load can be transferred from the fixed length into the free length and onto the back of the structure. Where appropriate, one or more of the following actions may be taken:

- *flush the grout out from behind the structure;*
- *replace the free length grout with a non-load transferring material;*
- *locate a packer at the proximal head of the fixed length.*

High-pressure multi-stage grouting may be used to increase anchor resistance by introducing further grout into the ground and raising the normal stresses at the ground/grout interface. This may be carried out before or after tendon installation.
Artesian water gain within a borehole should be counteracted by an excess load of grout or by pregrouting irrespective of the rate of the water gain.

5.0 – GROUTING ON GROUND ANCHORS (grouting on permanent and temporary anchors) (EURO NORM EN 1537-2002 paragraph 8.3)

Grouting on permanent and temporary anchors can be carried out with three different methods:

- ***I** (simple grouts);*
- ***I.R.** (repeated grouts);*
- ***I.R.S.** (repeated and selective grouts).*

5.1 - I grouting (on permanent and temporary anchors) (EURO NORM EN 1537-2002 paragraph 8.3)

***I** type grouting is carried out with 16x20 mm polyethylene tubes according to **EURO NORM 1537 2002 paragraph 6.10.01.** This solution allows only one grout, as the material hardening in the tube does not allow any new grout, thus limiting the application to a single use.*

TPE 02 permanent anchor with I grout.

TPE 02-A ground anchor

The effect of a simple grouting can be expanded by inserting a packer to increase the external pressure in the foundation, thus confining the effect of the primary grouting with its filling.

TPE 02-C anchor with smooth sheath on the free length

The primary grouting can be carried out with a central tube passing through or external to the anchor. This solution may reduce the diameter of the anchor.

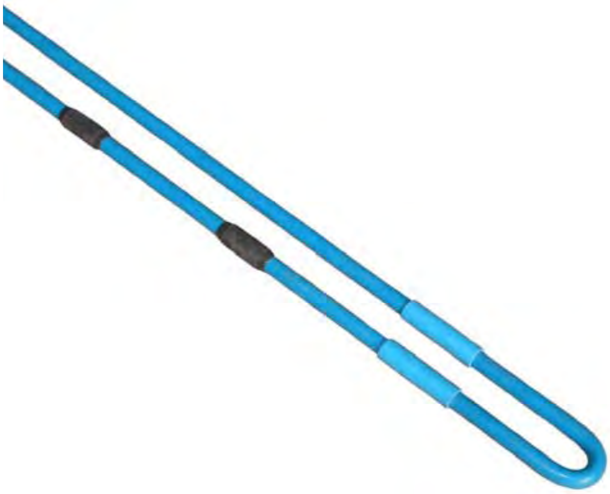
Temporary TPR 00 anchor

5.2 - I.R. grouting (on permanent anchors)
(EURO **NORM EN 1537-2002** paragraph 8.3)

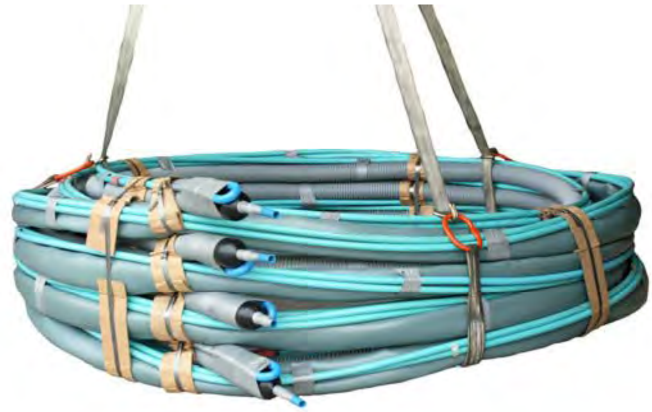
I.R. grouting is carried out with 15x21 mm U-shaped tubes with a valvate side. Duct tubes are in PVC stabilized according to EURO NORM 1537 2002 paragraph 6.10.01.
This solution allows several regroutings. Their number depends on the level of cleaning that can be achieved on a site. I.R. regroutings are not selective, as it is not possible to enter the 15x21 mm tube with a double piston. The opening of the valves is not controlled, when the tube is put under pressure the weakest valve will open, thus guaranteeing a not localized but random regrouting. The opening effect can be limited with several grouts repeated over time.
This kind of application is usually used on anchors where the regrouting installed is only guaranteed if the primary grouting has not produced any fixing effect on the foundation.
I.R. grouts allow to recover the anchor at a later time, allowing for a greater cementation.

TPE 08 permanent anchor with I.R. grout

TPE 08-A ground anchor



15x21 mm U-shaped tube for I.R. repeated grouts



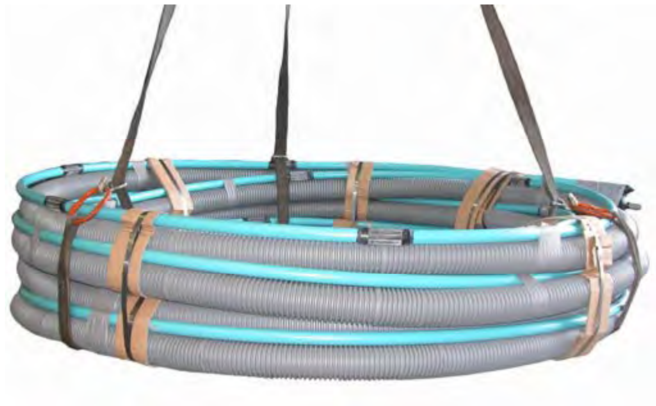
TPE 02-SP-C ground anchor

*The valvate 15x21 mm **T-003-U** tube for repeated grout is made of stabilized PVC added with resins to guarantee the required flexibility to allow the rolling up on a 2.2 m diameter.*
T-003-U** tubes allow the simultaneous grouting of the valves, applying repeated grouts to the anchor. After each grouting operation the tube must be washed. The **T-003-U** tube can cause a valve opening pressure of **150 bar.

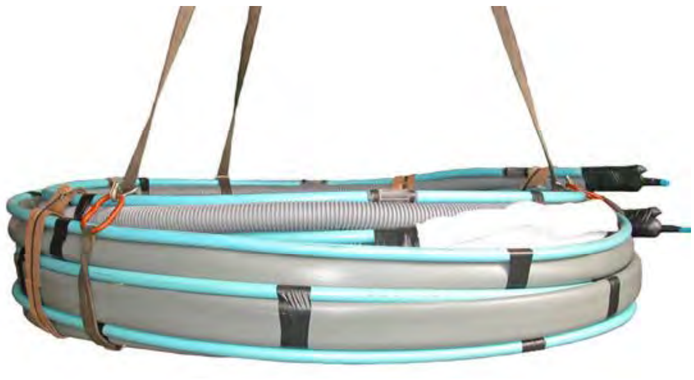
5.3 - I.R.S. grouting (*on permanent anchors with external valvate)*
***(EURO NORM EN 1537-2002** paragraph 8.3)*

I.R.S**. grouts are carried out with 27x34 mm valvate tubes with manchette valves. Duct tubes are made of PVC stabilized according to **EURO NORM 1537 2002 paragraph 6.10.01.
This solution allows several selective regroutings. Their number depends on the level of cleaning that can be achieved on a site.
I.R.S. are selective as it is possible to enter the 27x34 mm tube with a double piston and open valve by valve by carrying out a volume grouting as well as a grouting under pressure.
The opening of the valves is therefore under control.

TPE 02SP permanent anchor with I.R.S. regrouting



TPE 02-SP-A ground anchor



TPE 02-SP-C ground anchor with packer and smooth sheath

This kind of application is usually used on anchors where regrouting is necessary due to serious problems of anchoring the foundation to the ground.
*This solution guarantees the possibility of regrouting over time. If the foundation is observed to sink by means of the **T001** external valvate, the anchor can be regrouted to restore the initial stressing. The number of regroutings depends on an accurate cleaning after each use; after each use, we suggest to introduce into the **T001** (27x34 mm) tube a duct with water up to the tip. Water must be left to flow until it no longer carries any cement.*
*After cleaning, the tube should then be further cleaned by passing the **XG27-900** piston a few times (piston with valve on the tip).*

5.4 - I.R.S. grouting (*on permanent anchors with RRM valves)*
***(EURO NORM EN 1537-2002** paragraph 8.3)*

I.R.S. *grouts are carried out with 27x34 mm tubes with RRM valves on the foundation. Duct tubes are made of PVC stabilized according to* ***EURO NORM 1537 2002 paragraph 6.10.01.***
This solution allows several selective regroutings with an anchor with internal valvate, which easier to insert into the drilling. The reuse and duration of the valve depends on the level of cleaning that can be achieved on a site. I.R.S. regroutings are carried out with a double piston to open valve by valve by carrying out a volume grouting as well as a grouting under pressure, if required. The opening of the valves is therefore under control.

TPE 05 permanent anchor with I.R.S. regrouting

TPE 05-A anchor

RRM valve on TPE 05 anchor

External centralized on TPE 05 anchor foundation

This kind of application is usually used on anchors where regrouting is necessary due to serious problems of anchoring the foundation to the ground where the external valvate tube cannot be applied, thus creating problems at the insertion or application.
This solution guarantees the possibility of regrouting over time. If the foundation is observed to sink by means of the ***T001*** *external valvate, the anchor can be regrouted to restore the initial stressing. The number of regroutings depends on an accurate cleaning after each use; after each use, we suggest to introduce into the* ***T001*** *(27x34 mm) tube a duct with water up to the tip. Water must be left to flow until it no longer carries any cement.*
After cleaning, the tube should then be further cleaned by passing the ***XG27-900*** *piston a few times (piston with valve on the tip).*

5.5 - I.R.S. grouting (*on temporary anchors)*
(EURO NORM EN 1537-2002 *paragraph 8.3)*

I.R.S. *grouts are carried out with 27x34 mm valvate tubes with manchette valves, even on temporary anchors with the insertion into the anchor inside the strands of a 27x34 mm valvate tube. Tubes are made of PVC stabilized according to* ***EURO NORM 1537 2002 paragraph 6.10.01.*** *This solution allows several selective regroutings. Their number depends on the level of cleaning that can be achieved on a site. They are selective as it is possible to enter the 27x34 mm tube with a double piston and open valve by valve by carrying out a volume grouting as well as a grouting under pressure. The opening of the valves is therefore under control.*

TPR 04 temporary anchor with I.R.S. regrouting

TPR 04 ground anchor

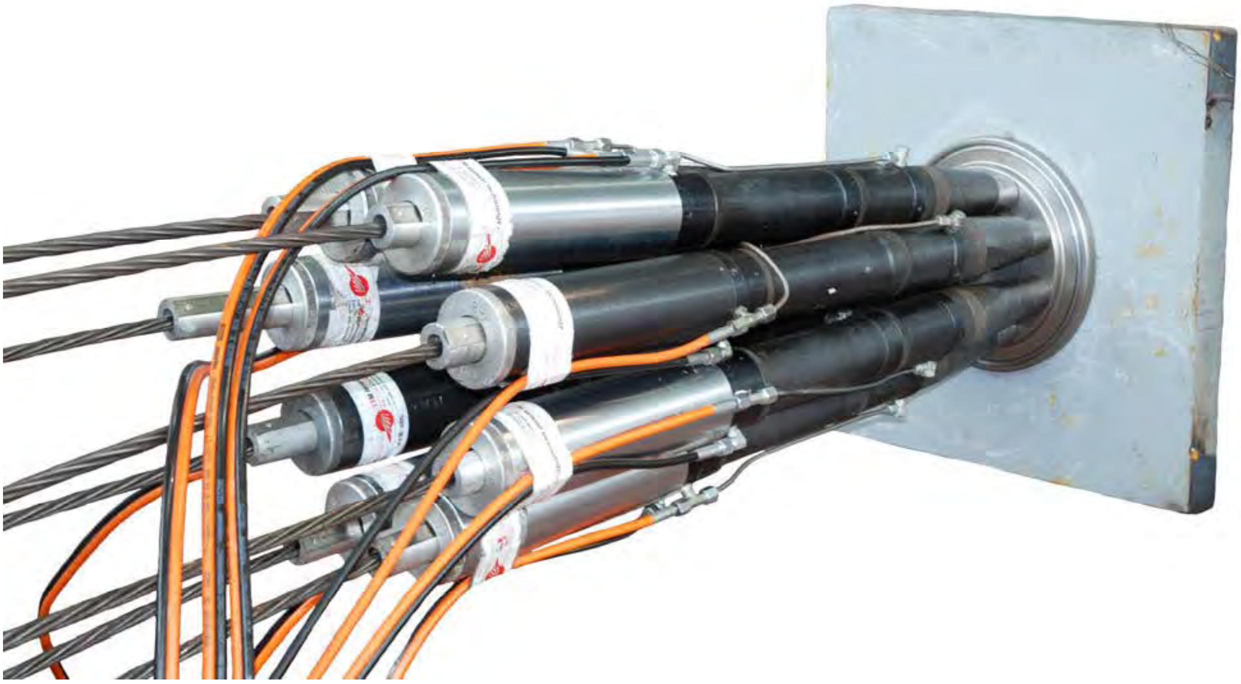
To guarantee the correct use of ***T-001****valvate tubes, anchors shall be unrolled as they arrive at the site. This kind of application is usually used on anchors where regrouting is necessary due to serious problems of anchoring the foundation to the ground and where temporary anchors are required. This solution guarantees the possibility of regrouting over time. If the foundation is observed to sink by means of the* ***T001*** *external valvate, the anchor can be regrouted to restore the initial stressing. The* ***T-001*** *27x34 mm valvate tube for selective grouting guarantees the double piston to be entered after unrolling, as its main characteristic is the internal calibration of the tube.* ***T-001*** *tubes allow the grouting valve by valve, applying repeated grouts to the anchor. They are made in a single bar. After each grouting cycle the tube must be washed. They can cause a valve opening pressure of* ***150 bar.***

6.0 – ANCHORAGES FOR PERMANENT AND TEMPORARY GROUND ANCHORS

Permanent and temporary ground anchors can be provided with several anchorage systems based on the applications required. The following systems may be installed: TTR, TTR-E, TTM-F, TTM and TTS.

6.1 - TTR anchorages

***TTR** anchorages represent most applications and allow to anchor 2 to 9 strands. They are laboratory tested and made of **C40-45 EN 10083/1**. They can be used with both short and long caps. On **TTR** anchorages, **TTM250KN** jacks can be simultaneously tensioned.*



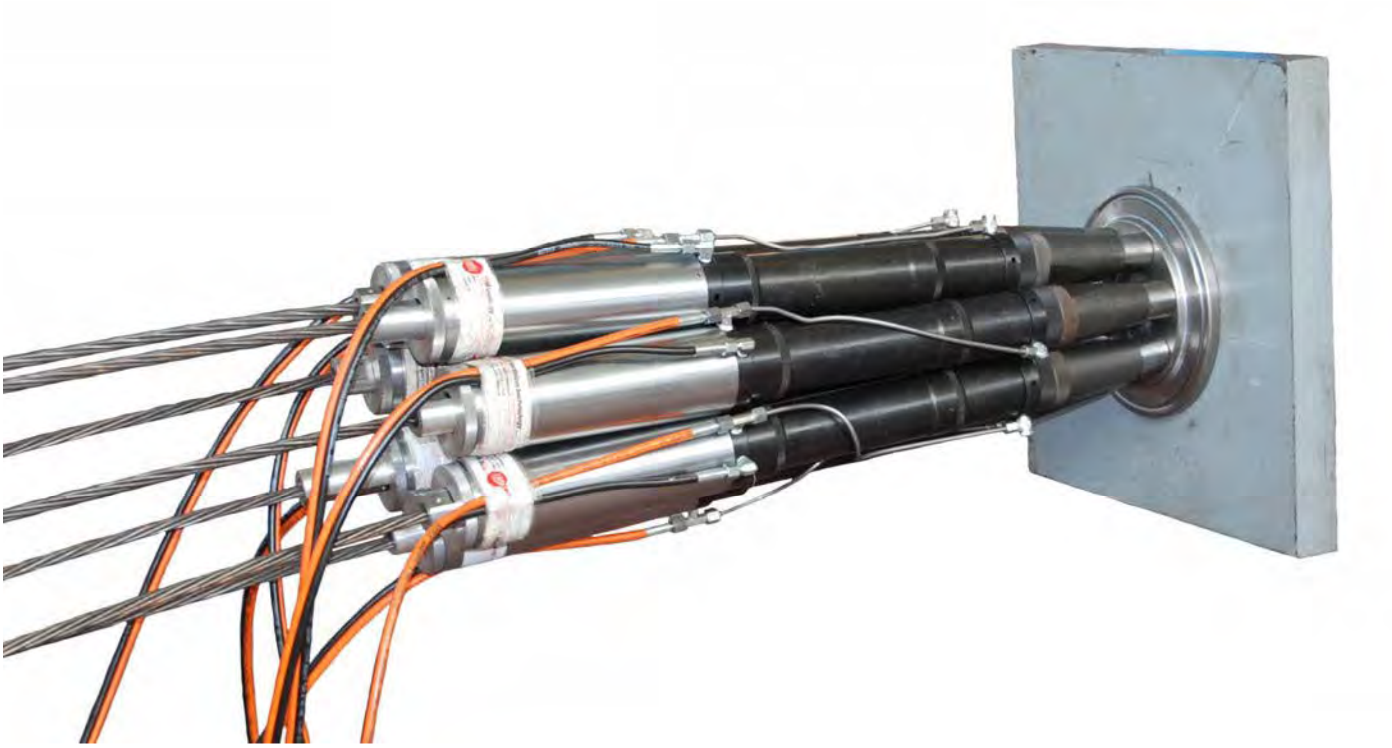
*The tensioning of **TTR** anchorages from 2 to 9 strands can be carried out manually without any mechanical lifting machine by moving one jack at a time.*
*The **TTR** anchor plate has to be checked when transferring load. If proper values do not result, it will be necessary to install a suitable distribution plate.*
The application requires a plain supporting surface that is orthogonal to the hole to prevent strands to be subjected to a tangential strength causing them to fail.

TTR anchorages

*The **TTR** plate cannot be certified according to an **"European Technical Approval"** but it is provided with qualification tests in compliance with the **Ministerial Memorandum dated 15th October 1996 no. 252 AA.GG./S.T.C. Paragraph F.** and qualified according to the **Construction technical regulations of the Ministerial Decree of 14.01.2008***

6.2 - TTR-E anchorages

TTR-E *anchorages are produced according to the* ***ETAG013*** *guidelines and are going to obtain a qualification. They are made according to the norm* ***EN 1537-2002 paragraph 6.3****, where a max deviation of the strand 3° is tolerated from the normal direction, and in compliance with the Eurocode 2. There are from 2 to 8 strands in* ***C40-45 EN 10083/1*** *that can be used with both short and long caps. On* ***TTR-E*** *anchorages,* ***TTM250KN****jacks can be simultaneously tensioned.*



The tensioning of ***TTR-E*** *anchorages from 2 to 8 strands can be carried out manually without any mechanical lifting machine by moving one jack at a time.*
The ***TTR-E*** *anchor plate has to be checked when transferring load. If proper values do not result, it will be necessary to install a suitable distribution plate.*
The application requires a plain supporting surface that is orthogonal to the hole to prevent strands to be subjected to a tangential strength causing them to fail.

TTR-E anchorages

The ***TTR-E*** *plate is going to be certified according to the ETAG013 guidelines and the "****European Technical Approval"*** *and qualified according to* ***Construction technical regulations of the Ministerial Decree of 14.01.2008***

6.3 - TTS anchorages

5TTS15 anchorages

***TTS** anchorages represent a solution to anchor a ground anchor with an inclination up to 15°. They are available up to max. 6 strands, while bigger applications are not recommended as they cause:*

- *an increase in the borehole,*
- *an increase in the thickness of the plate,*
- *a decrease in the angular compensation reducing the max value of 15° to check on each application with the plate thickness used.*

They cannot install caps, so they can only be used on temporary ground anchors.

Application of a 4TTS15 anchorage

*In the application of a **TTS** anchorage, the spherical bushes are laid on an oxygen-cut hole allowing their rotation when tensioning. This application cannot be protected with a standard cap, but a special inclined-base cap must be made from carpentry production. The **TTS** anchorage only has simple certifications regarding the materials used for its production.*

*The **TTS** plate <u>cannot be certified</u> according to the **Construction technical regulations of the Ministerial Decree of 14.01.2008** or according to a **“European Technical Approval”***

6.4 - TTM and TTM-F anchorages

TTM *anchorages represent a small part of applications. They are generally used for tensioning with the multi-strand single jack which reduces the anchorage dimensions on the contrary of a* ***M*** *jack that, for its weight and dimensions, must be handled with proper mechanical lifting machines. The M series has a variable weight of 120-390 Kg/each.*

Angular compensation with DD-SF spherical support on TTM anchorage

TTM-F *anchorages are externally equipped with a thread that allows on request to check the residual stress in the anchorage.*

TTM15 anchorage

12TTM-F15 anchorage

TTM-F15 anchorage

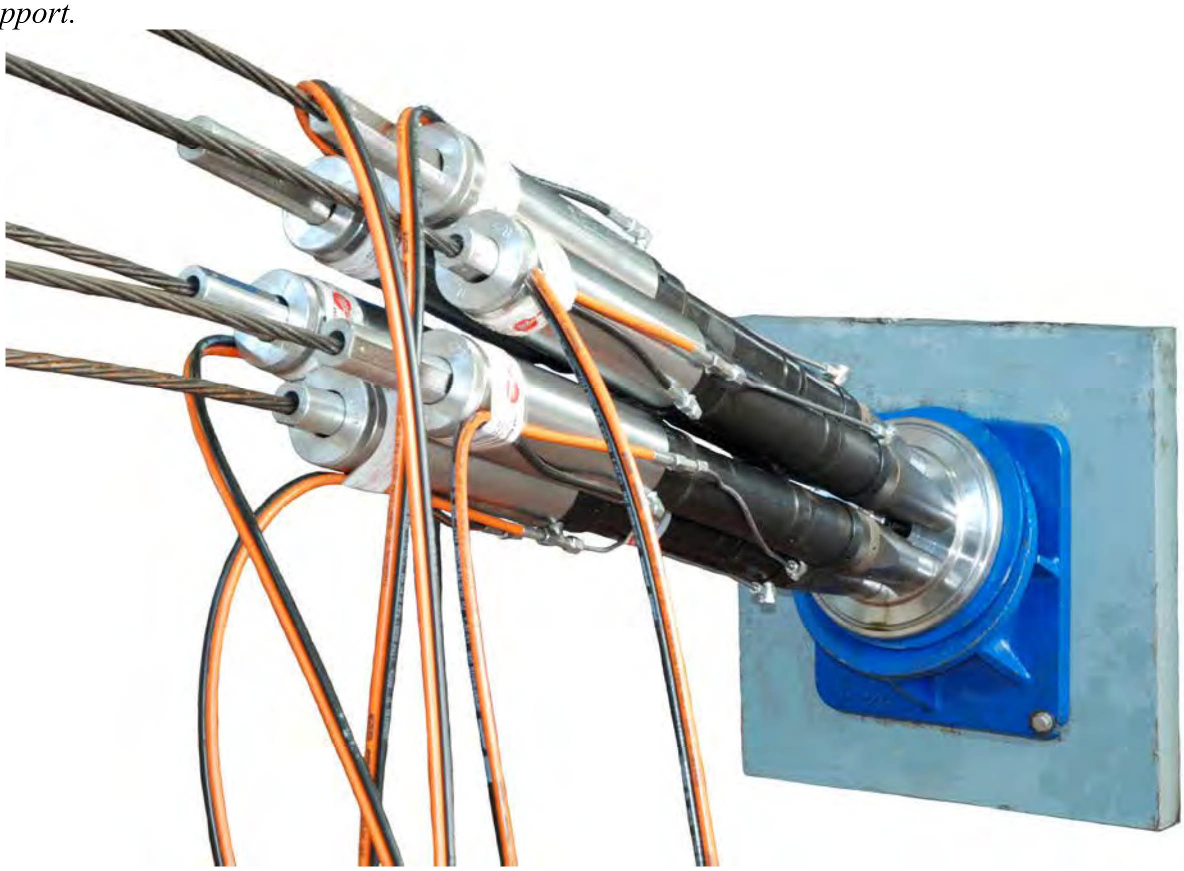
TTM and TTM-F *anchorages must be provided with a suitable distribution plate at the installation which must take into consideration the borehole and the transfer surface of the load applied to the anchor.*

The plate can be certified according to the ***Construction technical regulations of the Ministerial Decree of the 14.01.2008****and according to the Multi-****strand systems*** *European Technical approval* ***ETA-09-0013*** *and its relating marking* ***CE 0969-CPD-002/09-PT***

6.5 - TTR and TTR-E anchorages on DD-SF support

(DD-SF spherical support)

*The application of a **TTR** and **TTR-E** anchorage, on a **DD-SF** spherical support, allows the application of a wall-inclined anchor without any concrete edging or pile walls by means of a **DD-SF** spherical support.*

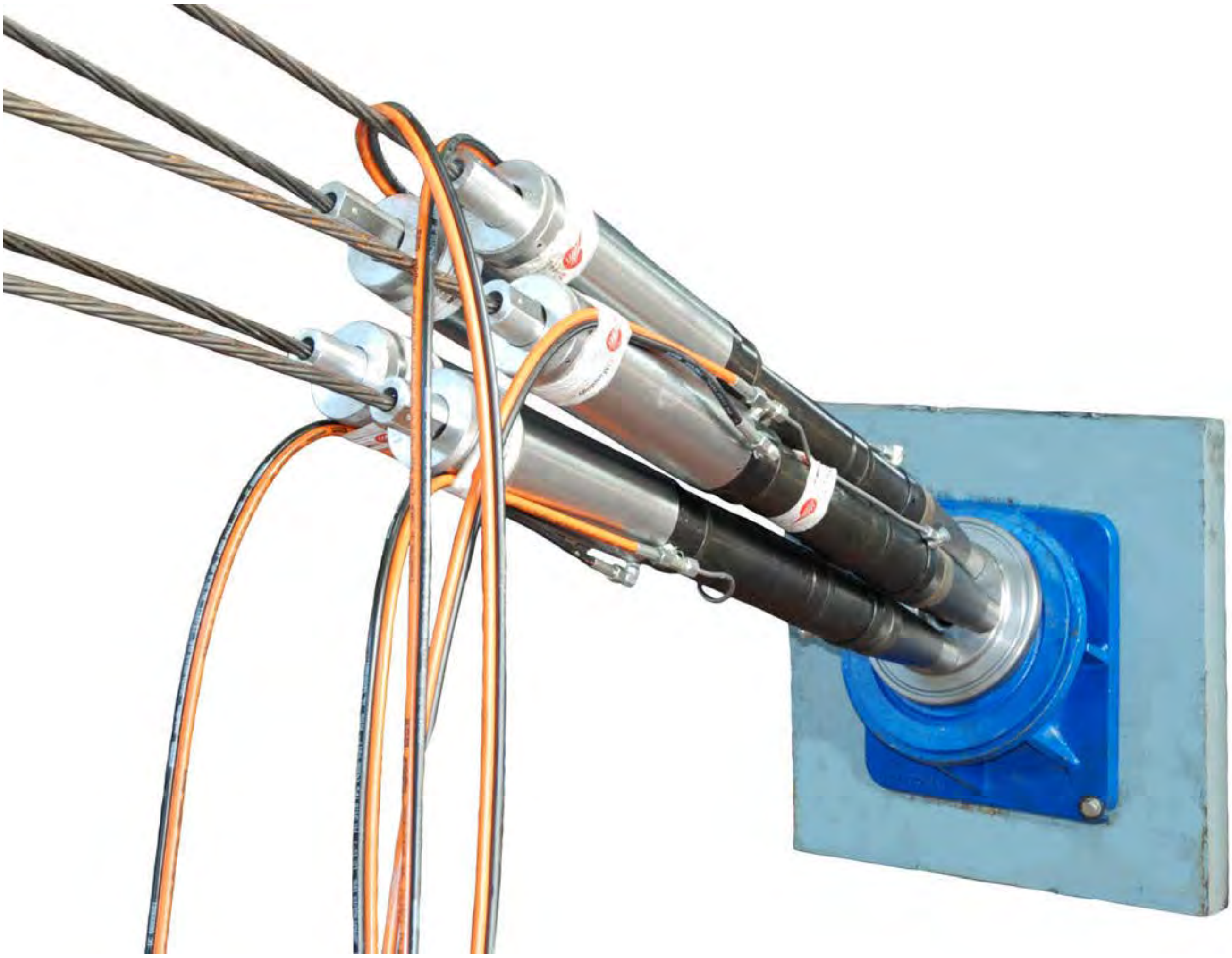


Application of a 6TTS15 anchorage

*The **DD-SF** spherical support allows to compensate inclinations up to max. 35 °, ensuring the perfect squareness of the load and the compensation of the transverse loads.*

*The **DD-SF** spherical support is made of two parts, a concave and a convex one, such as when they are coupled they will allow the sliding and relating positioning of the two parts at the balance point of the device, thus compensating the transverse forces.*
*The **DD-SF** spherical support is provided with seatings for gaskets to allow the installation of the plates: TTR, TTR-E, TTM and TTM-F.*

*Tensioning on the **DD-SF** spherical support with a **TTR** or **TTR-E** anchorage can usually be carried out with TTM250KN series jacks having a stroke of: 60 mm., 100 mm., 200 mm. and 400 mm.*



*The **DD-SF** spherical support can be provided with protection caps to ensure the protection of the anchorage against corrosion.*

7.0 – TEMPORARY GROUND ANCHORS

7.1 - TPR-00 temporary ground anchors

TPR-00 temporary *ground anchors are produced in compliance with the European and Italian Standard **"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" paragraph 6.9.3** and they are made of harmonic steel strands according to **EN 10138**, singularly encapsulated and greased on the free length.*
*The **TPR-00 temporary** ground anchor is usually used in the construction of bulkheads and diaphragms, where the type of ground does not have any particular geo-technical problems and where temporary ground anchors are needed.*

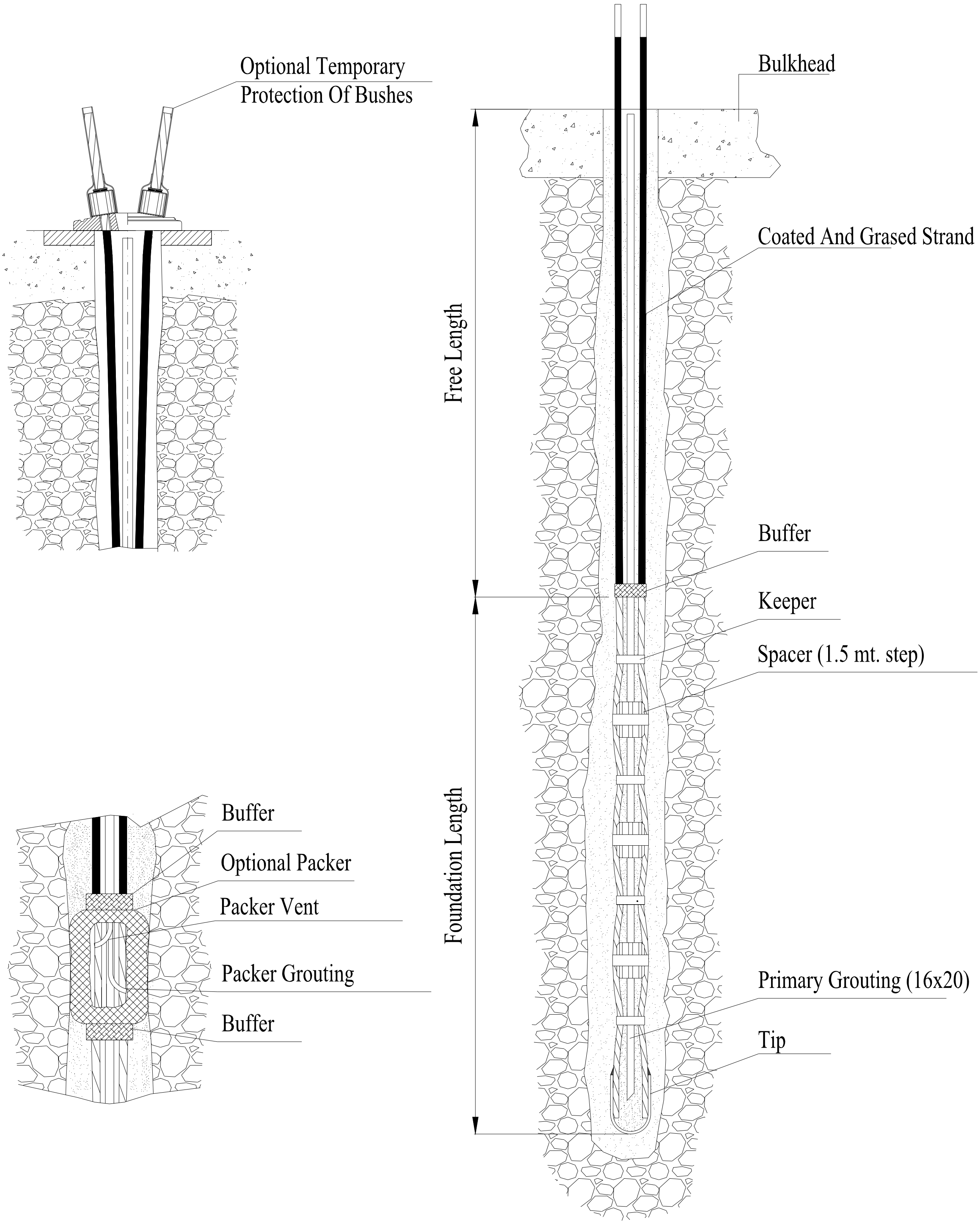
The anchor is made as follows:

- *In the active part, the strands are separated by special spacers which guarantee the tendon to maintain a sinusoidal shape. By means of suitable strapping and/or taping, the sinusoidal shape of the tendon increases the adherence with the foundation cement mix. Grouting takes place via a 16x20 mm polyethylene tube.*
- *The end part of the anchor is provided with a steel ogive to ease its insertion into the drilling hole.*
- *The free length is protected by greasing and sheathing each single strand. The separation of the free length from the active part is achieved by way of a buffer of sealing material, which allows both parts to be perfectly hermetic.*

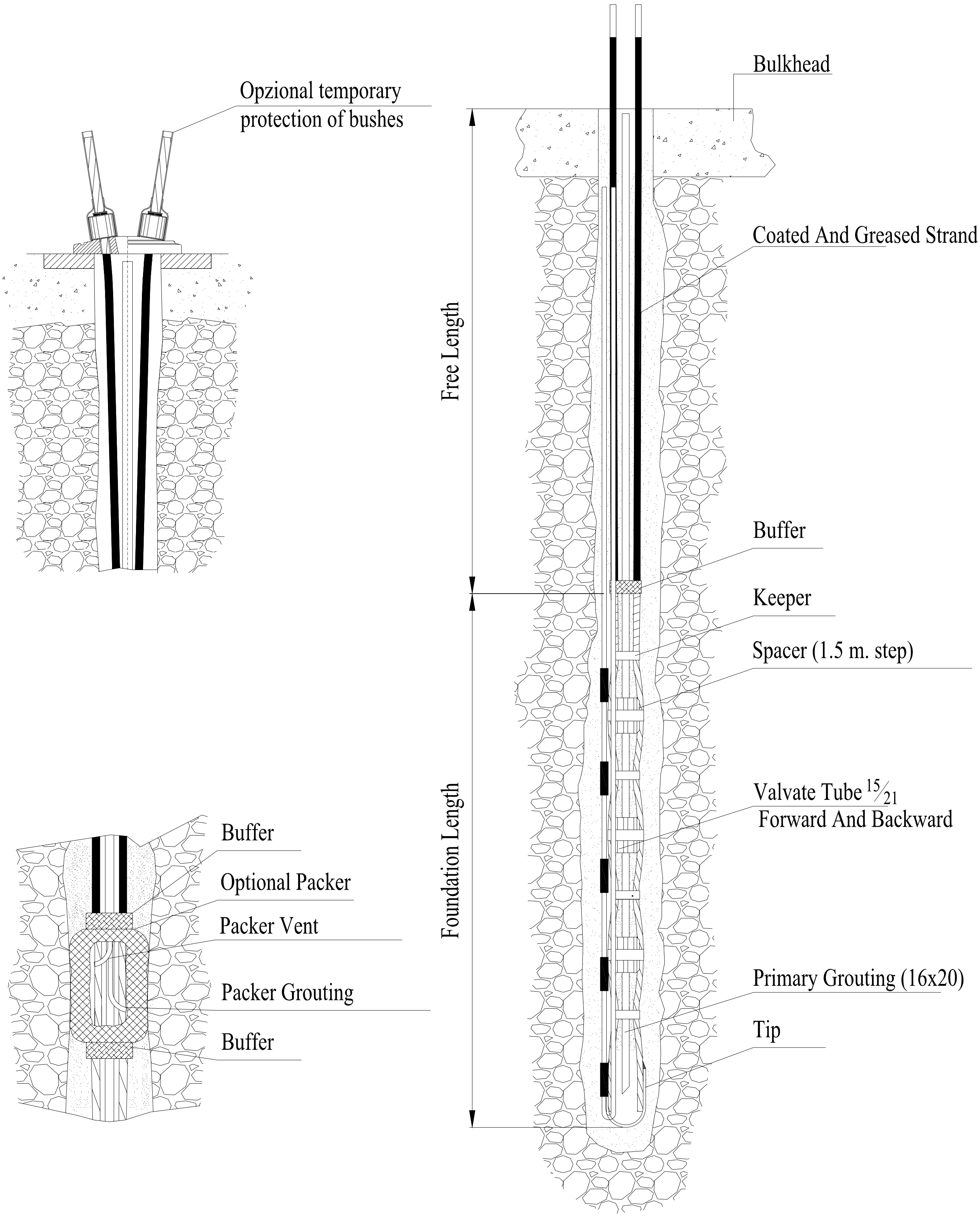
TPR 00 temporary ground anchor bulb

DD CT centralizer mounted on a 6-strand bulb

7.1.1 - TPR-00A temporary ground anchor diagram

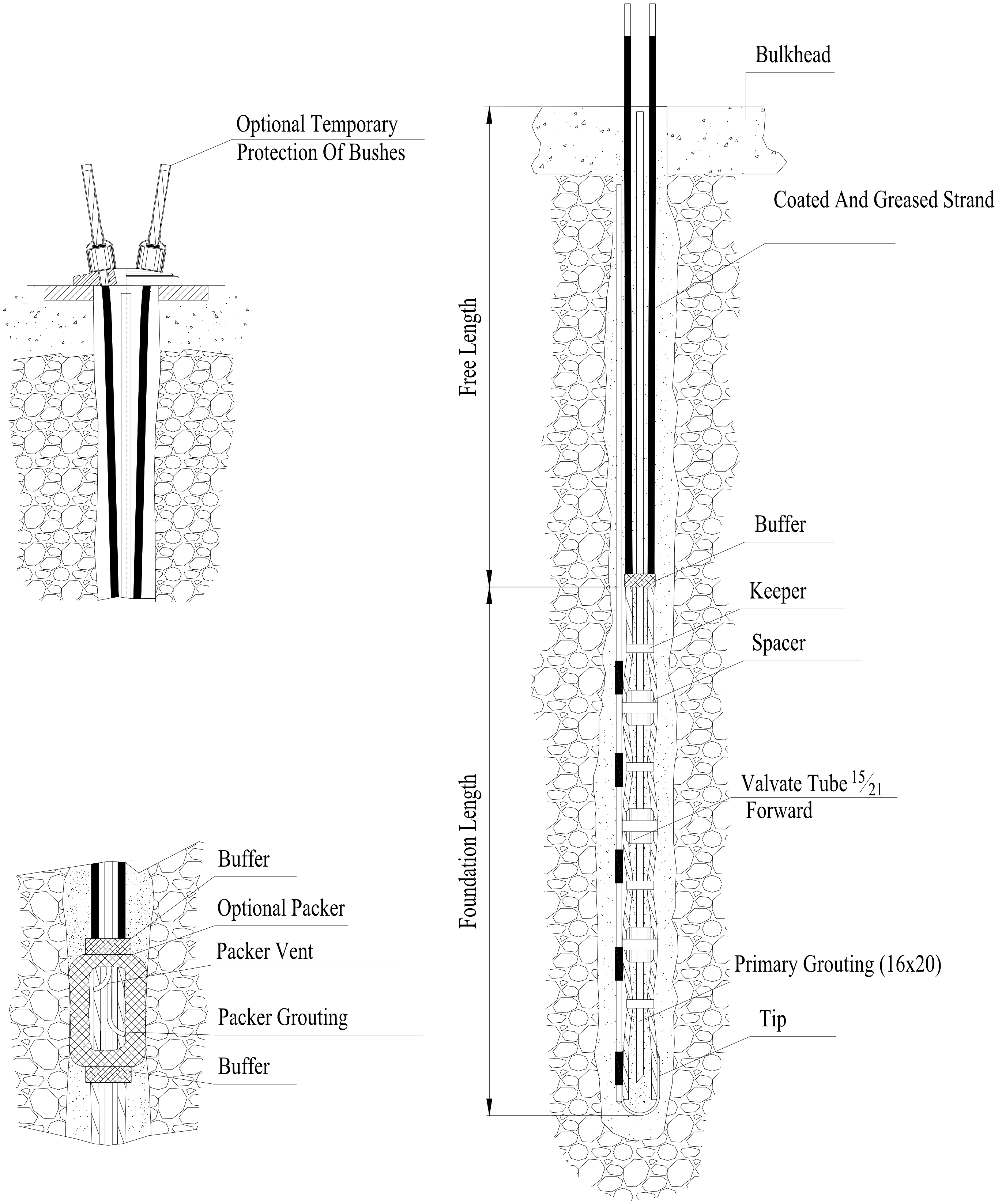


7.1.2 - TPR-00B temporary ground anchor diagram



*The **TPR-00B** temporary ground anchor is provided with a 15x21 mm valvate tube with mounted valves to allow the **I.R. regrouting** (repeated grouting).*

7.1.3 - TPR-00C temporary ground anchor diagram



*The **TPR-00C** temporary ground anchor is provided with a 27x34 mm valvate tube with mounted valves to allow the **I.R.S. regrouting** (repeated and selective grouts).*

TPR-00 temporary ground anchors

7.2 - TPR-01 temporary ground anchors

TPR-01 *temporary ground anchors are produced in compliance with the European and Italian Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" paragraph 6.9.3*** *and they are made of harmonic steel strands according to* ***EN 10138****, singularly sheathed and greased on the free length.*
They usually used in the construction of bulkheads and diaphragms, where the type of ground does not have any particular geo-technical problems and where temporary ground anchors are needed. The anchor is provided with a further protection on the free length with the insertion of a smooth or corrugated sheath.

TPR 01 temporary anchor bulb, provided with the free length protected by a smooth sheath and a packer

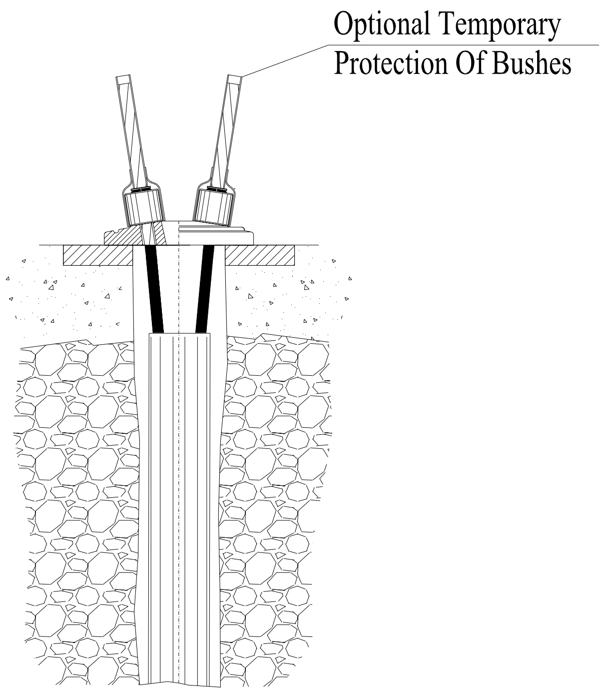
The anchor is made as follows:

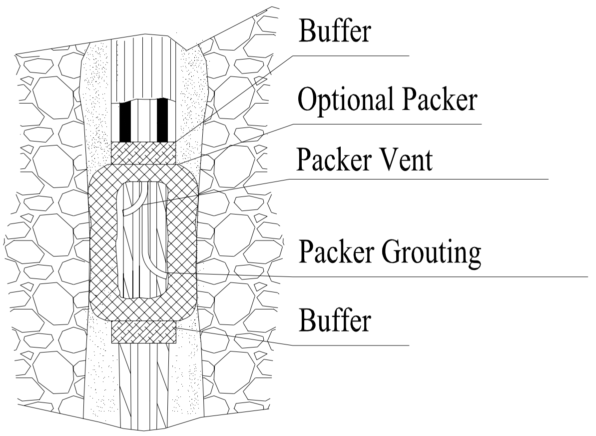
- *In the active part, the strands are separated by special spacers which guarantee the tendon to maintain a sinusoidal shape. By means of suitable strapping and/or taping, the sinusoidal shape of the tendon increases the adherence with the foundation cement mix. Grouting takes place via a 16x20 mm polyethylene tube.*
- *The end part of the anchor is provided with a steel ogive to ease its insertion into the drilling hole.*
- *The free length is protected by greasing and sheathing each single strand, and further protected by inserting a single sheath. The separation of the free length from the active part is achieved by way of a buffer of sealing material, which allows both parts to be perfectly hermetic.*

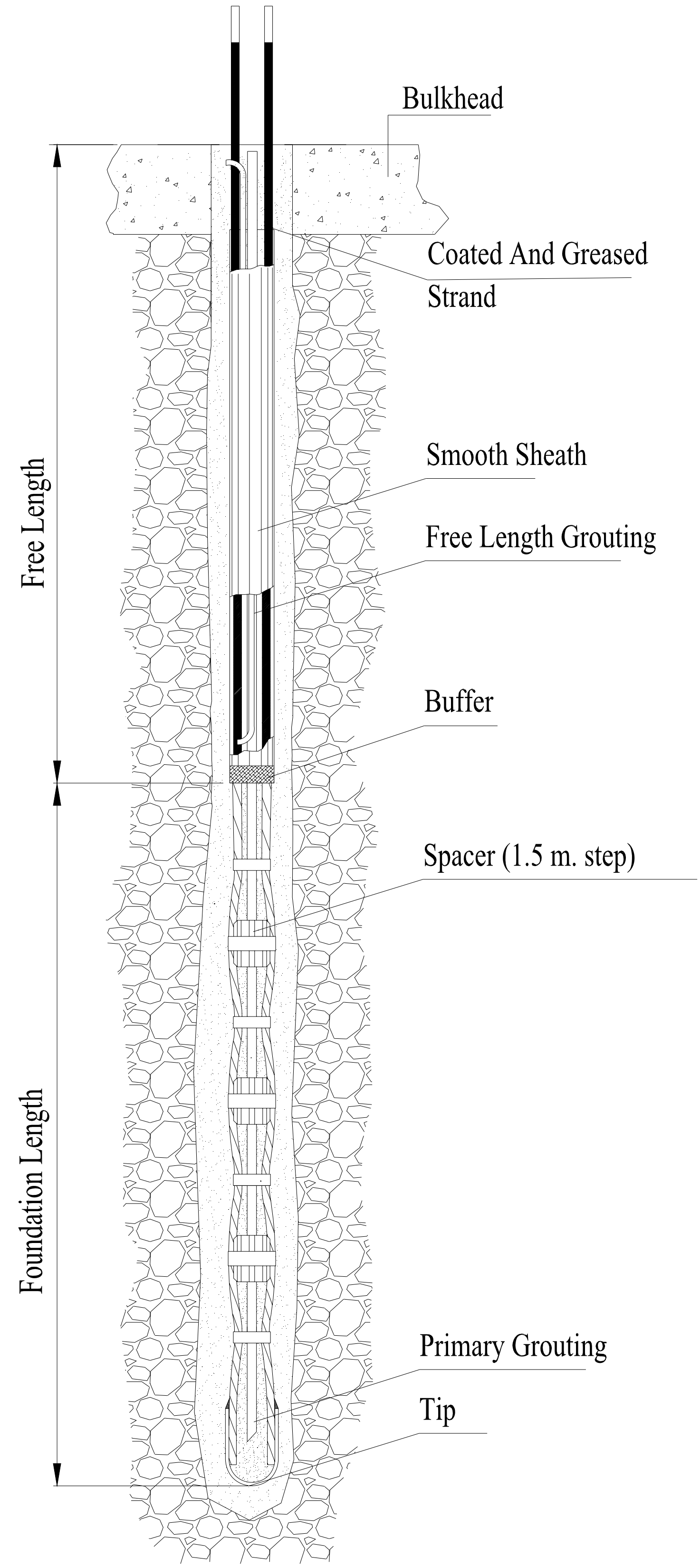
TPR 01 temporary ground anchor tip

Buffer for TPR 01 temporary ground anchors and protection of the free length with a smooth sheath

7.2.1 - TPR-01A temporary ground anchorage diagram

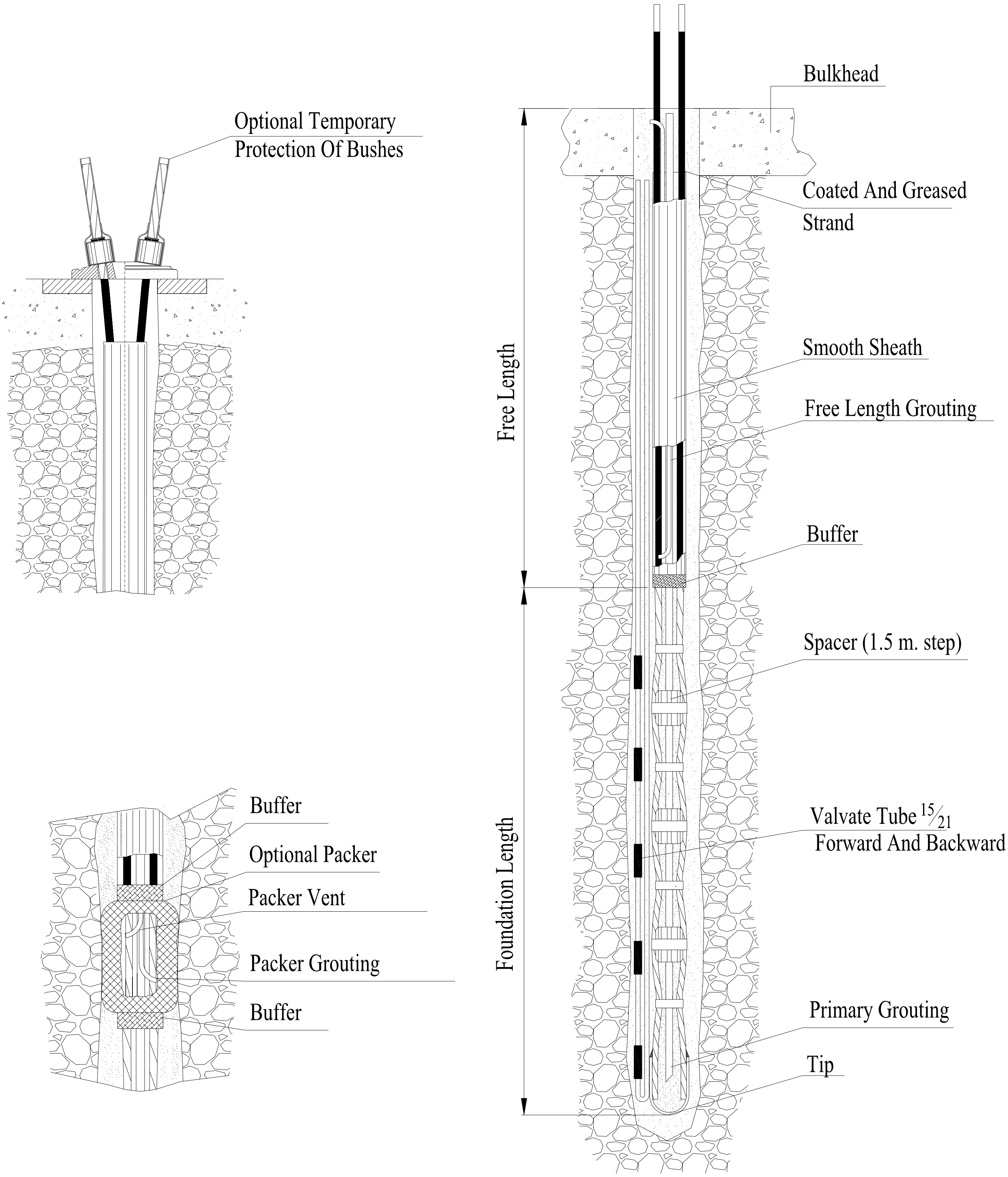






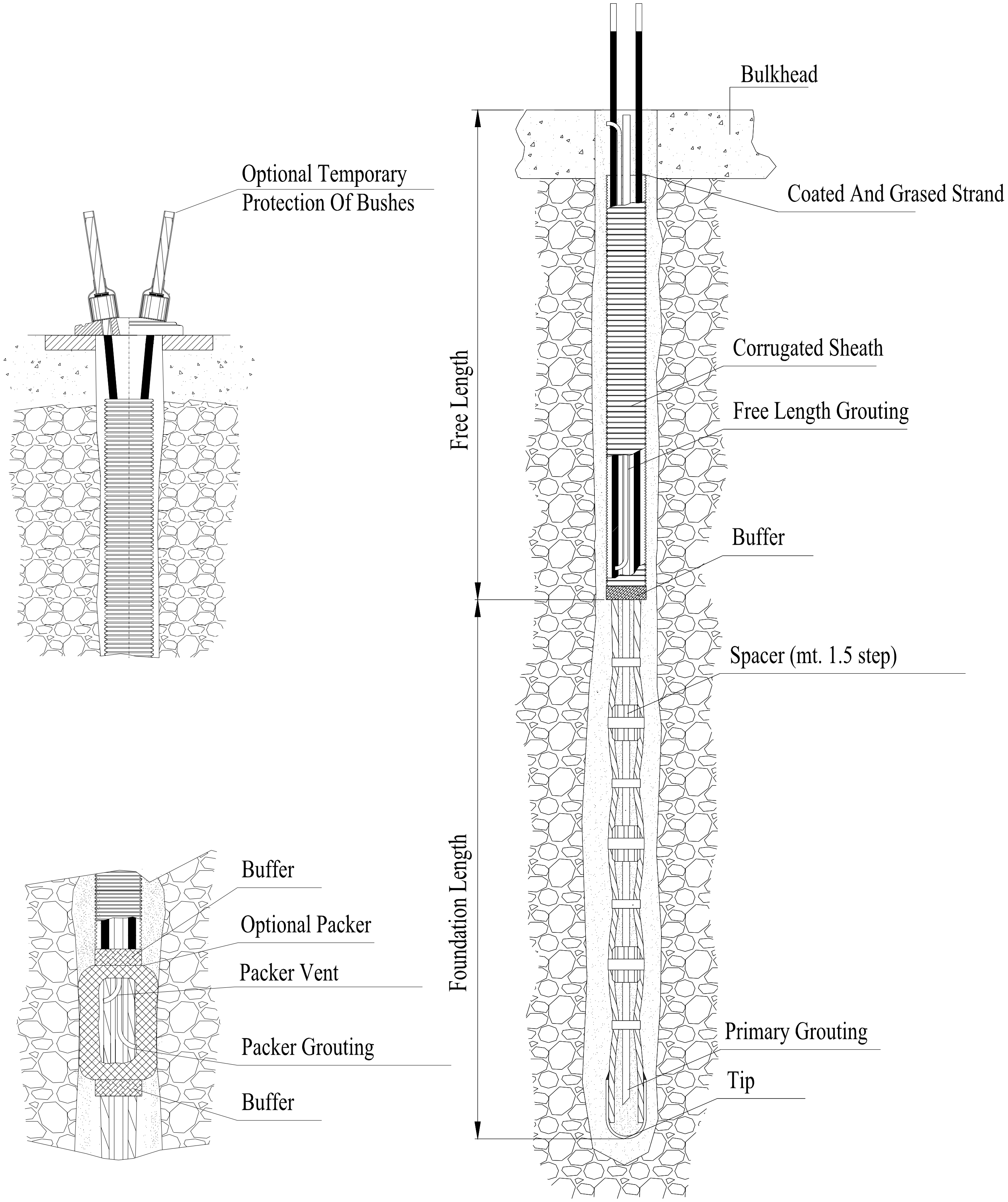
*The **TPR-01A** anchor is provided with a smooth sheath on the free length. Grouting takes place via two tubes: primary grouting and free length grouting.*

7.2.2 - TPR-01B temporary ground anchor diagram



*The **TPR-01B** anchor is provided with a smooth sheath on the free length. Grouting takes place via two tubes: primary grouting and free length grouting. This version allows the installation of a 15x21 mm valvate tube on the external part of the U-shaped anchor to allow the **I.R. repeated grouting***

7.2.3 - TPR-01C temporary ground anchor diagram



*The **TPR-01C** anchor is provided with a smooth sheath on the free length. Grouting takes place via two tubes: primary grouting and free length grouting.*

7.3 – TPR-04 temporary ground anchors

TPR-04 *temporary ground anchors are produced in compliance with the European and Italian Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" paragraph 6.9.3*** *and they are made of harmonic steel strands according to* ***EN 10138****, singularly sheathed and greased on the free length.*
They are usually used in the construction of bulkheads and diaphragms, where the type of ground has particular geo-technical problems that require the possibility of repeated and selective grouts ***(I.R.S.).***

TPR-04 temporary ground anchors

The anchor is made as follows:

- *In the active part, the strands are separated by special spacers which guarantee the tendon to maintain a sinusoidal shape. By means of suitable strapping and/or taping, the sinusoidal shape of the tendon increases the adherence with the foundation cement mix. Grouting takes place via a 16x20 mm polyethylene tube and a* ***valvate 27/34*** *mm tube provided with manchette valves* ***(I.R.S.).***
- *The end part of the anchor is provided with a steel ogive to ease its insertion into the drilling hole.*
- *The free length is protected by greasing and sheathing each single strand, and further protected by inserting a smooth or corrugated sheath. The separation of the free length from the active part is achieved by way of a buffer of sealing material, which allows both parts to be perfectly hermetic.*

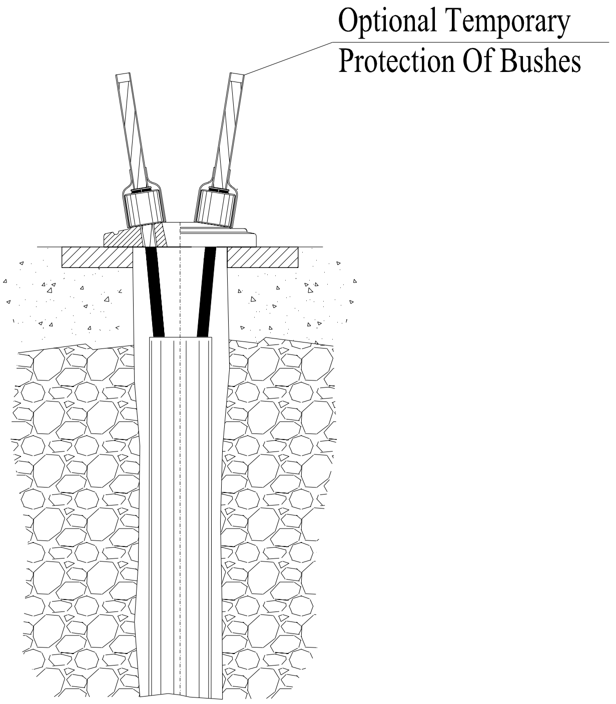
Bulb on TPR-04 temporary ground anchor with T 001 27x34 mm valvate tube

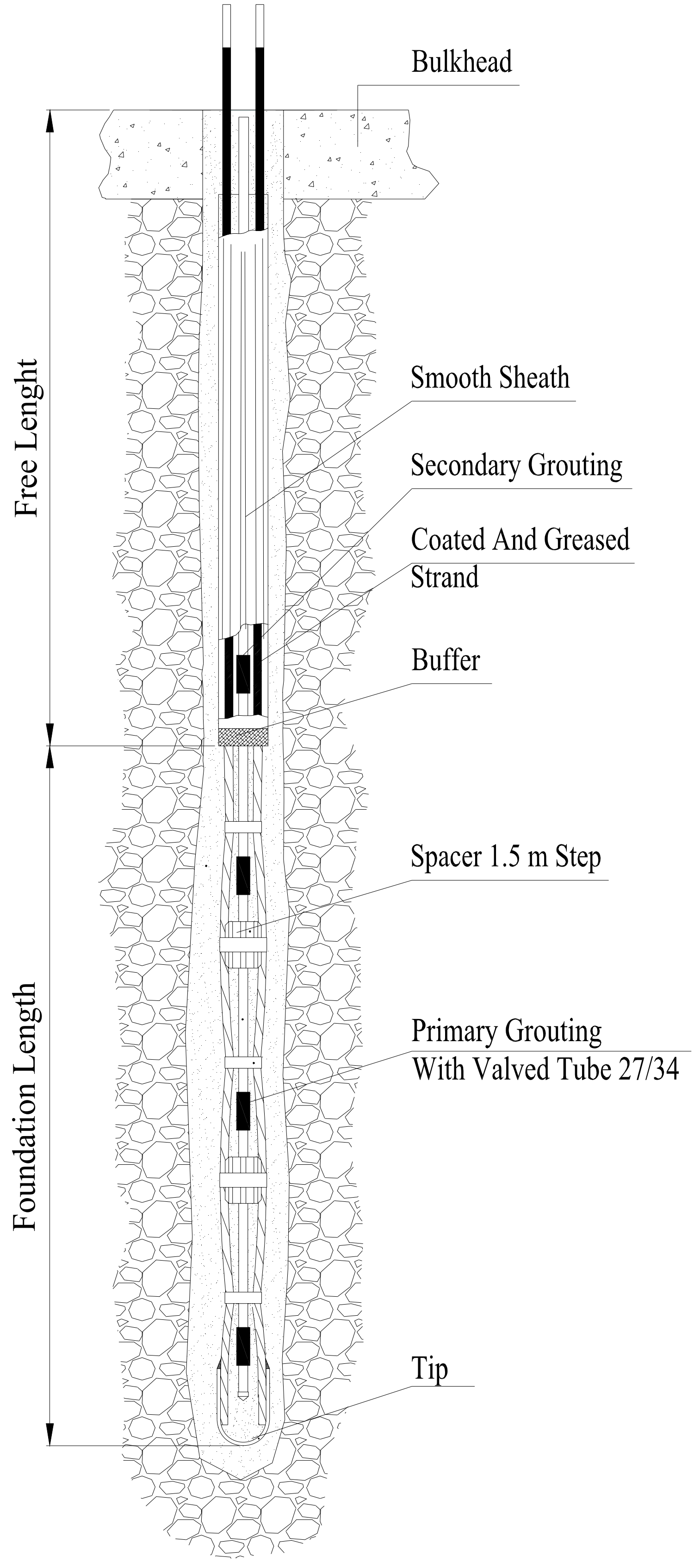
The buffer separates the free length from the foundation, which is provided with manchette valves and centralizers to allow the strand to maintain a sinusoidal shape.
TPR 04 *anchors can optionally be provided with a smooth sheath on the free length to ensure a double protection.*

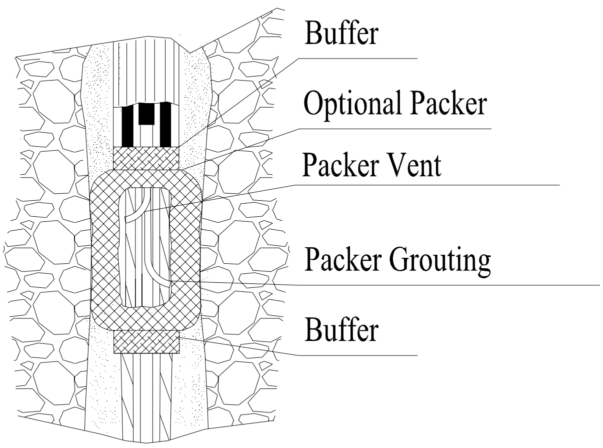
Buffer between free length and bulb on a TPR 04 temporary ground anchor

Manchette valves can be grouted with an ***I.R.*** *or* ***I.R.S.*** *system based on the grouting system required on a site.*
The I.R. grouting *is carried out by means of a T002 27x34 mm tube by injecting from the wellhead of the tube the mixture under pressure. This procedure allows repeated grouting only.*
The I.R.S. grouting *is carried out by means of a T002 27x34 mm tube by injecting with a double piston valve by valve. This procedure allows repeated grouting only.*

7.3.1 - TPR-04A temporary ground anchor diagram

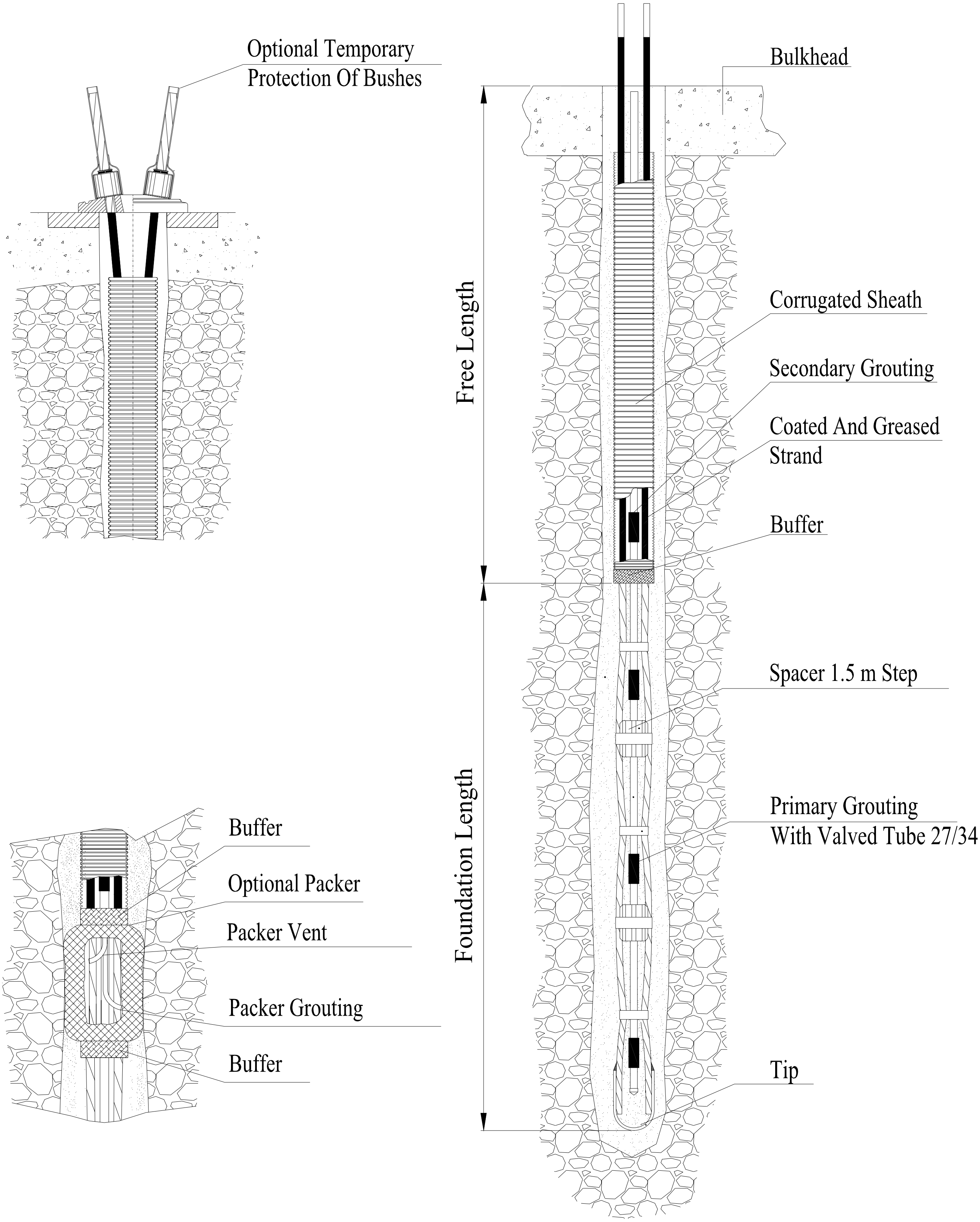






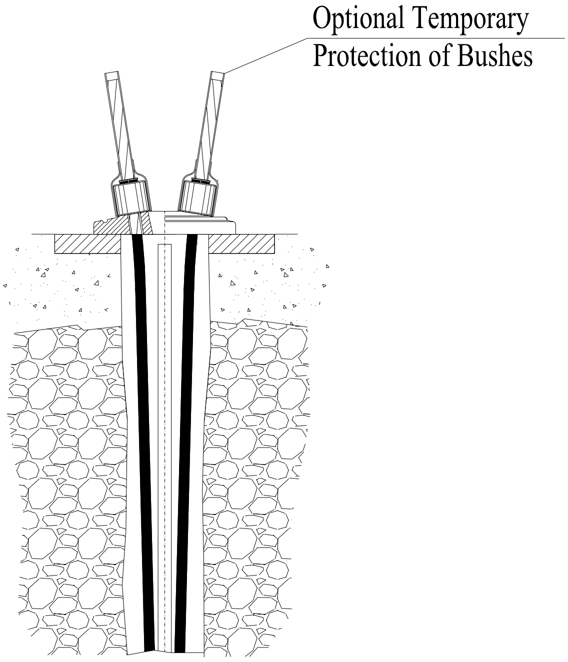
*The **TPR-04AA** anchor is provided with a smooth sheath on the free length. Grouting takes place via two tubes: primary grouting in the foundation and free length grouting (if required by the Client's Technical Representative). This version allows the installation of a central T001 27x34 mm valvate tube to allow repeated and selective regrouting **I.R.S.***

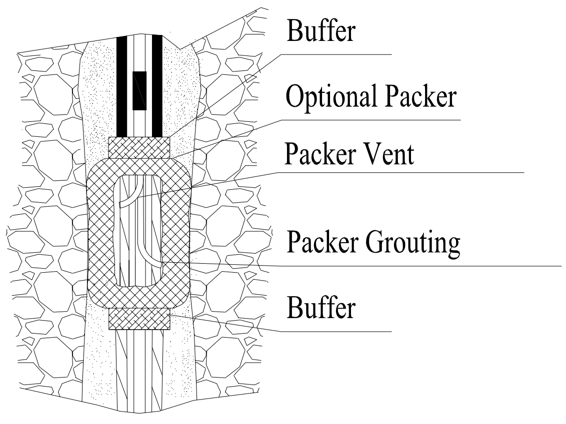
7.3.2 - TPR-04B temporary ground anchor diagram

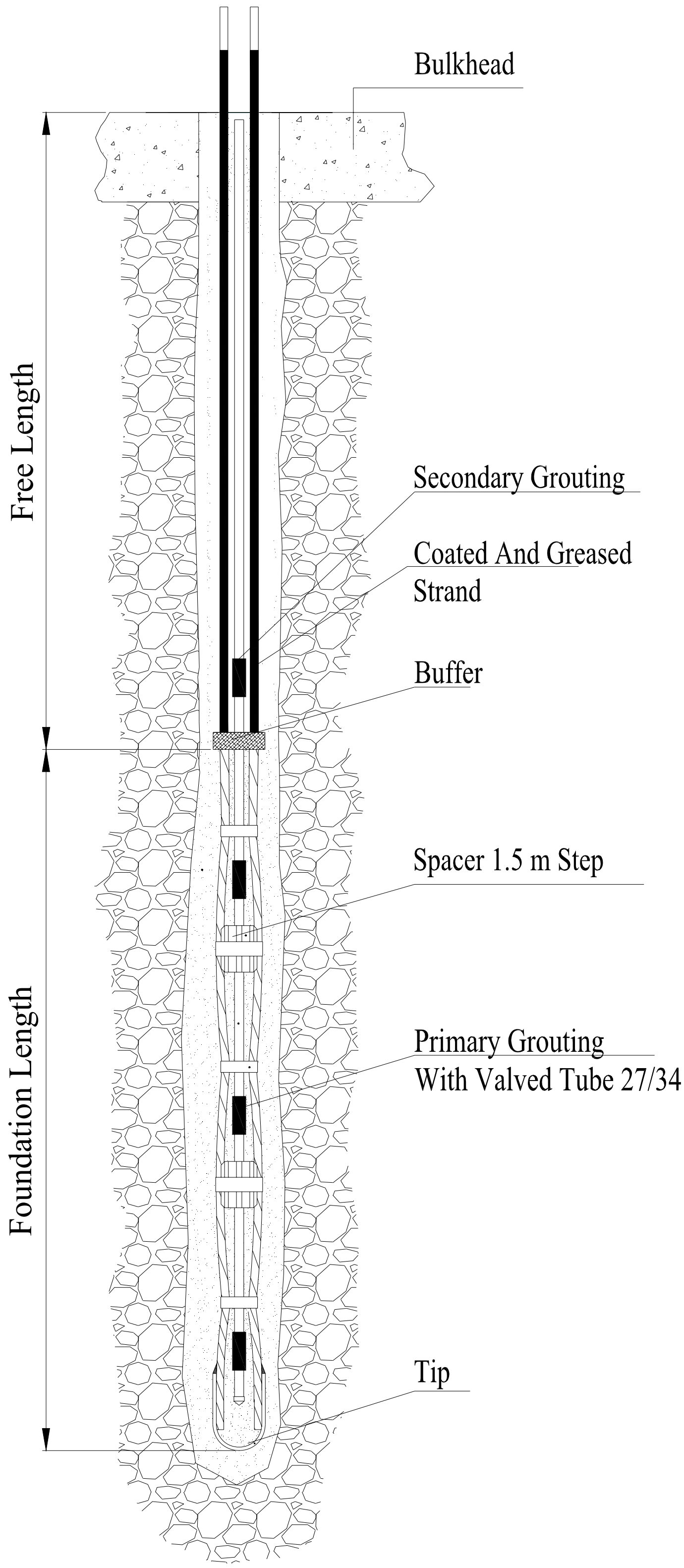


*The **TPR-04B** anchor is provided with a smooth sheath on the free length. Grouting takes place via two tubes: primary grouting in the foundation and free length grouting (if required by the Client's Technical Representative). This version allows the installation of a central T001 27x34 mm valvate tube to allow repeated and selective regrouting **I.R.S.***

7.3.3 - TPR-04C temporary ground anchor diagram







*The **TPR-04C anchor** is not provided with a smooth sheath on the free length. Grouting takes place via two tubes: primary grouting in the foundation and free length grouting (if required by the Client's Technical Representative). This version allows the installation of a central T001 27x34 mm valvate tube to allow repeated and selective regrouting **I.R.S.***

8.0 – PERMANENT GROUND ANCHORS

8.1 – TPE-02 permanent ground anchors

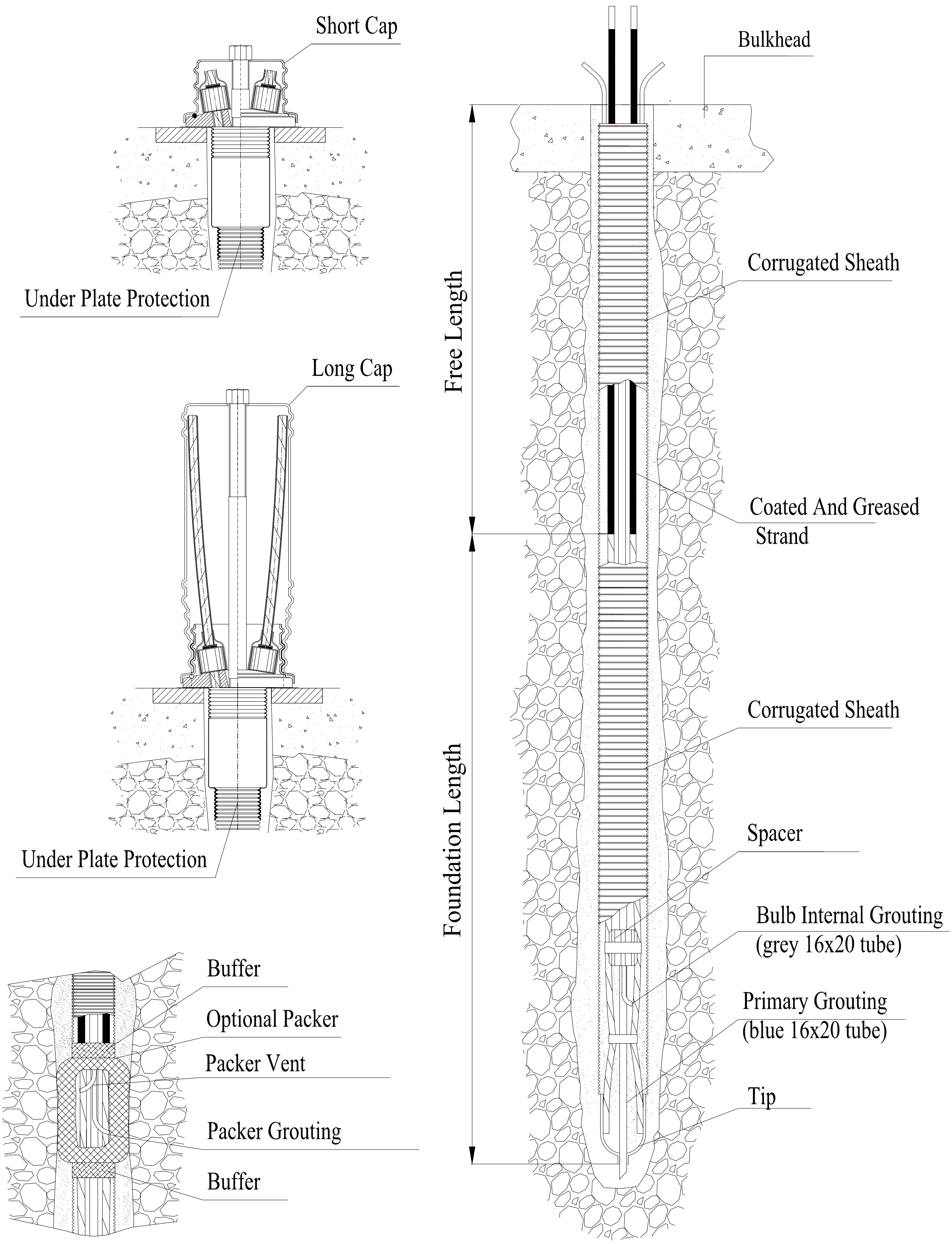
TPE-02 permanent *ground anchors are produced in compliance with the European and Italian Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" paragraph 6.9.3*** *and they are made of harmonic steel strands according to* ***EN 10138****.*
They are usually used in the consolidation of bulkheads and diaphragms, where the type of ground requires the use of permanent ground anchors.

The anchor is made as follows:

- *In the active part, the strands are separated by special spacers which guarantee the tendon to maintain a sinusoidal shape. By means of suitable strapping and/or taping, the sinusoidal shape of the tendon increases the adherence with the foundation cement mix. Grouting takes place via a 16x20 mm polyethylene tube which can guarantee a grouting pressure of max. 25 bar.*
- *The free length is protected by inserting a smooth or corrugated sheath in H.D.P.E. according to the instructions of the* ***"Client's Technical Representative".*** *The separation of the free length from the active part is achieved by way of a buffer of sealing material, which allows both parts to be perfectly hermetic. It can be on each strand or globally on all strands dividing the free length from the foundation.*
- *The end part of the ground anchor is provided with a polyethylene ogive to ease its insertion into the drilling hole and guarantee its total encapsulation.*
- *The free length is protected by greasing and sheathing each single strand via a 16x19.5 mm tube.*

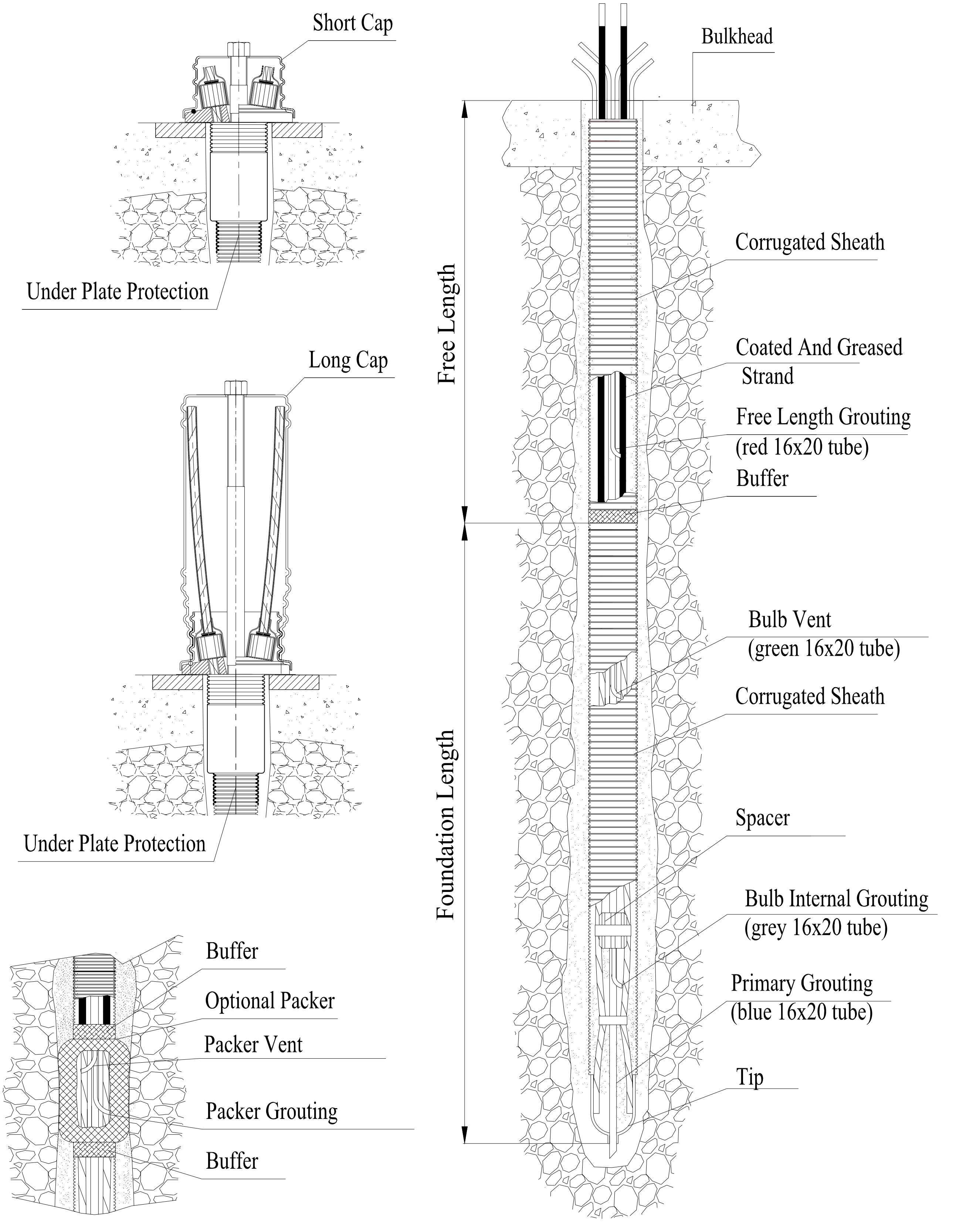
TPE 02 temporary ground anchor bulb

8.1.1 – TPE-02A permanent ground anchor diagram



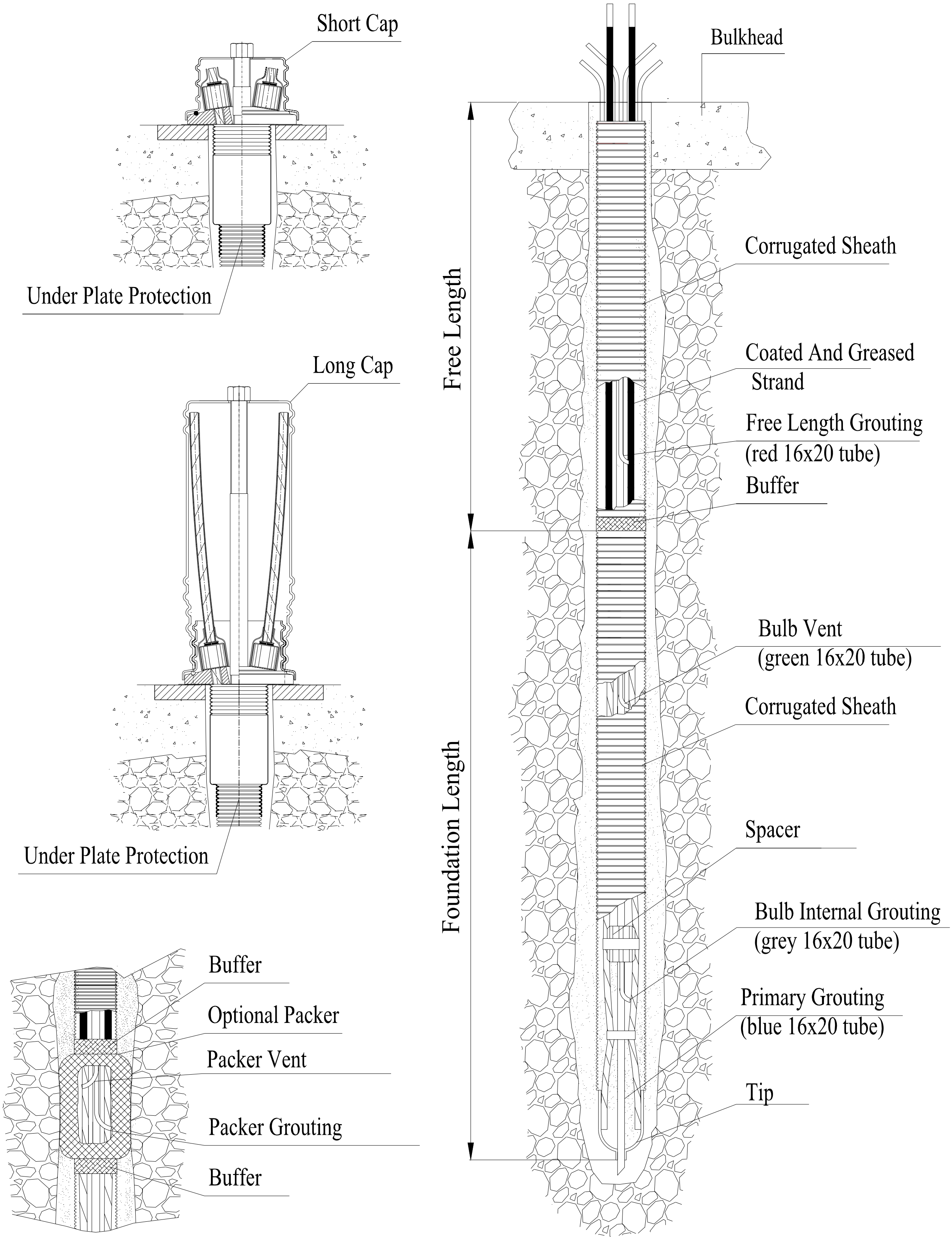
***TPE-02A** anchor provided with a corrugated sheath on the whole length. Grouting takes place via two tubes: primary grouting and internal grouting. This version allows to fix the total protection and it is provided with elementary buffers strand by strand between free length and foundation. The packer can be installed on request.*

8.1.2 – TPE-02B permanent ground anchor diagram



***TPE-02B** anchor provided with a corrugated sheath on the whole length. Grouting takes place via two tubes: primary grouting, foundation grout and vent.*
This version allows to fix the total protection and it is provided with a single buffer between free length and foundation. The packer can be installed on request.

8.1.3 – TPE-02C permanent ground anchor diagram



***TPE-02-C** anchor provided with a corrugated sheath on the bulb and a smooth sheath on the free length. Grouting takes place via three tubes: primary grouting, foundation grout and vent. This version allows to fix the total protection and it is provided with a single buffer between free length and foundation. The packer can be installed on request. **TPE-02-C** anchor provided with a corrugated sheath on the bulb and a smooth sheath on the free length.*

8.2 - TPE-02-SP permanent ground anchors

Permanent TPE-02-SP *type ground anchors are created according to the European and Italian standard* ***"Execution of special geo-technical*** *works anchoring ground anchors* ***EURO NORM EN 1537-2002" paragraph 6.9.3*** *and they are made from steel strands according to* ***EN 10138****.*
*The TPR****-02-SP type permanent*** *ground anchor is normally used for consolidating bulkheads and diaphragms where the type of earth requires the use of permanent rock anchor and where selective, repeated re-grout* ***I.R.S.*** *is required with sleeve valves.*

The ***TPE-02-SP-A*** *ground anchor has a corrugated sheath both on the free length and on the foundation. This model is characterized by a* ***T001*** *external valvate 27x34 mm tube fixed on the external part by means of taping on the whole length of the anchor.*

The ***TPE-02-SP-C*** *ground anchor has a smooth sheath on the free part and a corrugated sheath on the foundation. This model is characterized by a* ***T001*** *external valvate 27x34 mm tube fixed on the external part by means of taping on the whole length of the anchor. It is provided with packer between the free length and the foundation (variation).*

The anchor is made as follows:

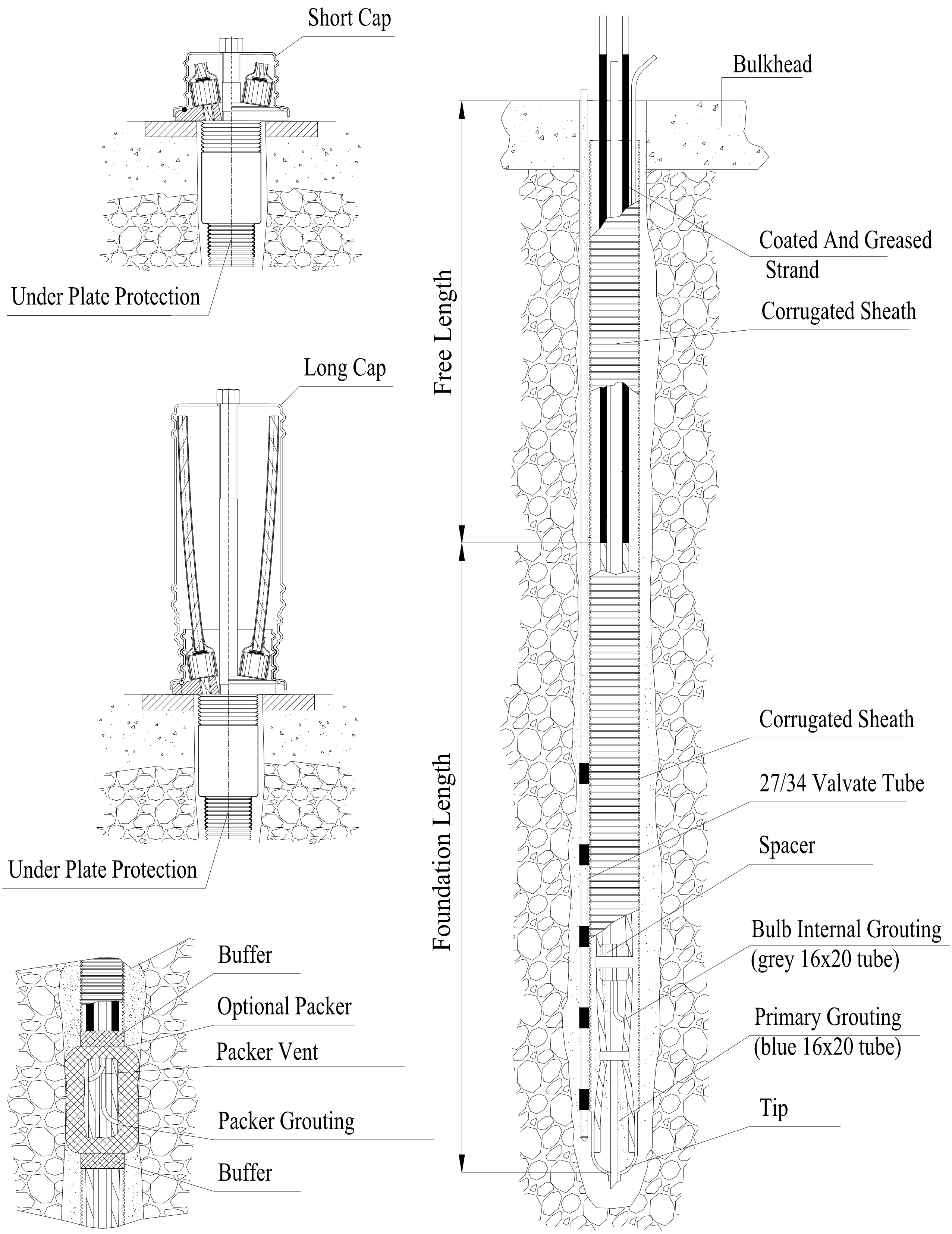
- *In the active part, the strands are separated by special spacers which guarantee the tendon to maintain a sinusoidal shape. By means of suitable strapping and/or taping, the sinusoidal shape of the tendon increases the adherence with the foundation cement mix.*

- *The grout (primary and free length) takes place via 16x20 mm polyethylene tubes. The I.R.S. re-grouts take place via an external T001 valvate 27/34 mm tube provided with manchette valves.*
- *The end part of the anchor is provided with a steel ogive to ease its insertion into the drilling hole.*
- *The free length is protected by greasing and sheathing each single strand, and further protected by inserting a single sheath. The separation of the free length from the active part is achieved by way of a buffer of sealing material, which allows both parts to be perfectly hermetic.*
- *The free length of harmonic steel strands is protected by inserting a smooth or corrugated sheath in H.D.P.E. and singularly with 16x91,5 mm sheaths in H.D.P.E. and grease. The separation of the free length from the active part is achieved by way of a buffer of sealing material, which allows both parts to be perfectly hermetic.*

TPE 02SP ground anchor with external valvate tube and DD-ED external spacers

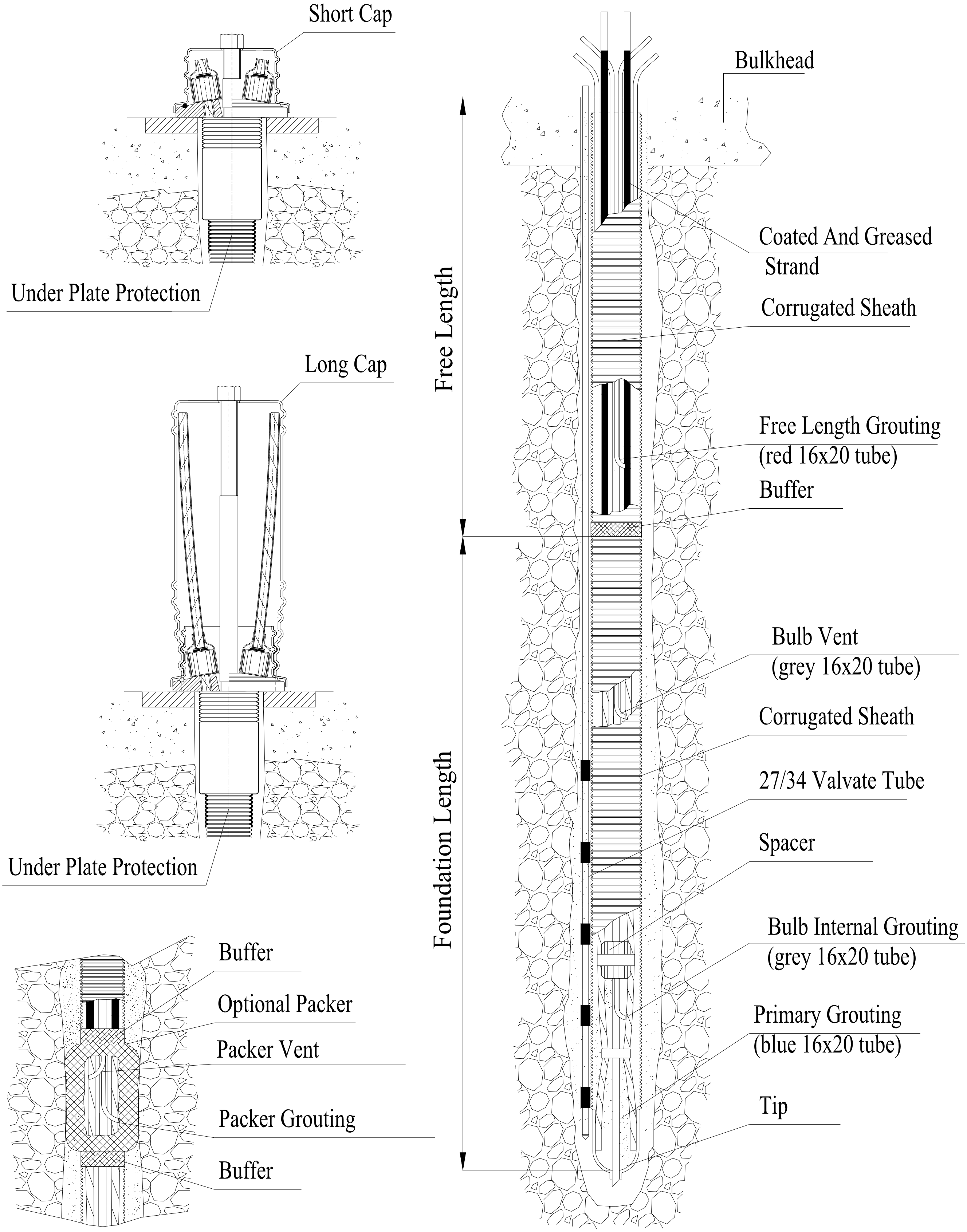
TPE 02SP ground anchor with external valvate tube and DD-EF external spacers

8.2.1 - TPE-02-SP-A permanent ground anchor diagram



***TPE-02SP-A** anchor provided with a corrugated sheath on the whole length. Grouting takes place via two tubes: primary grouting and internal grouting. This version allows to fix the total protection and it is provided with elementary buffers strand by strand between free length and foundation. On the **TPE-02-SP-A** permanent ground anchor a valvate 27/34 mm tube is installed on the outside in order to allow the **I.R.S.** repeated and selective re-grout.*

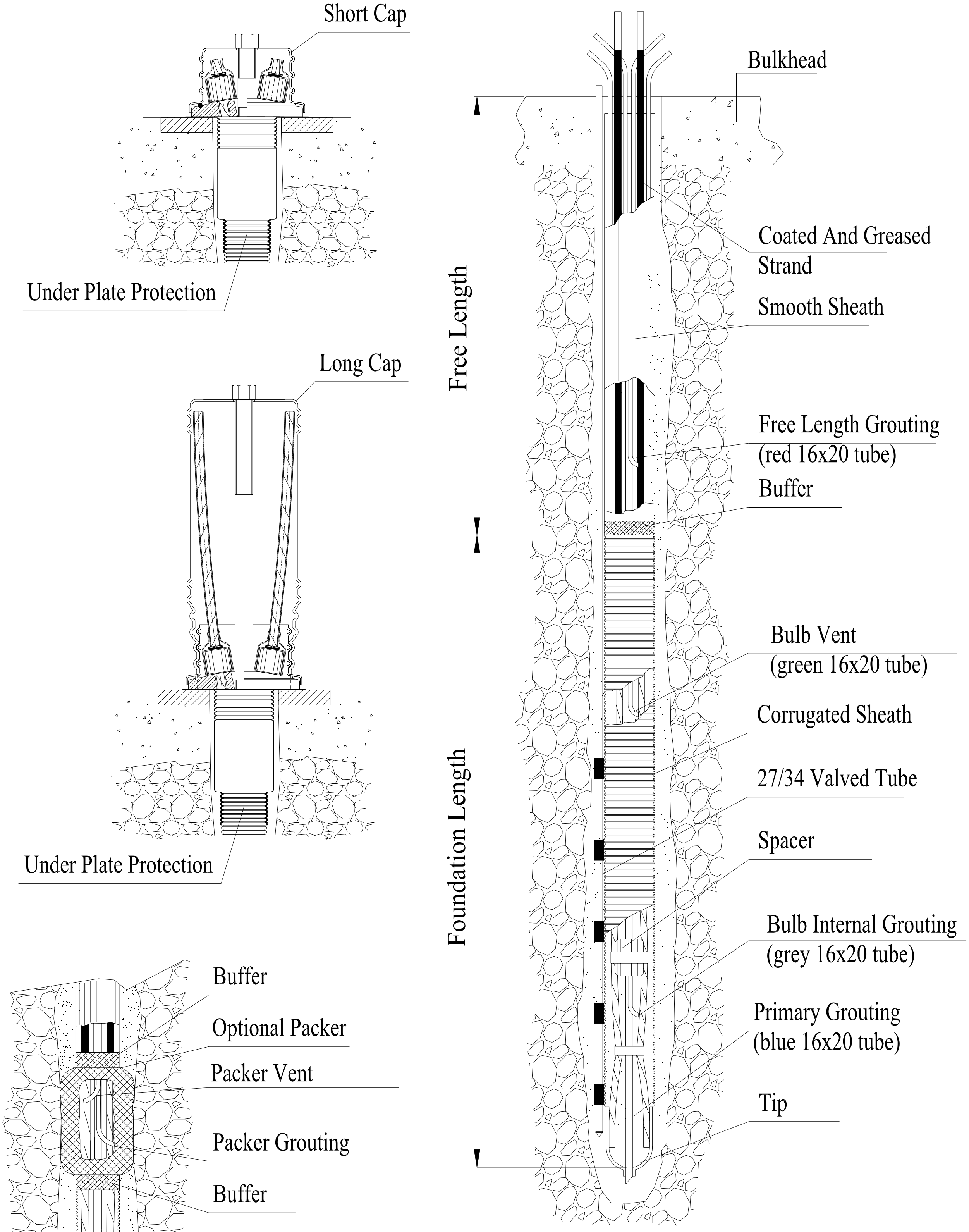
8.2.2 - TPE-02-SP-B permanent ground anchor diagram



TPE-02SP-B** anchor provided with a corrugated sheath on the whole length. Grouting takes place via three tubes: primary grouting, internal grouting and bulb vent. This version allows to fix the total protection and it is provided with a single buffer between free length and foundation. On the **TPE-02-

SP-B *permanent ground anchor a valvate 27/34 mm tube is installed on the outside in order to allow the* ***I.R.S.*** *repeated and selective grout.*

8.2.3 - TPE-02-SP-C permanent ground anchor diagram



TPE-02SP-C*anchor provided with a corrugated sheath on the bulb and a smooth sheath on the free length. Grouting takes place via three tubes: primary grouting, foundation grout and vent. This version allows to fix the total protection and it is provided with a single buffer between free length and* *foundation. On the **TPE-02-SP-C** permanent ground anchor a valvate 27/34 mm tube is installed on the outside in order to allow the **I.R.S.** repeated and selective grout.*

8.3 - TPE-03 permanent ground anchors

***TPE-03 permanent** ground anchors are produced in compliance with the European and Italian Standard **"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" paragraph 6.9.3** and they are made of harmonic steel strands according to **EN 10138**.*
They are usually used in the consolidation of bulkheads and diaphragms, where the type of ground requires the use of permanent ground anchors with double protection barrier bulb with two corrugated sheaths. It is suitable for highly aggressive environments, where the double protection provides the foundation tendon with two protection barriers.

TPE 03 permanent anchor bulb provided with the free length protected by a corrugated sheath

The anchor is made as follows:

- *In the active part, the strands are separated by special spacers which guarantee the tendon to maintain a sinusoidal shape. By means of suitable strapping and/or taping, the sinusoidal shape of the tendon increases the adherence with the foundation cement mix. Grouting takes place via a 16x20 mm polyethylene tube which can guarantee a grouting pressure of max. 25 bar.*
- *The protection of the active part is considered as a double protection having two concentric corrugated sheaths applied according to **Table 2 (**page11) **EURO NORM EN 1537-2002 paragraph 6.10.***
- *The free length is protected by inserting a corrugated sheath in H.D.P.E. according to the instructions of the **"Client's Technical Representative"** The separation of the free length from the active part is achieved by way of a buffer of sealing material, which allows both parts to be perfectly hermetic. It can be on each strand or globally on all strands dividing the free length from the foundation.*
- *The end part of the ground anchor is provided with a polyethylene ogive to ease its insertion into the drilling hole and guarantee its total encapsulation.*
- *The free length is protected by greasing and sheathing each single strand via a 16x19.5 mm tube.*

Application of a double protection to bulbs on TPE03 permanent anchors:

*1. **Anchor bond length** solution (protective barriers offered insitu) solution b) "two plastic ducts"Table **3 (**page 13) **EURO NORM EN 1537-2002 paragraph 6.10.***

***b) two concentric corrugated plastic ducts** containing the tendon(s), fully pregrouted (with cement or resin) within the core and the annulus between the ducts prior to installation;*
The solution requires the use of two corrugated tubes on the foundation/bulb part. The two tubes/corrugated sheaths must be grouted into the annulus with cement grout.

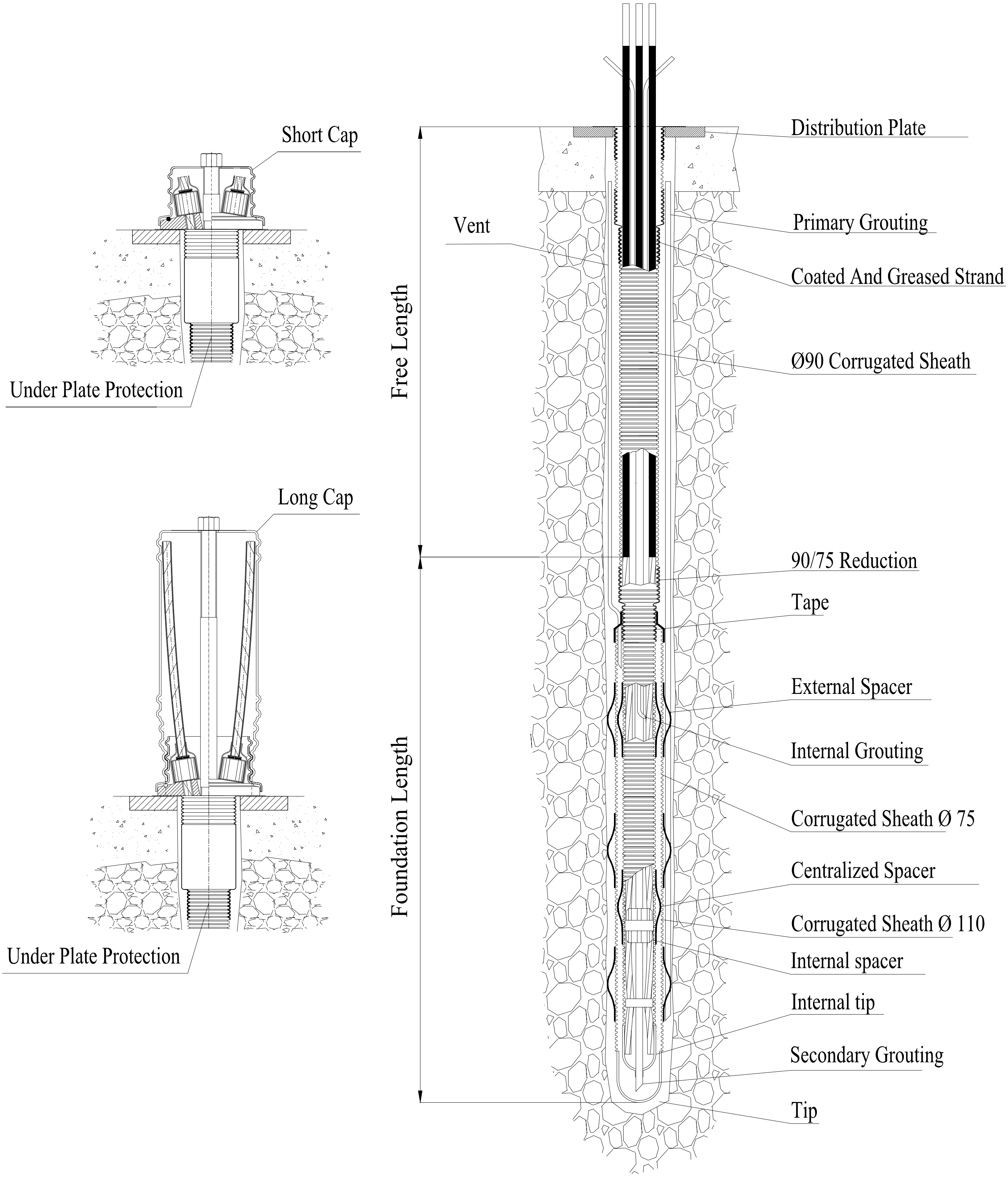
*The **TPE-03** has two concentric sheaths on the foundation to ensure a second level of protection.*
They are provided with grout and vent, a system which ensures a proper grouting into the annulus of the two sheaths.
*In the**TPE-03A** version with the foundation only covered by a second sheath and in the **TPE-03B** version with the free length also covered with two corrugated sheaths.*

Anchor encapsulated in a double protection with external grout wit 16x20 mm tube.

Bulb on TPE 03 permanent anchor in a double protection

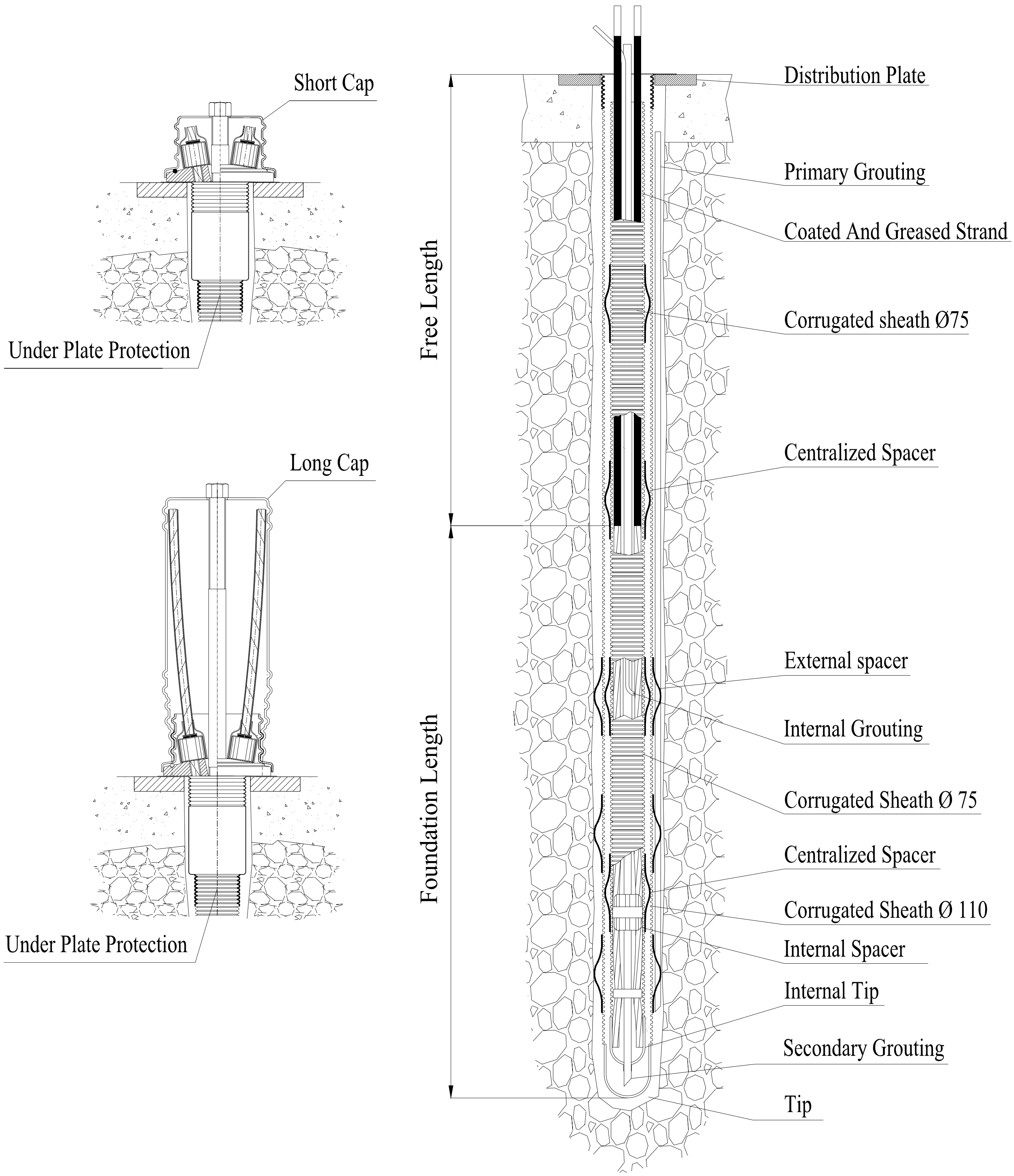
Anchor encapsulated in a double protection

8.3.1 - TPE-03A permanent ground anchor diagram



TPE-03A *anchor provided with a corrugated sheath on the bulb and a corrugated sheath on the free length. Grouting takes place via five tubes: external primary grouting, foundation grout and vent, grout between the two sheaths in the bulb and their vent. This version allows to fix the total protection and it is provided with a strand buffer between free length and foundation.*

8.3.2 - TPE-03B permanent ground anchor diagram



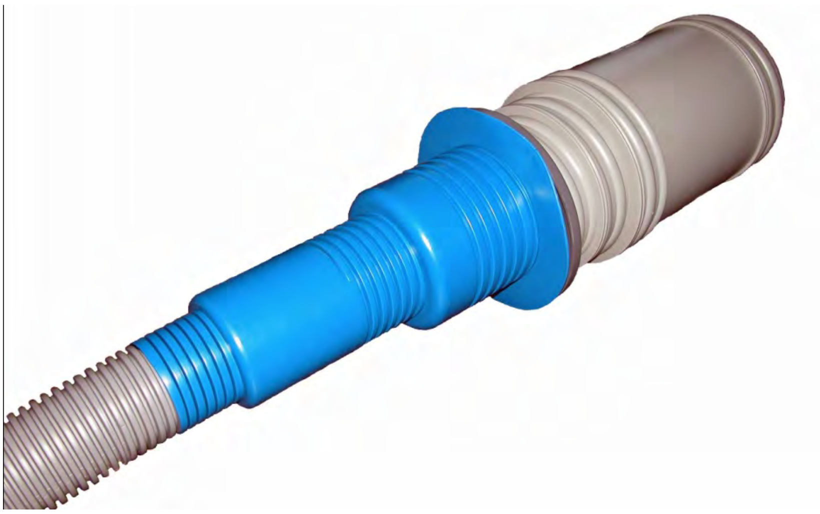
***TPE-03B** anchor provided with a corrugated sheath on the bulb and on the free length. Grouting takes place via three tubes: external primary grouting, foundation grout and wellhead vent, grout between the two sheaths in the bulb and their vent from the wellhead. This version allows to fix the total protection and it is provided with a strand buffer between free length and foundation.*

8.4 - TPE-07 permanent ground anchors

TPE-07 permanent *ground anchors are produced in compliance with the European and Italian Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" paragraph 6.9.3*** *and they are made of harmonic steel strands according to* ***EN 10138****.*
They usually used in the construction of bulkheads and diaphragms, where the type of ground has serious highly corrosive geo-technical problems in the presence of groundwater where a total protection needed. The ***TPE-07*** *anchor is totally encapsulated, all its parts are encapsulated in polyethylene, thus ensuring a total protection (hermetic of all its components)*

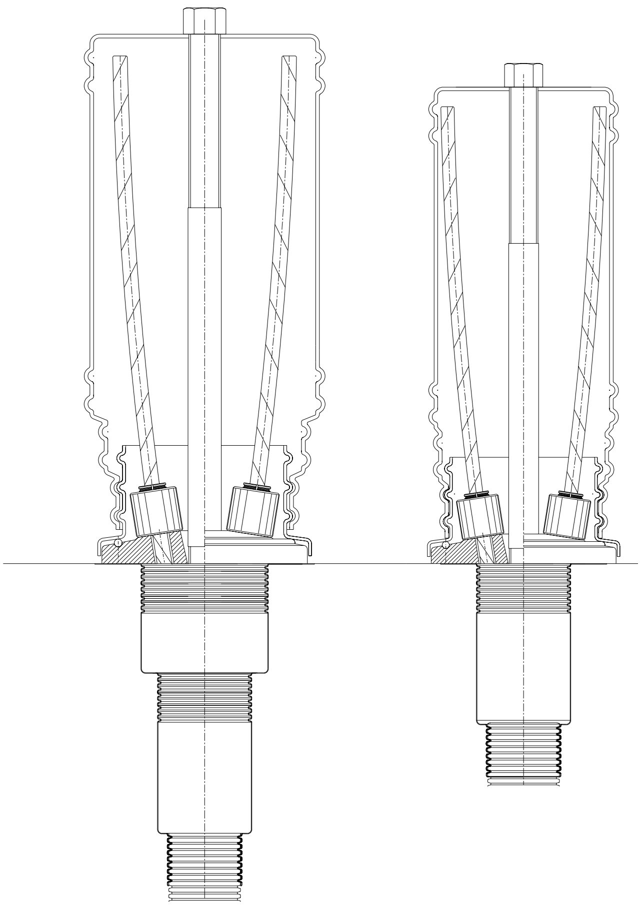
The anchor is made as follows:

- *In the active part, the strands are separated by special spacers which guarantee the tendon to maintain a sinusoidal shape. By means of suitable strapping and/or taping, the sinusoidal shape of the tendon increases the adherence with the foundation cement mix. Grouting takes place via a 16x20 mm polyethylene tube which can guarantee a grouting pressure of max. 25 bar.*
- *The free length is protected by inserting a corrugated sheath in H.D.P.E. according to the instructions of the* ***"Client's Technical Representative"*** *The separation of the free length from the active part is achieved by way of a buffer of sealing material, which allows both parts to be perfectly hermetic. It can be on each strand or globally on all strands dividing the free length from the foundation.*
- *The end part of the ground anchor is provided with a polyethylene ogive to ease its insertion into the drilling hole and guarantee its total encapsulation.*
- *The total encapsulation of the anchorage is guaranteed by the components applied as well as by all the connections on the sheath obtained with male/female thread to guarantee the seal of the protection.*



Totally encapsulated TPE 07 ground anchor

- *The anchor is provided with a corrugated sheath on all its length. The corrugated sheath is provided with a threaded corrugation every 500 mm. This characteristic allows to connect the anchor with the **DD200SP** under plate protection to protect the tendon length under the bearing plate and ensure the continuity of the sheath up to the anchor. The purpose of the protection is defined in the Standard **EURO NORM EN 1537-2002 paragraph 6.11.3**.*
- *The total encapsulation of the anchorage is guaranteed by the use of TTM-100 or TTM-450 protection caps that can connect to the **DD200SP** under plate protection, requiring to seal the edge of the cap with silicone only after the installation is complete to ensure a higher protection of the TTR plate.*
- *The free length is protected by greasing and sheathing each single strand via a 16x19.5 mm tube.*
- *Since there is no separation buffer, the grouting tube of the bulb also grouts the free part.*

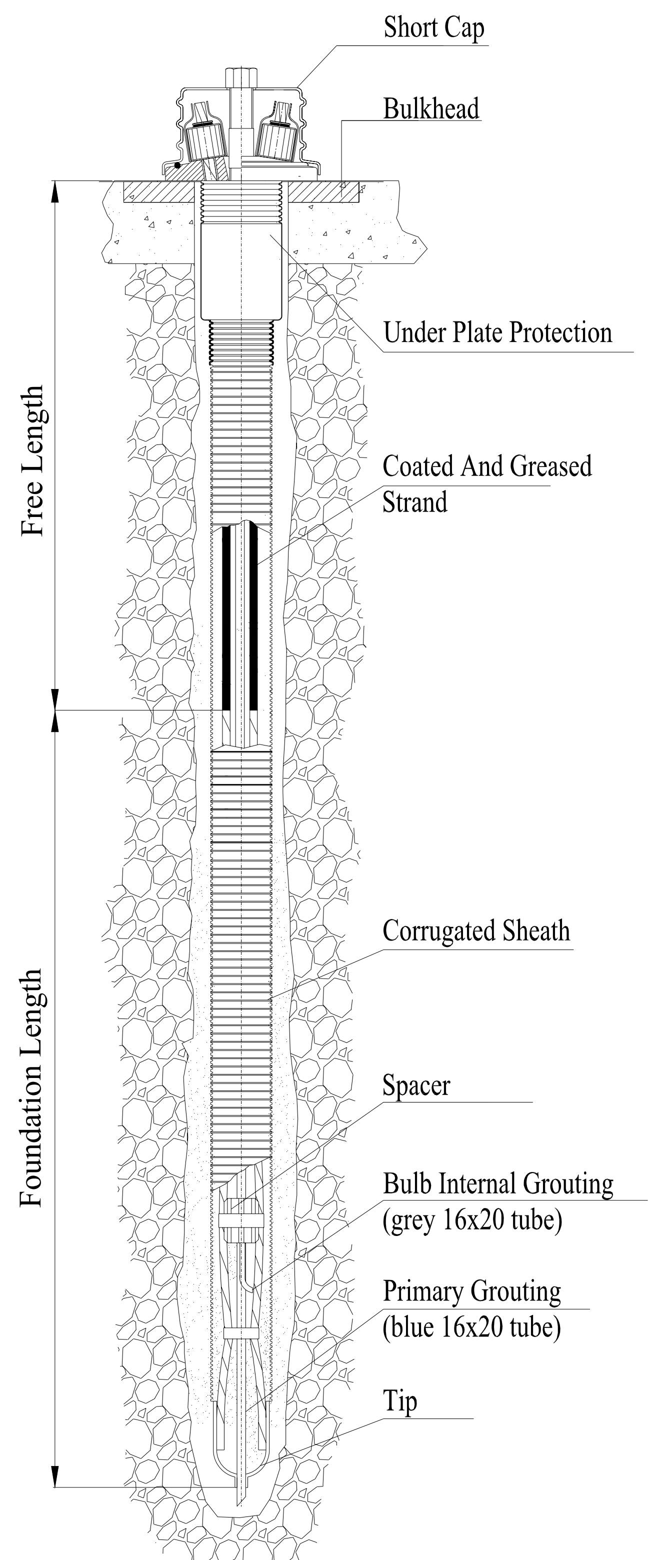


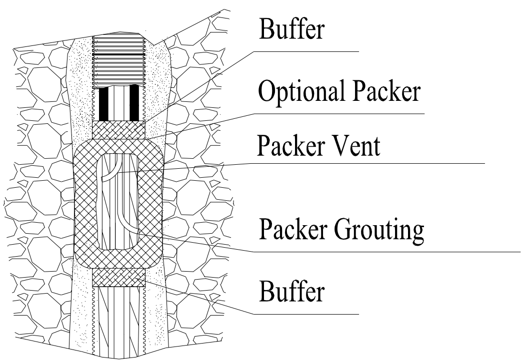
*The **DD200SF** connection is made of polyethylene with a minimum thickness of 1.5 mm. It can be connected to a flange in the upper part to ensure connection with the TTR or TTM anchor plate,*
it must be placed between plate and contrast. The application of the total protection requires the use of TTM corrugated sheaths, provided with a 100 mm long thread every 500 mm of sheath.
In order to solve the problem of the continuity of the seal between free length and anchorage, the device was provided with a thread on the end part to connect it to the thread placed on the corrugated sheath.
*The **DD200SP** under plate connection is made for the coupling with the 110 mm sheath. Further reductions for a correct connection with the anchor sheath can be made by using **DD-RC** connections.*

TTM-450 *cap on* ***DD-SF*** *spherical support to encapsulate the anchorage and ensure its double protection and the possibility to retension it.*

TTM-100 *cap on* ***DD-SF*** *spherical support to encapsulate the anchorage and ensure its double protection.*

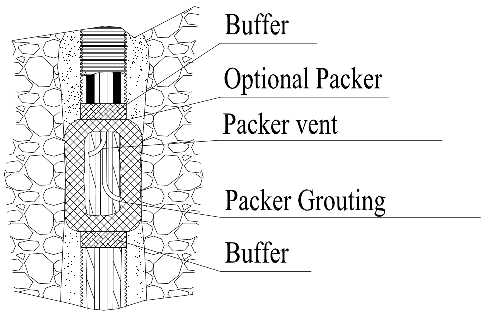
8.4.1 - TPE-07A permanent ground anchor diagram

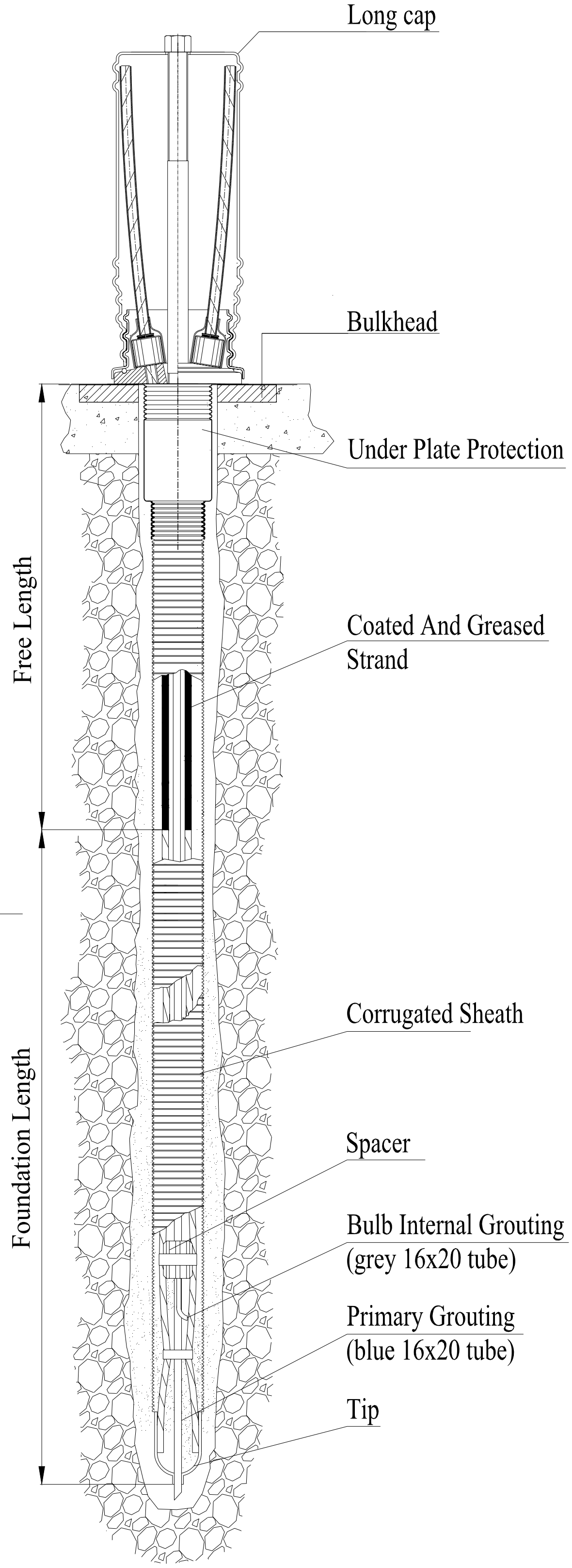




The ***TPE-07B*** *anchor is provided with a corrugated sheath on the bulb and on the free length. Grouting takes place via two tubes: external primary grouting and foundation grout. This version is provided with the total protection and a strand buffer between free length and foundation. The* ***TPE-07A*** *anchor cannot be retensioned as it is provided with a short cap.*

8.4.2 - TPE-07B permanent ground anchor diagram

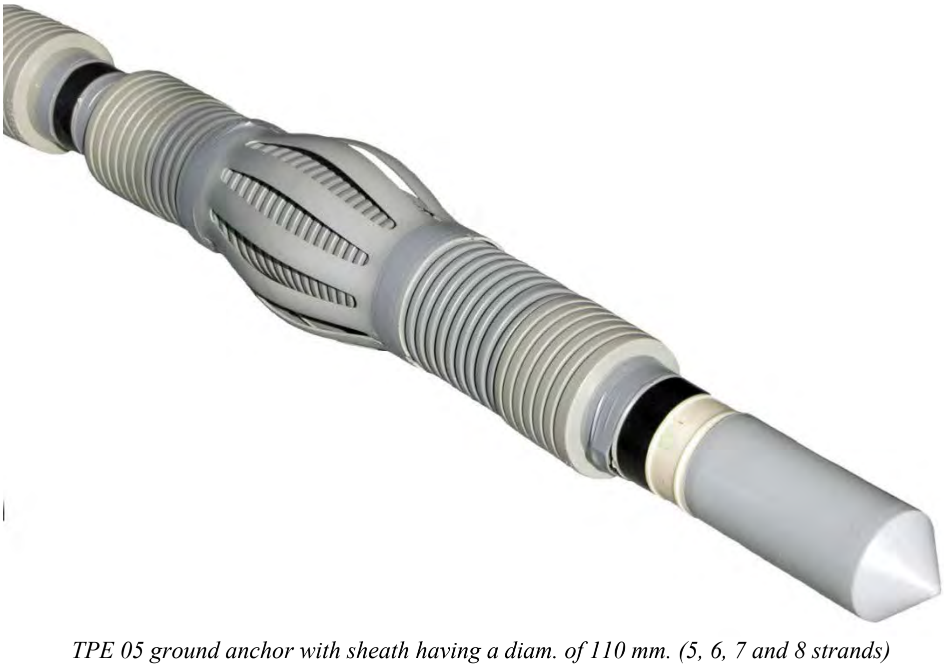




*The **TPE-07B** anchor is provided with a corrugated sheath on the bulb and on the free length. Grouting takes place via two tubes: external primary grouting and foundation grout. This version is provided with the total protection and a strand buffer between free length and foundation. The **TPE-07B** anchor can be retensioned as it is provided with a long cap.*

TPE-05 permanent *ground anchors are produced in compliance with the European and Italian Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" paragraph 6.9.3*** *and they are made of harmonic steel strands according to* ***EN 10138****.*
*The****TPE-05 permanent*** *ground anchor is usually used in the construction of bulkheads and diaphragms, where the type of ground has particular geo-technical problems which require the* ***I.R.S.*** *repeated, selective, radial re-grout on the whole foundation.*

It allows the ***I.R.S.*** *grout without using external valvate tubes which may be difficult to apply in some cases. The* ***TPE 05*** *ground anchor is provided with an internal valvate tube and* ***I.R.S.*** *valves that are protected against rubbing by the recess for an easy insertion under difficult conditions.*



TPE 05 ground anchor with sheath having a diam. of 110 mm. (5, 6, 7 and 8 strands)

It allows the I.R.S. grout radial to the anchor, ensuring a more homogeneous mortar covering with respect to the applications with side valvate.

The ground anchor is made as follows:

- *The separation of the free length from the active part is achieved by way of a buffer of sealing material, which allows both parts to be perfectly hermetic. Ground anchors are made of harmonic steel strands that are singularly protected and greased. The free length is protected by polyethylene 16x19.5 mm tubes and can also be protected by: smooth or corrugated sheath in P.E.A.D. according to the instructions of the* ***"Client's Technical Representative"***
- *The corrugated sheaths to be used with this type of anchor are: sheaths with outside diam. 110 mm. for anchors from 4 to 8 strands, sheaths with outside diam. 90 mm. for anchors from 1 to 4 strands.*

- *In the active part, the strands are separated by special spacers which guarantee them to maintain a sinusoidal shape by means of suitable strapping and taping. The sinusoidal shape increases the adherence of the strands with the foundation cement mix.*
- *This type of anchor is provided with a T001 27/34 mm tube on which special **RRM** valves are fixed on the foundation part to allow single and repeated external grouts **(I.R.S.).** On the same tube there are also: no. 2 manchette valves to allow the internal grouting of the bulb and the grout of the packer. Another valve may be required for the grout of the free length upon request of the **"Client's Technical Representative".***

RRM valve mounted on a TPE 05 ground anchor foundation

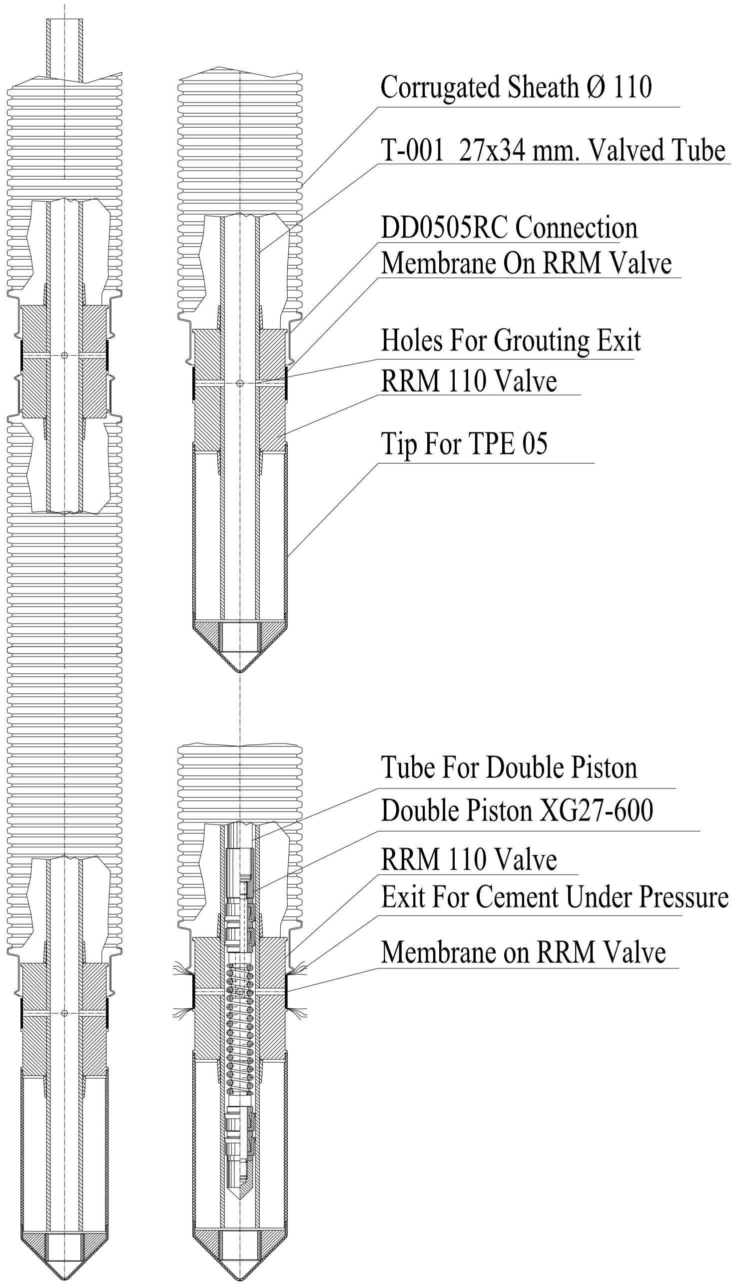
RRM valve on TPE 05 anchor

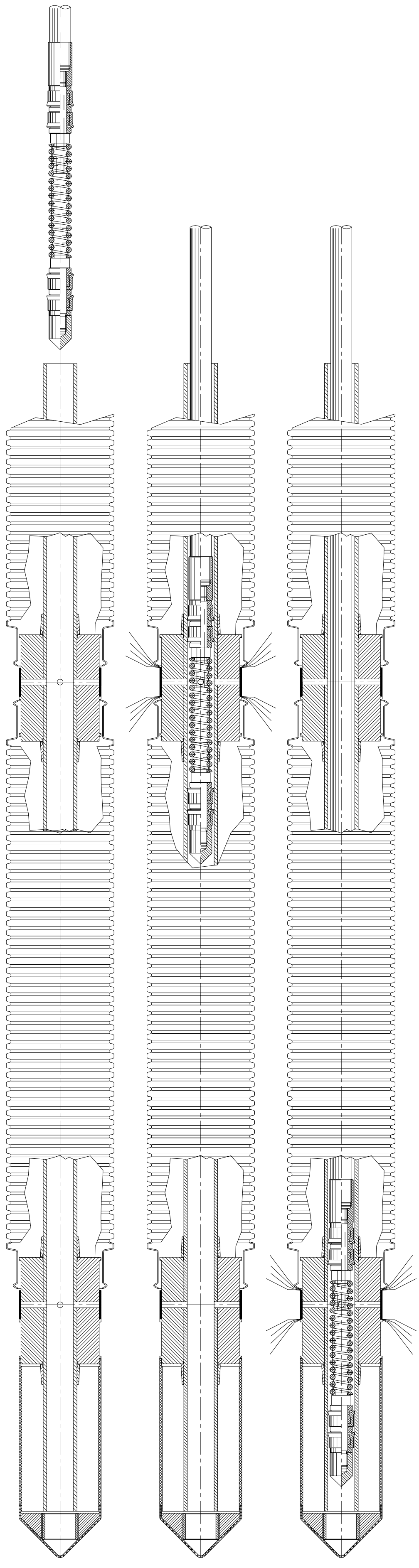
RRM valves

RRM valve on TPE 05 ground anchor with strands inserted

TPE 05 ground anchor with sheath having a diam. of 90 mm. (2, 3 and 4 strands)

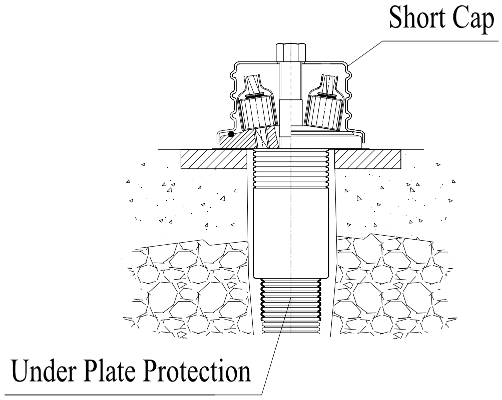
8.5.1 - RRM valves grout with double XG27-600 piston diagram

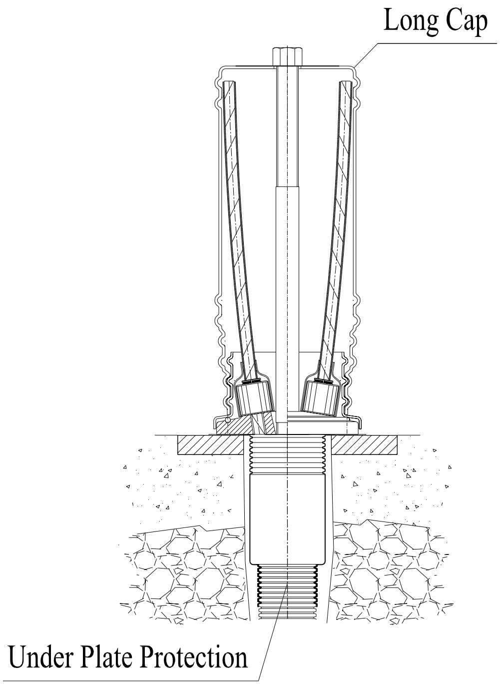


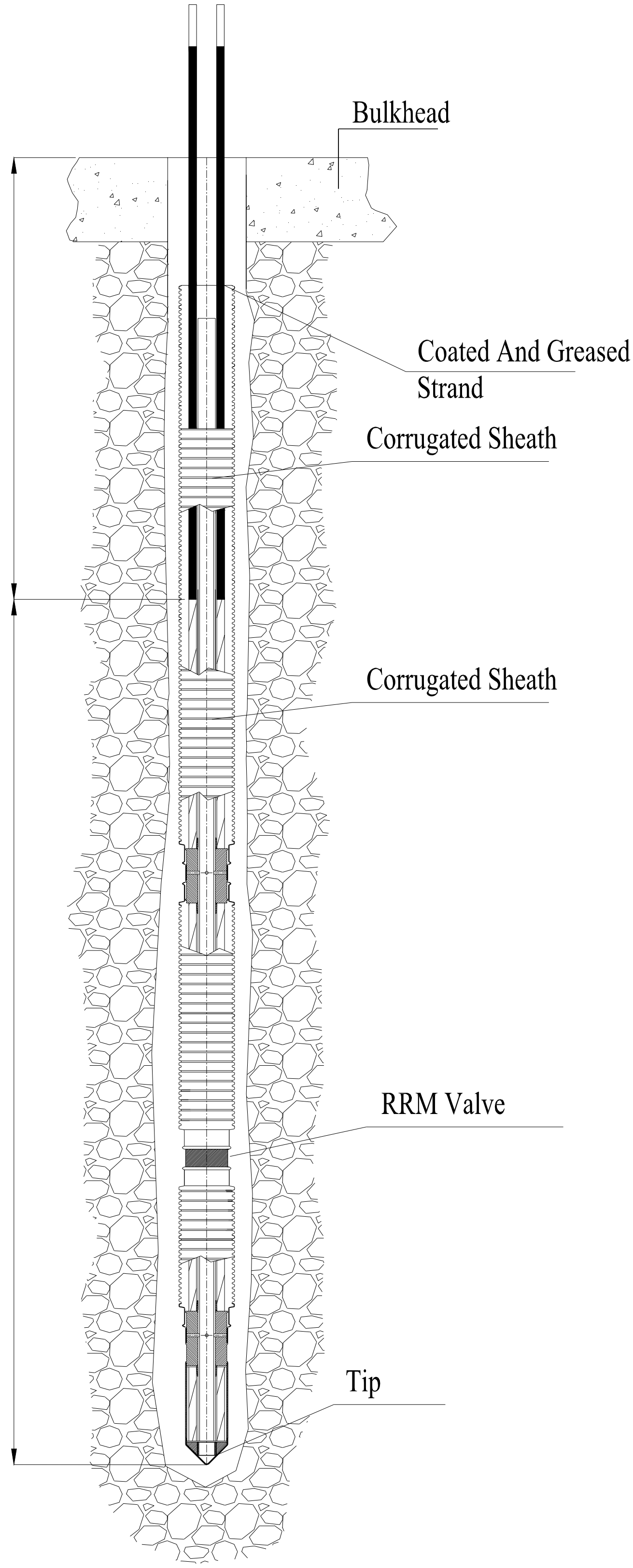


XG27-600 double piston

8.5.2 - TPE-05A permanent ground anchor diagram

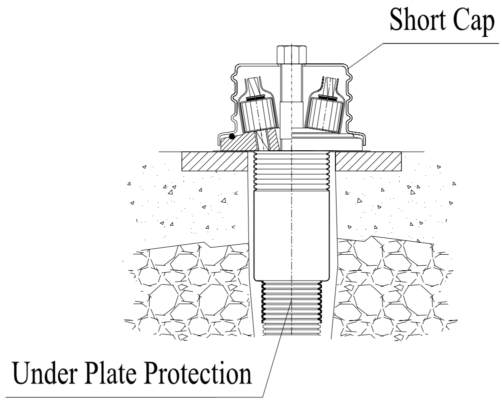


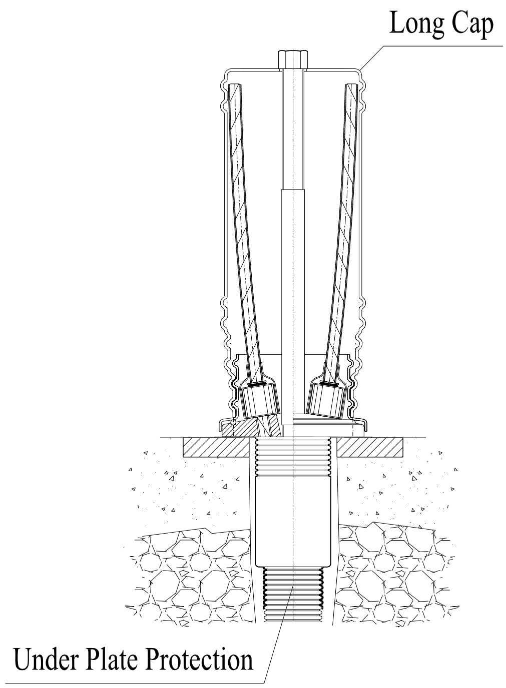


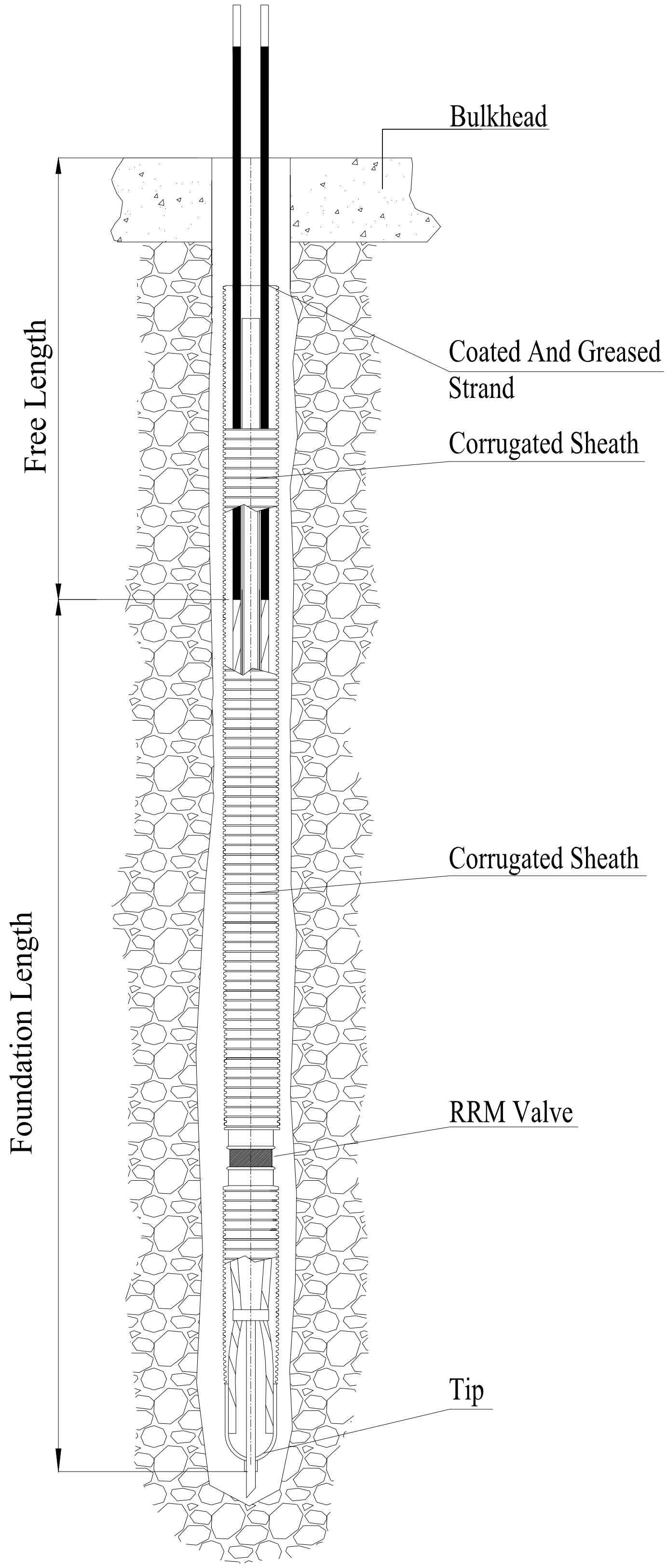


TPE-05-A *anchor provided with a corrugated sheath on the whole length. Grouting is carried out via the T001 27x34 mm central tube which allows to grout both the internal and the external part. This version allows to fix the total protection and it is provided with elementary buffers strand by strand between free length and foundation. On the* ***TPE-05A*** *permanent ground anchor a valvate 27/34 mm tube is installed in order to allow the* ***I.R.S.*** *repeated and selective re-grout.*

8.5.3 - TPE-05B permanent ground anchor diagram







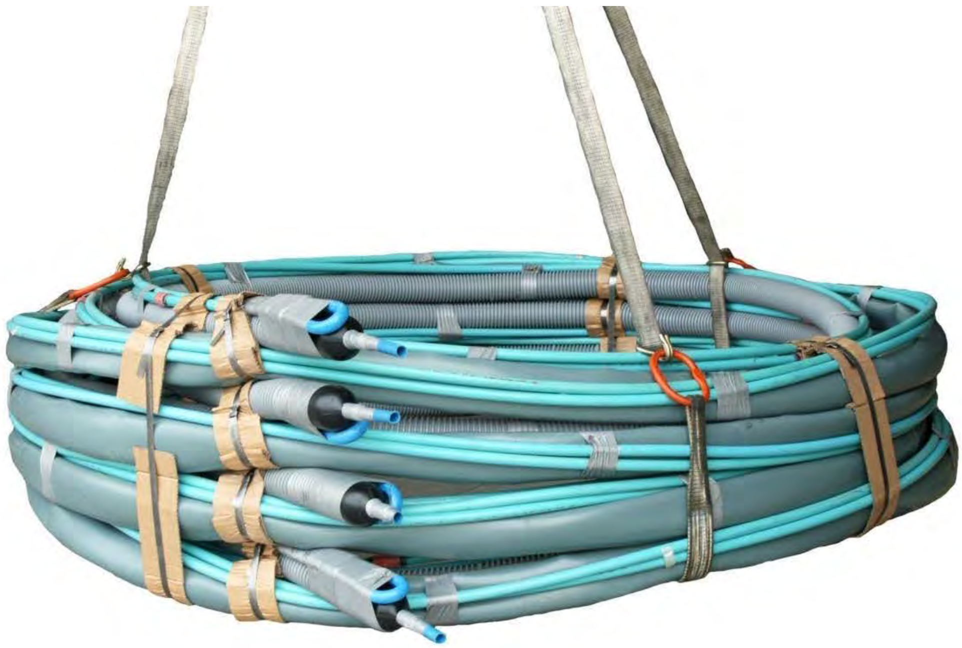
***TPE-05-B** anchor provided with a corrugated sheath on the whole length. Grouting is carried out via the T001 27x34 mm central tube which allows to grout both the internal and the external part. This version allows to fix the total protection and it is provided with elementary buffers strand by strand between free length and foundation. On the **TPE-05B** permanent ground anchor a valvate 27/34 mm tube is installed in order to allow the **I.R.S.** repeated and selective re-grout.*

TPE-08 permanent *ground anchors are produced in compliance with the European and Italian Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" paragraph 6.9.3*** *and they are made of harmonic steel strands according to* ***EN 10138****.*
*The****TPE-08 permanent*** *anchor is usually used in the construction of bulkheads and diaphragms, where the type of ground has particular geo-technical problems which require the simultaneous repeated non selective re-grout* ***I.R.*** *(repeated regrout), of the ½" valves installed on the 15x21 mm external tube.*

The anchor is made as follows:

- *In the active part, the strands are separated by special spacers which guarantee the tendon to maintain a sinusoidal shape. By means of suitable strapping and/or taping, the sinusoidal shape of the tendon increases the adherence with the foundation cement mix. Grouting takes place via a 16x20 mm polyethylene tube which can guarantee a grouting pressure of max. 25 bar.*
- *The free length is protected by inserting a smooth or corrugated sheath in H.D.P.E. according to the instructions of the* ***"Client's Technical Representative"****. The separation of the free length from the active part is achieved by way of a buffer of sealing material, which allows both parts to be perfectly hermetic. It can be on each strand or globally on all strands dividing the free length from the foundation.*
- *The end part of the ground anchor is provided with a polyethylene ogive to ease its insertion into the drilling hole and guarantee its total encapsulation.*
- *The free length is protected by greasing and sheathing each single strand via a 16x19.5 mm tube.*
- *This type of anchor is also provided with a U-shaped ½" tube where special manchette valves are installed to allow* ***I.R.*** *repeated non selective re-grouts (repeated regrout). Since there is no separation buffer, the grouting tube of the bulb also grouts the free length.*

TPE-08A *anchor provided with a corrugated sheath on the whole length both on the free length and on the foundation part.*

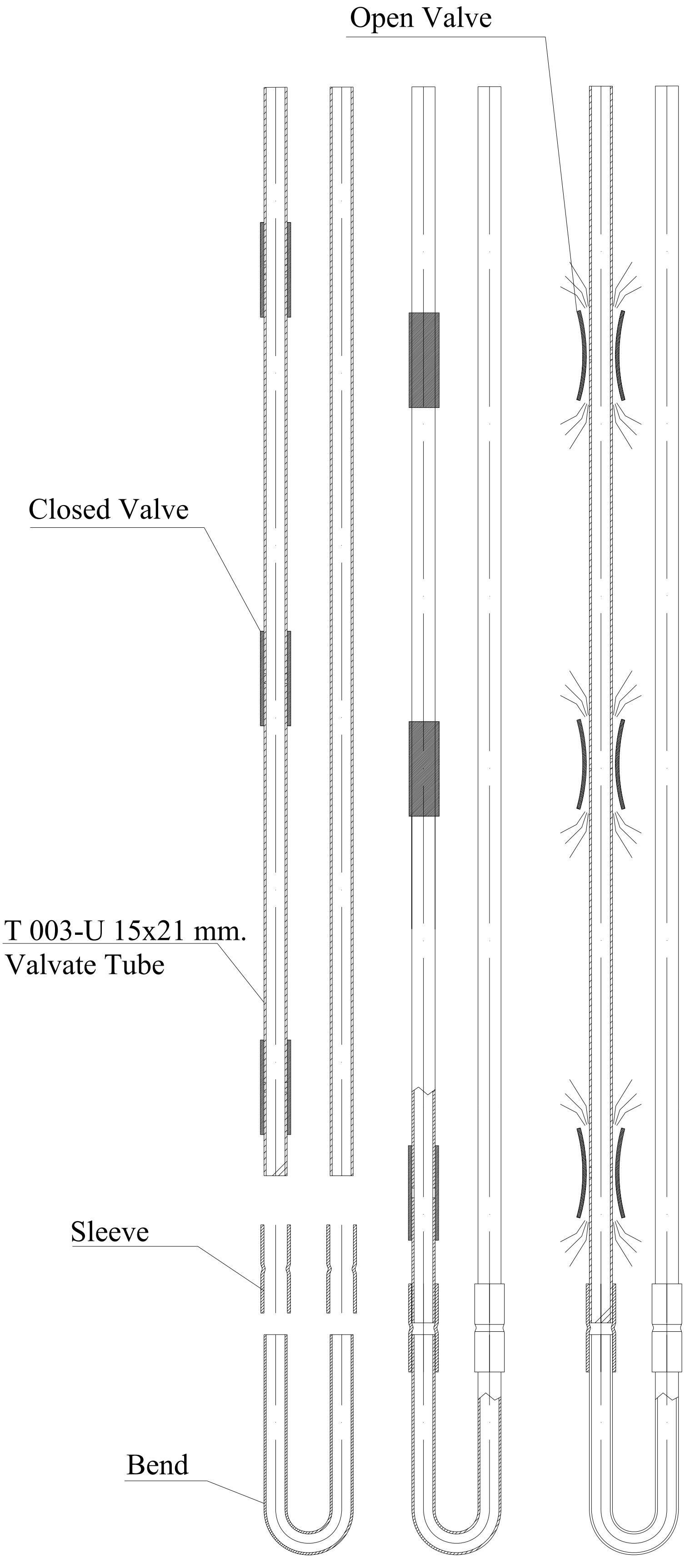


TPE-08B *anchor provided with corrugated sheath on the foundation and smooth sheath on the free length.*

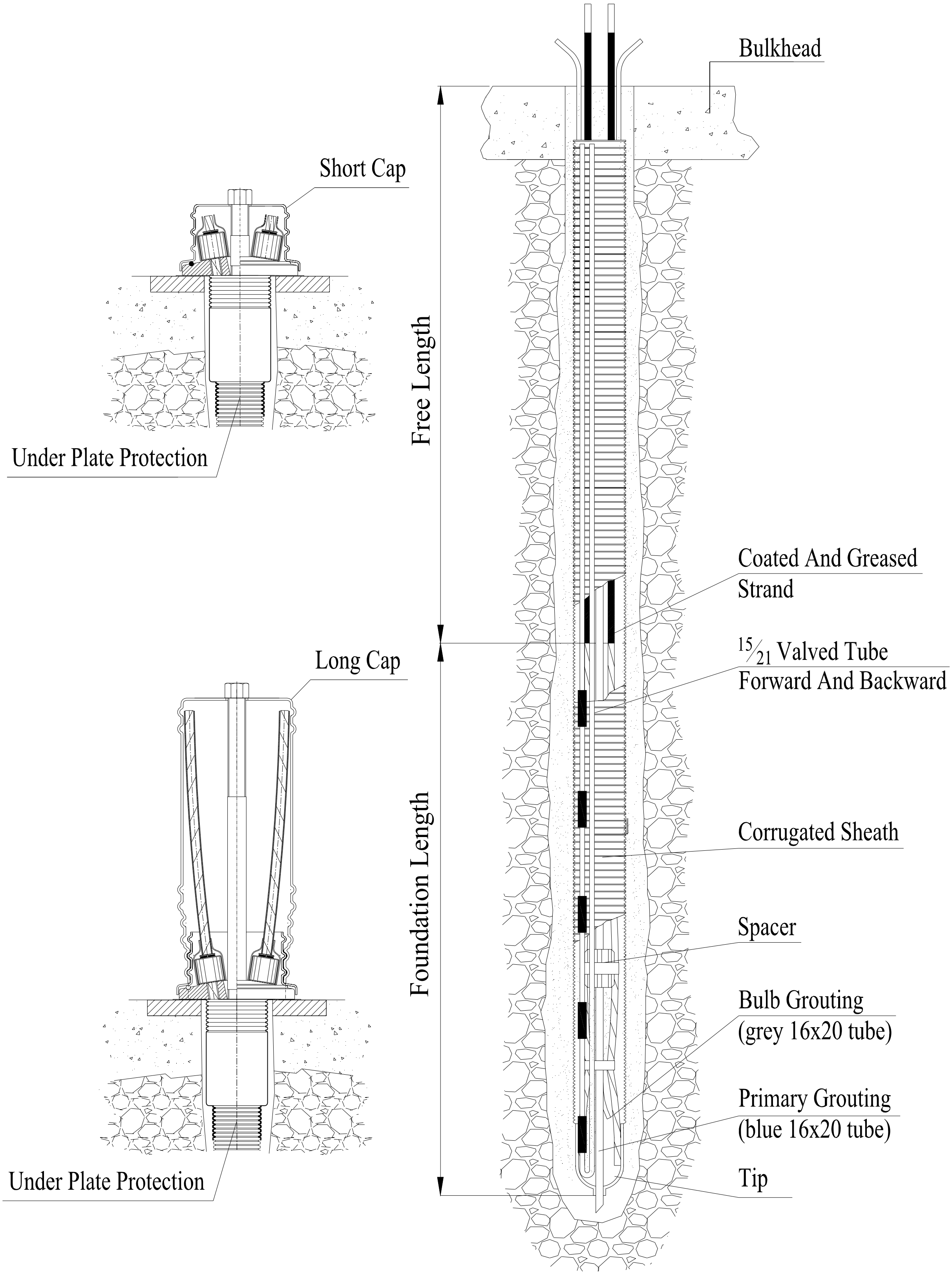
TPE 08 ground anchor for external U-shaped re-grout

15x21 mm tube for TPE 08 ground anchor

8.6.1- TPE-08 permanent ground anchor diagram

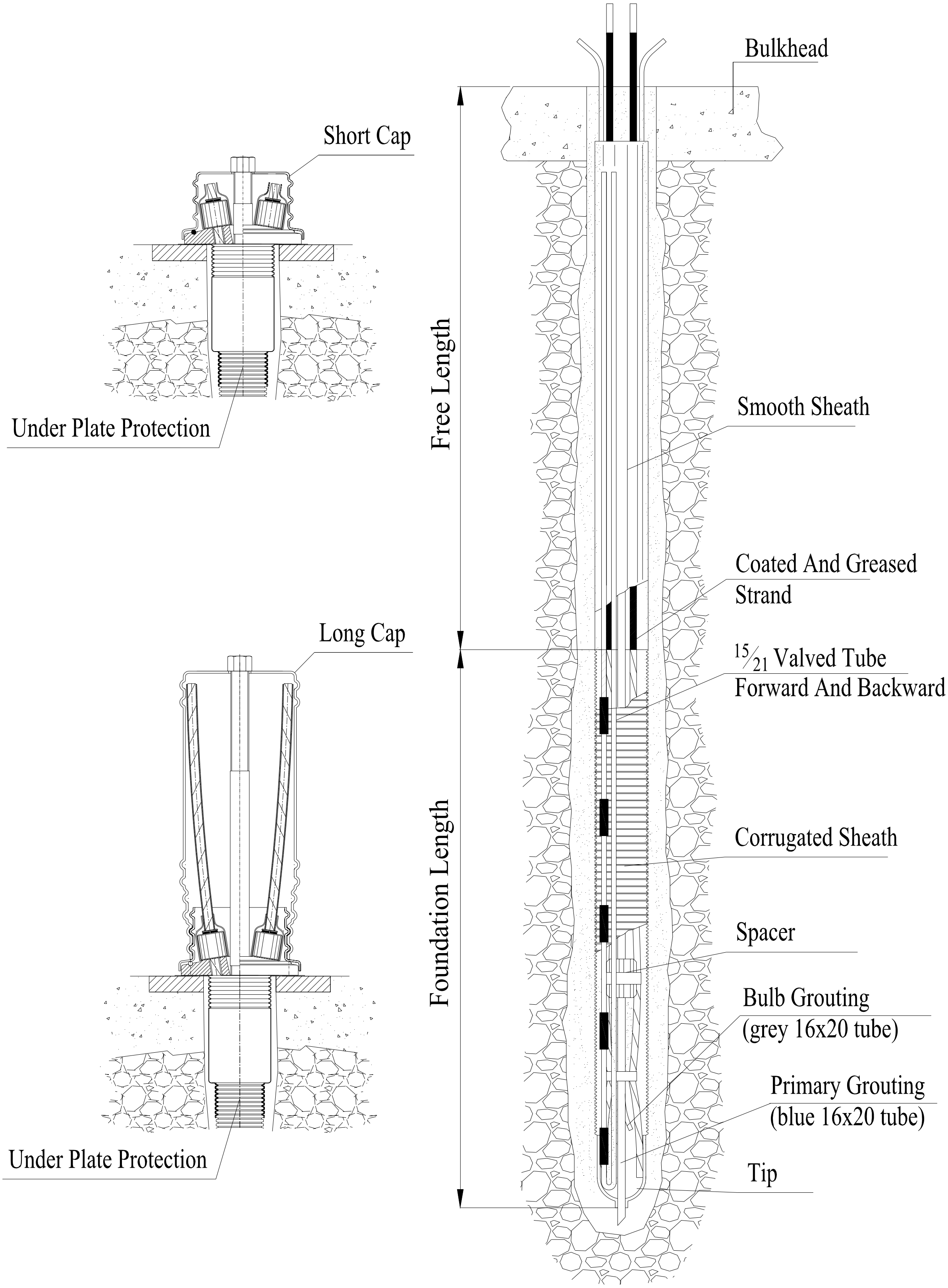


8.6.2- TPE-08A permanent ground anchor diagram



TPE-08A *anchor provided with a corrugated sheath on the whole length. Grouting takes place via two tubes: primary grouting and internal grouting. This version allows to fix the under plate protection and it is provided with elementary buffers strand by strand between free length and foundation. On the* ***TPE-08A*** *permanent ground anchor a valvate U-shaped 15x21 mm tube is installed on the outside in order to allow the* ***I.R.*** *repeated re-grout.*

8.6.3 - TPE-08 permanent ground anchor diagram



*The **TPE-08B** anchor is provided with a corrugated sheath on the bulb and on the free length. Grouting takes place via two tubes: primary grouting and internal grouting. This version allows to fix the under plate protection and it is provided with elementary buffers strand by strand between free length and foundation. On the **TPE-08B** permanent ground anchor a valvate U-shaped 15x21 mm tube is installed on the outside in order to allow the **I.R.** repeated re-grout.*

9.0 – GROUND ANCHORS FOR SPECIAL APPLICATIONS

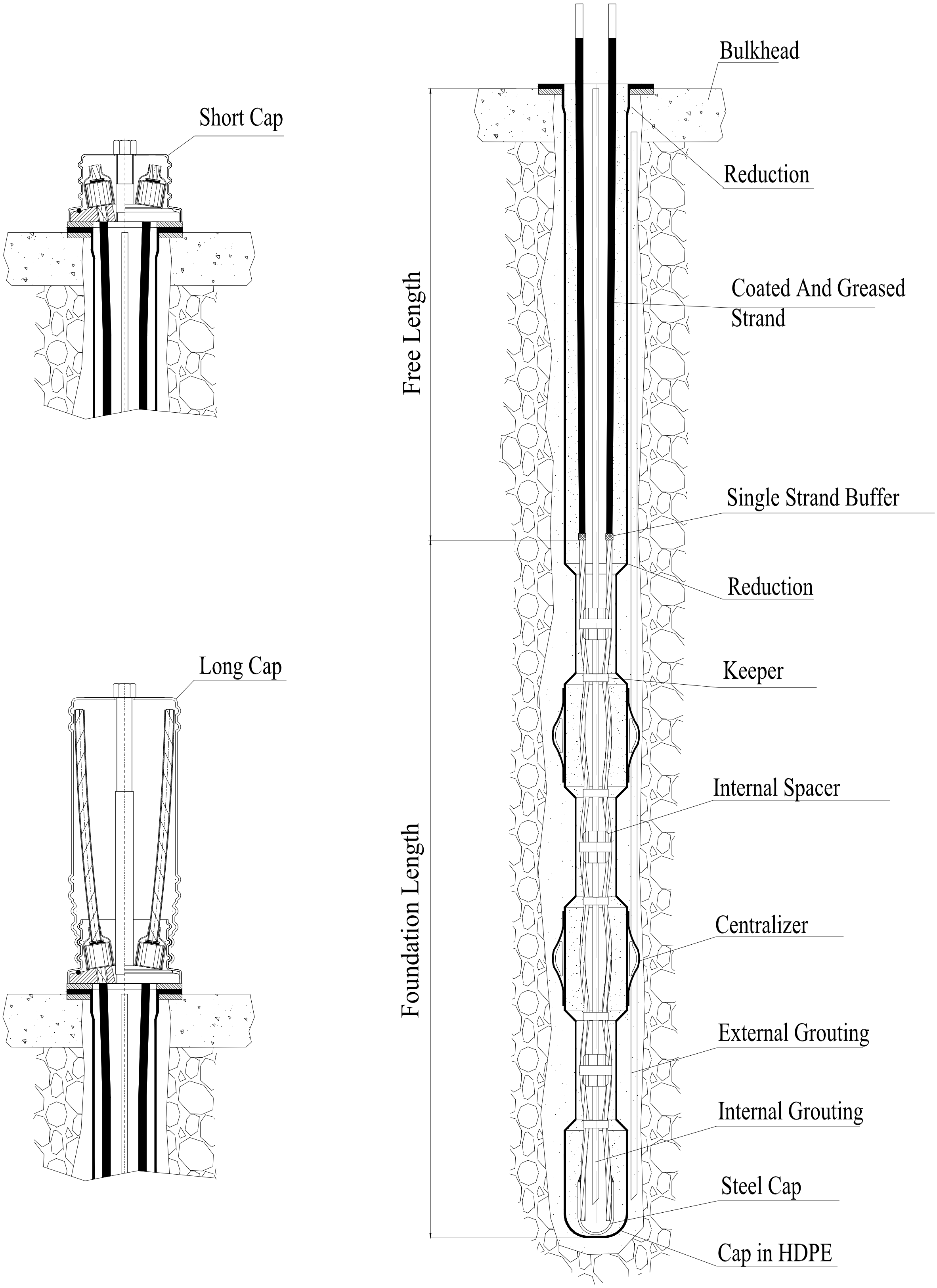
9.1 – TDP-09 dielectric permanent ground anchors

TPD-09 permanent *ground anchors are produced in compliance with the European and Italian Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" paragraph 6.9.3*** *and they are made of harmonic steel strands according to* ***EN 10138*** *and protected for their whole length with a sheath in H.D.P.E.* ***PN8.***
The ***TPD-09 permanent*** *ground anchor is used to consolidate bulkheads and diaphragms, where the type of ground requires protection against stray currents. It guarantees the dielectricity of the device over time.*

The anchor is made as follows:

- *In the active part, the strands are separated by special spacers which guarantee the tendon to maintain a sinusoidal shape. By means of suitable strapping and/or taping, the sinusoidal shape of the tendon increases the adherence with the foundation cement mix. Grouting takes place via a 16x20 mm polyethylene tube which can guarantee a grouting pressure of max. 25 bar.*
- *In the external part, the ground anchor is protected outwards by an H.D.P.E.* ***PN8*** *tube which, thanks to its variations in diameter, guarantees the protection of the tendons over time and the dielectric property. The external part can be equipped on request with DD**-ED** (dynamic) or* ***DD-EF*** *(fixed) external spacers.*
- *The anchor plate is coupled with the protection sheath via a special H.D.P.E. connection that guarantees the insulation of the anchorage.*
- *The adherence of the bulb is guaranteed by special narrowings of the main tube containing the anchor.*

9.1.1 – TPD-09 permanent ground anchor diagram (dielectric ground anchors)



ELECTRICAL TESTING of corrosion protection according to EURO NORM EN 1537-2002

This test consists in the measurement of the electrical resistance between an anchor and the surrounding soil or structure to determine the effectiveness of the applied corrosion protection system.

Description of the two test systems:
- *Measurement of the isolation of the anchor from the soil and structure,* ***ERM I system***
- *Measurement of the isolation between head and structure only,* ***ERM II system***

Electrical resistance measurement I -** ERM **I system

For the method of execution of the ERM** I system **the following equipment specification is adopted:
- *measurement voltage 500 V. d.c.,*
- *measuring range* ***> 10 KΩ (0.01 MΩ)***

During measurement the anchor shall be connected to the positive pole with the earth connection at the negative pole of the measuring circuit. Generally the moist site soil of the site is used as the earth. Lengths of reinforcing steel in reinforced concrete construction in contact with the soil, metallic pipes buried in the soil, or soil and rock nails may also be used as the earth connection. During measurement the points of contact are kept clean.
The ***ERM I*** *may be executed in two separate phases:*

Phase a)
This tests the integrity of a plastic sheath on the free anchor length and the bond length after the subsequent stages of the installation of the anchor i.e. before lock-off of the anchor:
- *after setting the anchor into the borehole,*
- *after the primary grouting,*
- *after a possible secondary grouting,*
- *after the acceptance test.*

A measured electrical resistance between the tendon and ground ≥ ***0.1 MΩ*** *demonstrates an acceptable level of plastic sheath integrity.*

Phase b)
This tests the overall electrical isolation of the anchor from ground and structure:
- *after lock-off of the anchor,*
- *after the anchor head injection,*
- *at any time during the working life of the anchor,*

A resistance $R_I \geq$ ***0.1 MΩ*** *between anchor and ground / structure demonstrates overall electrical isolation of the anchor from the ground and structure.*

Electrical resistance measurement II - ERM II system

This measurement is only executed if R_I *after lock-off of the anchor is lower than* ***0.1 MΩ*** *in order to prove that, at least, there is no direct contact between anchor head and reinforcing steel of the anchored structure.*

ERM II *is executed on the stressed anchor. For the method of execution the following equipment specification is adopted:*
- *measurement voltage circa 40 V. a.c.,*
- *measuring range* ***0-200 KΩ (0-0.2 MΩ)***

Generally, the bearing plate is used as the earth connection. The steel in the anchored structure may be used if the bearing plate is coated by an electrically isolating material.

During measurement the anchor head and in particular the isolating plate between anchor head and bearing plate is kept dry. The electrical contacts are kept clean and the metal bare. In order to ensure good contacts either clamps or strong magnets are used. Pins are not used for this type of measurement.
Measurement ***ERM II*** *is sensitive to climatic influences such as air humidity in the area of the anchor head and also possibly to stray currents in the ground.*
If several measurements are carried out on an anchor then, given the correct execution of the measurement, the greatest resistance measurement should be adopted.
A resistance R_{II} ***greater than 100 KΩ*** *between anchor head and bearing plate or reinforcing steel of the structure demonstrates no direct contact between anchor head and reinforcing steel of the anchored structure.*

9.2 – TPS-10 temporary ground anchors
(Partially removable ground anchors)

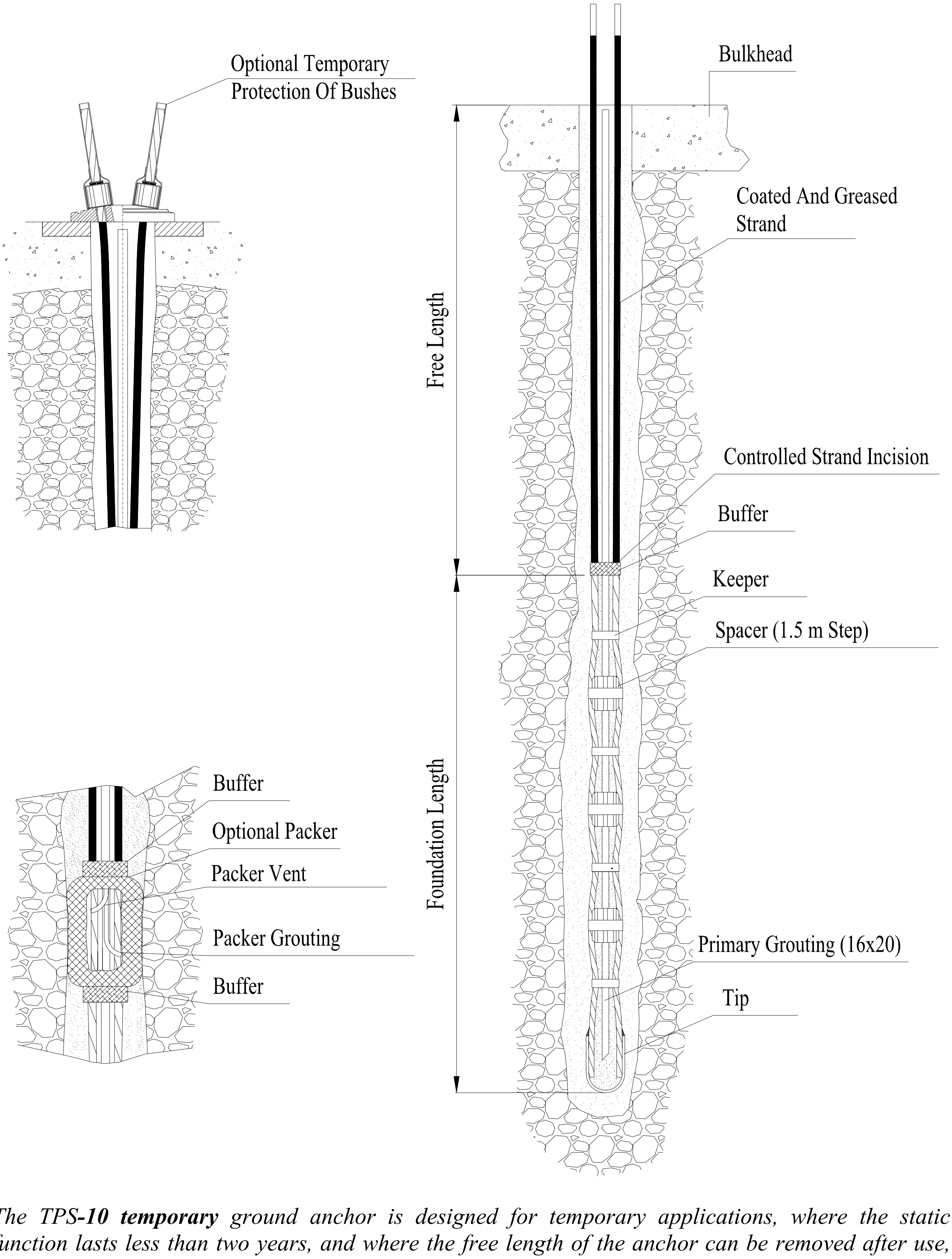
TPS-10 temporary *ground anchors are produced in compliance with the European and Italian Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" paragraph 6.9.3*** *and they are made of harmonic steel strands according to* ***EN 10138*** *singularly sheathed and greased on the free length.*
They are usually used in the construction of bulkheads and diaphragms, where the type of ground does not have any particular geo-technical problems and where ground anchors must be removed after use.

The anchor is made as follows:

- *In the active part, the strands are separated by special spacers which have a sinusoidal shape, by means of suitable strapping and taping, to increase their adherence with the foundation cement mix. Grouting takes place via a 16x20 mm polyethylene tube. The anchor is removed by making an incision on the strand between the free length and the foundation, allowing to break the strands as the working load is increased after using the anchor. The controlled incision is made by using a special equipment during the anchor assembly.*
- *The free length is protected by greasing and sheathing each single strand with 16x19.5 mm sheaths in H.D.P.E. according to the instructions of the* ***"Client's Technical Representative".*** *The separation of the free length from the active part is achieved by way of a buffer of sealing material, which allows both parts to be perfectly hermetic. It can be on each strand or globally on all strands dividing the free length from the foundation.*

9.2.1 – TPS-10 temporary ground anchor diagram

(Partially removable ground anchors)



*The TPS-**10 temporary** ground anchor is designed for temporary applications, where the static function lasts less than two years, and where the free length of the anchor can be removed after use, leaving the foundation inactive in the ground.*

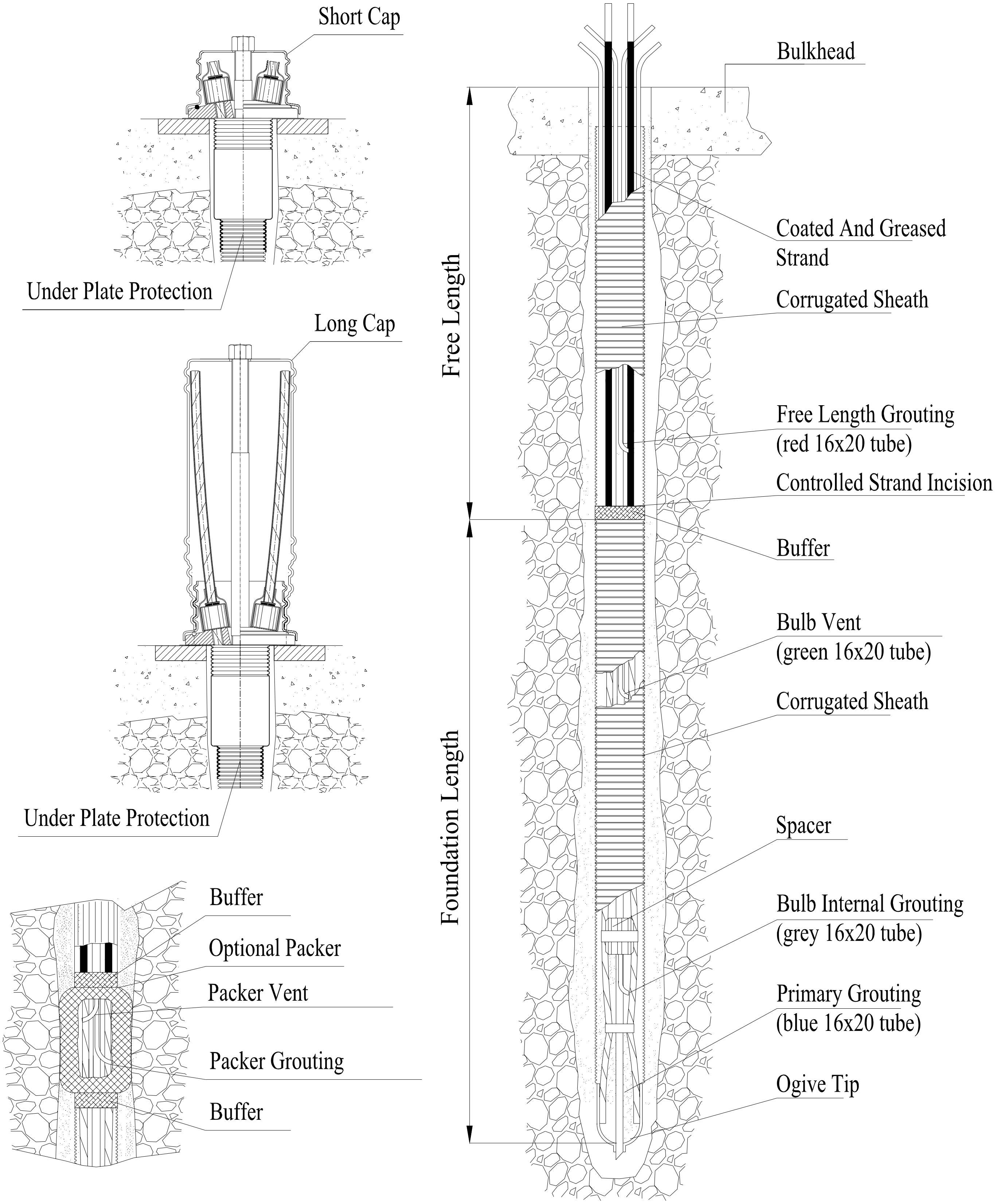
9.3 – TPS-11 permanent ground anchors
(Partially removable ground anchors)

TPR-01 permanent *ground anchors are produced in compliance with the European and Italian Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" ,paragraph 6.9.3*** *and they are made of harmonic steel strands according to* ***EN 10138****, singularly sheathed and greased on the free length.*
They are usually used in the construction of bulkheads and diaphragms, where the type of ground does not have any particular geo-technical problems and where ground anchors must be removed after use but they must guarantee a permanent service at the same time.

The anchor is made as follows:

- *In the active part, the strands are separated by special spacers which have a sinusoidal shape, by means of suitable strapping and taping, to increase their adherence with the foundation cement mix. Grouting takes place via a 16x20 mm polyethylene tube. The foundation is protected by a corrugated sheath making the anchor permanent. The anchor is removed by making an incision on the strand between the free length and the foundation, allowing to break the strands as the working load is increased after using the anchor.*
- *The free length is protected by inserting a smooth or corrugated sheath in H.D.P.E. according to the instructions of the* ***"Client's Technical Representative".*** *The separation of the free length from the active part is achieved by way of a buffer of sealing material, which allows both parts to be perfectly hermetic. It can be on each strand or globally on all strands dividing the free length from the foundation.*
- *The end part of the ground anchor is provided with a polyethylene ogive to ease its insertion into the drilling hole and guarantee its total encapsulation.*
- *The free length is protected by greasing and sheathing each single strand via a 16x19.5 mm tube.*

9.3.1 – TPS-11 permanent ground anchor diagram



The ***TPS-11 permanent*** *ground anchor is designed for permanent applications, where the static function lasts more than two years, and where the free length of the anchor can be removed, leaving the foundation inactive in the ground.*

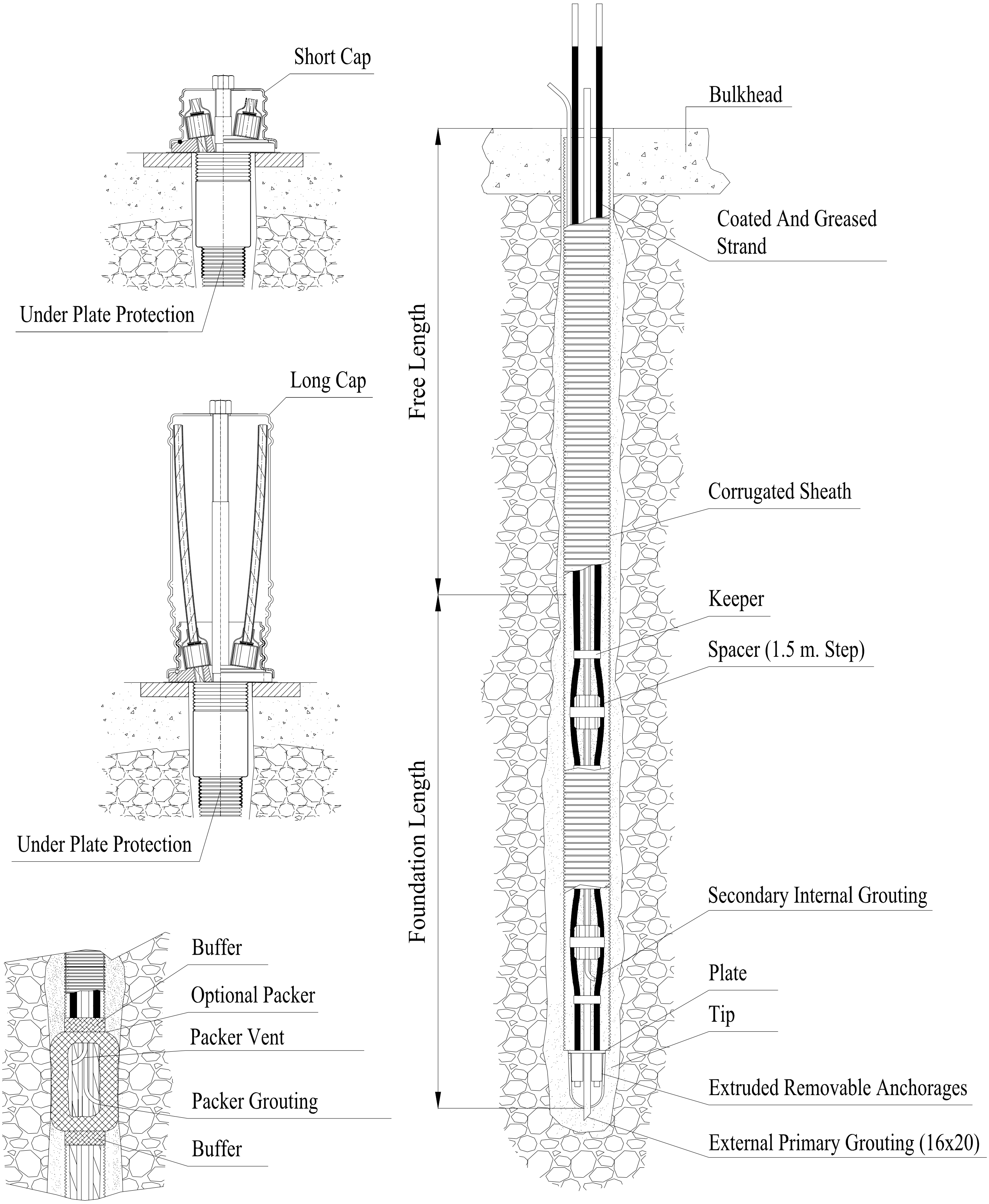
9.4 – TPF-12 permanent ground anchor
(Totally removable ground anchors)

TPF-12 permanent *totally removable ground anchors are produced in compliance with the European Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" ,paragraph 6.9.3*** *and they are made of harmonic steel strands according to* ***EN 10138****, singularly sheathed and greased on the free length.*
They are usually used in the construction of bulkheads and diaphragms, where the type of ground does not have any particular geo-technical problems and where ground anchors must be totally removed after use, but they must guarantee a permanent service at the same time. The removal is obtained by means of extruded anchors with a resistance calculated according to the removal value required.

The anchor is made as follows:

- *In the active part, the strands are separated by special spacers which have a sinusoidal shape, by means of suitable strapping and taping, to increase their adherence with the foundation cement mix. Grouting takes place via a 16x20 mm polyethylene tube. The foundation is protected by a corrugated sheath making the anchor permanent. The anchor is removed by making an incision on the strand between the free length and the foundation, allowing to break the strands as the working load is increased after using the anchor.*
- *The free length is protected by inserting a smooth or corrugated sheath in H.D.P.E. according to the instructions of the* ***"Client's Technical Representative".*** *The separation of the free length from the active part is achieved by way of a buffer of sealing material, which allows both parts to be perfectly hermetic. It can be on each strand or globally on all strands dividing the free length from the foundation.*
- *The end part of the ground anchor is provided with a polyethylene ogive to ease its insertion into the drilling hole and guarantee its total encapsulation.*
- *The free length is protected by greasing and sheathing each single strand via a 16x19.5 mm tube.*
- *The reaction of the active part is obtained by means of an end plate to which special anchorages are connected having their resistance calibrated according to the removal required;*

9.4.1 – TPF-12 permanent ground anchor diagram
(Totally removable)



*The TPS-**12 permanent** ground anchor is designed for permanent applications, where the static function lasts more than two years, and where the whole anchor can be removed at the end of its static use.*

9.4.2 - Removable ground anchors types

Removable ground anchors are required for all the applications where, after their static use is over, it will be necessary to remove them and to restore the ground to allow safe future activities.

There are several types of removable anchors:

- Partially removable ground anchors;
- Totally removable ground anchors;

9.4.2.1 - Partially removable ground anchors

After their static function is over, partially removable ground anchors are removed by taking them to failure with special jacks near the bulb, thus releasing the tension on the strands at the free length. With this type, the bulb of the cemented anchor will remain inside the ground in its original position.

9.4.2.2 - Totally removable ground anchors

After their static function is over, totally removable ground anchors are completely removed by taking them to failure with special jacks, thus releasing the tension on the whole anchor and restoring the ground to allow safe future activities.

9.4.3 - Removable and partially removable ground anchors, removal value

The partially removable ground anchor is removed by making an incision on each strand between the free length and the foundation; the incision is made with a special numerical control equipment that guarantees the repeatability of the operation and the breakage of the strand when it is subjected to the maximum breaking strain (Psf.) that must be limited to 0.75 ÷ 0.80 Ptk.
The anchor can be usually tensioned at the maximum lock-off stress (Po) that must be limited to 0.6 Ptk; in this application the use at 0.5 Ptk is recommended; once its temporary function is over, stressing is increased strand by strand (load must be applied to one strand at a time) at the value Psf. = 0.75 ÷ 0.80 Ptk to obtain the removal (breaking the strand) between free length and foundation where the strand is incised. The removal is carried out by using TTM300KN jacks.

9.4.4 - Totally removable ground anchors, removal values

The totally removable ground anchor is removed by blocking the strand at the end opposite to the foundation with extruded anchorages, which can react to the working stressing at the maximum lock-off stressing (Po) that must be limited to 150 KN, as well as the removal by increasing the stressing strand by strand (load must be applied to one strand at a time) at the value Psf. = 0.85 ÷ 0.90 Ptk. To ease the removal activities, T15C strands are used (compact strands). The removal is carried out by using TTM300KN jacks.

Removable ground anchors can be temporary or permanent. They are produced according to ***"EURO NORM EN 1537-2002".***
The activities of removal must be carried out with special equipment and technicians that are qualified in its use. However, it is a dangerous activity if it is not carried out according to the procedures indicated by TTM.

9.5 - TPE-15 permanent ground anchor
(increased adherence ground anchors)

TPE-15 permanent *ground anchors are produced in compliance with the European Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" ,paragraph 6.9.3*** *and they are made of harmonic steel strands according to* ***EN 10138****, singularly sheathed and greased on the free length.*
They are usually used in the construction of bulkheads and diaphragms, where the type of ground has serious highly corrosive geo-technical problems in the presence of groundwater, where an increased adherence of the bulb is required. The ***TPE-15*** *anchor is totally encapsulated, all its parts are encapsulated in polyethylene, thus ensuring a total protection (hermetic of all its components)*

TPE-15 increased adherence permanent ground anchor

In ***TPE-15 permanent*** *ground anchors the foundation is provided with devices that increase the adherence to the drilling hole. The advantages of this anchor are:*

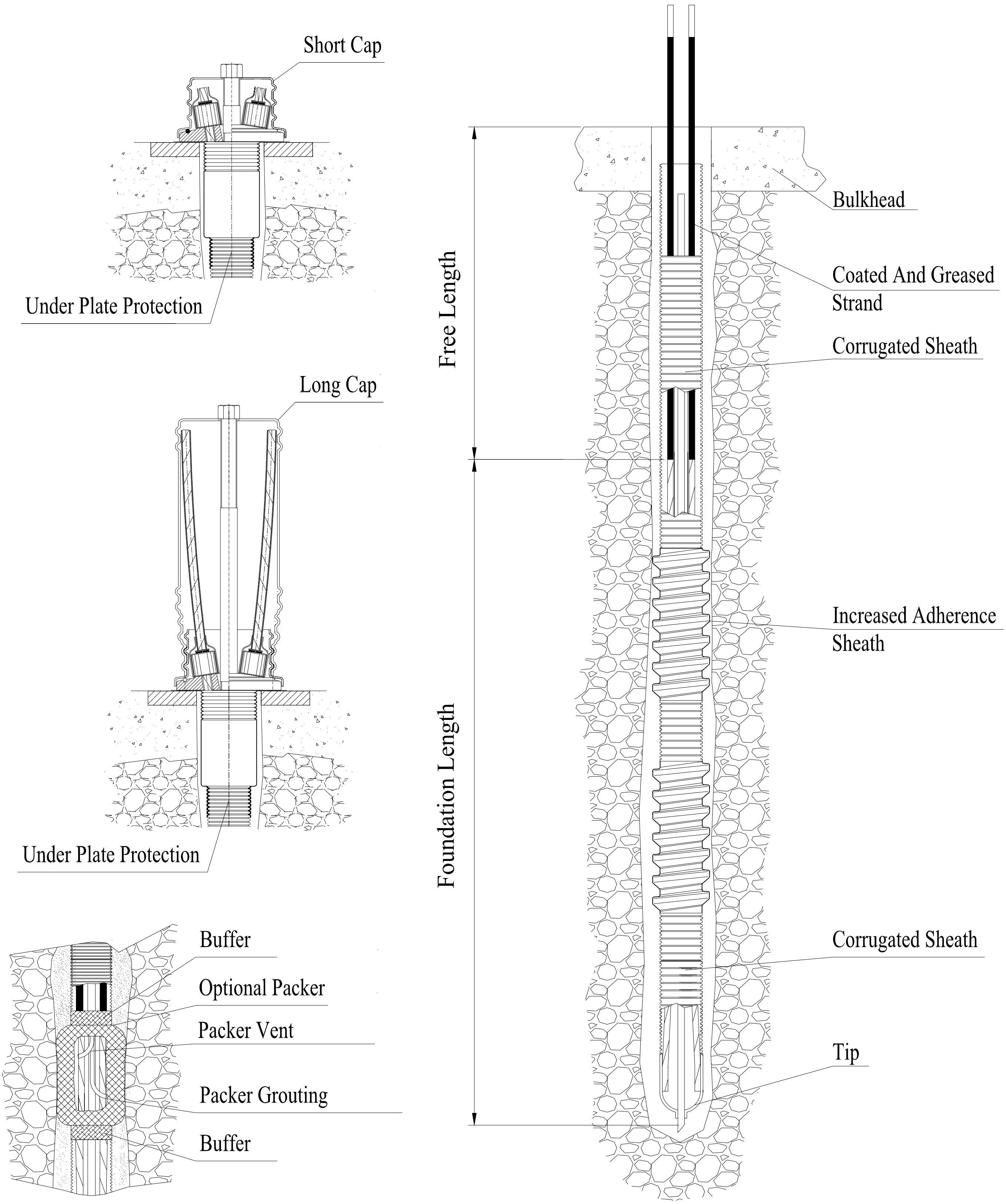
- *reduction of the anchor length by reducing the foundation length,*
- *reduction of the length of drilling holes,*
- *easy to install,*
- *high adherence,*

The anchor is made as follows:

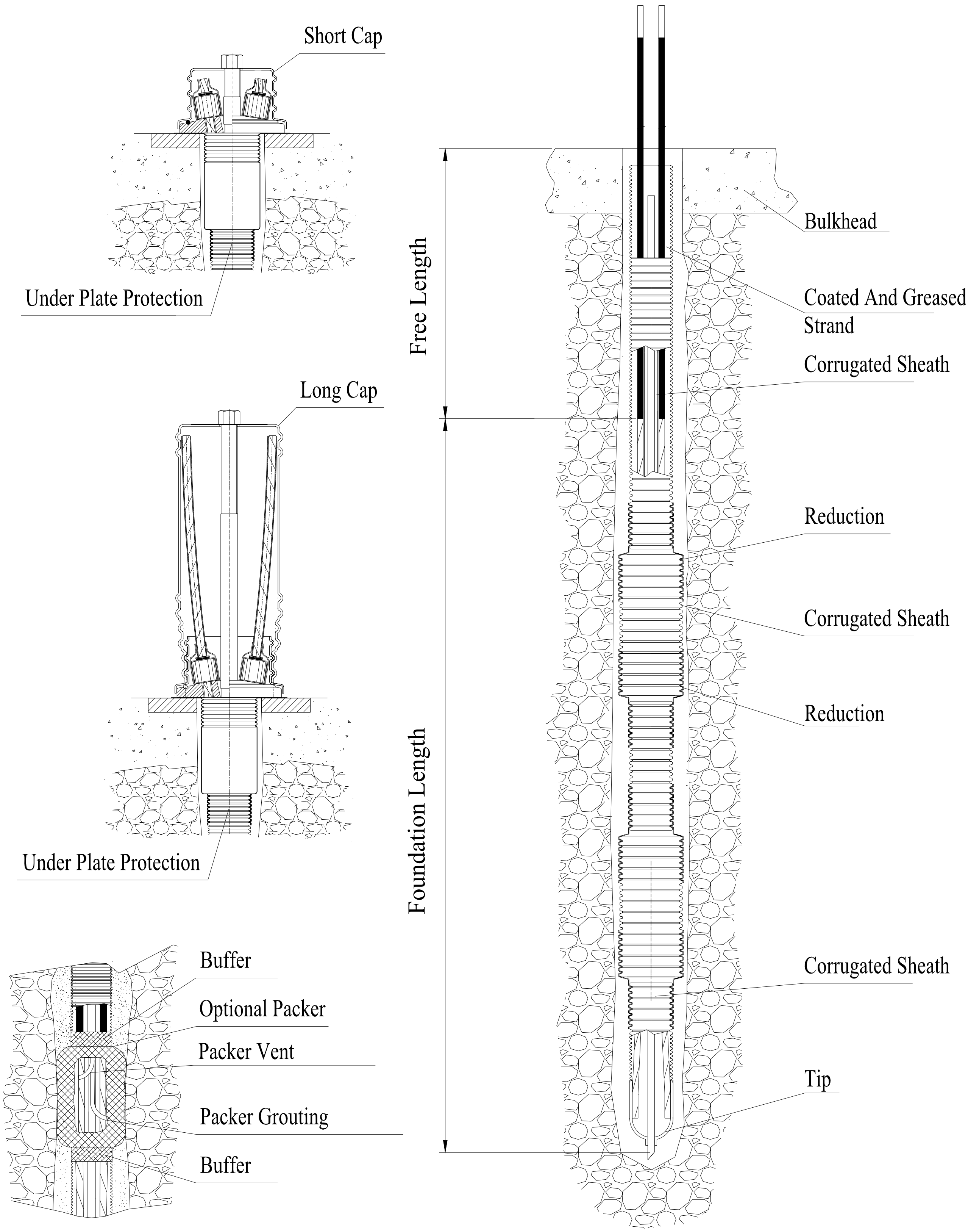
- ***TPE-15*** *ground anchors are made of harmonic steel protected on the free length by a corrugated sheath in P.H.A.D. having diam. 16x19.5 mm. and grease. The separation of the free length from the active part is achieved by way of a sealing strand by strand of sealing material, which allows strand and 16x20 P.H.E.D. mm tube to be perfectly hermetic, according to the instructions of the* ***"Client's Technical Representative"***

- *On the foundation (bulb) the external sheath is provided with devices to increase the anchor adherence. While maintaining the continuity of the sheath, they offer a greater adherence to the grouting than normal permanent anchors.*
- *In the active part, the strands are separated by special spacers which have a sinusoidal shape, by means of suitable strapping and taping, to increase their adherence with the foundation cement mix. Grouting (primary and free length) takes place via 16x20 mm polyethylene tubes and allows the grouting of the whole anchor by starting from the bottom. Since there is no separation buffer, the tube also grouts the free length.*
- *The anchor is provided with a corrugated sheath on all its length, which is provided with a threaded corrugation every 500 mm. This characteristic allows to connect the anchor with the DD200SP under plate protection to protect the tendon length under the bearing plate and ensure the continuity of the sheath up to the anchor. The purpose of the protection is defined in the Standard* ***EURO NORM EN 1537-2002 paragraph 6.11.3****.*

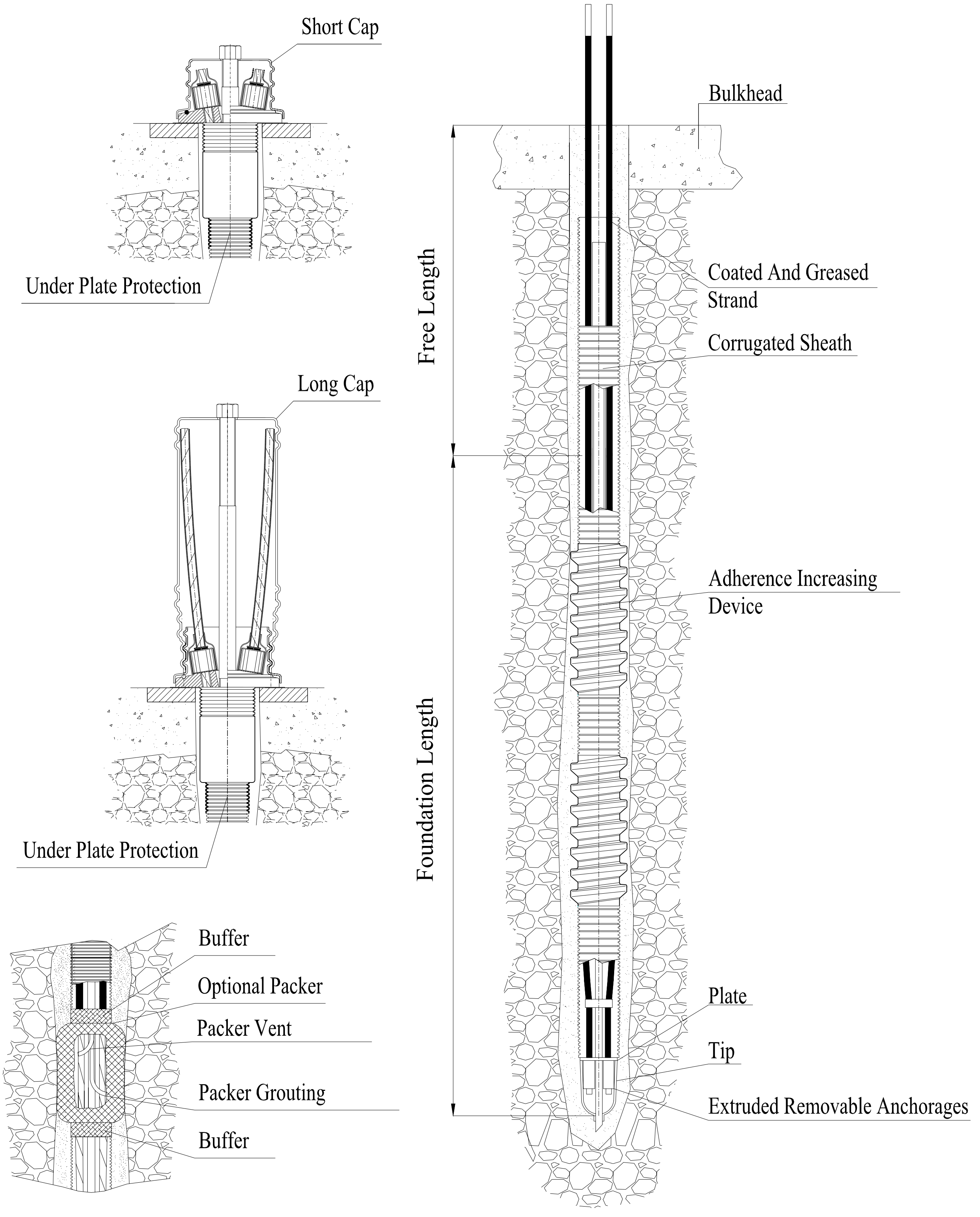
*9.5.1 - **TPE**-15-A permanent ground anchor diagram*
(increased adherence)



9.5.2 - **TPE-*15-B*** ***permanent ground anchor diagram***
(increased adherence)



9.5.3 - TPE-15-C permanent ground anchor diagram
(increased adherence and totally removable)



9.6 - TPE-16 permanent ground anchors

(increased adherence anchors with I.R.S. groutings)

TPE-16 permanent *ground anchors are produced in compliance with the European Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" ,paragraph 6.9.3*** *and they are made of harmonic steel strands according to* ***EN 10138****, singularly sheathed and greased on the free length.*
They are usually used in the construction of bulkheads and diaphragms, where the type of ground has serious highly corrosive geo-technical problems in the presence of groundwater, where an increased adherence of the bulb and the possibility of I.R.S. grouting is needed ***(repeated selective grouting)*** *without using anchor external valvate tubes, but RRM valves. The* ***TPE-16*** *anchor is totally encapsulated, all its parts are encapsulated in polyethylene, thus ensuring a total protection (hermetic of all its components)*

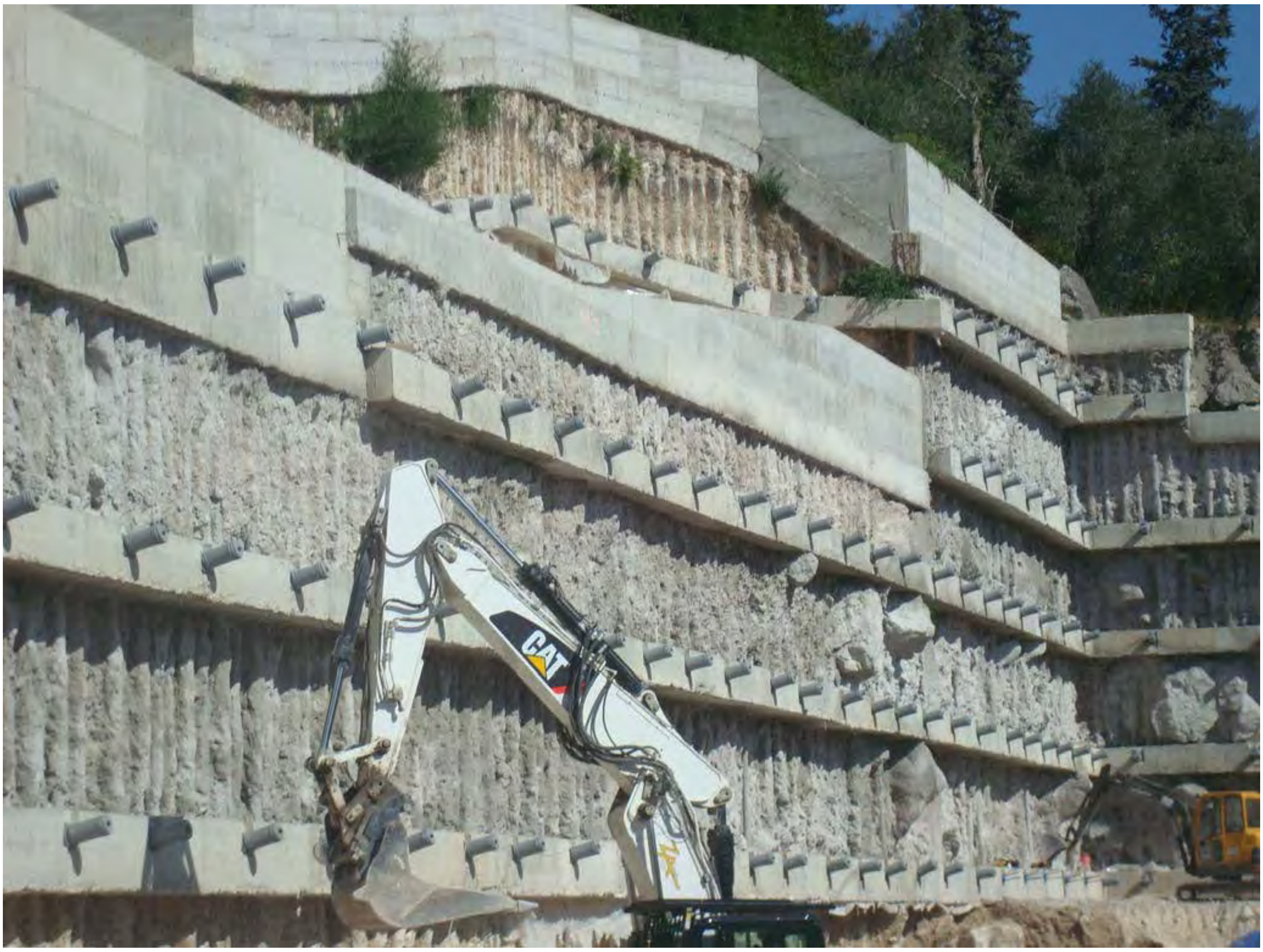
TPE 16-A permanent ground anchor

In ***TPE-16 permanent*** *ground anchors the foundation is provided with devices that increase the adherence to the drilling hole. The advantages of this anchor are:*

- *reduction of the anchor length by reducing the foundation length,*
- *reduction of the length of drilling holes,*
- *easy to install,*
- *high adherence, with the possibility of carrying out* ***I.R.S.*** *(repeated and selective groutings).*

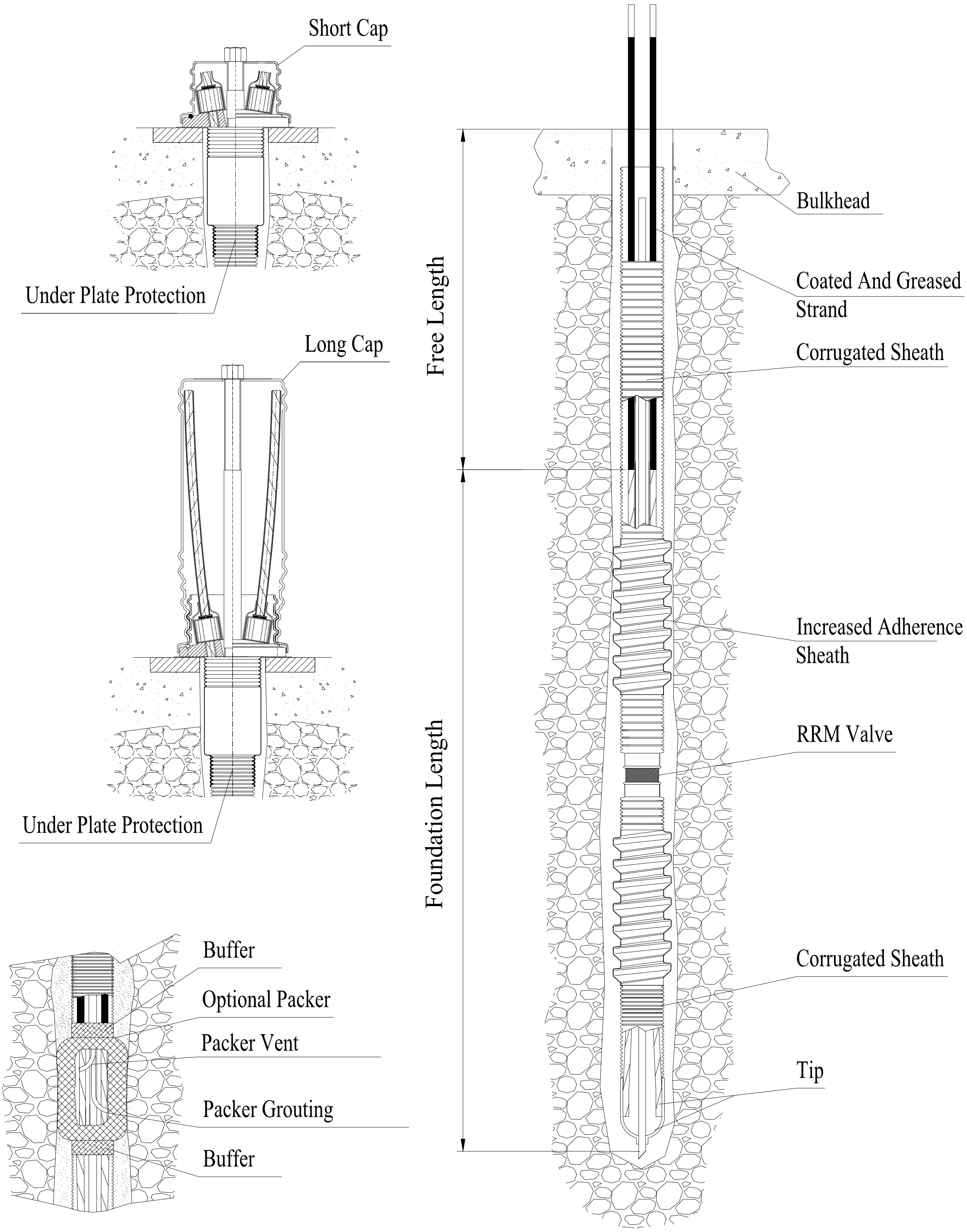
The anchor is made as follows:

- ***TPE-16*** *ground anchors are made of harmonic steel protected on the free length by a corrugated sheath in P.H.E.D. and grease. The separation of the free length from the active part is achieved by way of a sealing strand by strand of sealing material, which allows strand and 16x20 P.H.E.D. mm tube to be perfectly hermetic, according to the instructions of the* ***"Client's Technical Representative"***
- *On the foundation (bulb) the external sheath is provided with devices to increase the anchor adherence. While maintaining the continuity of the sheath, they offer a greater adherence to normal bulbs at grouting.*
- *In the active part, the strands are separated by special spacers which have a sinusoidal shape, by means of suitable strapping and taping, to increase their adherence with the foundation cement mix. This type of anchor is provided with a T001 27/34 mm tube on which special valves are fixed on the foundation part to allow single and repeated external* ***I.R.S.*** *groutings. On the same tube there are also: no. 2 manchette valves to allow the internal grouting of the bulb, a valve that allows the grouting of the packer, if required, and the free length grouting. On the foundation, the anchor is protected by a corrugated sheath in P.H.E.D.*
- *The anchor is provided with a corrugated sheath on all its length, which is provided with a threaded corrugation every 500 mm. This characteristic allows to connect the anchor with the DD200SP under plate protection to protect the tendon length under the bearing plate and ensure the continuity of the sheath up to the anchor. The purpose of the protection is defined in the Standard* ***EURO NORM EN 1537-2002 paragraph 6.11.3****.*
-



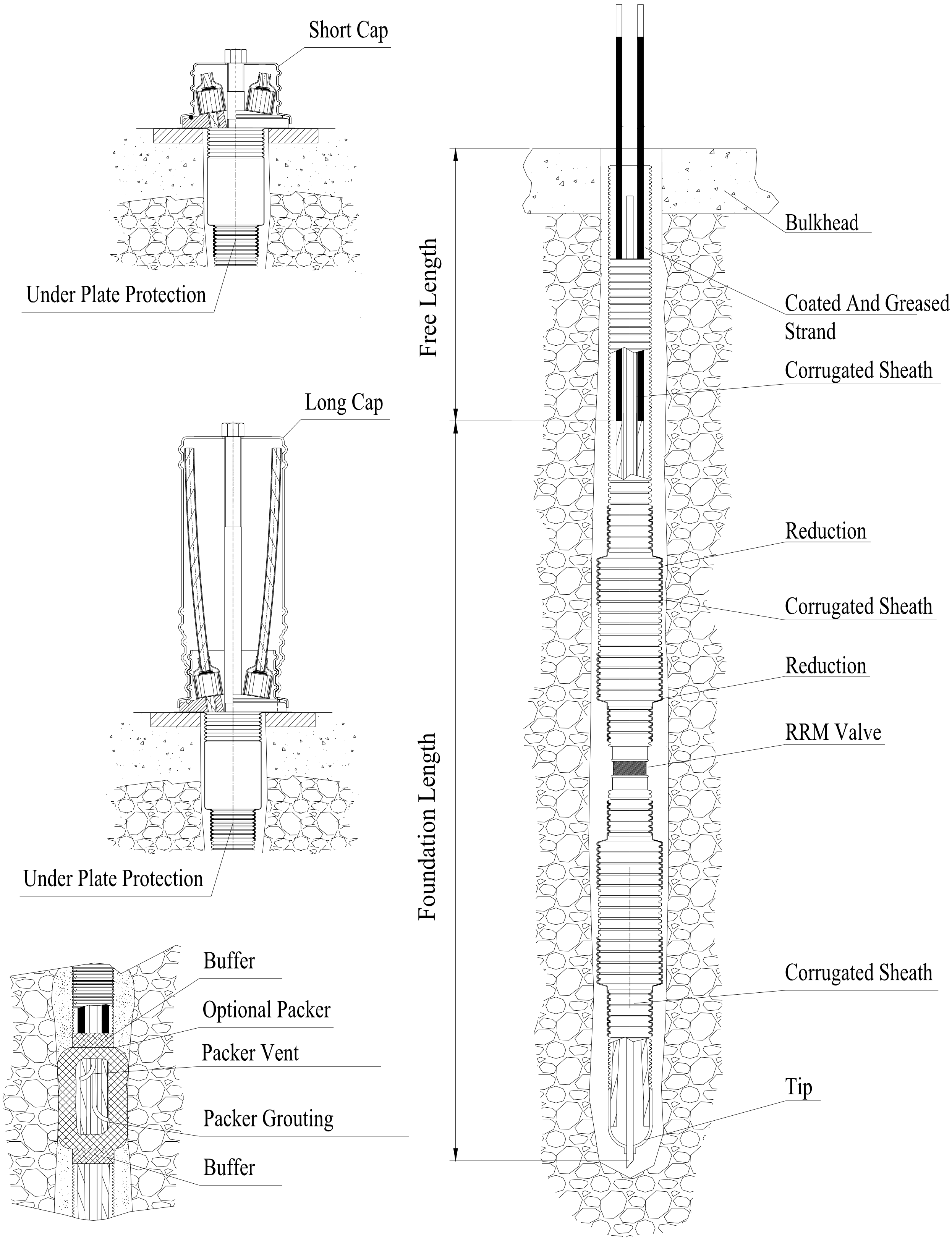
9.6.1 - TPE 16-A permanent ground anchor diagram

(increased adherence repeated and selective I.R.S. groutings)



9.6.2 - TPE 16-B permanent ground anchor diagram

(increased adherence repeated and selective I.R.S. groutings)



9.7 - TPE-17 permanent ground anchors
(multi-bulb permanent ground anchors)

TPE-17 permanent *ground anchors are produced in compliance with the European Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" ,paragraph 6.9.3*** *and they are made of harmonic steel strands according to* ***EN 10138****, singularly sheathed and greased on the free length.*
They usually used in the construction of bulkheads and diaphragms, where the type of ground requires to increase the adherence of the bulb by transferring a homogeneous rectangular strength to the ground and not a triangular one as with common anchors.

TPE 17-A permanent ground anchor

In ***TPE-17 permanent*** *ground anchors the foundation is provided with devices that increase the adherence to the drilling hole. The advantages of this anchor are:*

- *reduction of the anchor length by reducing the foundation length,*
- *reduction of the length of drilling holes,*
- *easy to install,*
- *high adherence, obtaining a rectangular strength transmission,*
- *tendon saving by adopting the system of differentiated strands.*

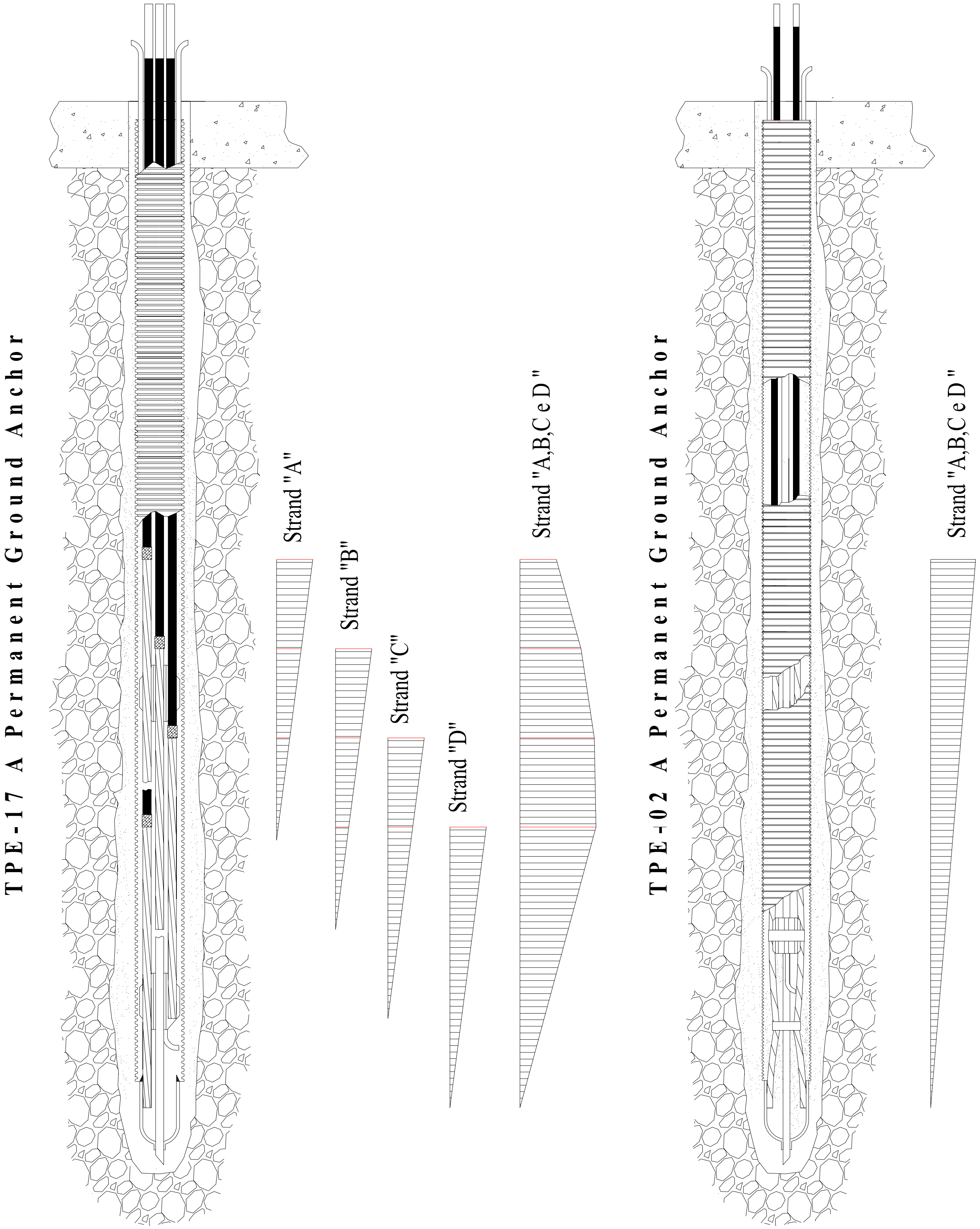
The anchor is made as follows:

- ***TPE-17*** *ground anchors are made of harmonic steel protected on the free length by a corrugated sheath in P.H.E.D. and grease. The separation of the free length from the active part is achieved by way of a sealing strand by strand f sealing material, which allows strand and 16x20 P.H.E.D. mm tube to be perfectly hermetic, according to the instructions of the* ***"Client's Technical Representative"***

- *On the foundation (bulb) strands have different length thus making a multibulb to offer the anchor a higher adherence than normal bulbs,*

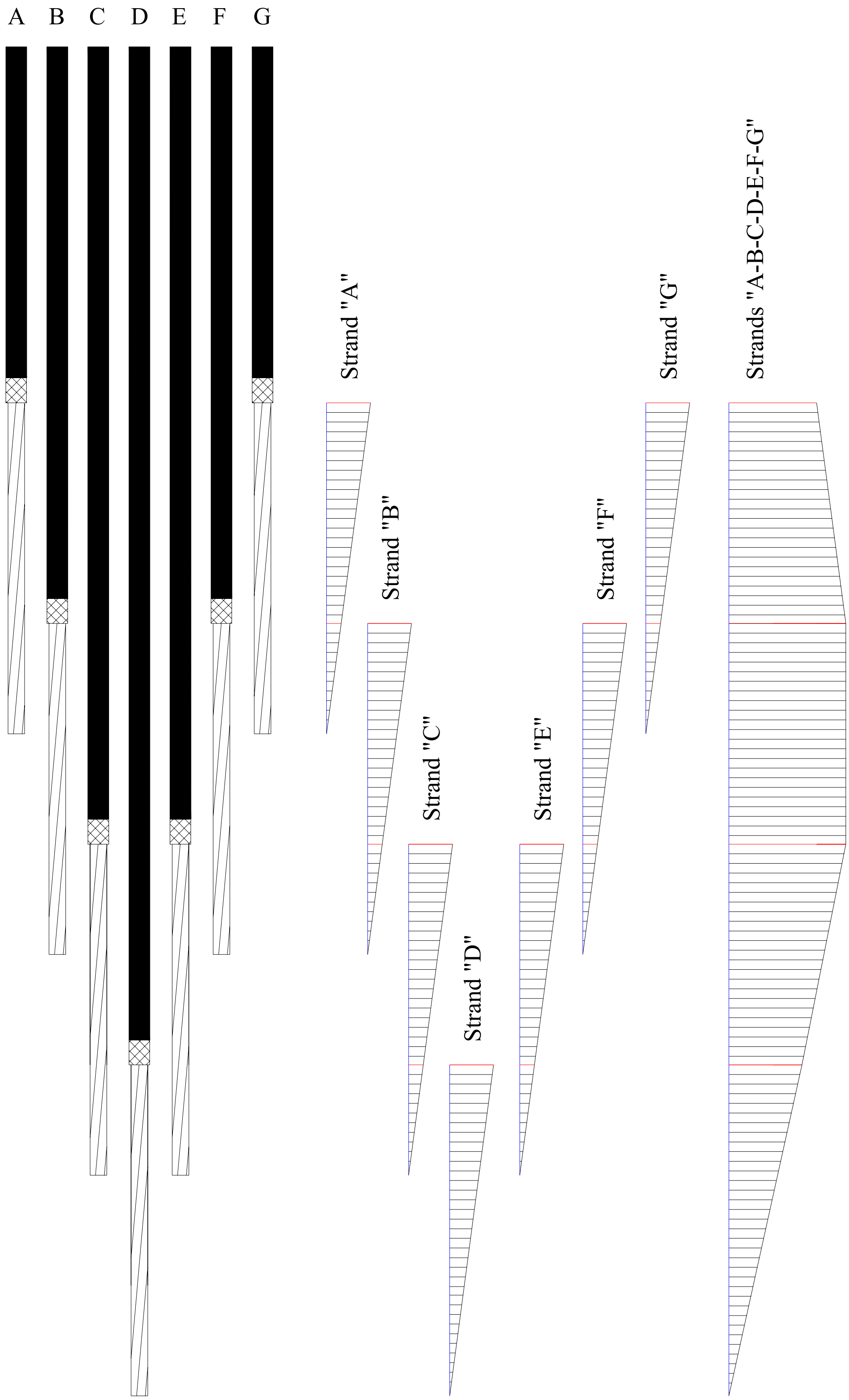
TPE 17 *multi-bulb permanent anchors allow the application a more homogeneous distribution of the load applied to the anchor on the foundation bulb.*

9.7.1 - Load transfer on the foundation diagram
*(**TPE 17** multi-bulb permanent ground anchors)*



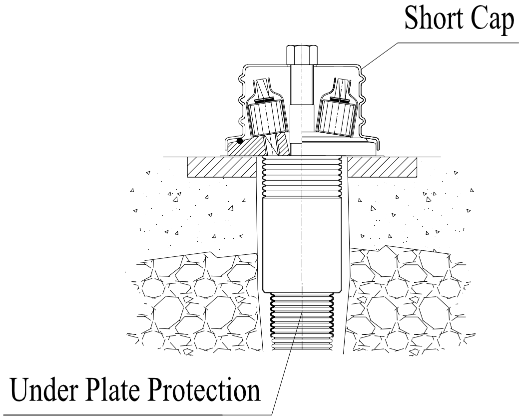
A normal anchor presents a triangular strength diagram, where the shorter side of the diagram is given by the adherence of walls to the anchor, so as strands increase the tightening is limited to the adherence of the walls. On the contrary, on a multi-bulb anchor the single diagrams of the single strands can be summed and the load can be distributed more evenly to the foundation, thus ensuring a greater response of the anchor to removal.

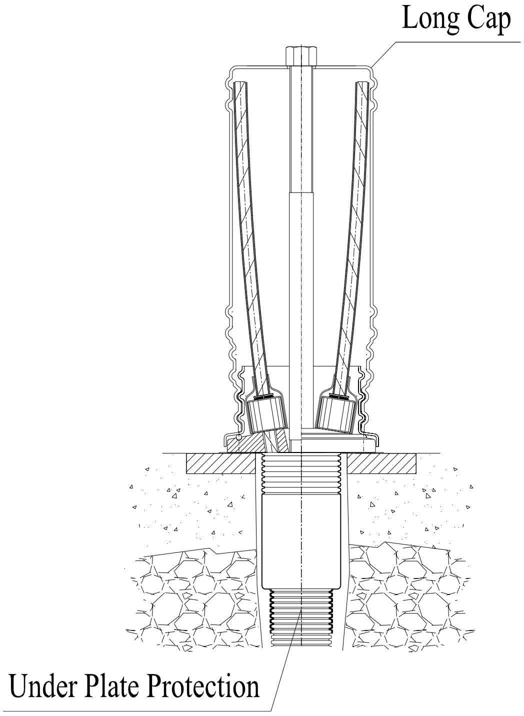
The new diagram will be the sum of the single diagrams generated by single strands, so the load can be distributed more evenly to the foundation and a greater resistance to removal is offered.
*The **TPE 017** multi-bulb anchor allows to reduce the quantity of tendon used in the foundation. The advantages of the application increase as the number of strands increases, too.*

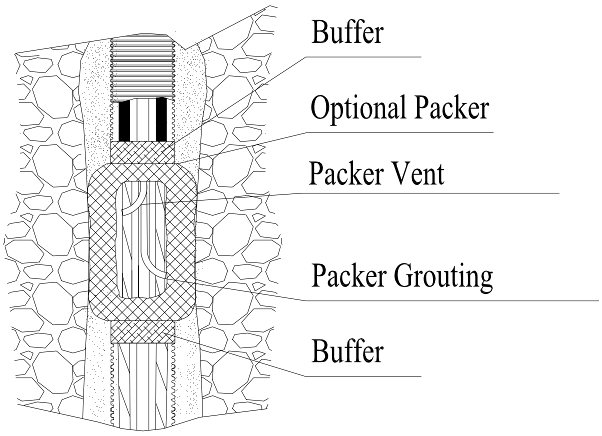


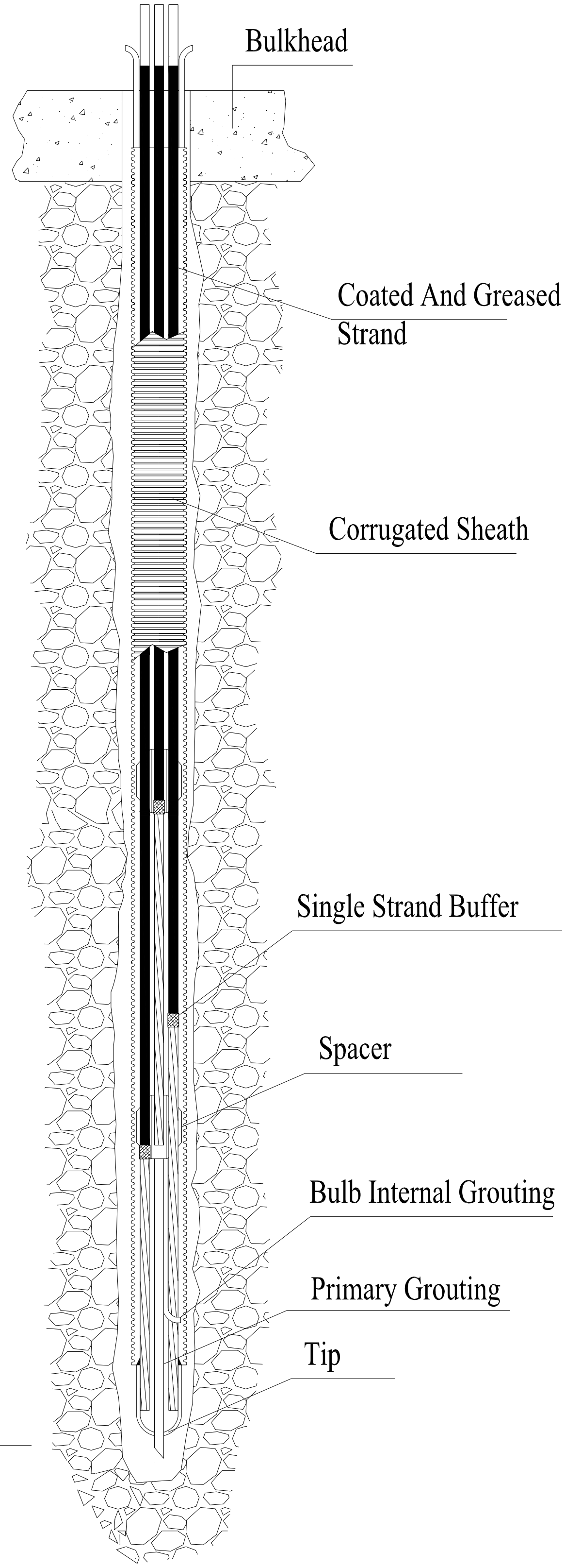
9.7.2 – TPE 17A permanent ground anchor diagram

(multi-bulb permanent ground anchor)



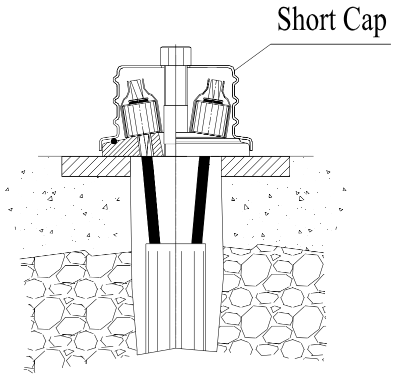


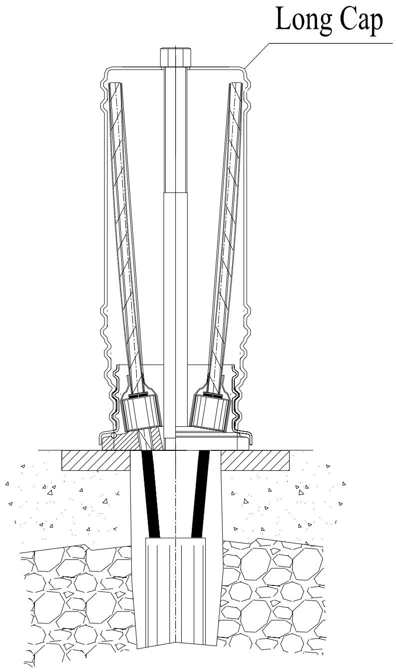


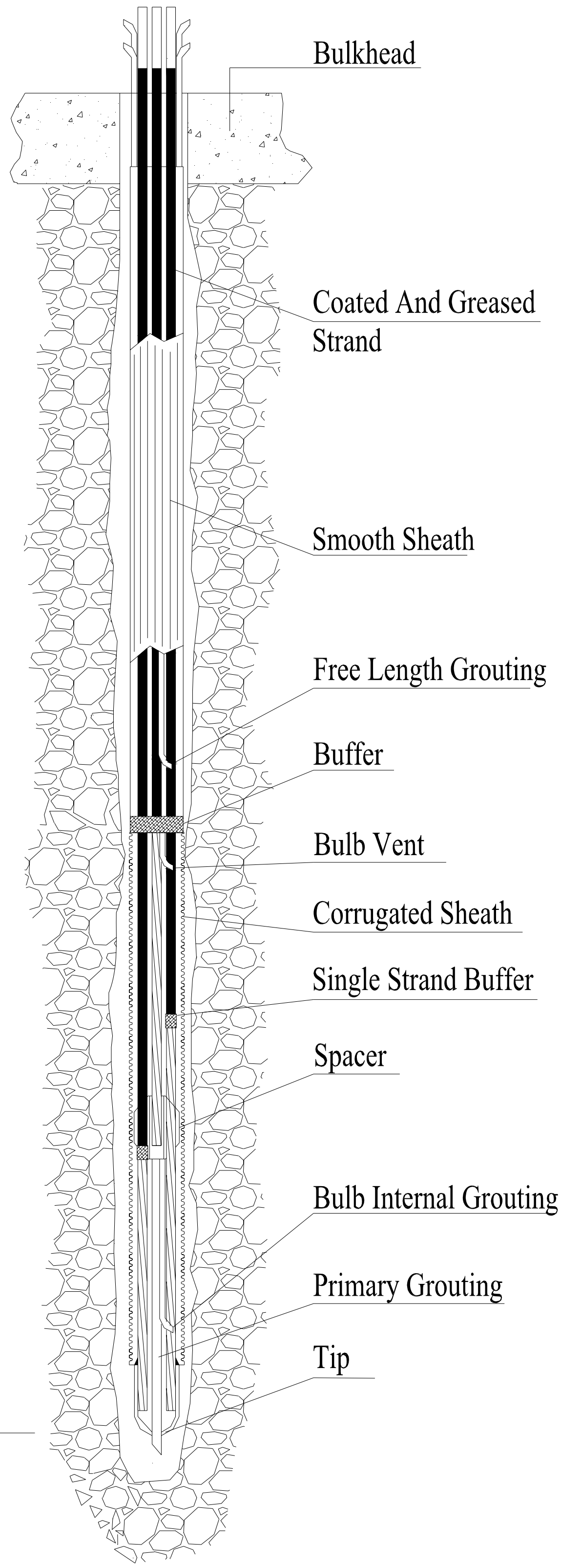


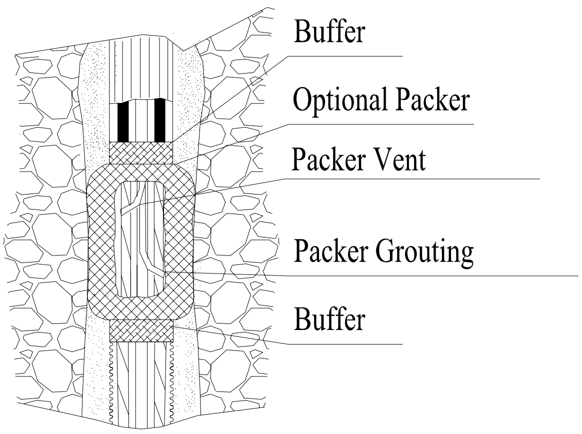
9.7.3 – TPE 17B permanent ground anchor diagram

(multi-bulb permanent ground anchor)



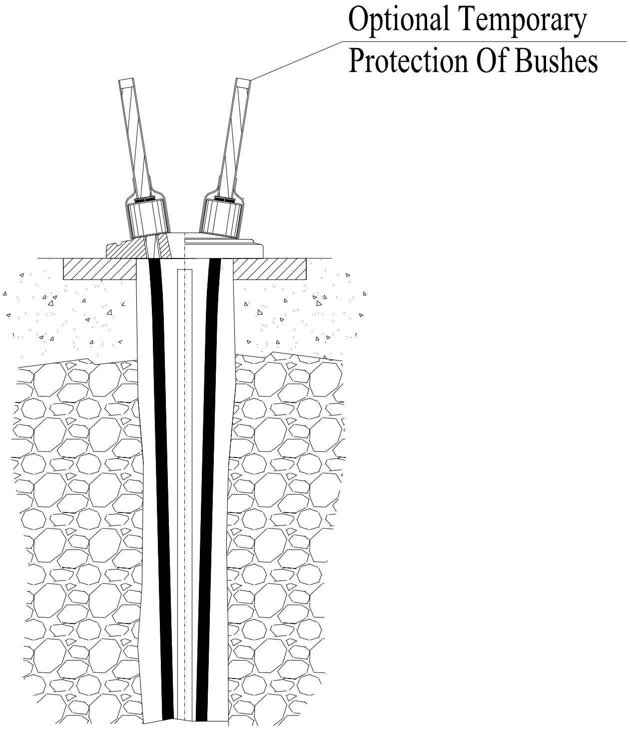


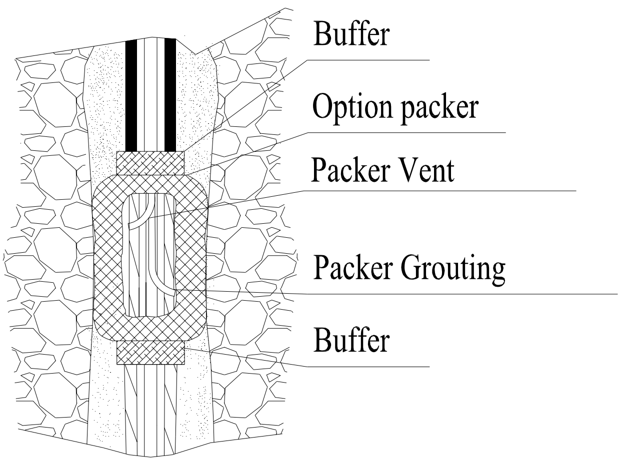


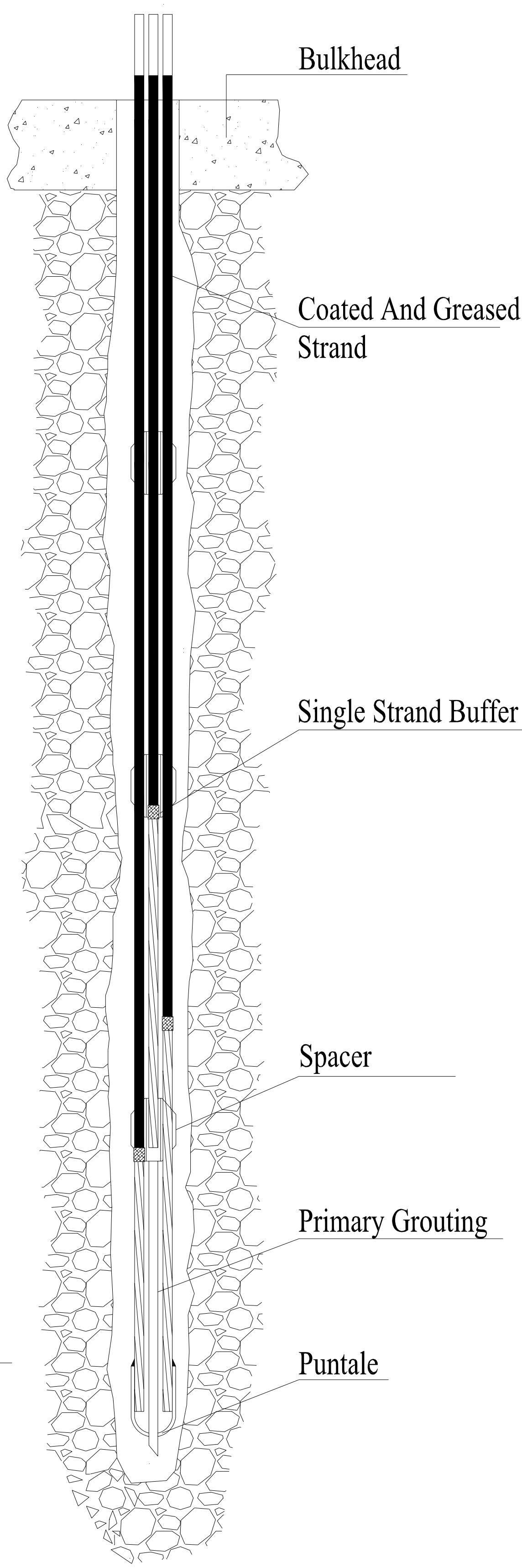


9.7.4 – TPE 17C permanent ground anchor diagram

(multi-bulb permanent ground anchor)







9.8 - TPR-18 temporary ground anchors
(multi-bulb temporary ground anchors)

TPE-18 temporary *ground anchors are produced in compliance with the European Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" ,paragraph 6.9.3*** *and they are made of harmonic steel strands according to* ***EN 10138****, singularly sheathed and greased on the free length.*
They usually used in the construction of bulkheads and diaphragms, where the type of ground requires to increase the adherence of the bulb by transferring a homogeneous rectangular strength to the ground and not a triangular one as with common anchors.

TPR 18 temporary ground anchor

In ***TPR-18 temporary*** *ground anchors the foundation is provided with devices that increase the adherence to the drilling hole. The advantages of this anchor are:*

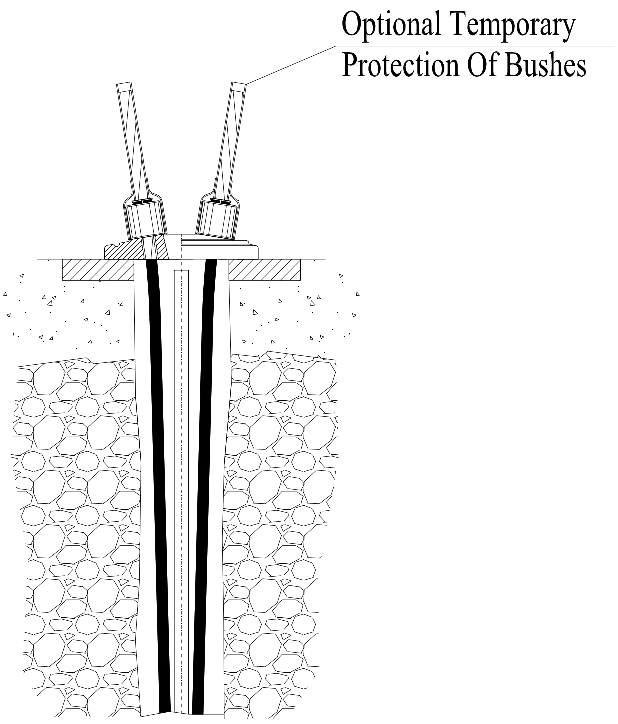
- *reduction of the anchor length by reducing the foundation length,*
- *reduction of the length of drilling holes,*
- *easy to install,*
- *high adherence, obtaining a rectangular strength transmission,*
- *tendon saving by adopting the system of differentiated strands.*

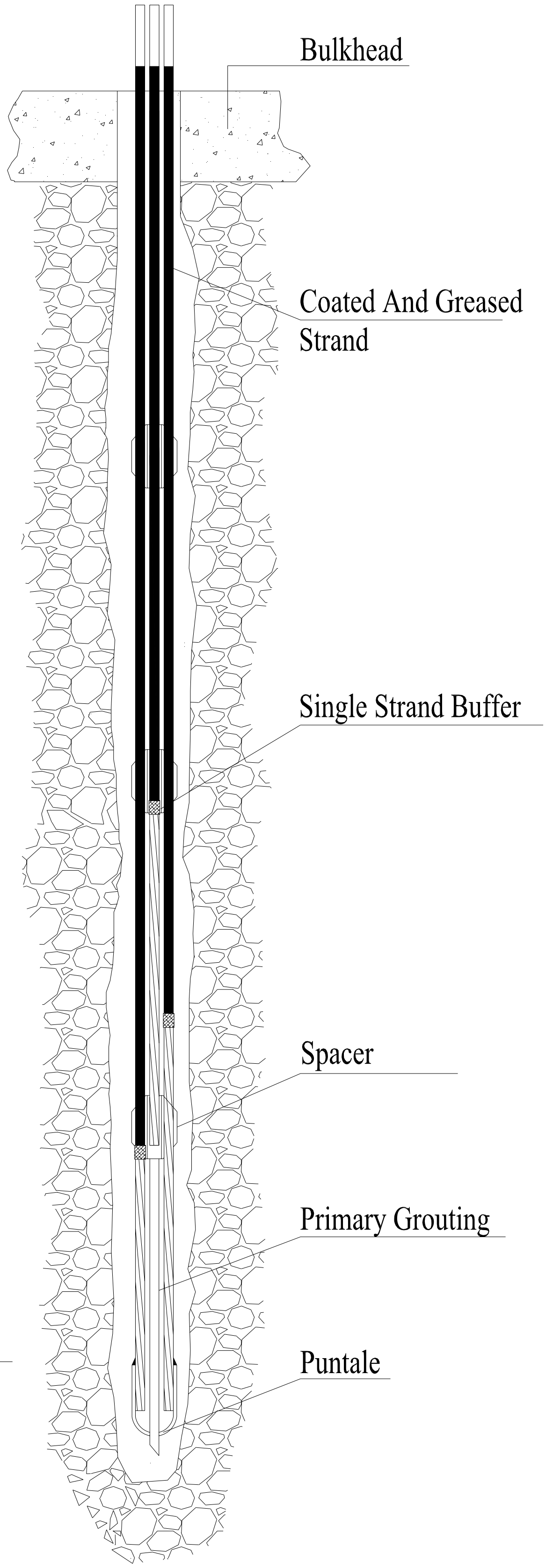
The anchor is made as follows:

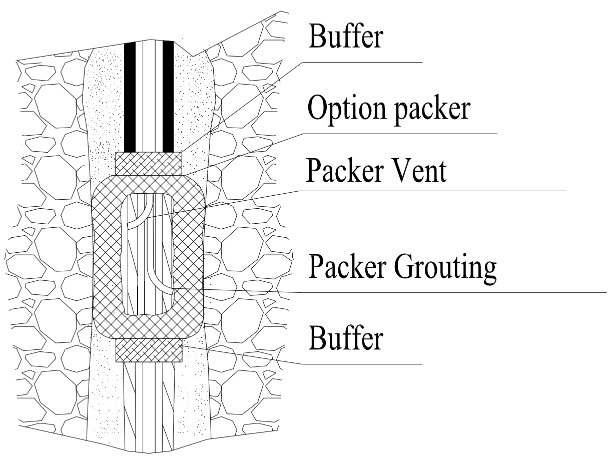
- ***TPE-18*** *ground anchors are made of harmonic steel protected on the free length by a corrugated sheath in P.H.E.D. and grease. The separation of the free length from the active part is achieved by way of a sealing strand by strand f sealing material, which allows strand and 16x20 P.H.E.D. mm tube to be perfectly hermetic, according to the instructions of the* ***"Client's Technical Representative"***

- *On the foundation (bulb) strands have different length thus making a multibulb to offer the anchor a higher adherence than normal bulbs.*

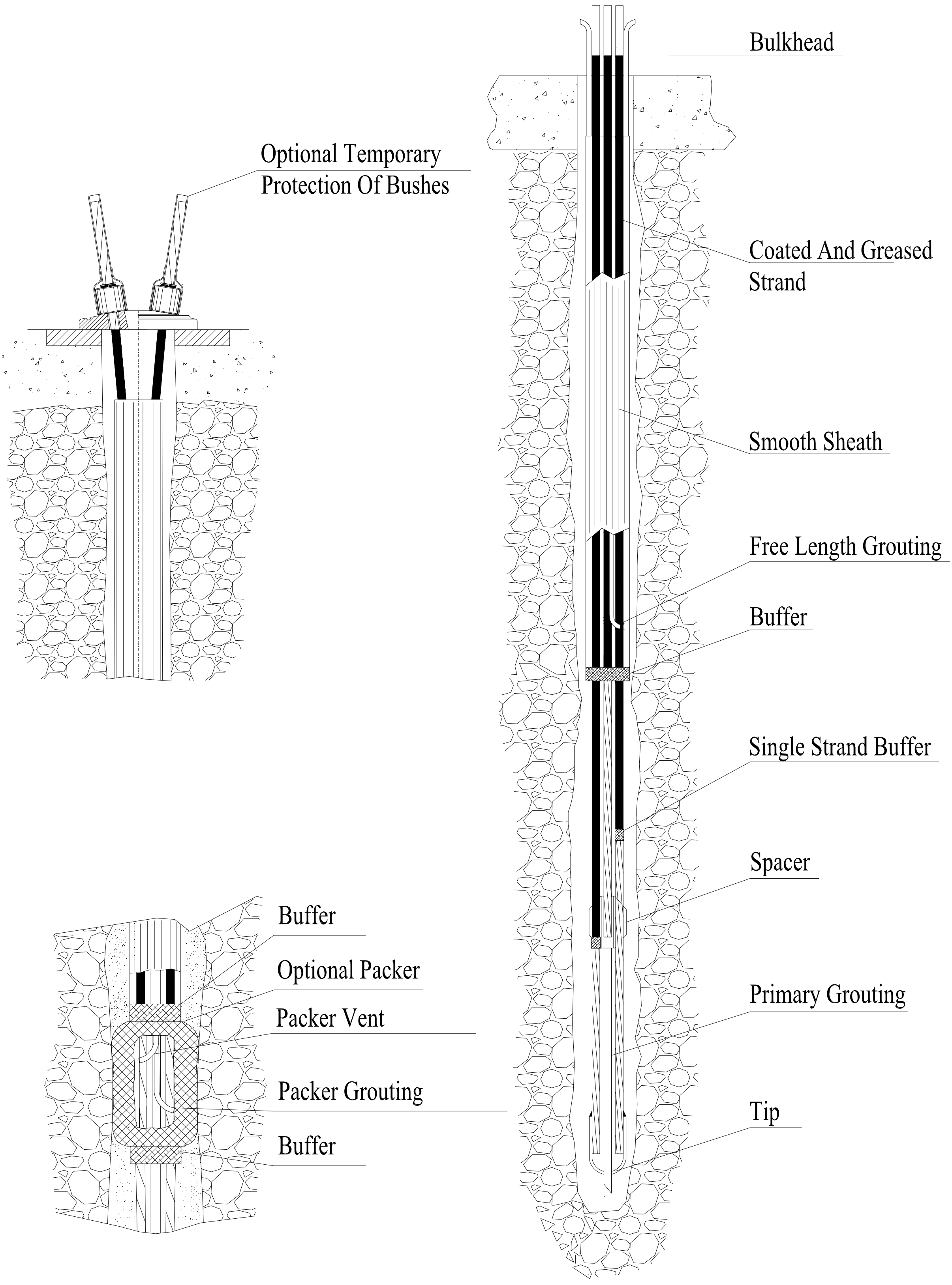
9.8.1 – TPR-18A temporary ground anchor diagram
(multi-bulb temporary ground anchor)





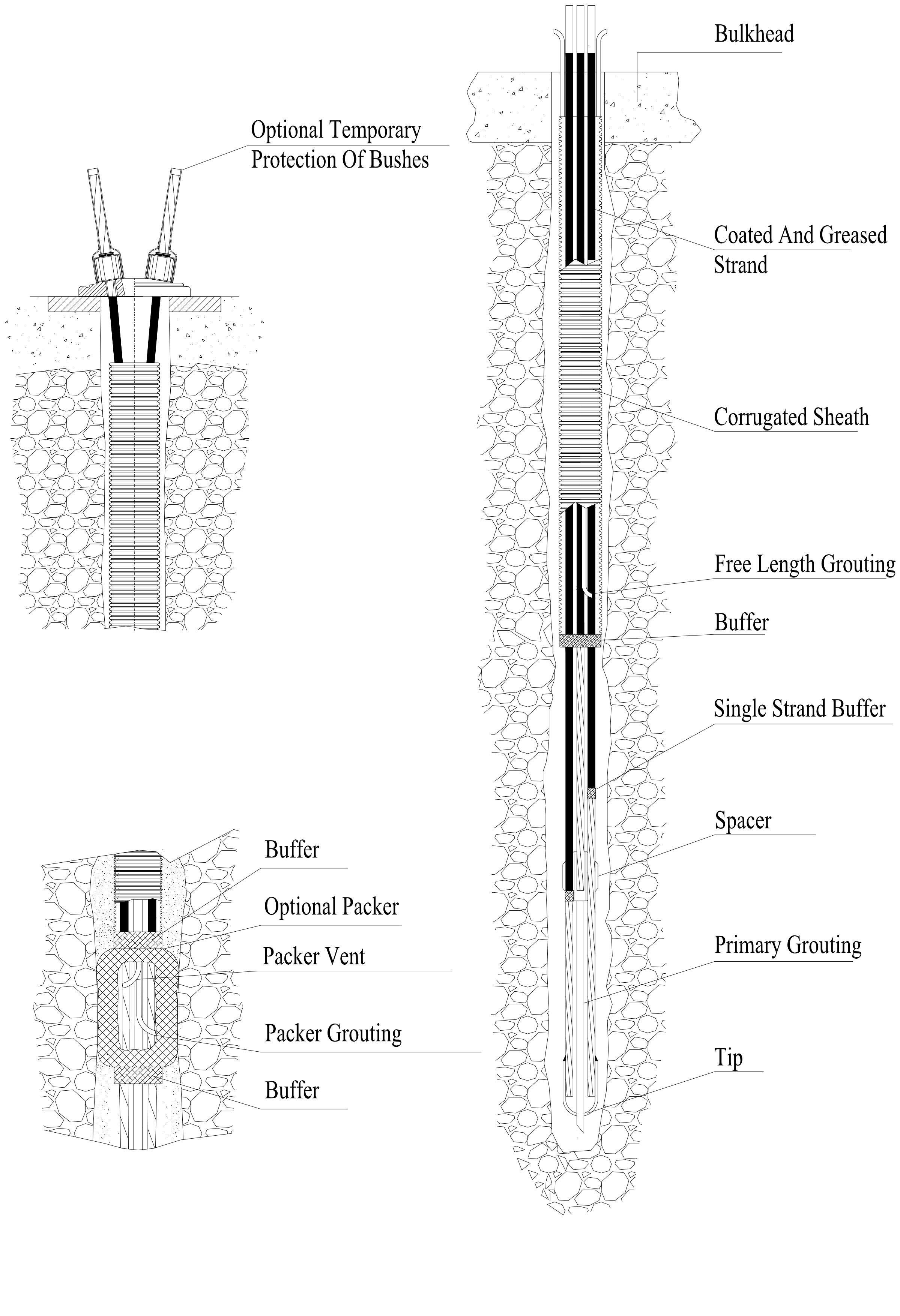


9.8.2 – TPR-18B temporary ground anchor diagram
(multi-bulb temporary ground anchor)



9.8.3 – TPR-18C temporary ground anchor diagram

(multi-bulb temporary ground anchor)



9.9 - TPE-19 permanent ground anchors

(Ground anchors to hook avalanche protection ropes)

TPE-19 temporary *ground anchors are produced in compliance with the European Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" ,paragraph 6.9.3*** *and they are made of harmonic steel strands according to* ***EN 10138****, usually pregrouted and inserted into the drilling by external grouting.*

They are usually used to hook avalanche protection ropes to respond to accidental loads caused by falling rocks or avalanches.

TPE 19 temporary ground anchor

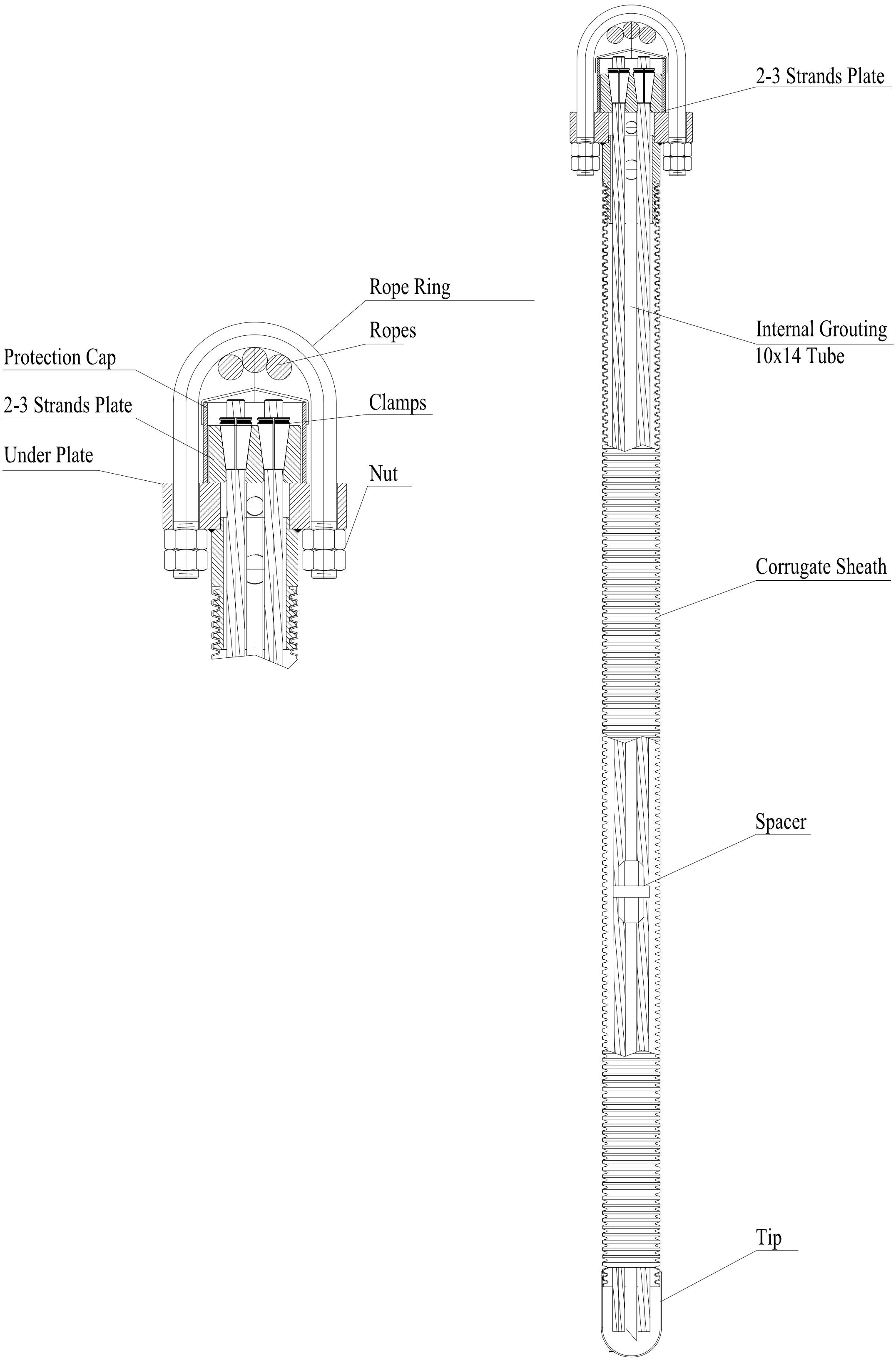
The ***TPE-19 temporary*** *ground anchors is made of strands spaced by proper external centralizers and by a corrugated sheath on their whole length to encapsulate all the parts subjected to corrosion.*

The anchor is made as follows:

- ***TPE-19*** *anchors are made of harmonic steel protected on the whole length by a corrugated sheath in P.H.E.D according to the instructions of the* ***"Client's Technical Responsible".***
- *On the foundation (bulb) strands are separated by spacers which favour the sinusoidal shape and a higher adherence to the internal grout.*
- ***TPE-19*** *anchors are generally pregrouted as they must be provided with a vent for the internal grout and a head buffer with grease injection in the clamp locking area.*

9.9.1 – TPE-19A temporary ground anchor diagram

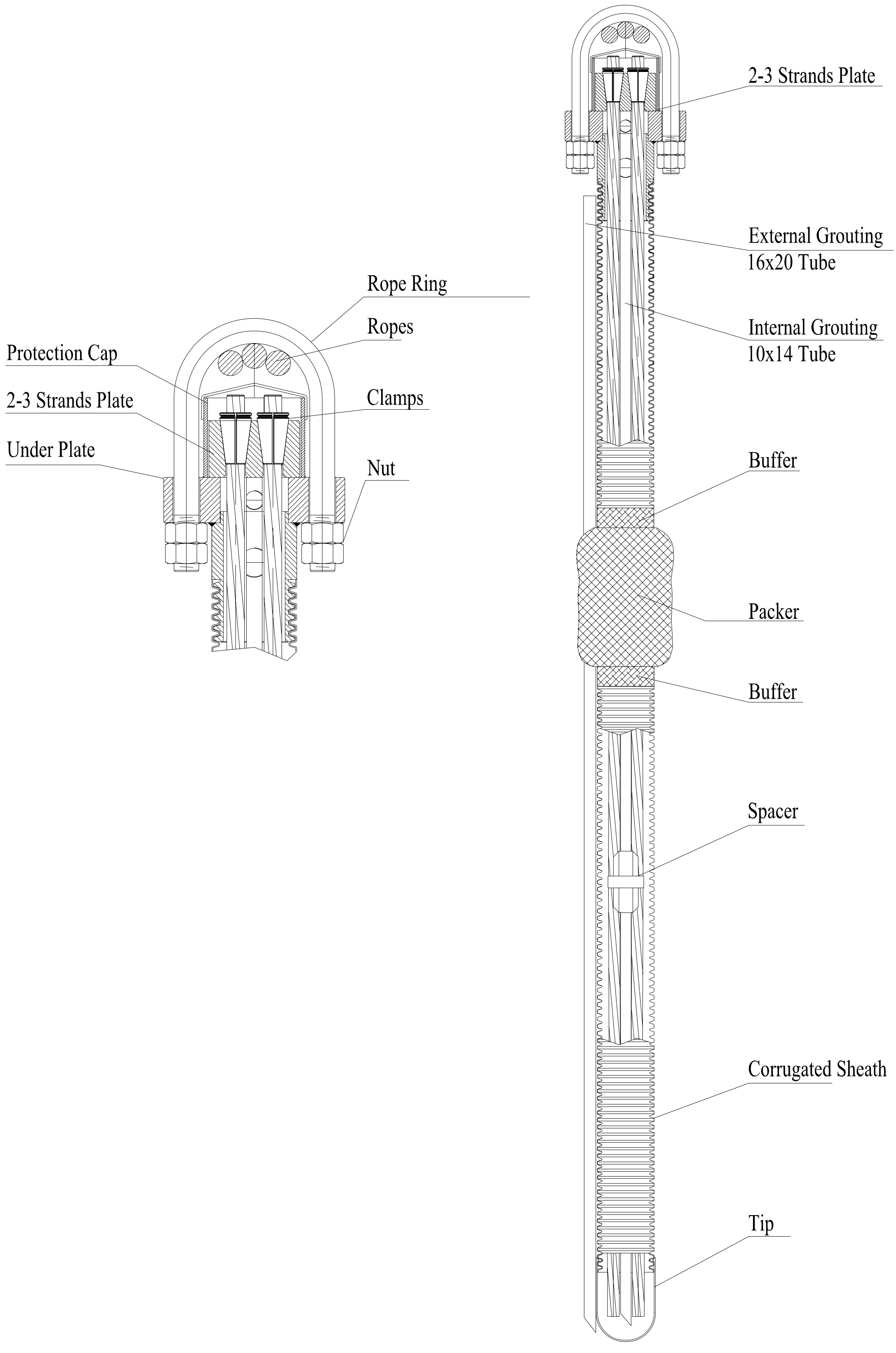
(Ground anchors to hook avalanche protection ropes)



The ***TPE-19A*** *permanent ground anchor is the simplest version, which is supplied ready for the internal pregrouting and its insertion in a hole full of cement.*

9.9.2 – TPE-19B temporary ground anchor diagram

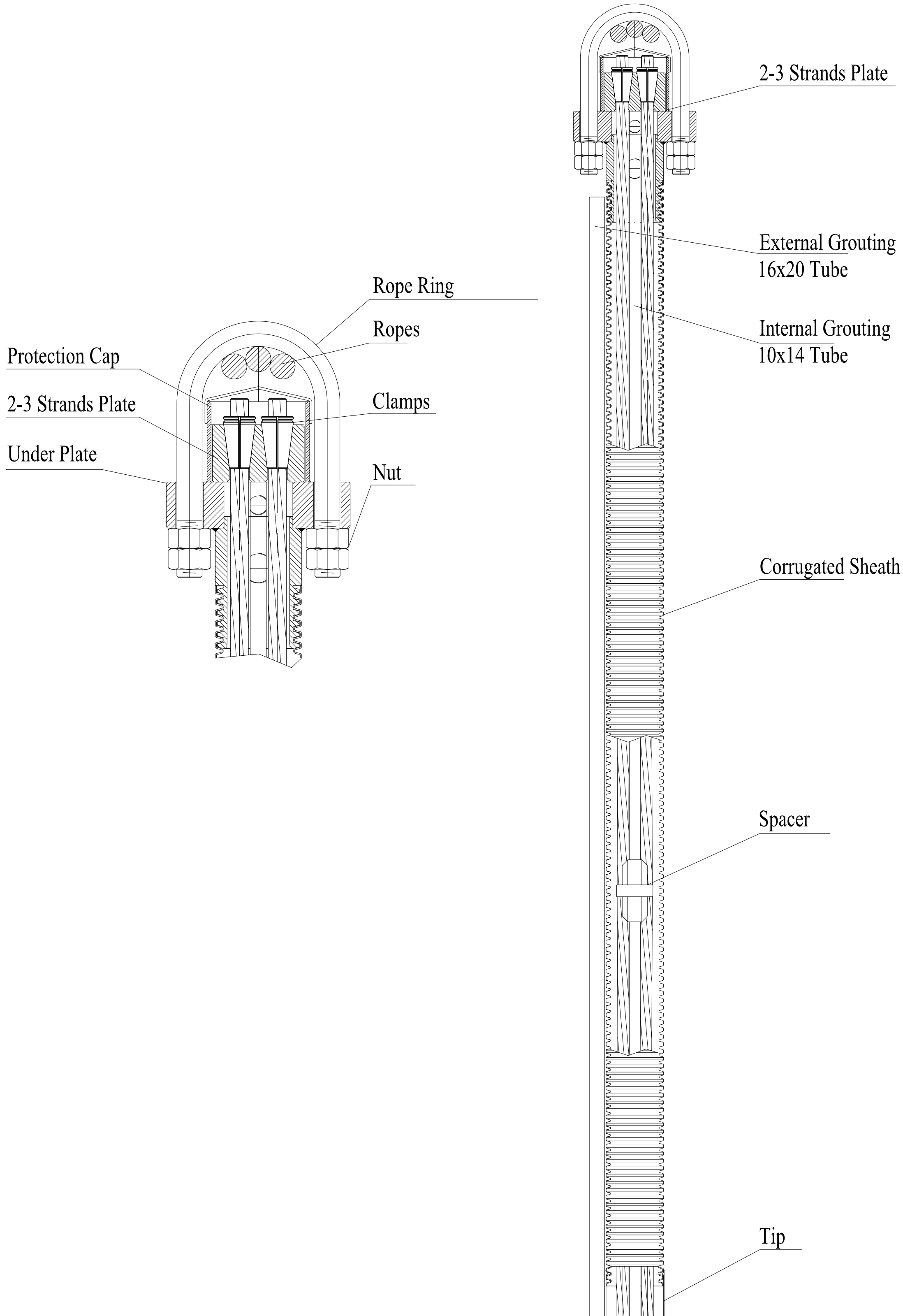
(Ground anchors to hook avalanche protection ropes with packer)



*The **TPE-19B** is provided with packer to limit grouting in the anchor foundation. It allows a greater expansion of the primary grouting by increasing its pressure.*

9.9.3 – TPE-19C temporary ground anchor diagram

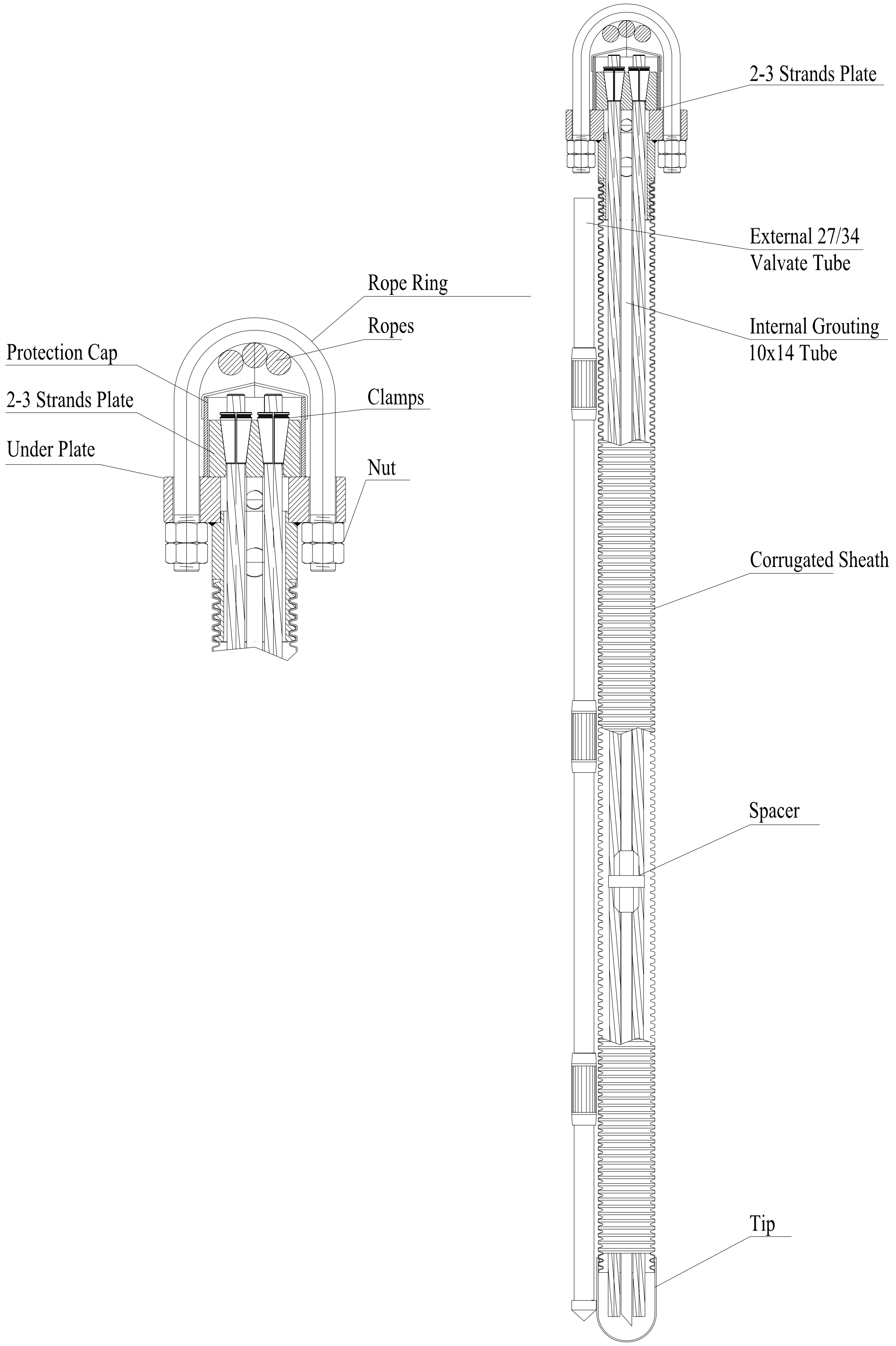
(Ground anchors to hook avalanche protection ropes)



TPE-19C permanent *anchors are provided with an external tube for primary grouting. It is supplied ready for the internal pregrouting and its insertion in a hole to carry out the external grouting.*

9.9.4 – TPE-19D temporary ground anchor diagram

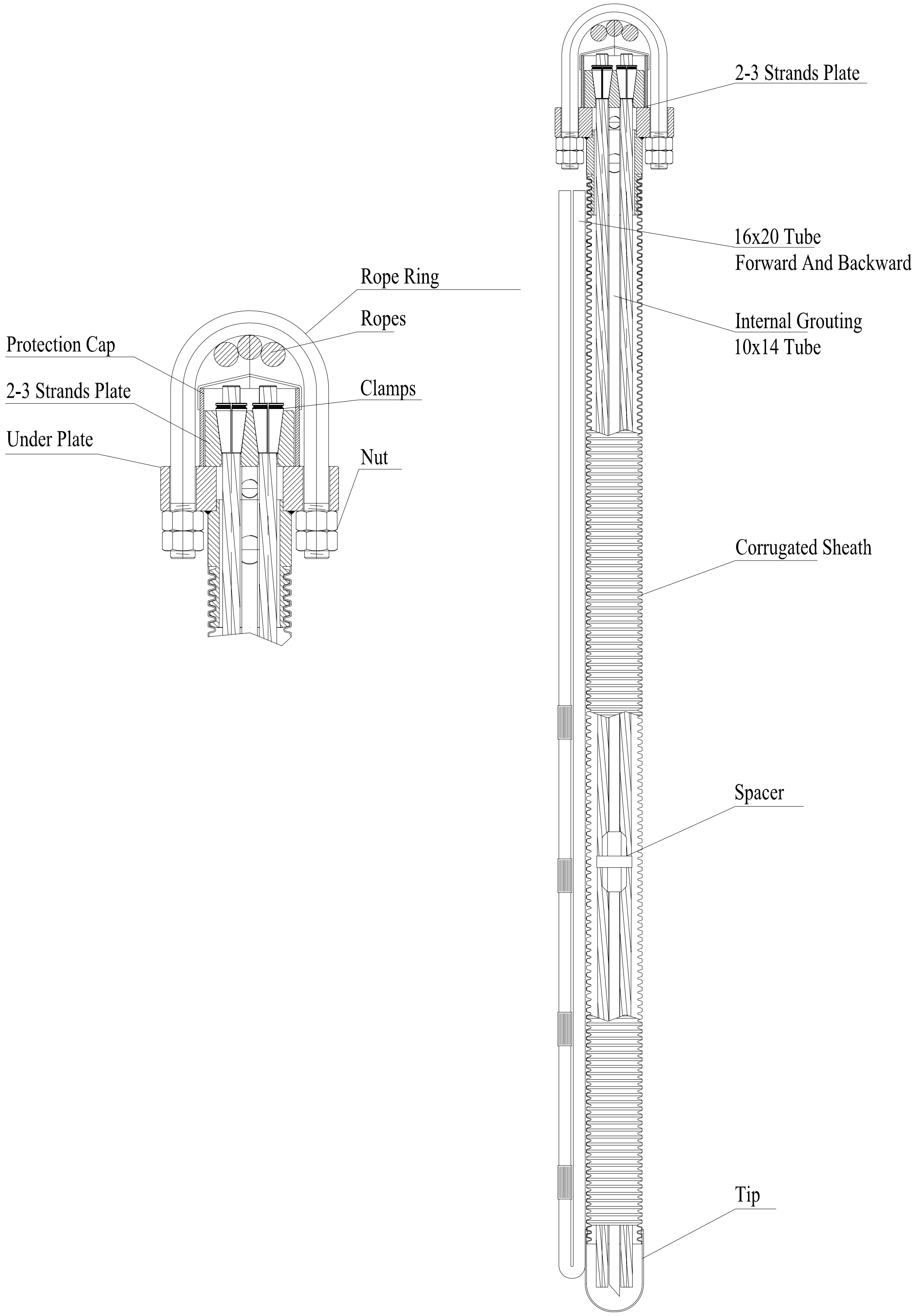
*(Ground anchors to hook avalanche protection ropes with **I.R.S.** grouting)*



***TPE-19D** permanent ground anchors are provided with a **T001** 27x34 mm external valvate tube to carry out **I.R.S.** (repeated and selective groutings).*

9.9.5 – TPE-19E temporary ground anchor diagram

*(Ground anchors to hook avalanche protection ropes with **I.R.** grouting)*



***TPE-19E** permanent ground anchors are provided with a T003 15x21 mm external valvate tube to carry out **I.R.** (repeated grouting).*

9.10 - TPR-20 temporary ground anchors

(temporary ground anchor with mechanical preventer for the installation into strata under pressure)

TPR-20 temporary *ground anchors are provided with preventer and produced in compliance with the European Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" ,paragraph 6.9.3*** *and they are made of harmonic steel strands according to* ***EN 10138****, singularly sheathed and greased on the free length and with bare strands on the foundation.*

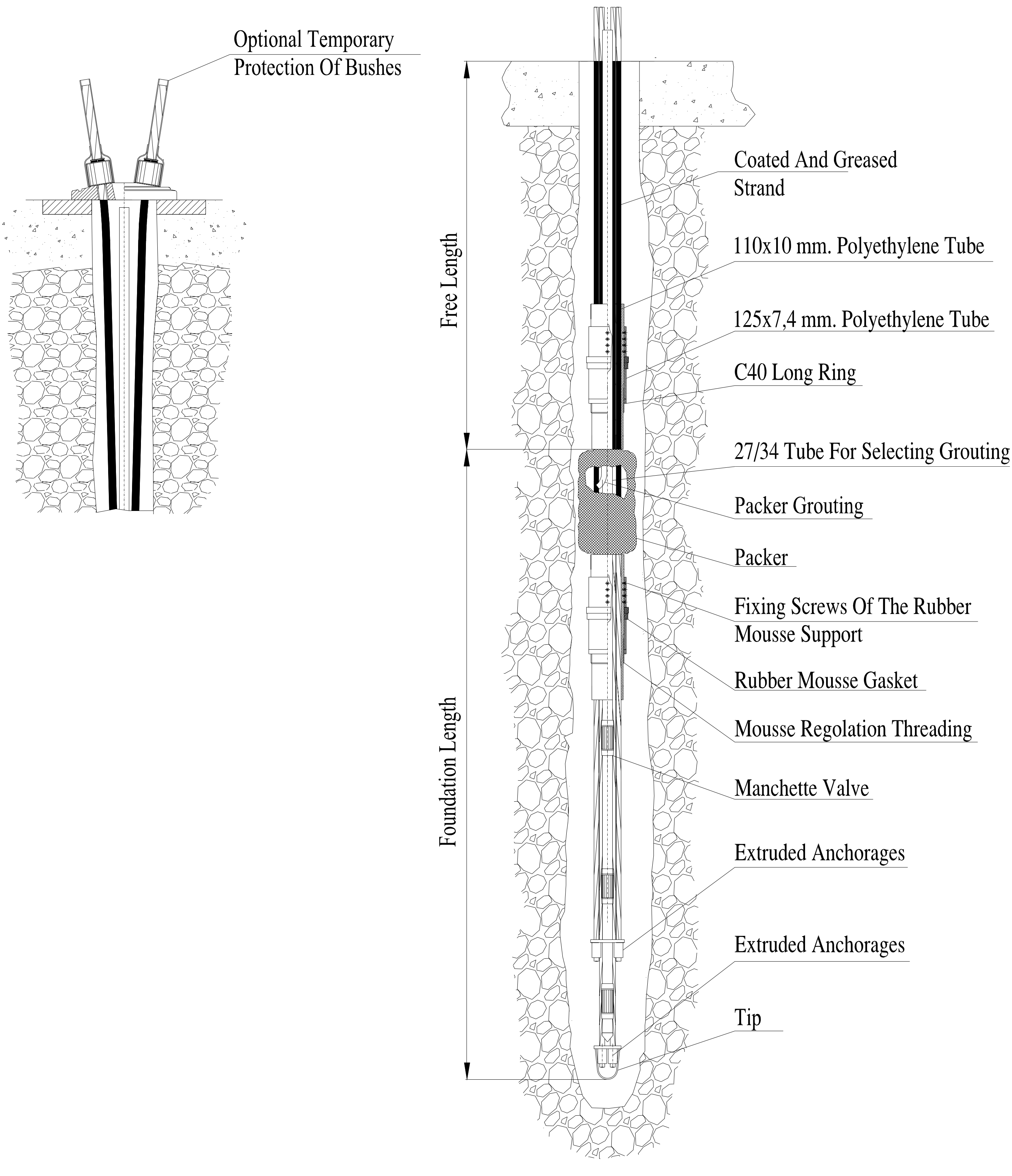
They are usually used in the construction of bulkheads and diaphragms, where the type of ground has particular geo-technical problems in the presence of strata under pressure and where the containment of hydraulic pressure is required during the installation.

The anchor is made as follows:

- *In the active part, the strands are separated by special spacers which guarantee the tendon to maintain a sinusoidal shape. By means of suitable strapping and/or taping, the sinusoidal shape of the tendon increases the adherence with the foundation cement mix. Grouting takes place via a 16x20 mm polyethylene tube. Grouting (primary and free length) is carried out via a* ***valvate 27/34*** *mm tube provided with manchette valves* ***(I.R.S.).***
- *The end part of the anchor is provided with a steel ogive to ease its insertion into the drilling hole.*
- *The free length is protected by greasing and sheathing each single strand, and by inserting proper gaskets on the external part to ensure the removal of the drill rod and sealing from groundwater under pressure at the same time.*
- *All anchors are provided with packer to ensure the obstruction against the leakage of groundwater when the drill rod is totally removed.*

9.10.1 – TPR-20 temporary ground anchor diagram

(temporary ground anchors with mechanical preventer)



*The **TPR 20** ground anchor is provided with a mechanical preventer for stratum applications, it allows I.R.S. repeated and selective groutings.*

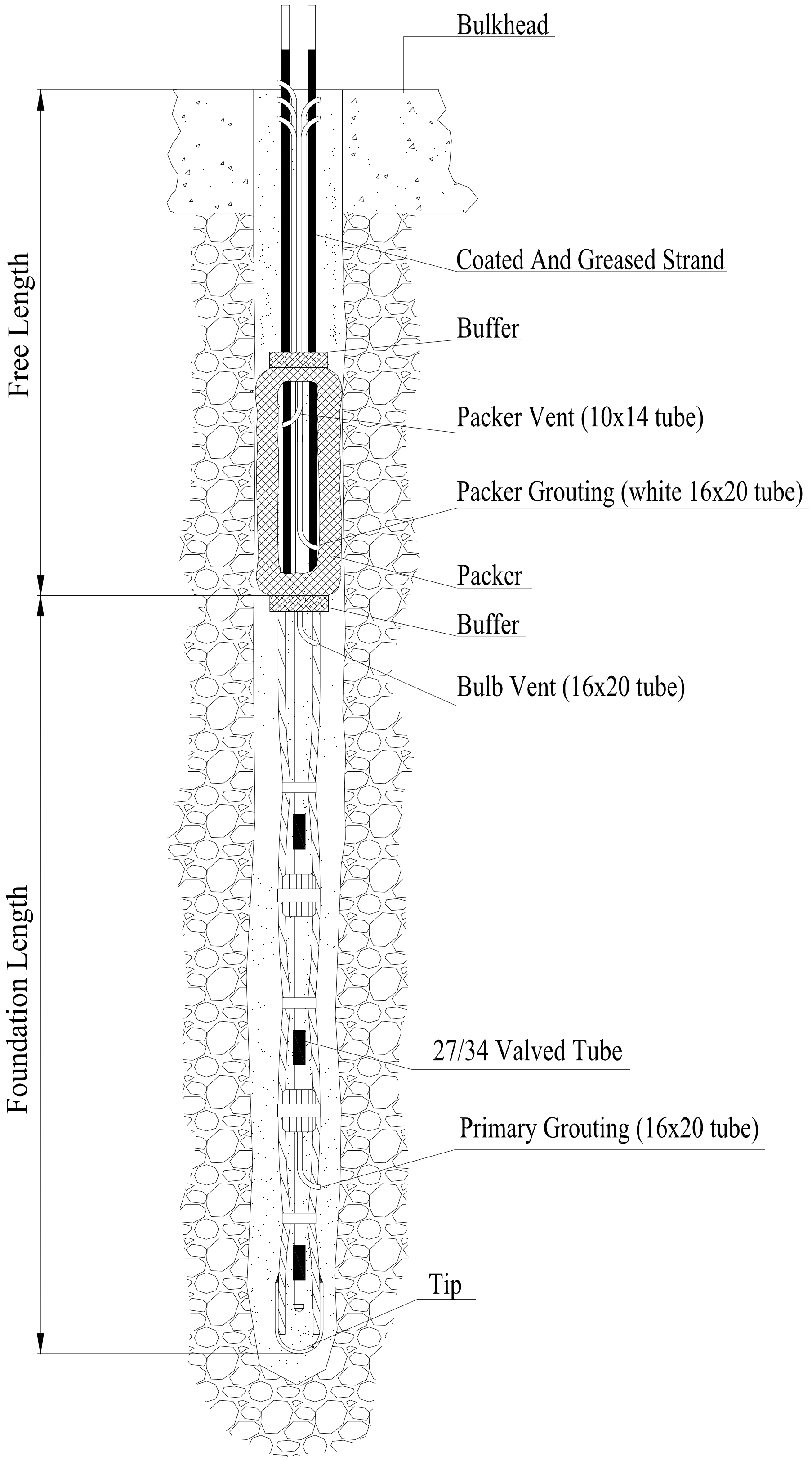
9.11 - TPR-21 temporary ground anchors
(temporary ground anchor with preventer for the installation into strata under pressure)

TPR-21 temporary *ground anchors are provided with preventer and produced in compliance with the European Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" ,paragraph 6.9.3*** *and they are made of harmonic steel strands according to* ***EN 10138****, singularly sheathed and greased on the free length and with bare strands on the foundation.*
They are usually used in the construction of bulkheads and diaphragms, where the type of ground has particular geo-technical problems in the presence of strata under pressure and where the containment of hydraulic pressure is required during the installation.

The anchor is made as follows:
- *In the active part, the strands are separated by special spacers which guarantee the tendon to maintain a sinusoidal shape. By means of suitable strapping and/or taping, the sinusoidal shape of the tendon increases the adherence with the foundation cement mix. Grouting takes place via a 16x20 mm polyethylene tube. Grouting (primary and free length) is carried out via a* ***valvate 27/34*** *mm tube provided with manchette valves* ***(I.R.S.)*** *inside the anchor such as to guarantee the selective regrouting, according to the instructions of the* ***"Client's Technical Representative"***
- *The end part of the anchor is provided with a steel ogive to ease its insertion into the drilling hole with no damage to its walls.*
- *The free length is protected by greasing and sheathing each single strand and with a smooth or corrugated sheath.*
- *All anchors are provided with packer, generally 2-3 m long, to ensure the obstruction against the leakage of groundwater when the drill rod is totally removed and filled up.*

9.11.1 – TPR-21 temporary ground anchor diagram

(temporary ground anchors with preventer)



9.12 – TPE-22 permanent ground anchors

(permanent ground anchor with preventer for the installation into strata under pressure)

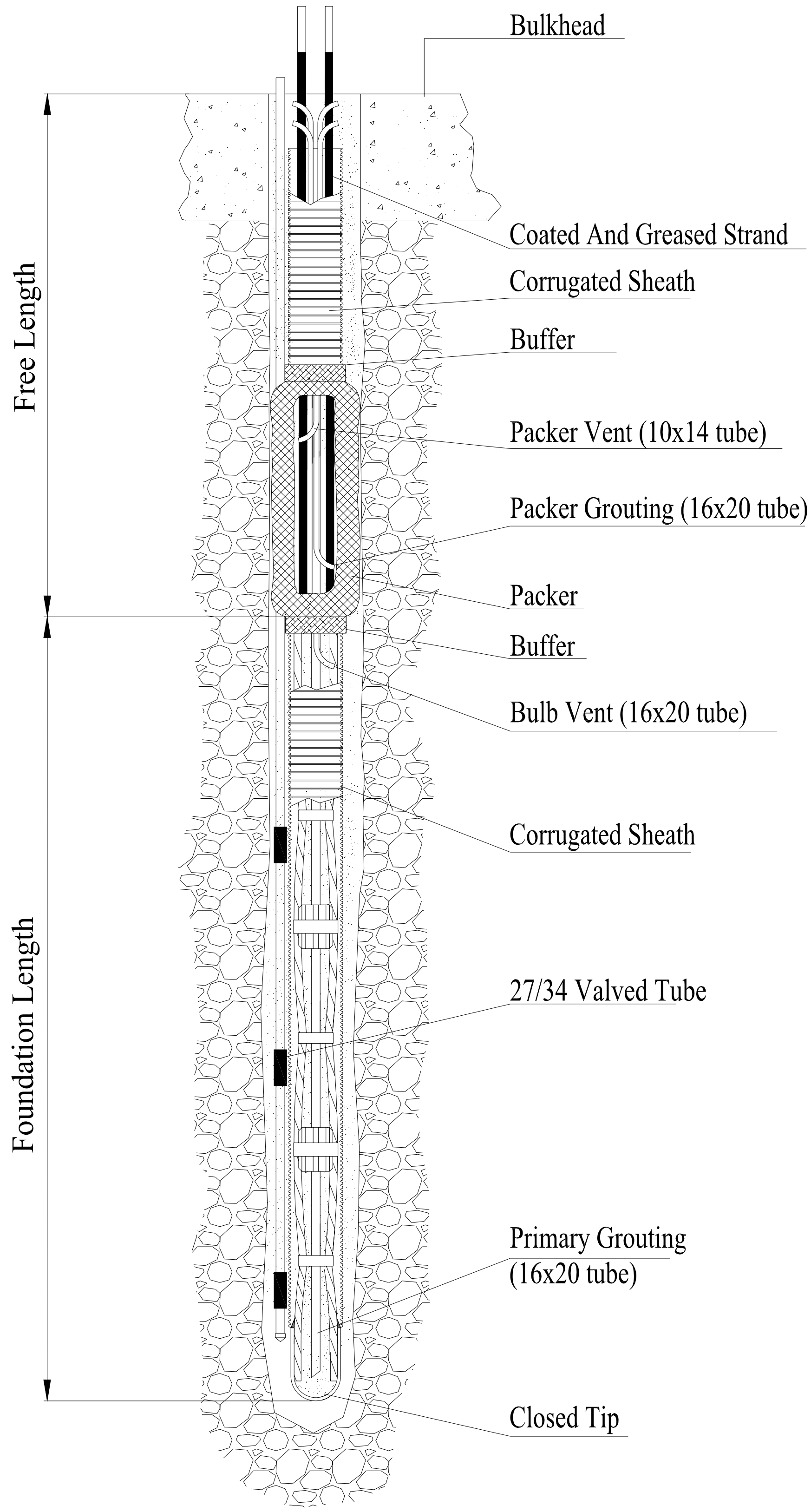
***TPR-22 permanent** ground anchors are provided with preventer and produced in compliance with the European Standard **"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" , paragraph 6.9.3** and they are made of harmonic steel strands according to **EN 10138**, singularly sheathed and greased on the free length and completely covered with a corrugated sheath.*

They are usually used in the construction of bulkheads and diaphragms, where the type of ground has particular geo-technical problems in the presence of strata under pressure and where the containment of hydraulic pressure and the use of permanent ground anchors are required during the installation.

The anchor is made as follows:

- *In the active part, the strands are separated by special spacers which guarantee the tendon to maintain a sinusoidal shape inside the corrugated sheath. By means of suitable strapping and/or taping, the sinusoidal shape of the tendon increases the adherence with the foundation cement mix. Grouting takes place via a 16x20 mm polyethylene tube. Grouting (primary and free length) is carried out via a **valvate 27/34** mm tube provided with manchette valves **(I.R.S.)** outside the anchor such as to guarantee the selective regrouting, according to the instructions of the **"Client's Technical Representative".***
- *The end part of the anchor is provided with a polyethylene ogive to ease its insertion into the drilling hole with no damage to its walls.*
- *The free length is protected by greasing and sheathing each single strand and with a corrugated sheath.*
- *All anchors are provided with <u>packer, generally 2-3 m long,</u> to ensure the obstruction against the leakage of groundwater when the drill rod is totally removed and filled up.*

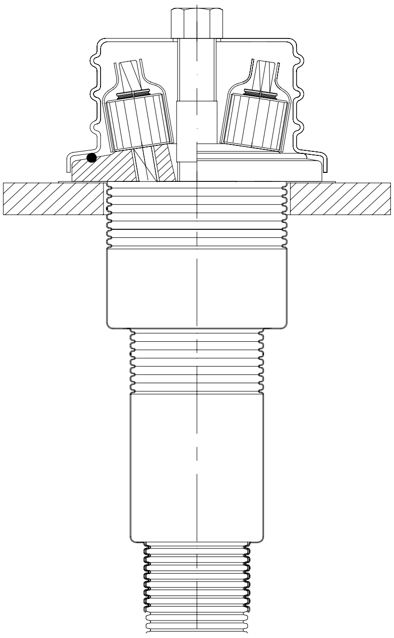
9.12.1 – TPE-22 permanent ground anchor diagram
(permanent ground anchors with preventer)



10.0 - PROTECTION CAPS
(EURO NORM EN 1537-2002 *paragraphs 6.10.9 and 6.11.3)*

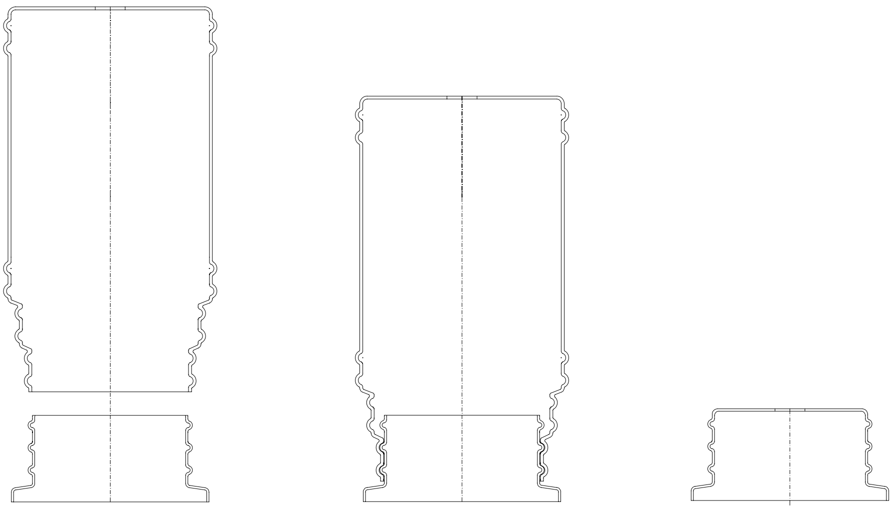
Protection caps comply to ***EURO NORM EN 1537-2002 paragraphs 6.10.9 and 6.11.3****. On customer's request, they are available in the TTR-100 and TTR-450 versions for TTR anchor heads.*

- ***TTR-100*** *normal caps where the protruding tensioning strands are cut off close to the anchorage*
- ***TTR-450*** *special caps where the protruding tensioning strands are 450 mm long so as to allow re-tensioning over time.*



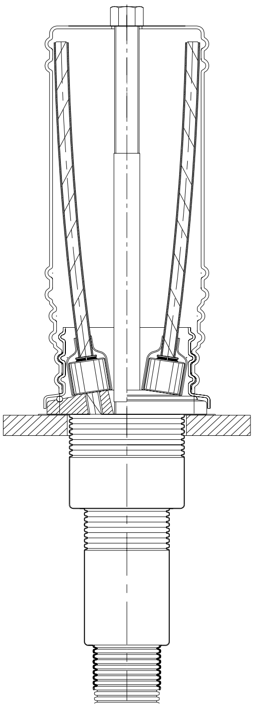
TTR-100 short range cap installed complete with accessories

TTR-100 cap (short type) for TTR anchorage protection on spherical support or bulkheads.
The cap made of polyethylene according to ***EURO NORM EN 1537-2002,*** *paragraph 3 guarantees anchorage protection over time.*



TTR-100 short cap with extension fitted for a TTR 450 long cap

*All the caps are made of high density polyethylene. The long **TTR-450** cap is created as an extension of the short **TTR-100** cap so as to allow the containment of the long strands for re-tensioning.*



TTR-450 long cap installed complete with accessories

***TTR-450** cap (long type) for strand protection on spherical support or bulkheads.*
*The cap made of polyethylene according to **EURO NORM EN 1537-2002** paragraph 3, guarantees strand protection and re-tensioning over time.*

*Protection caps according to Table 3 paragraph 4 **EURO NORM EN 1537-2002** must be made of rigid plastic connected to the bearing plate. If removable, it is filled with a flexible corrosion protection compound and sealed with a gasket. If non-removable it may be filled with cement or resin.*

*Strands are protected on three levels: grease, **DD0015-CV** elementary protection and TTR-450 protection cap. The strand protection protruding from the bush consists of a black tube that is bent on top to make it close.*

*The protection maintains the grease preventively applied around the elementary anchorage thus preserving it. The **DD0015-CV** elementary protection is pressure installed on the tensioned bush.*

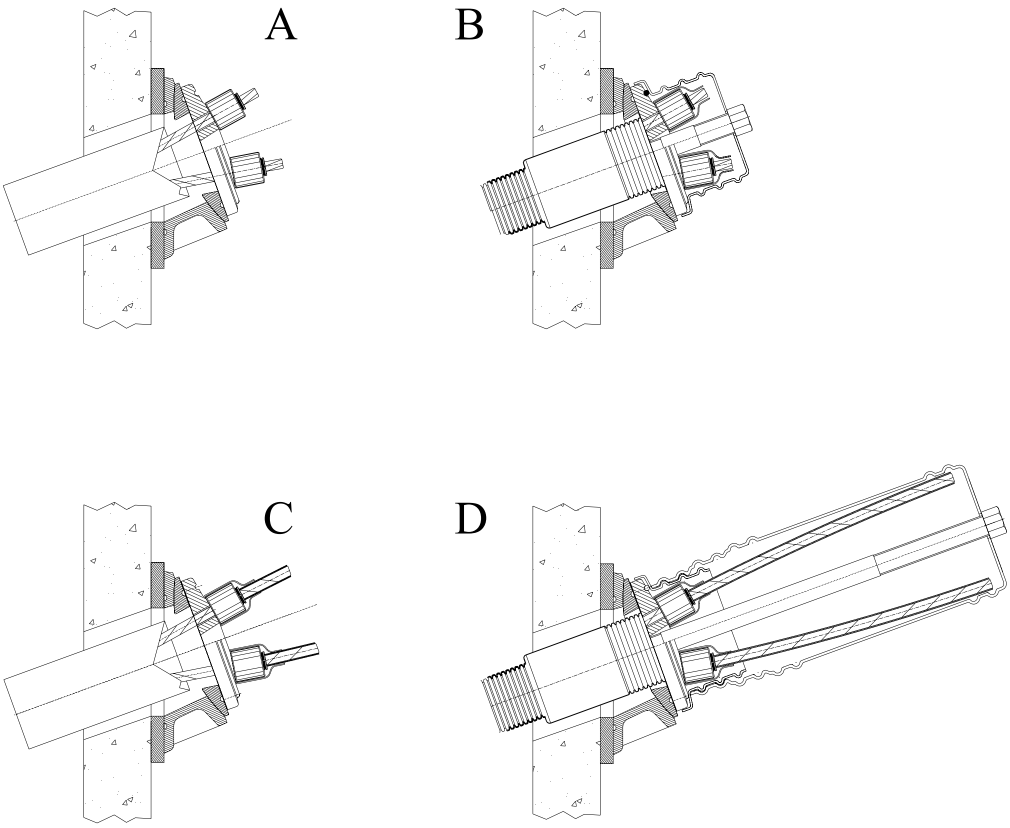
*All the caps are made of high density polyethylene. The long **TTR-450 cap** is created as an extension of the short **TTR-100 cap** so as to allow the containment of the long strands for re-tensioning.*
***TTR-100** normal caps where the protruding tensioning strands are cut off close to the anchorage.*
***TTR-450** special caps where the protruding tensioning strands are 450 mm long so as to allow re-tensioning over time.*
*Caps according to **EURO NORM EN 1537-2002 paragraphs 6.10.9 and 6.11.3** are produced for permanent anchors and where the anchor is subjected to several tensioning cycles over time even if temporary to prevent corrosion. A solution to this problem in the case of temporary anchors is represented by elementary **DD0015-CV** protections, which allow to protect elementary anchorages at single level.*

7TTR15 anchorage with elementary anchorages protected against corrosion

*7TTR15 anchorage with elementary DD0015-CV **protections***

*The protection given by elementary **DD0015-CV** protections is installed on anchorages by covering them with grease and recovering the polyvinyl chloride removed from strands to carry out tensioning.*
Polyvinyl chloride reapplied on the anchorage must be bent on top to guarantee the tightness of the system.
*Polyvinyl chloride couplings with elementary **DD0015-CV** protections are obtained with pressure and grease inside the system.*
The use of elementary protections avoids filling the cap with grease or anti-corrosion material which is difficult to handle on site, protecting anchorages by means of a series of barriers: grease, polyethylene and caps.

Bulkheads with long caps installed where permanent anchorages installed must be surveyed over time.



A = *anchorages for temporary ground anchors,*
B = *anchorages for permanent ground anchors not for re-tensioning, with short cap,*
C = *anchorages for temporary ground anchors with single anchorage protection,*
D = *anchorages for permanent ground anchors where re-tensioning is prearranged and long cap,*

11.0 - ELEMENTARY PROTECTIONS ON TEMPORARY GROUND ANCHORS

*(**EURO NORM EN 1537-2002** paragraphs 6.10.9 and 6.11.3)*

DD0015-CV *bush covers guarantee a temporary protection of elementary anchorages on temporary anchors.* ***DD0015-CV*** *are particularly effective when anchors in several orders are subjected to several tensioning phases, as they protect: bush, clamp and strand against corrosion. They are easy to install, they require the protection of the anchoring element with a layer of grease and are simply inserted over elementary anchorages.*

DD0015-CV *bush covers protect single T15 anchors against corrosion. The anchorage must be manually covered with grease and then covered with the* ***DD0015-CV*** *casing. The strand protruding from the casing is protected by a 16x20mm polyethylene tube that is cut to size and is such as to protect the strand on its whole length.*

7TTR15 anchorage with protected elementary anchorages

Tubes and bush covers are directly made of P.H.E.D. The protection therefore results easy to remove for future tensioning.

A simple protection does not replace the cap protection ***EURO NORM EN 1537-2002 paragraph 6.10.9.*** *, although it guarantees a corrosion protection for strands on temporary anchors such as to allow several tensioning phases on TTR anchorages without affecting the surface of the strand.*

DD0015-CV *bush covers can be installed on temporary anchors and are easily removed for retensioning.*

12.0 - "DI" LOAD CELLS ON TTR ANCHORAGES

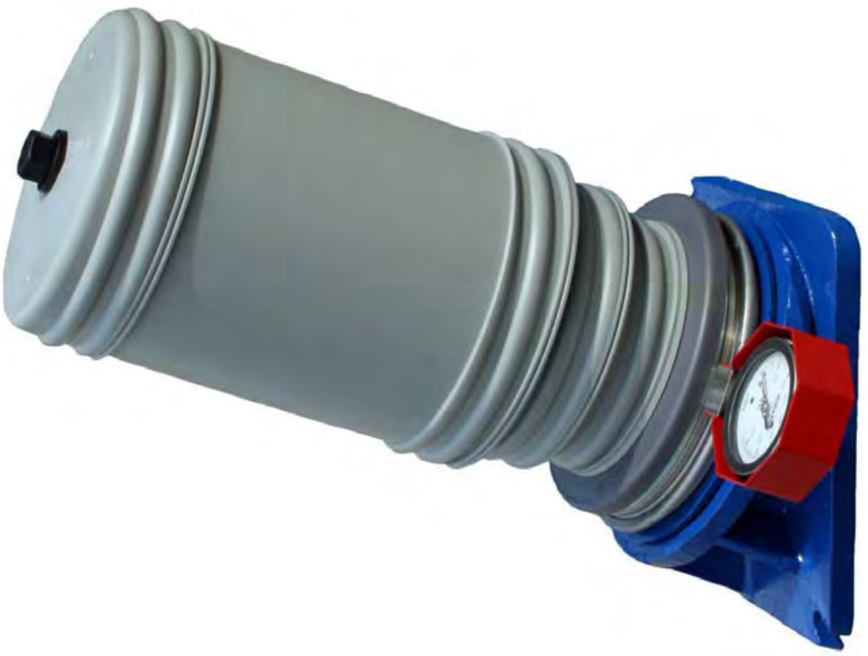
DI 1000KN cell

***DI** load cells are mainly hydraulic cells without gaskets and entirely made of AISI 304.*
Because of these characteristics, they are ideal for temporary or permanent ground anchors to control the tension of the anchorage over time. They are available with analogue reading (side gauge).

***DI** load cells are provided with an analogue gauge to detect the applied load, they are placed on a distribution plate where a 7TTR15 plate is positioned. The system is provided with protection caps and elementary protections of the single strands.*
*They are provided with the **CE marking,** completely protected and with traceable part number.*
*They can be provided in the **DI** version with analogue gauge (hydraulic cell version) and **DI-E** with transducer for the detection of pressure (electrohydraulic cell version). In this version they require the use of a portable electronic reading device.*

The load cell must be placed on a sufficiently flat, indeformable surface to ensure square cell loading, with no transverse components.

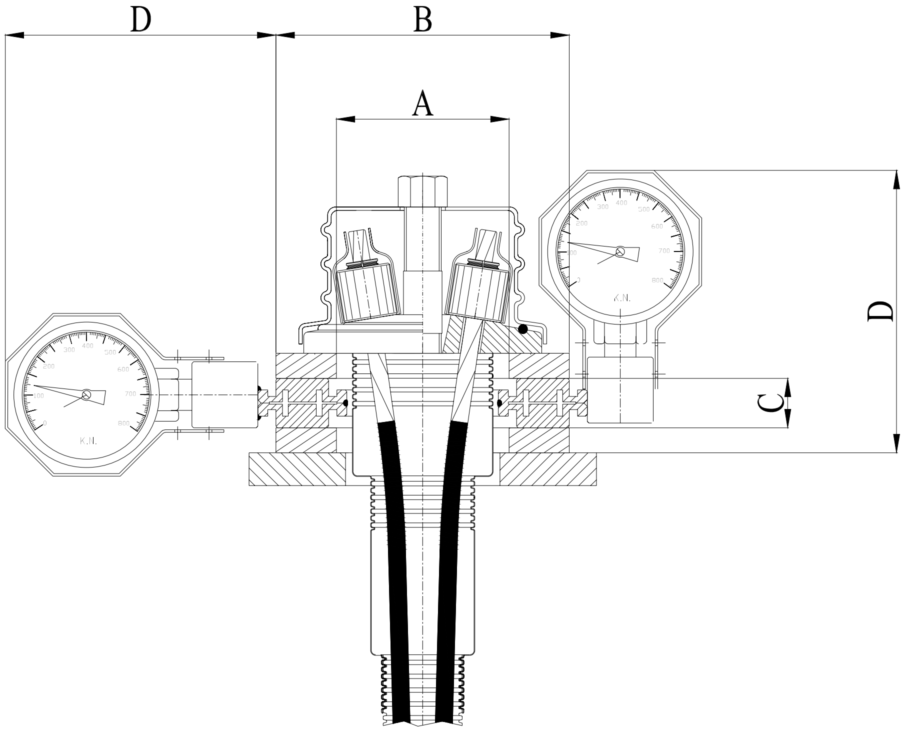
For the cell to work properly, the load must be applied on the cell and the drilling hole must be made with particular attention. Hydraulic cells must be installed avoiding: deviation of the drill rod and mistakes on the drilling angle with respect to the plane of the load.



Application of a TTR anchorage with TTR-450 cap on a DI load cell on a DDSF spherical support

Hydraulic cells require all the strands to be tensioned at the same time to guarantee an even distribution of the load. The cell makes a reading in KN directly, and in Ton on request.
The applied load reading suffers various losses and therefore, with a hydraulic pump calibrated to the load application, a load loss is read after locking between 20% and 40%.
This loss directly depends on the lengthening loss of the ground anchor. This loss is as big as the free length is short and the tensioning value applied to the anchor is small.

12.1 - “DI” hydraulic cells
(dimensions)



“DI” hydraulic cells

DI 1000KN cell

Capacity	Model	A	B	C	D	Precision	Overload	Material	Unit weight
(KN)		(mm.)	(mm.)	(mm.)	(mm.)				(Kg.)
500	**DI-500KN**	70	165	40	195	+/- 1% F.S.	120 %	AISI 304	4,5
750	**DI-750KN**	90	205	40	195	+/- 1% F.S.	120 %	AISI 304	5,5
1000	**DI-1000KN**	110	230	40	195	+/- 1% F.S.	120 %	AISI 304	7,5
1000	**DI-1000SKN**	135	250	40	195	+/- 1% F.S.	120 %	AISI 304	7,5
1500	**DI-1500KN**	160	300	40	195	+/- 1% F.S.	120 %	AISI 304	10
2500	**DI-2500KN**	180	360	40	195	+/- 1% F.S.	120 %	AISI 304	16
2500	**DI-2500SKN**	220	380	40	195	+/- 1% F.S.	120 %	AISI 304	16

Subject to modification *Further data is available on request*

Anchorage	Cell type	Cell load	Max. cell load	Strand dim. diam.
		(KN)	(KN)	(mm.)
2TTR15	**DI-1.000KN**	1.000	1.200	102
3TTR15	**DI-1.000KN**	1.000	1.200	102
4TTR15	**DI-1.000KN**	1.000	1.200	102
5TTR15	**DI-1.500KN**	1.500	1.800	113
6TTR15	**DI-1.500KN**	1.500	1.800	125
7TTR15	**DI-1.500KN**	1.500	1.800	147
8TTR15	**DI-2500KN**	2.500	3.000	166
9TTR15	**DI-2500SKN**	2.500	3.000	193

Subject to modification *Further data is available on request*

Characteristics:
- *Maximum load without calibration alterations: 120% of capacity;*
- *Scale end precision 1% for analogue reading, 0.5% for digital;*
- *Material **AISI 304;***
- *The cell ha a lock ring for inter-placement on the anchor plate; if the plate already has an under plate, this lock ring will not be necessary.*

5TTR15 *anchorage on the* ***DD 0525SF*** *spherical support that is equipped with the* ***DI1500KN*** *load cell and a short cap. The internal anchors can be protected with anti-corrosion material by grouting, or singularly with strand by strand protection with a* ***DD0015-CV*** bush cover.

Application of a TTR anchorage with TTR-450 cap on a DI load cell on a DDSF spherical support

Application of a TTR anchorage with TTR-100 cap on DI load cell on a DDSF spherical support

12.2 - Losses on "DI" cells

The cell loss measured derives from the sum of the following losses:

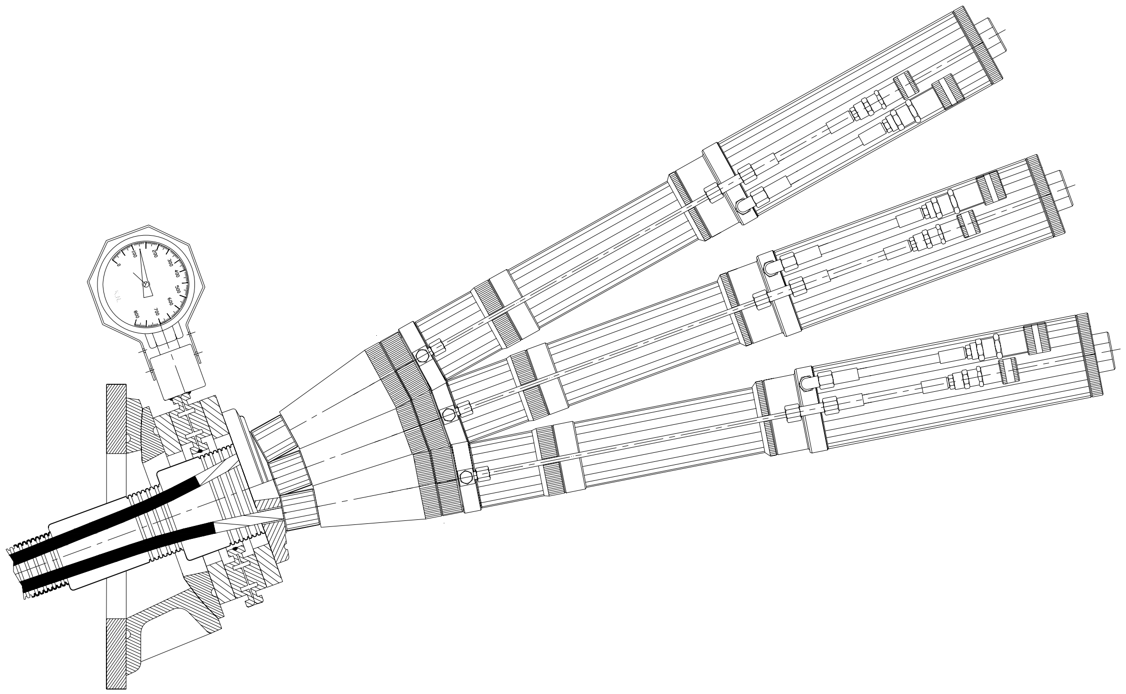
- *loss due to locking, (re-entering of wedges $P_{locking}$);*
- *losses in the jack, (extension of the jack P_{jack});*
- *losses due to angle deviation, (deviation in the anchorage $P_{angle\ dev.}$);*
- *losses due to offset load, (small transverse components $P_{transverse}$).*

$$P_{Tot.} = P_{locking} + P_{jack} + P_{angle\ dev.} + P_{transverse}$$

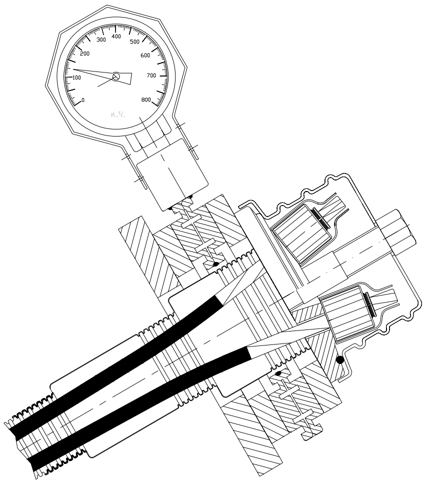
$P_{Tot.}$ represents total load losses

12.3 - Tensioning

During the tensioning phase, taking account of the load loss read on the first anchor, the anchor is re-tensioned. By over-retensioning it, the load loss in the system will be recovered to guarantee the correct applied load, as projected.
All TTR plates allow the OR to be mounted to install the cap and guarantee its seal.



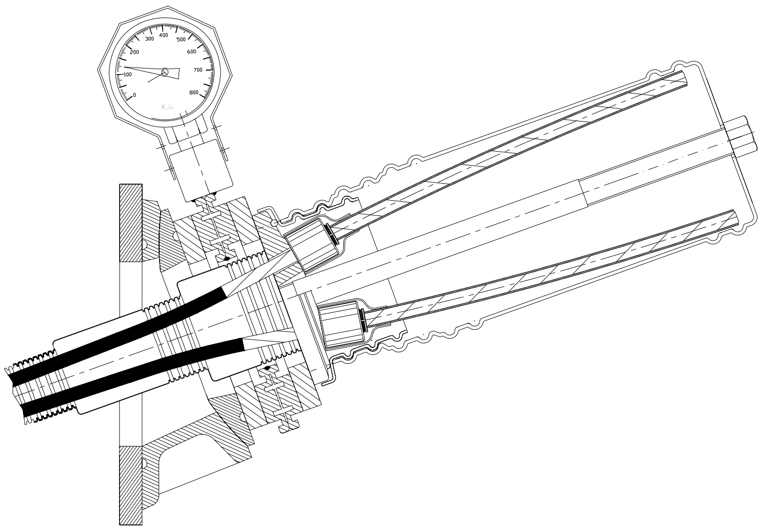
DI load cell tensioning with TTM250KN jacks



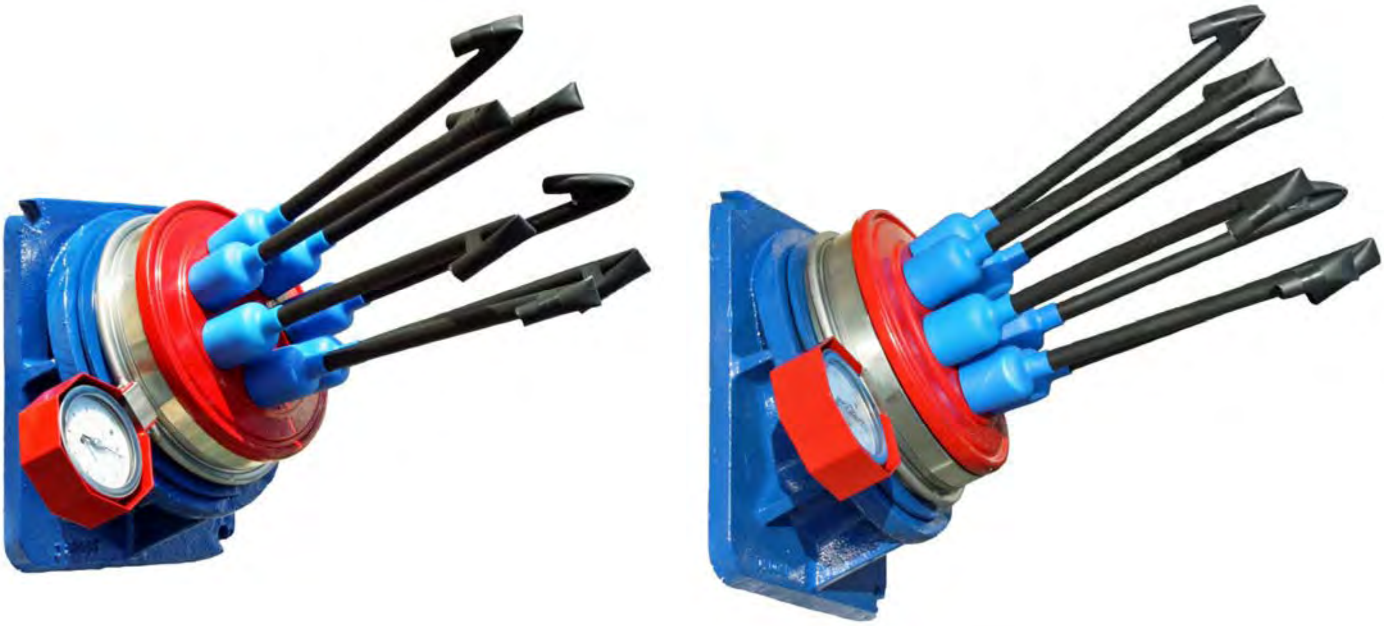
Application of a TTR anchorage on a DI load cell

***5TTR15** anchorage on the **DD 0525SF** spherical support that is equipped with the **DI1500KN** hydraulic load cell. This anchorage is equipped with a long cap to allow re-tensioning over time. The internal anchors can be protected with anti-corrosion material by grouting, or singularly with strand by strand protection with a **DD0015-CV** bush cover*.

Application of a TTR anchorage on a DI load cell on a DDSF spherical support with a TTR-450 long cap and elementary protections



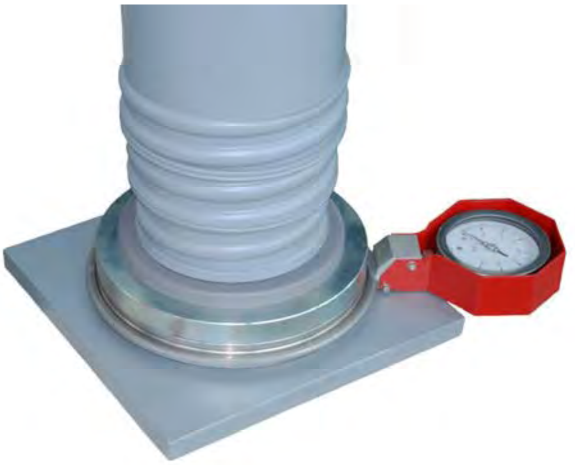
Section of a TTR anchorage on a DI load cell on a DDSF spherical support with a TTR-450 long cap and elementary protections



Application of a TTR anchorage on a DI load cell on a DDSF spherical support

12.4 – Monitoring
***(EURO NORM EN 1537-2002** paragraph 9.11)*

Ground anchors can be installed with a monitoring facility. Where a structure is sensitive to changes in load or ground movement use can be made of this facility to monitor the behaviour throughout its design life.



DI load cell on TTR anchorage

*The series **"DI"** of load cells can be used together with the TTR-100 and TTR450 cap system, which allows to entirely cover the anchor plate: a protection over time and compliance with the **EURO NORM EN 1537-2002** paragraph 6.9.3. Ground anchors are defined permanent if their expected service life is over two years.*

DI load cell with distribution plate and long cap

*With the **"DI"** load cells the use of long protection caps is recommended to allow the re-tensioning of the TTR anchorages over time.*

***EURO NORM EN 1537-2002** paragraph 9.11*

In certain cases do to structural movement, it may be necessary to restress anchors periodically to keep the residual anchor force above the minimum required level.

The corrosion protection of the accessible parts of the anchors heads shall be inspected periodically and renewed, if necessary.

*(“**DE** e **DS**”) electrical load cells*

***DE** and **DS** toroidal compression load cells are used to control the tensioning of anchors, bolts for rock or soil nails; it is also useful to keep them under control while used by revealing any tension losses or overloads. When subjected to a load, the cell will undergo deformation that is measured by strain gauges, which produce an output electric signal proportional to the applied load by varying their resistance values.*

***DE** load cell on a distribution plate where a 5TTR15 plate is positioned. The system is provided with a protection cap.*
***DE** and **DE-S** cells are completely encapsulated, provided with an IP67 screw connector and a shielded wire having a length on request.*
They are made of stainless steel so they do not need the coverage with caps. They can be left bare without any protection under the anchor plate.

Electrical load cells are supplied in two versions:
- ***DE** electrical cells with special dimensions;*
- ***DE-S** standard cells with basic dimensions.*

DE cells characteristics

Capacity	*80, 100, 120, 150, 180 Ton.*
Accuracy class	*0.5%*
Sensitiveness	*2mV/V/FS*
Input impedance	*~700 Ohm*
Output impedance	*~700 Ohm*
Excitement voltage	*Max. 15Volt*
Overload allowed	*150%*
Maximum overload	*300%*
Insulation	*>5 G Ohm*
Operating temperature	*from -20 to +50 ºC*
Compensation at temperature	*from 0 to +50 °C*
Protection class	*IP67*
Type of material	*Stainless steel*
Cover welding	*Laser*

The load cell must be placed on a flat, indeformable surface to ensure square cell loading, with no transverse components.
For the cell to work properly, the load must be applied on the cell and the drilling hole must be made with particular attention. Hydraulic cells must be installed avoiding: deviation of the drill rod and mistakes on the drilling angle with respect to the plane of the load. Hydraulic cells require all the strands to be tensioned at the same time to guarantee an even distribution of the load. They make a reading in KN directly, and in Ton on request. The applied load reading suffers various losses and therefore, with a hydraulic pump calibrated to the load application, a load loss is read after locking between 20% and 40%. This loss directly depends on the lengthening loss of the ground anchor. This loss is as big as the free length is short and the tensioning value applied to the anchor is small.

DE1000KN cell on TTR-100 anchorage

TT2000 reading device for DE cells

During the tensioning phase, taking account of the load loss read on the first anchor, the anchor is re-tensioned. By over-retensioning it, the load loss in the system will be recovered to guarantee the correct applied load, as projected.

DE1000KN cell on TTR-450 anchorage

The cell loss measured derives from the sum of the following losses:

- *loss due to locking, (re-entering of wedges $P_{locking}$);*
- *losses in the jack, (extension of the jack P_{jack});*
- *losses due to angle deviation, (deviation in the anchorage $P_{angle\ dev.}$);*
- *losses due to offset load, (small transverse components $P_{transverse}$).*

$P_{Tot.} = P_{locking} + P_{jack} + P_{angle\ dev.} + P_{transverse}$

$\boldsymbol{P_{Tot.}}$ *represents total load losses.*

13.1 – Monitoring with DE and DS cells
*(**EURO NORM EN 1537-2002** paragraph 9.11)*

Ground anchors can be installed with a monitoring facility. Where a structure is sensitive to changes in load or ground movement use can be made of this facility to monitor the behaviour throughout its design life.

*The series **"DE and DS"** of load cells can be used together with the TTR-100 and TTR450 cap system, which allows to entirely cover the anchor plate: a protection over time and compliance with the **EURO NORM EN 1537-2002** paragraph 6.9.3. Ground anchors are defined permanent if their expected service life is over two years.*

*With the **"DE and DS"** load cells the use of long protection caps is recommended to allow the re-tensioning of the TTR anchorages over time.*

***EURO NORM EN 1537-2002** paragraph 9.11*
In certain cases do to structural movement, it may be necessary to restress anchors periodically to keep the residual anchor force above the minimum required level.
The corrosion protection of the accessible parts of the anchors heads shall be inspected periodically and renewed, if necessary.

14.0 - DE 150KN LOAD CELLS

*(**DE 150KN** load cells)*

*The **DE 150KN** is designed for the installation on ground anchors, and in particular on single strands anchored to TTR plates. The shape and dimensions of the cells make the instrument suitable for the installation on an elementary strand under the anchoring bush. By cutting costs with respect to the application of a classic cell, this allows to evaluate the tension condition of the entire ground anchor. All the strands are tensioned with multiple jack systems connected in parallel to a manifold, and under isotension with TTM equipment. Therefore, by monitoring one strand, the ground anchor is monitored by applying a **DE 150KN** load cell. The compression toroidal **DE 150KN** load cell is used for ground anchors tensioning control; it is also useful to keep them under control while used by revealing any tension losses or overloads. When subjected to a load, the cell will undergo deformation that is measured by strain gauges, which produce an output electric signal proportional to the applied load by varying their resistance values.*

6TTR15 anchorage complete with load cell on a single strand

*The **DE 150KN** are completely encapsulated, provided with an IP67 screw connector and a shielded wire having a length on request.*
They allow to assess the load on each strand. The re-tensioning of the anchorage under isotension allows to consider as identical the loads applied to all strands. The application of DE150KN load cells allows to contain them in protection caps to protect them over time and ease the value check/control. They are supplied with IP 67 connectors and portable digital reader.
Centralised reading systems can also be supplied with wiring structured in pumps for up to 50 simultaneous reading points. Multi-reading systems are designed on customer's needs and vary from structure to structure. The DE150KN load cell can be installed on one or more strands. It must be placed under the anchorage with two special indeformable washers that guarantee a correct load application. They are made of stainless steel so they do not need the coverage with caps, which is nonetheless recommended.
The load cell must be placed on a flat, indeformable surface to ensure square cell loading, with no transverse components.
For the cell to work properly the load must be applied on the cell and the drilling hole must be made with particular attention. Hydraulic cells must be installed avoiding: deviation of the drill rod and mistakes on the drilling angle with respect to the plane of the load.

6TTR15 anchorage complete with load cell on a single strand

Characteristics of the DE150KN cells

Capacity	*200 KN*
Accuracy class	*0.5%*
Sensitiveness	*2 mV/V/FS*
Input impedance	*~350 Ohm*
Output impedance	*~350 Ohm*
Excitement voltage	*Max. 10 Volt*
Overload allowed	*150%*
Maximum overload	*300%*
Insulation	*>5 G Ohm*
Operating temperature	*from -20 to +50 ºC*
Compensation at temperature	*from 0 to +50 °C*
Protection class	*IP67*
Type of material	*Stainless steel*

Hydraulic cells require all the strands to be tensioned at the same time to guarantee an even distribution of the load. They make a reading in KN directly, and in Ton on request.
The applied load reading suffers various losses and therefore, with a hydraulic pump calibrated to the load application, a load loss is read after locking between 20% and 40%. This loss directly depends on the lengthening loss of the ground anchor. This loss is as big as the free length is short and the tensioning value applied to the anchor is small.

The cell loss measured derives from the sum of the following losses:

- *loss due to locking, (re-entering of wedges $P_{locking}$);*
- *losses in the jack, (extension of the jack P_{jack});*
- *losses due to angle deviation, (deviation in the anchorage $P_{angle\ dev.}$);*
- *losses due to offset load, (small transverse components $P_{transvere}$).*

$P_{Tot.} = P_{locking} + P_{jack} + P_{angle\ dev.} + P_{transverse}$

$P_{Tot.}$ represents total load losses

15.0 - TTR ANCHORAGES TENSIONING ON DI HYDRAULIC LOAD CELLS AND DE AND DS ELECTRICAL CELLS

During the tensioning phase, taking account of the load loss read on the first anchor, the anchor is re-tensioned. By over-retensioning it, the load loss in the system will be recovered to guarantee the correct applied load, as projected. All systems have losses and the extent of the same is given by the loss containment shown above.

DE load cell

DI load cell on TTR anchorage

Retensioning to recover the read cell losses must always take into account the creep value of the tendons used, which must never be reached but which is recommended as maximum value applicable to the single strand.

*The maximum tensioning stress (**Pi**) must be limited:*
Pi** = 0,85 x $f_{p\,(1)k}$ x nominal area* ***Pi** = maximum tensioning stress in **KN

16.0 - "DI" LOAD CELLS ON TTM ANCHORAGES

"DI" hydraulic cells

"DI" *load cells are hydraulic, without gaskets and they are made of AISI 304 steel. These characteristics make them especially suitable for use in monitoring the long-term tension of strand and bar anchors as well as temporary and permanent bar anchors. They are available with both analogue and digital reading on request.*

Load cell with 4 TTM-F15 plate

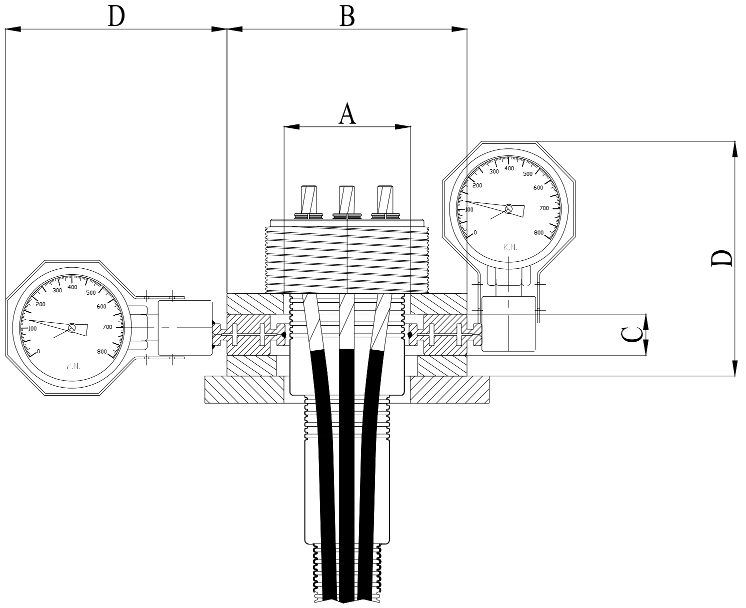
Characteristics of "DI" load cells:

- *Maximum load without calibration alterations: 120% of capacity*
- *Scale end precision 1% for analogue reading, 0.5% for digital*
- *Material* ***AISI 304***
- *The cell ha a lock ring for inter-placement on the anchor plate; if the plate already has an under plate, this lock ring will not be necessary.*

Load cells are provided with the ***CE marking,*** *completely protected and with traceable part number. They must be placed on a flat, indeformable surface to ensure square cell loading, with no transverse components. For the cell to work properly the load must be applied on the cell and the drilling hole must be made with particular attention. Hydraulic cells require all the strands to be tensioned at the same time to guarantee an even distribution of the load.*
The cell makes a reading in KN directly. The applied load reading suffers various losses and therefore, with a hydraulic pump calibrated to the load application, a load loss is read after locking of more than 30%;
this loss directly depends on the loss in the extension of the rock anchorage. The loss is as big as the free part will be short and the tensioning value applied to the rock anchorage small.

During the tensioning, taking account of the load loss read on the first anchor, the anchor is re-tensioned. By over-retensioning it, the load loss in the system will be recovered to guarantee the correct applied load, as projected. All systems have losses and the extent of the same is given by the loss containment shown above.

16.1 - "DI" hydraulic cells, dimensions



Capacity	*Model*	*A*	*B*	*C*	*D*	*Precision*	*Overload*	*Material*	*Unit weight*
(KN)		*(mm)*	*(mm)*	*(mm)*	*(mm)*				*(gr)*
500	***DI-500KN***	*70*	*165*	*40*	*195*	*+/- 1% F.S.*	*120 %*	*AISI 304*	*4,5*
750	***DI-750KN***	*90*	*205*	*40*	*195*	*+/- 1% F.S.*	*120 %*	*AISI 304*	*5,5*
1000	***DI-1.000KN***	*110*	*230*	*40*	*195*	*+/- 1% F.S.*	*120 %*	*AISI 304*	*7,5*
1000	***DI-1000SKN***	*135*	*250*	*40*	*195*	*+/- 1% F.S.*	*120 %*	*AISI 304*	*7,5*
1500	***DI-1.500KN***	*160*	*300*	*40*	*195*	*+/- 1% F.S.*	*120 %*	*AISI 304*	*10*
2500	***DI-2500KN***	*180*	*360*	*40*	*195*	*+/- 1% F.S.*	*120 %*	*AISI 304*	*16*
2500	***DI-2500SKN***	*220*	*380*	*40*	*195*	*+/- 1% F.S.*	*120 %*	*AISI 304*	*16*

Subject to modification *Further data is available on request*

Anchorage	***Cell type***	***Cell load***	***Max. cell load***	*Strand dim. diam.*
		(KN)	***(KN)***	*(mm)*
3TTM15	***DI-750KN***	*750*	*900*	*80*
4TTM15	***DI-750KN***	*750*	*900*	*80*
5TTM15	***DI-750KN***	*750*	*900*	*100*
6TTM15	***DI-1.000KN***	*1.000*	*1.200*	*100*
7TTM15	***DI-1.500KN***	*1.500*	*1.800*	*100*
9TTM15	***DI-1.500KN***	*1.500*	*1.800*	*105*
12TTM15	***DI-2500KN***	*2.500*	*3.000*	*125*
15TTM15	***DI-2500KN***	*2.500*	*3.000*	*135*
19TTM15	*****	*****	*****	*150*
22TTM15	*****	*****	*****	*175*
27TTM15	*****	*****	*****	*195*

Subject to modification *Further data is available on request*

The cell loss measured derives from the sum of the following losses:

- *loss due to locking, (re-entering of wedges $P_{locking}$)*
- *losses in the jack, (extension of the jack P_{jack})*
- *losses due to angle deviation, (deviation in the anchorage $P_{angle\ dev.}$)*
- *losses due to offset load, (small transverse components $P_{transverse}$)*

$P_{Tot.} = P_{locking} + P_{jack} + P_{angle\ dev.} + P_{transverse}$

$P_{Tot.}$ represents total load losses

17.0 - GROUND ANCHORS PRODUCTION

*(**Manufacture EURO NORM EN 1537-2002** paragraph 8.2.1.)*

In order to guarantee a constant production over time and a quick service to customers, highly automatic plants were implemented to achieve a high level of production ensuring quality at the same time.

The production of ground anchors is developed over four lines. The whole production system has a daily capacity of cutting of about 80,000 meter of strands by means of extremely high productiveness numerical control plants.

Manufacture is controlled by a central unit which directly connects the approved offers with the schedule of production, thus making the production plan easier and faster and guaranteeing the traceability of items over time.

TPE 02-C ground anchor

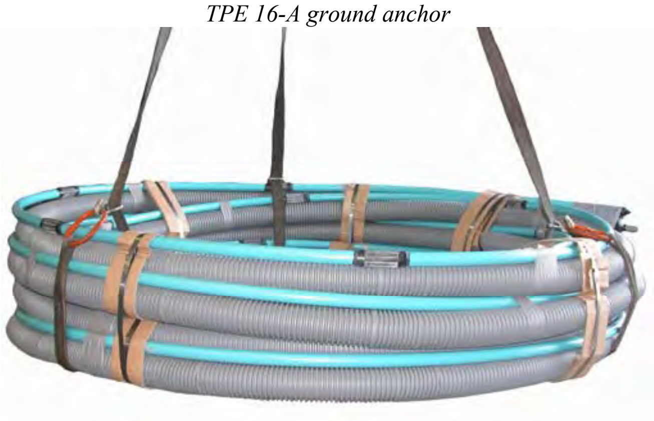
Each ground anchor has its lot number and identification label and it is stocked into proper open cages which preserve the integrity of all anchor components.
*Manufacture of anchors complies with **EURO NORM EN 1537-2002 paragraph 8.2.1**, observing the indications for storage and assembly required.*

TPE 02-A ground anchor

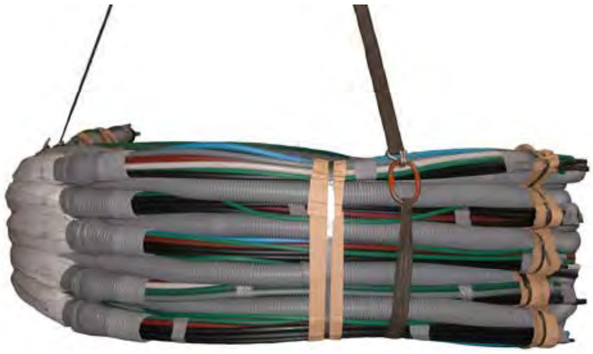
TPR 00 ground anchor with CT centralizers

Ground anchors are produced and then rolled with a diameter of 2.2 m. This kind of package allows easy moving of goods with normal means. Ground anchors are rolled together with a metallic keeper covered by carton. They are then loaded into the trucks horizontally. We suggest discharging them by tying them by means of three grabbing points, using hemp bandages.

TPE 16-A ground anchor



TPE 02-SP-A ground anchor



TPE 02-A ground anchor

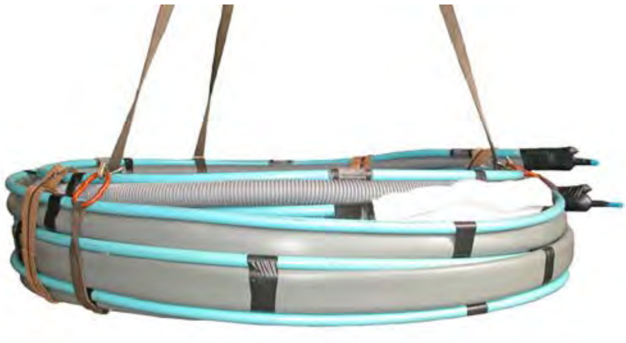
TPE 02-SP-A ground anchor

TPE 02-A ground anchor

TPE 02-C ground anchor

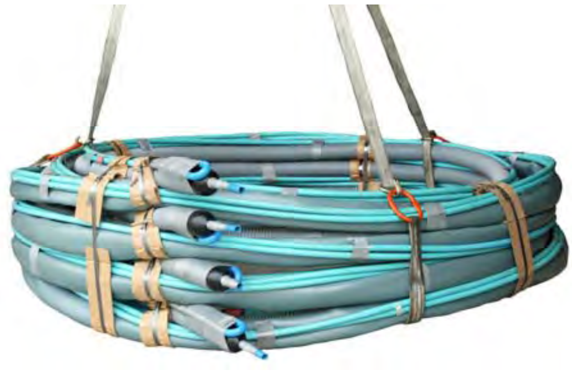
TPE 10-A ground anchor

TPR 01 ground anchor with packer

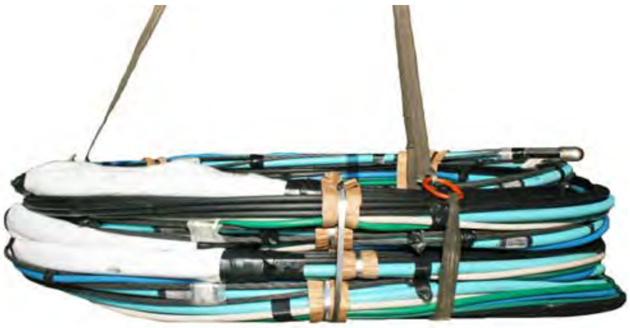


TPE 02-SP-C ground anchor with packer

TPE 08-A ground anchor



TPE 08-B ground anchor



TPR 04 ground anchor

TPE 02-C ground anchor

TPE 05-A ground anchor

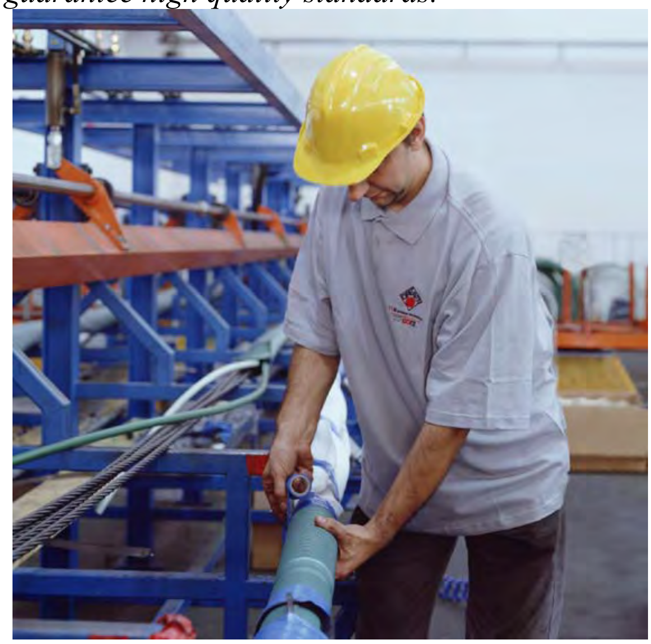
TPR 01 ground anchor with packer and DD-TC centralizers

17.1 - Ground anchors assembly

*(**Assembly according to EURO NORM EN 1537-2002** paragraph 8.2.1.)*

Ground anchors are assembled on automatic lines where the manual intervention is only limited to those activities which cannot be cycled. A high level of specialization of workers, internal procedures, operating instructions, calibration of plants, periodic controls, personnel training, product traceability and a management of line production that is highly computerized: these are the means adopted to guarantee high quality standards.

The production is articulated in the full respect of the product traceability and with an electronic identification of all the anchors produced.



Taping on a ground anchor

Bulb assembly

Ground anchors are perfectly identified by a proper label to separate them by lot, customer and type.

*Manufacture of anchors complies with **EURO NORM EN 1537-2002 paragraph 8.2.1.** observing the indications for storage and assembly required.*

TPR 00 ground anchors

TPE 02 ground anchors

17.2 – Storage

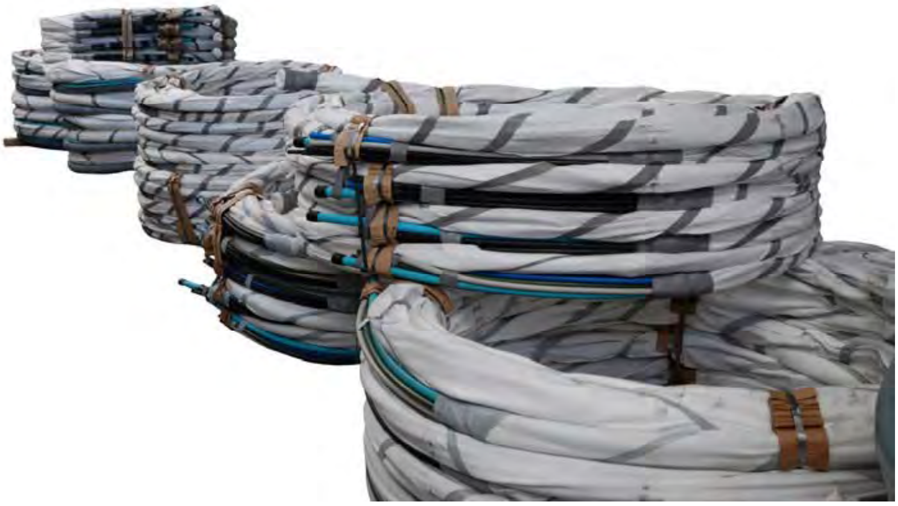
(Storage according to EURO NORM EN 1537-2002 *paragraph 8.2.1.)*

The stocking phase is the most important part of the whole production. The storage inside the warehouse, a proper handling, a division per lot and customer, an adequate protection and a suitable package guarantee high quality products that keep their characteristics from production until the customer site.

The ground anchors are lifted by means of proper lifting means to avoid any damage to the sheaths. They are then moved to a stocking area ready for shipment. The ground anchors are placed into special containers which allow to keep each product divided by lot, type and customer.

All anchors are packaged in several pieces and identified one by one with a proper label. After a proper stocking, they are handled using the three grabbing points lifting system, and then placed onto the truck by preventing any damage to the sheaths and to labels.

In order to make discharging easier on sites, we suggest to use proper lifting machines and to lay the rolled up ground anchors onto a suitable surface.



17.3 - Grouting and vent tubes
*(**EURO NORM EN 1537-2002** paragraph 6.10.1.)*

*These are made of H.D.P.E. and the colours used respect the following operating instruction as well as the **EURO NORM EN 1537-2002 paragraph 6.10.1.***

Indications of colour/use correspondence are shown from the beginning of the free length of each ground anchor with a precise operating instruction applied with adhesive.

GROUT TUBE COLOURS	
COLOUR	GROUT TYPE DESCRIPTION
Blue	PRIMARY GROUTING
Grey	BULB GROUTING
White	PACKER GROUTING (1)
Red	FREE LENGTH GROUTING**
Green	BULB-FOUNDATION VENT*

NOTE (1) ***Only when the ground anchor has a packer***

All the tubes used are 16x20 mm.
In special cases, where the insertion of all the tubes is difficult due to dimensions, 10x14 tubes are used for the vent only.

Black – Polyvinyl chloride for strand protection in the free length of the anchor.
** Only if the anchor has a smooth sheath*
*** Only if the anchor has a buffer*

17.4 - Sheaths and plastic tubes
*(**EURO NORM EN 1537-2002** paragraph 6.10.1.)*

*The tubes used for the ground anchors assembly comply with the requirements of the standard **EURO NORM EN 1537-2002 paragraph 6.10.1** and they are guaranteed for working pressures of up to 25 bar.*

17.5 - Corrugated sheaths for ground anchors

*(**EURO NORM EN 1537-2002** paragraph 6.10.1.)*

*The sheaths and all the materials used in the ground anchor assembly comply with the requirements of the Standard EURO **NORM EN 1537-2002 paragraph 6.10.1.** The corrugated sheaths are provided with a thread every 0.5 m to join them without overlapping the two ends. They can be connected by respecting the diameters or the sheath with a different diameter, reducing or increasing it.*

Corrugated sheaths for ground anchors

17.6 - Sleeves for "DD-SL" corrugated sheaths

*(**EURO NORM EN 1537-2002** paragraph 6.10.1.)*

Sleeves for corrugated sheaths

***DD-SL** sleeves are produced to connect corrugated sheaths.*
Sleeves can be screwed on corrugated sheaths with the following diameter: 75 mm. 90 mm. and 110 mm, they are provided on their length with a 100 mm thread every 500 mm.

17.7 - Connections for "DD-RC" corrugated sheaths

*(**EURO NORM EN 1537-2002** paragraph 6.10.1.)*

Connections for corrugated sheaths

***DD-RC** connections are made for corrugated sheaths. They allow to connect sheaths by adapting different diameters and with enlargements and narrowings. They can be screwed on corrugated sheaths with the following diameter: 75 mm., 90 mm. and 110 mm, they are provided on their length with a 100 mm thread every 500 mm. Corrugated sheaths are used to protect the bulb and on request to protect the anchor free length.*

17.8 - Smooth sheaths

*(**EURO NORM EN 1537-2002** paragraph 6.10.1.)*

*The smooth sheaths are made of H.D.P.E. and are used as protection of the free length, with thickness according to the Standard **EURO NORM EN 1537-2002 paragraph 6.10.1.***

All the sheaths are supplied with controlled thickness respecting the internal specifications prepared by our quality control department and the standards.

17.9 - Buffers

Buffers, made of butyl rubber, have the property of isolating the two zones they separate from fluids and of maintaining their characteristics unaltered over time as the temperature varies.
Buffer quality is very important for successful ground anchorage execution as it permits isolation of the grout bond length from the free length; in this way, it allows correct tensioning and correct strand elongation.

Manual buffer execution

The special mix that is rolled around the strands creating a division zone prevents the cement mixture from interfering with the free length of the anchor. Special attention must be paid when unrolling the anchor on site; if this operation is not performed properly, the strands may slide against each other leading to buffer damage due to their elastic force. In order to prevent this, we recommend handling anchors carefully by placing them down correctly on a surface and by taking care over unrolling them.
Specific weight 1.54÷1.62 g/cm3 ASTM D792-91
Cohesion resistance: 95 – 105 °C
Penetration: 50÷60 @ 20° C ASTN D217-94

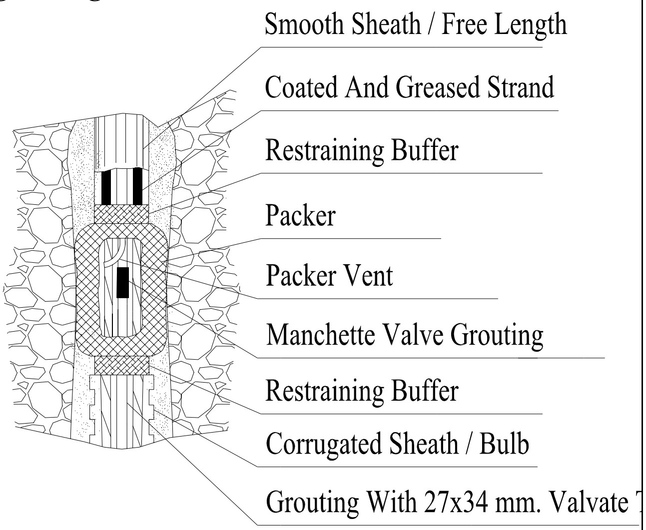
17.10 – Soft PVC tapes

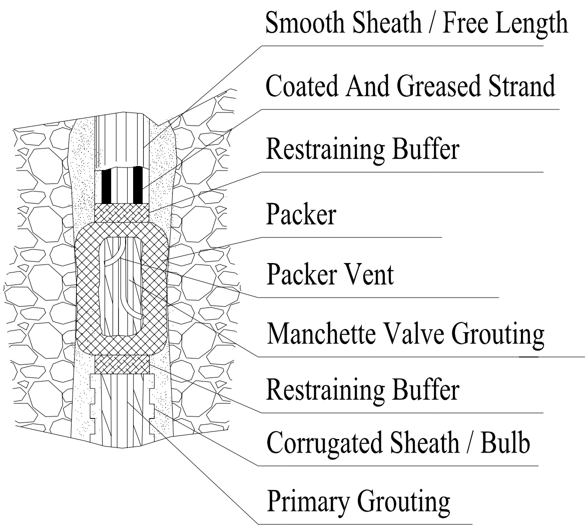
(Adhesive tape for sealing)

The soft adhesive tape made of soft PVC allows a high-level sealing of the interested parts and allows to cover surfaces by respecting their characteristics. The tape also offers a high resistance to temperature variations.

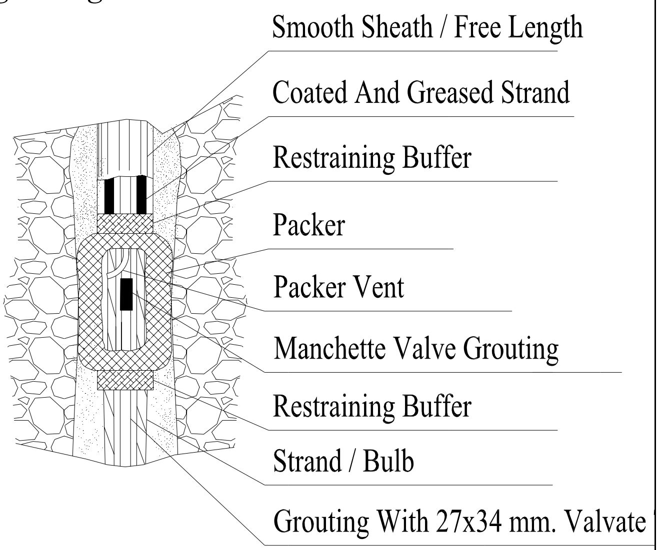
The packer is applied on permanent and temporary anchors, made according to the ***EURO NORM EN 1537-2002,*** *to restrain the primary grouting and allow it to be carried out in the bulb under pressure, thus guaranteeing a greater expansion. The properly inflated packer allows to obstruct the drilling hole as grout cement or groundwater leak.*

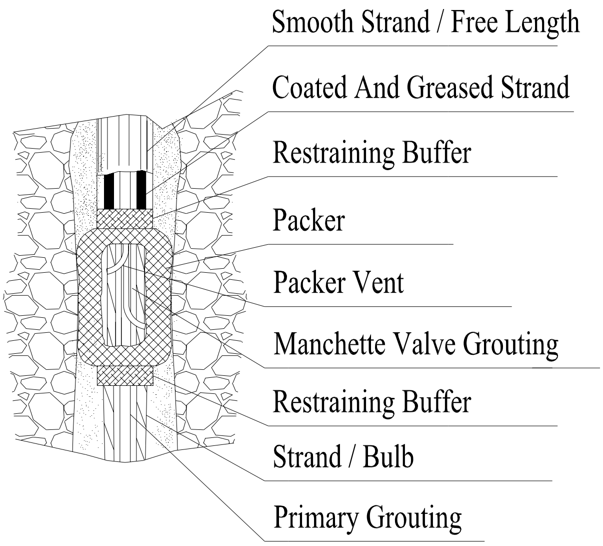
Packer on ***permanent ground anchors*** *made according to* ***EURO NORM EN 1537-2002.***
Packer grouting with manchette valve by means of a T001 27x34 mm valvate tube, application on TPE 05 permanent anchors.
The packer can be inflated via the central T001 27x34 mm valvate tube by using a ***XG27-600*** double piston.
The vent tube allows to control the correct packer grouting.

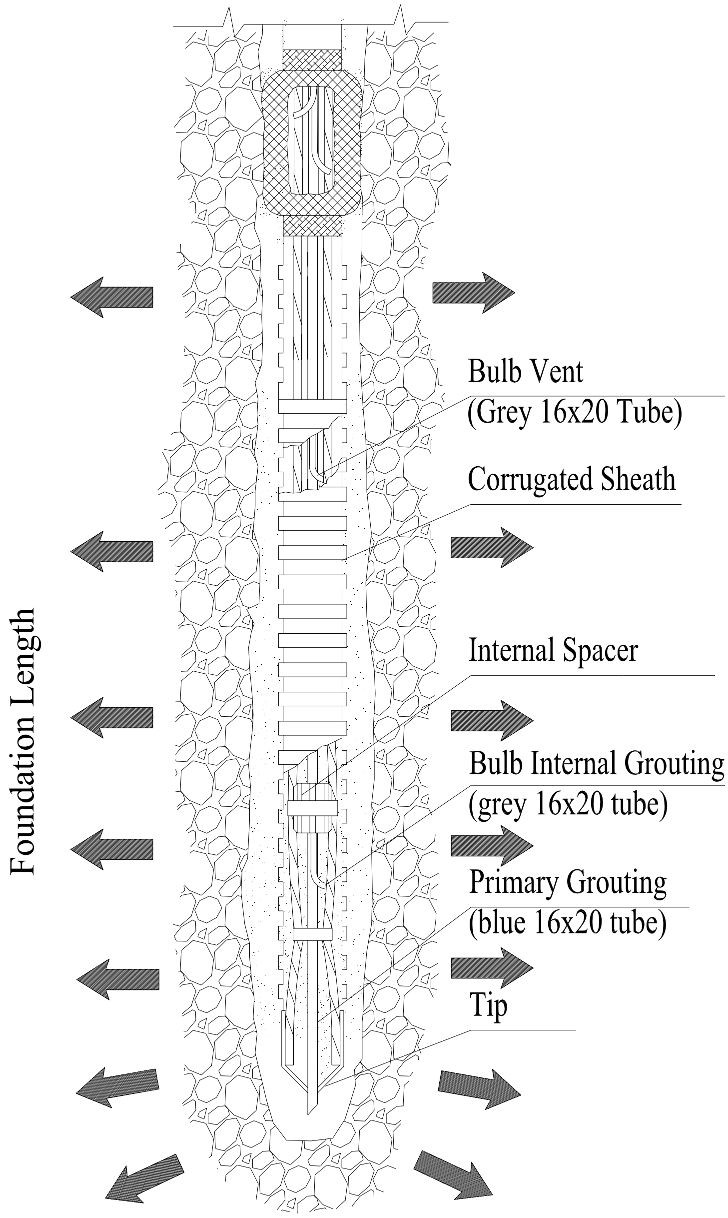




Packer on ***temporary ground anchors*** *made according to* ***EURO NORM EN 1537-2002.***
Packer grouting with manchette valve by means of a T001 27x34 mm valvate tube, application on TPE 05 permanent anchors.
The packer can be inflated via the central T001 27x34 mm valvate tube by using a ***XG27-600*** double piston.
The vent tube allows to control the correct packer grouting.







Packer grouting with 16x20 mm tube is the easiest one. Two tubes having the same diameter and a different colour allow a grouting/vent.

The properly inflated packer allows to obstruct the drilling hole as grout cement or groundwater leak.
It allows to restrain the primary grouting and allow it to be carried out in the bulb under pressure, thus guaranteeing a greater expansion and therefore a greater filling of the anchor foundation.
The packer is also used in all cases where the anchor is installed with an inclination that is greater than horizontal. In this case it is the only device that can guarantee the primary grouting to maintain its position.
The packer is made of nonwoven polyester fabric, with a diameter of 180 mm. and a weight of 300 gm. / m^2. Fabric is supplied sewed on a side. Packers can simply be grouted with a 16x20 mm tube or a manchette valve. Vent is guaranteed by a 16x20 mm tube.

Rolled TPE 02 ground anchors with packer

Nonwoven polyester fabric is also used to restrain grouting in dispersive ground.

The primary grouting of any anchor can be restrained in a nonwoven fabric bag, which by inflating allows the cement compound to stay inside it by limiting the absorption by the ground as well as its consumption.

TPE 02 ground anchors made of nonwoven polyester fabric to cover the bulb

Although convenient to restrain grouting, this application is difficult to insert into the drilling hole due to friction.

TPE 08 ground anchors made of nonwoven polyester fabric to cover the bulb

17.12 - T-001 valvate tubes

These tubes are the most delicate part of the anchor as they must guarantee its rolling in small diameters, resistance to working pressures, no deformation, seal at low and high working pressures, resistance to jumps in temperature always maintaining the same characteristics and the possibility of I.R.S. Paker grouting, valve by valve.

17.13 - T-001 and T-002 27x34 mm valvate tubes

T-001 27x34 mm valvate tube

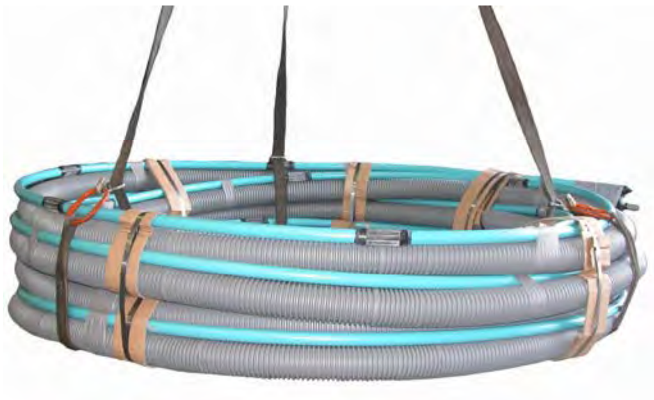
*The**T-001** 27x34 mm valvate tube for selective grouting guarantees the double piston to be entered after unrolling, as its main characteristic is the internal calibration of the tube. It is made of stabilised PVC with resin additives that guarantee the required flexibility.*
*With **T-001** tubes it is possible to grout valve by valve, by applying repeated grout to the anchor. All **T-001** tubes are created in a single bar.*
In order to guarantee repeated grout, the tube must be washed after each grouting cycle.

*The **T-001** tube can cause a valve opening pressure of **150 bar.***

To guarantee the correct use of T-001 valvate tubes, anchors shall be unrolled as they arrive at the site by creating a stock of unwound anchors.

T-001 27x34 mm valve on a valvate tube

*On request, **T-002** 27x34 mm tubes are available that do not guarantee selective grouting, but grouting only in the wellhead. They are made of polythene (H.D.P.E.) and tend to become oval on rolling up, offering poor geometric memory of the internal tube calibration dimensions.*
*We recommend against using **T-002** tubes with a double piston due to loss of the same that can have the problem of remaining blocked in the oval section.*
*The **T-002** tube cannot be used for repeated regrouting as it is difficult to wash after the first one.*
*The **T-002** tube can cause a valve opening pressure of **100 bar.***



TPE 02-A ground anchor

All anchors produced with a
***T-001 27/34 mm valvate tube**s are produced in a single bar.*
The single bar solution was adopted to guarantee correct Paker grouting and increased certainty in recovering it at the end of grouting.

RRM valves gluing on a 27x34 mm valvate tube

*The high quality of the materials used in the extrusion of the **T-001 27/34 mm.** tube make it a very ductile product so as to guarantee suitable elastic return after rolling up. Nevertheless, we always recommend unrolling the anchor on arrival at the site so as to facilitate the return of the 27/34 tube to its initial shape.*

Ground anchors with T-001 27x34 mm valvate tubes

17.14 - T-003-U 15x21 mm. valvate tubes

*The **T-003-U** 15x21 mm valvate tube for repeated injections is made of stabilised PVC with a resin additive that guarantees the required flexibility. It allows the **I.R.** repeated grouting.*
***T-003-U** tubes allow the simultaneous grouting of the valves, applying repeated grouts to the anchor. After each grouting operation the tube must be washed.*

*The **T-003-U** tube can cause a valve opening pressure of **150 bar.***

U- shaped tube for repeated grouting on a permanent anchor.

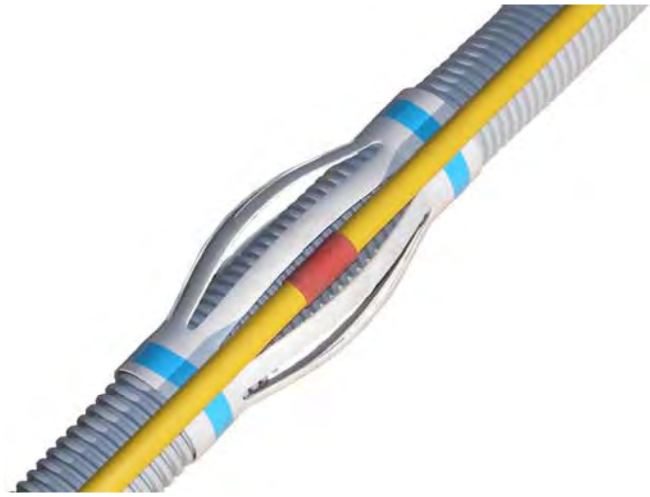
Valvate 15x21 tube coupled with a U-shaped tube

U-shaped tube for repeated groutings

17.15 - T-004 10x14 mm valvate tubes *(micro-valvate)*

*The **10x14 mm. T-004** valvate tube for repeated injections is made of stabilised PVC with a resin additive that guarantees the required flexibility. It allows the **I.R.** repeated grouting.*

T-004-S tube external to a permanent ground anchor



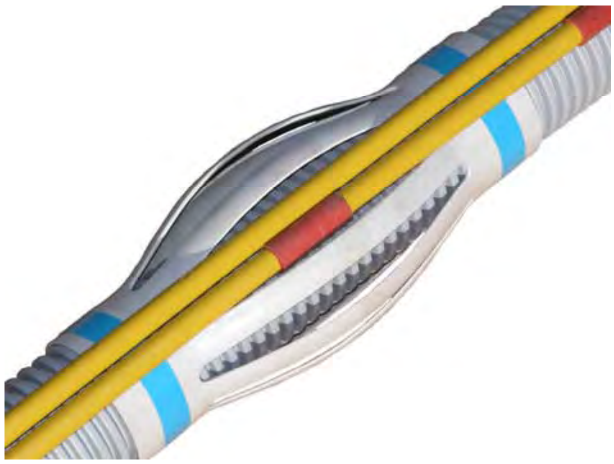
T-004-S tube external to a permanent ground anchor with DD-ED spacer

T-004-U tube external to a permanent ground anchor

*With **T-004-U** tubes it is possible to grout valves simultaneously, by applying repeated grout to the anchor. **T-004** tubes are used with two different application systems:*

- ***T-004-S** tube in a single bar with valves every 0.5 metres; re-grouting is guaranteed in this version.*
- ***T-004-U** tube in a single bar with valves every 0.5 metres of the input only to guarantee regrouting.*

T-004-U tube external to a permanent ground anchor with DD-EF spacer



T-004-U tube external to a permanent ground anchor with DD-ED spacer

*In order to guarantee repeated grouting, the tube must be washed after each grouting cycle. The **T-004** tube can cause a valve opening pressure of **150 bar.***

17.16 - T-005 15x21 mm valvate tubes (micro-valvate)

T-005-S tube external to a permanent ground anchor

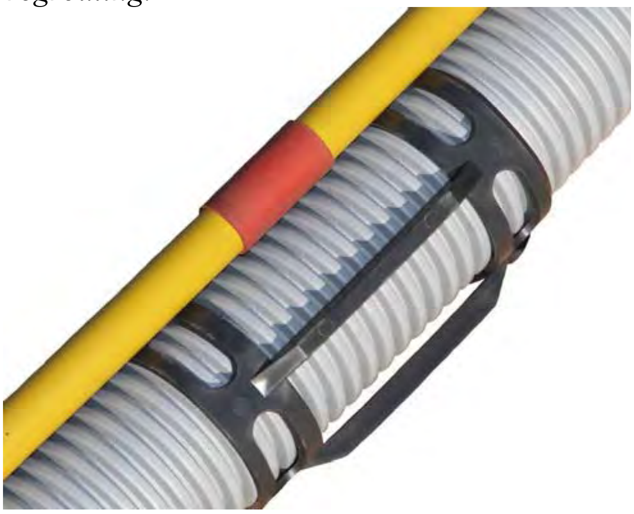
*The **15x21 mm. T-005** valvate tube for repeated injections is made of stabilised PVC with a resin additive that guarantees the required flexibility.*

*With **T-005-U** tubes it is possible to grout valves simultaneously, by applying repeated grout to the anchor. **T-005** tubes are used with two different application systems:*

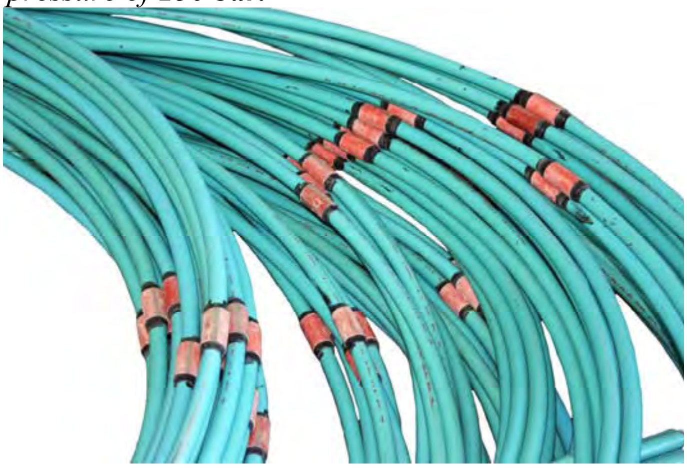
- ***T-005-S** tube in a single bar with valves every 0.5 metres; re-grouting is not guaranteed in this version.*
- ***T-005-U** tube in a single bar with valves every 0.5 metres of the input only to guarantee regrouting.*

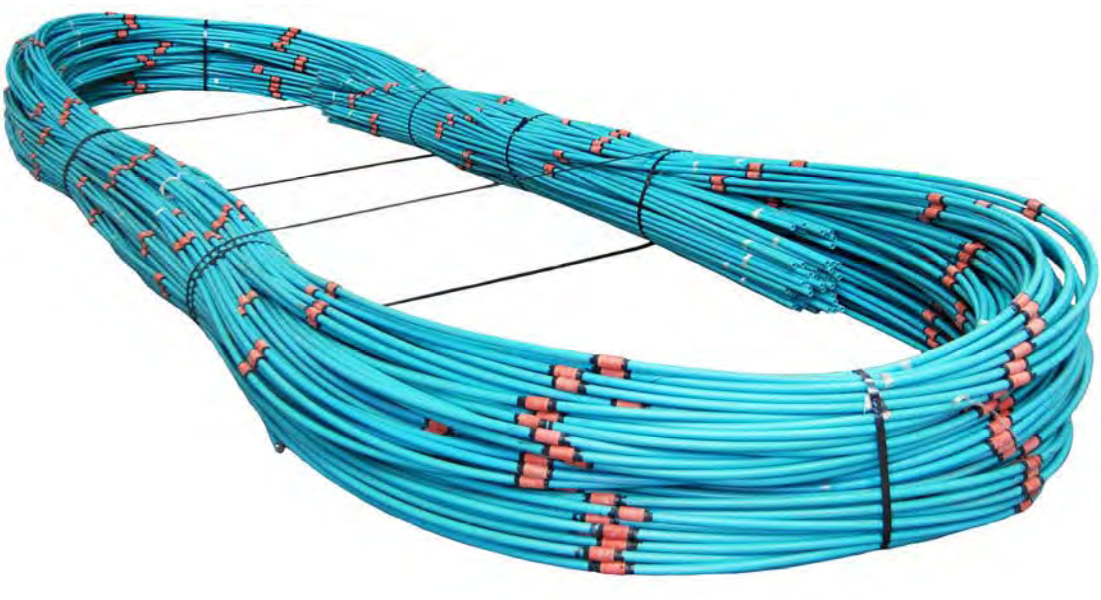
In order to guarantee repeated grout, the tube must be washed after each grouting cycle.

*The **T-005** tube can cause a valve opening pressure of **150 bar.***

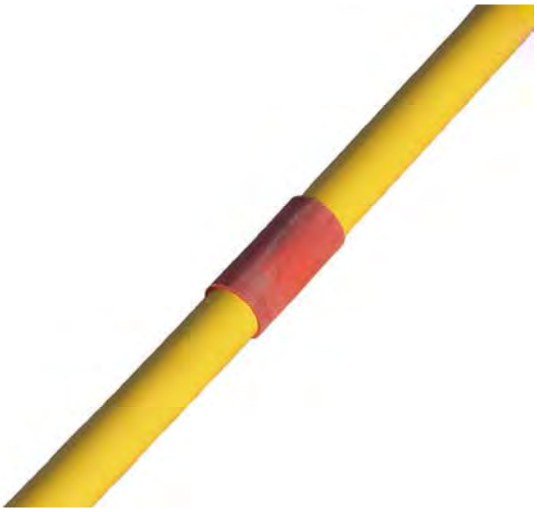


T-005-U tube external to a permanent ground anchor with DD-EF spacer





17.17 - T-004 and T-005 valvate tubes on temporary ground anchors *(micro valvate)*



Rubber valve on micro-valvate

T-004 and T-005 valvates *are created with tubes of lower quality, size and cost compared to normal grouting tubes.*
They are created to permit installers to fit a single channel or U-shaped valvate to temporary anchors, so as to guarantee the possibility of recovery in the case of anchor extraction by grouting the bond length at high pressure.

T-004-S tube external to a temporary ground anchor

Valvate types (micro-valvate)

- ***T-004-S*** *mono valvate tube with valves every 0.5 m, dimensions 10x14 mm.*
- ***T-004-U*** *double U-shaped valvate with valves every 0.5 m dimensions 10x14 mm.*
- ***T-005-S*** *mono valvate tube with valves every 0.5 m, dimensions 15x21 mm.*
- ***T-005-U*** *double U-shaped valvate with valves every 0.5 m dimensions 15x21 mm.*

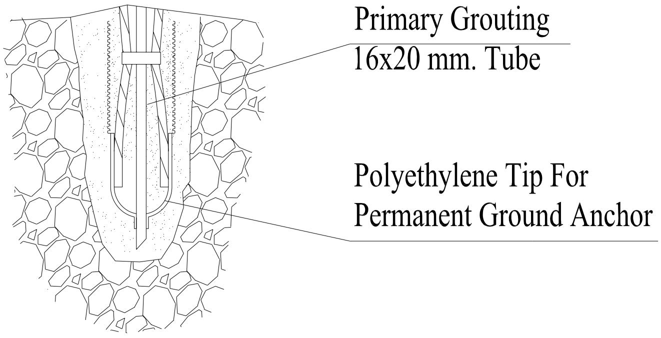
T-005-S tube external to a temporary ground anchor

With classic valvate tubes it has always been impossible to supply temporary anchors with the possibility of re-grouting at low costs. With ***T-004 and T-005*** *tubes with valves every 0.5 metres the installer has a simple system to handle the extraction of temporary anchor.*

The valves put at a distance of 0.5 m guarantee grout diffusion and more even re-grouting in all the active length. The 0.5 m. spacing requires to each valve a side diffusion of 25 cm, which is certainly possible at pressures over 50 bar.

17.18 - Tips

There are two types of anchor tips; steel ones for temporary ground anchors and polyethylene ones for permanent ground anchors. Steel tips are welded to the end of the strand and ease the anchor insertion into the drilling hole.
The sole purpose of the welding is to secure the tip to the strands, as the strand by its nature cannot be welded. All permanent anchors have an H.D.P.E. tip connected to the corrugated protection sheath. The plastic tip is fixed to the corrugated sheath with a suitable tape to secure it and ease the insertion into the drilling hole.



Polyethylene tip for permanent ground anchors, used on: TPE02, TPE02SP and TPE08 anchors

Permanent ground anchors with DD7032 and DD7033 tips

17.18.1 - Tips for permanent ground anchors

They are screwed on the corrugated sheath and they are provided with a lock against removal.

They guarantee that the thickness is maintained as required by the UNI EN 1537 2002. They are made o polyethylene and provided with a lock against removal. They are screwed on the corrugated sheath and guarantee a protection against bending of the output tube for primary grouting.

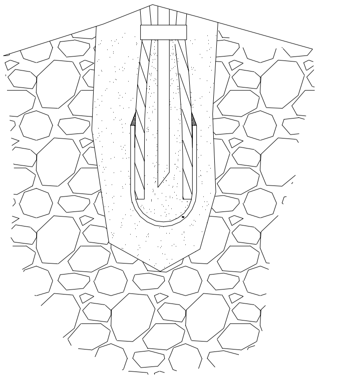
T85 PVC tips *have an internal thread compatible with T001 27/34 mm tubes.*
The end cap can be supplied on request already provided with the hole for the 16x20 mm. tube.

Tips made of PVC T85

TPE 02 permanent ground anchor with anti-removal tips

17.18.2 - Tips for temporary ground anchors

They are made of steel and fixed to the lower part of the anchor by welding. This process is difficult to carry out as the strand cannot be welded.



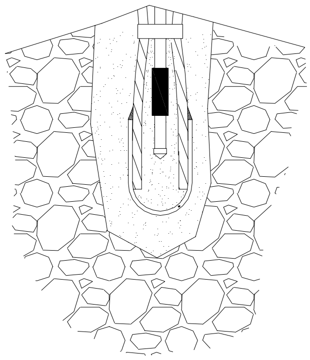
Steel tip for temporary anchors used on TPR00 and TPR01 ground anchors

T60 welded tip

T40, T60 and T90 tips are made of Fe360 steel. During temporary anchors assembly, they are welded to the end of the bulb. Welding is always imperfect as the strand cannot be welded having aluminium in its components.

The steel tip facilitates the insertion of the rock anchorage into the drilling hole preventing damages to the walls caused by strands and by the weight of the anchor.

T60 steel tips

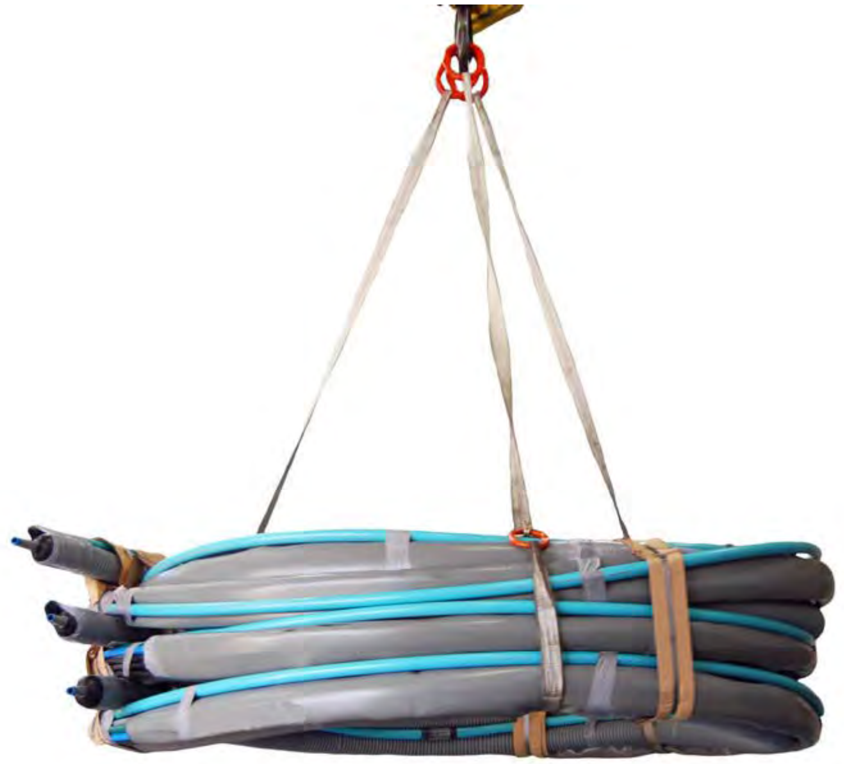


Steel tip for temporary anchors with T001 27x34 mm valvate tube used on TPR04 ground anchors

TPR 00 ground anchor with welded metallic tip

17.19 – Handling

*(**Handling according to EURO NORM EN 1537-2002** paragraph 8.2.1.)*

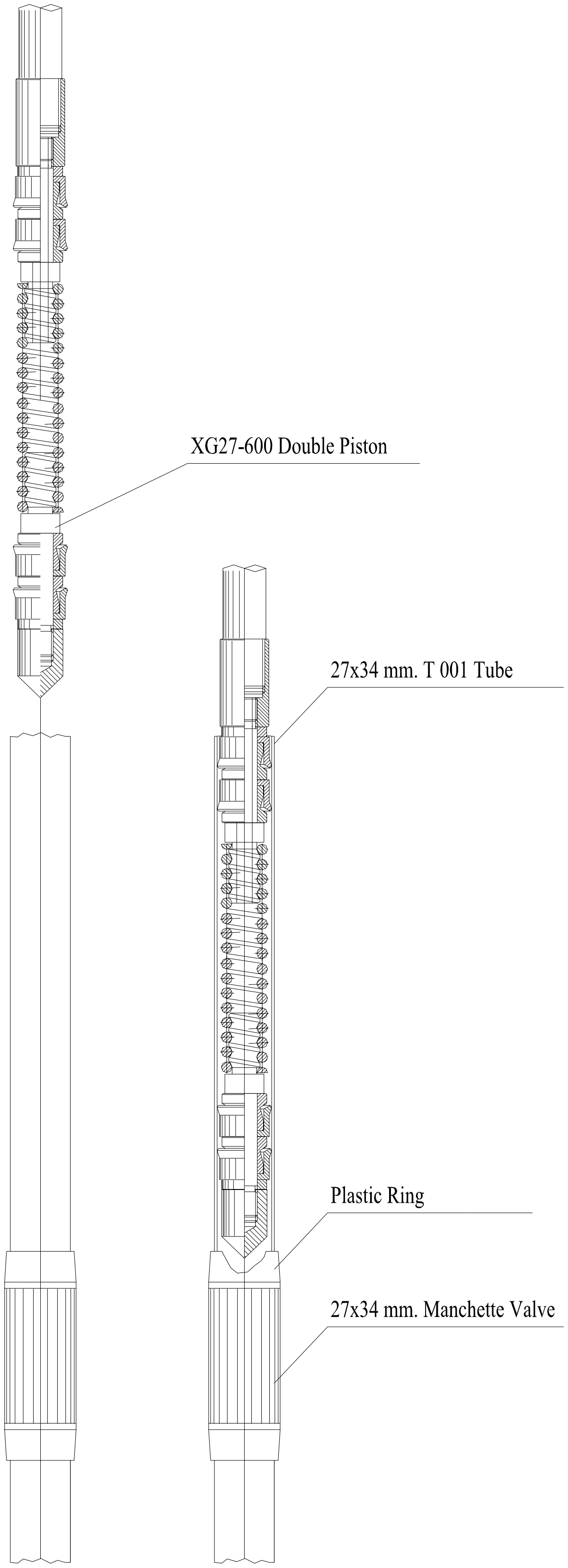


During loading and unloading activities, ground anchors must be handled with hemp ropes to maintain the integrity of the anchor protection sheaths.

*Transport, handling and installation according to **EURO NORM EN 1537-2002** paragraph 8.2. During loading, transporting and installation of the tendon, care shall be taken not to kink the tendon or cause damage to its components and corrosion protection elements.*

17.20 - T-001 valvate tubes with manchette valves for I.R.S. groutings

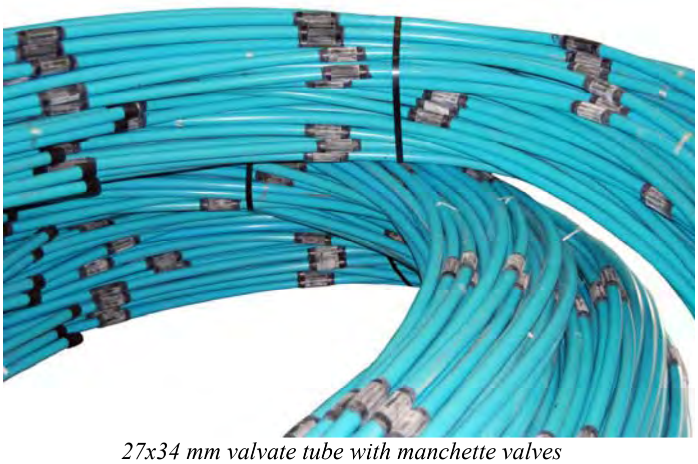
These tubes are the most delicate part of the anchor as they must guarantee its rolling in small diameters, resistance to working pressures, no deformation, seal at low and high working pressures, resistance to jumps in temperature always maintaining the same characteristics and the possibility of I.R.S. Paker grouting, valve by valve.



Manchette 27x34 mm. valves are used on a T 001 tube and on permanent and temporary ground anchors, where these types of grouting are required: repeated and selective (I.R.S.) or repeated only (I.R.). Manchette 27x34 mm. valves represent a solution to provide an anchor with regrout by placing a valvate tube on its outside.

Manchette 27x34 mm valve

27x34 mm valvate tube with manchette valves on a permanent ground anchor



27x34 mm valvate tube with manchette valves

The external tube increases the dimensions of the anchor and of the drilling necessary for the anchor. On request, the spacing of the valves used can be: 0.65 m, 1.3 m, 2.6 m etc.
The 27x34 mm. manchette valve can be used for I.R.S grouting (repeated selective) one by one, with a XG 27-600 double piston, as well as for I.R. grouting (repeated) for grouting from the wellhead. The double piston allows to concentrate grouting on each specific valve. The grouting thus allows to provide each 27x34 mm valve with selective grouting.

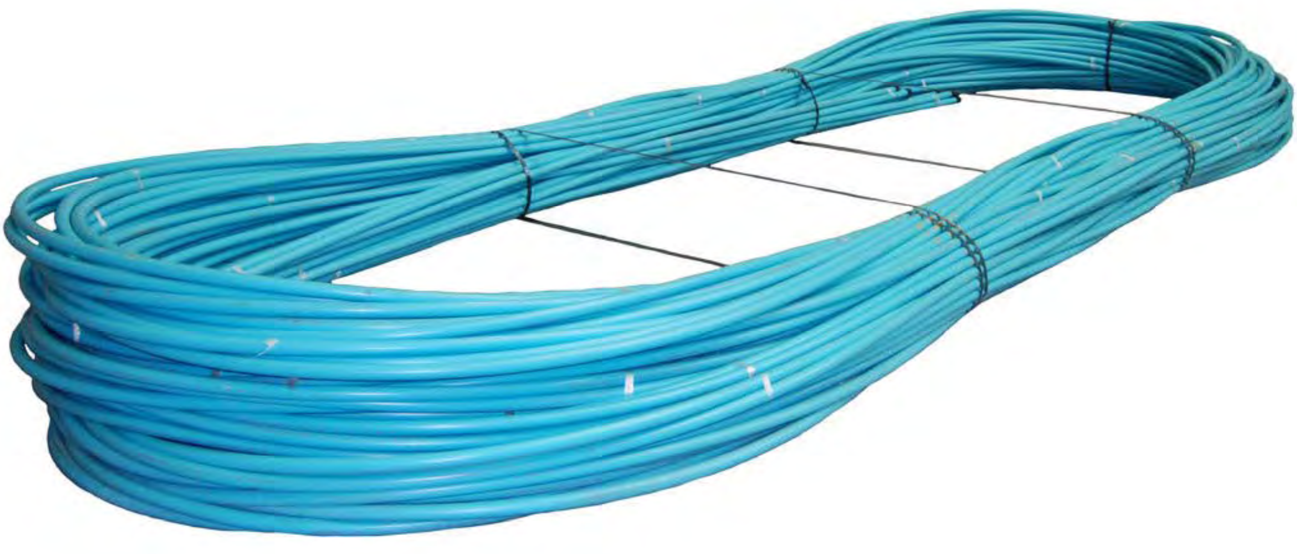
27x34 mm valvate tube with manchette valves on a permanent ground anchor

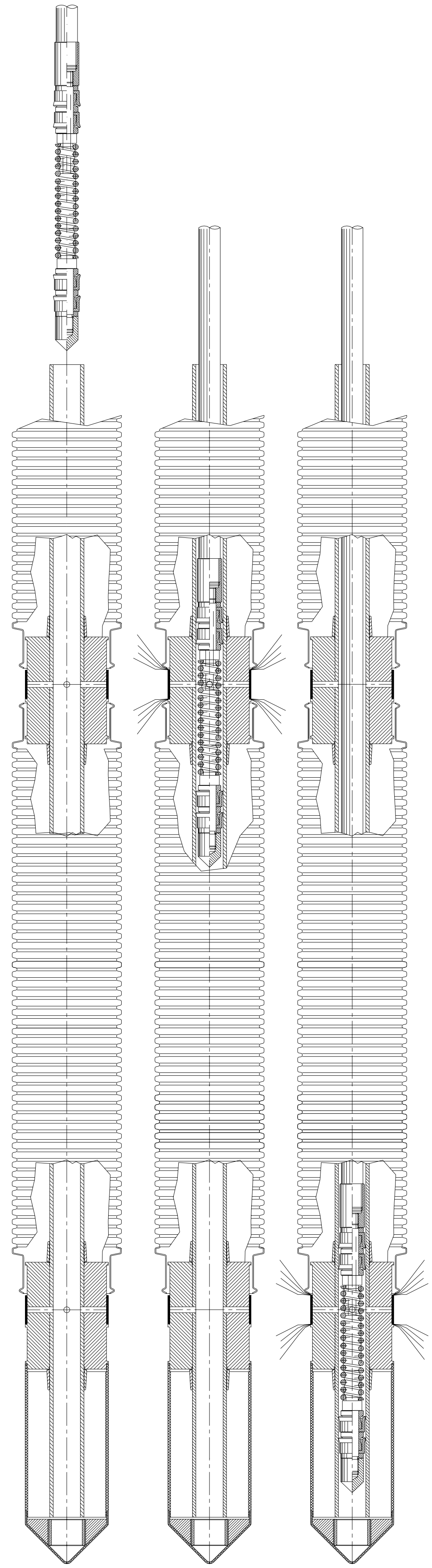
Selective or repeated regrouting can be carried out again at 12 hour intervals in case of non sealing of the foundation bulb.

17.21 - T-001 valvate tubes with RRM valves for I.R.S. groutings

All the ground anchors produced with a ***T-001 27/34 mm*** *valvate tube are produced in single bar. The single bar solution was adopted to guarantee correct Paker grouting and increased certainty in recovering it at the end of grouting.*

The high quality of the materials used in the extrusion of the ***T-001 27/34 mm.*** *tube make it a very ductile product so as to guarantee suitable elastic return after rolling up. Nevertheless, we always recommend unrolling the anchor on arrival at the site so as to facilitate the return of the 27/34 tube to its initial shape.*

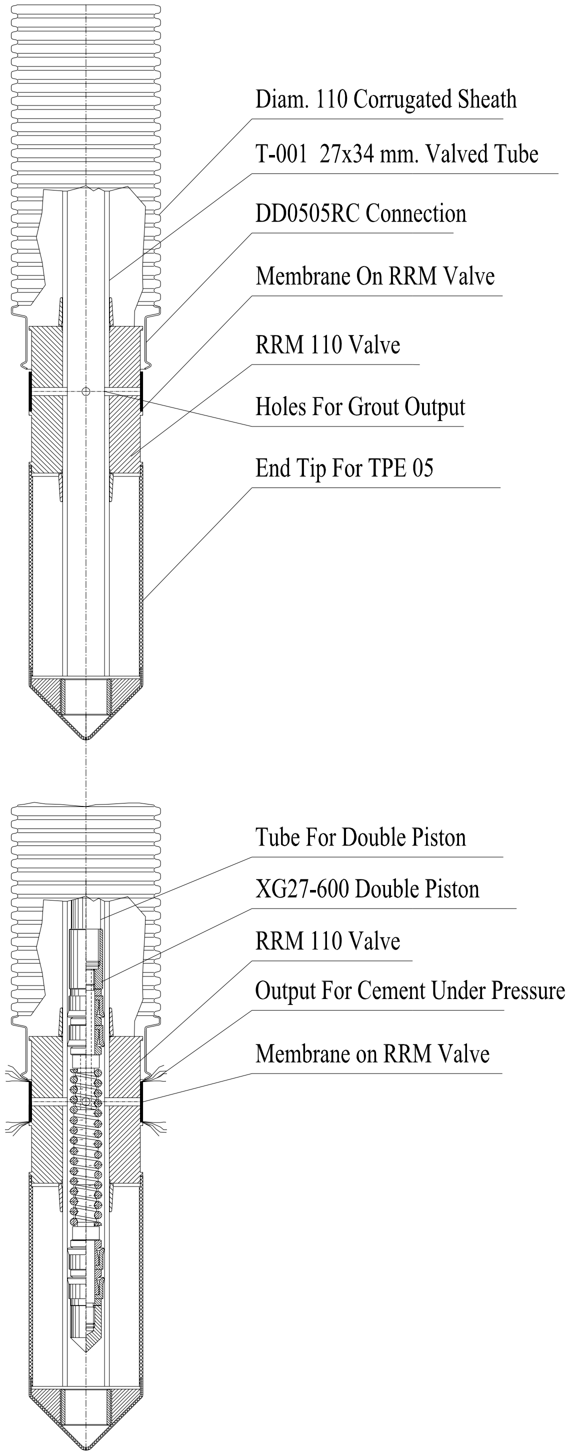




RRM *valves are used on* ***TPE05****permanent ground anchors which allow repeated and selective grouting* ***(I.R.S.).***
RRM *valves represent a solution to provide an anchor with regrouting without using additional valvate tubes on the outside, thus increasing the dimensions of the anchor and of the drilling necessary for the anchor. The new concept of the* ***RRM*** *110 valve guarantees a better sealing of the sheath, which is improved by using special adapters at one end. They are especially designed to be easily fixed on the sheath.*

TPE 05-A ground anchor

DD0505RC *adapters are screwed on a corrugated sheath diam. 110 mm. and strapped on* ***RRM*** *valves. The corrugated sheaths used have a diam. of 110 mm and are provided with a thread that can be coupled to the connection every 500 mm. The spacing of the valves that can be used is a multiple of 0.65 m: 0.65 m, 1.3 m, 1.95 m etc.*



*The **RRM** valve can be used for **I.R.S.** repeated selective grouting one by one, with XG 27-600 double piston.*

The double piston allows to concentrate grouting on each specific valve.

*The grouting thus allows to provide each **RRM** valve with 360° radial selective grouting.*
The valve recess with respect to the sheath offers to the anchor completely radial compound distribution areas that can keep the valve away from the walls of the drilling hole for a better distribution of the cement mix.

TPE 05-A ground anchor

Selective regrouting (I.R.S.) can be carried out again at 12 hour intervals in case of non sealing of the foundation bulb.

17.22 - External spacers

*(**EURO NORM EN 1537-2002** paragraph 6.6)*

*We offer centering systems of two types: **DD-EF**, **DD-ED and DD-CT**, in compliance with **EURO NORM EN 1537-2002 paragraph 6.6**. They are supplied separately from the anchor in the types **DD-EF** and **DD-ED** and must be installed on the anchor before its installation, while the **DD-CT** spacer/centralizer is installed at the factory at the anchor assembly as stated by the **Client's Technical Representative**.*

***DD-EF** spacers mounted on a permanent ground anchor*

*The **DD-EF** only guarantees the fixed spacing of the anchor from the hole walls at four points as stated by the Standard **EN 1537 2002 paragraph 6.6***

***DD-EF** spacer mounted with an external 27x34 mm valvate tube.*

***DD-ED** spacer mounted with an external 27x34 mm valvate tube*

*The **DD-ED** (dynamic type) spacer guarantees a dynamic centring of the centralizer. As it deforms it centres itself in the entire section of the drilling hole and on the entire circumference of the section concerned.*

***DD-ED** spacers mounted on a permanent ground anchor*

***DD-ED** centralizers for temporary ground anchors*

17.22.1 - DD-ED spacers (dynamic)
*(**EURO NORM EN 1537-2002** paragraph 6.6)*

*On customer's request, anchors are supplied with centralizers/spacers that allow the anchor centering in the hole and a minimum of 10 mm grout cover to the borehole wall. Spacers and centralizers shall not impede grout flow and are manufactured from corrosion resistant materials. There are two types of centering systems in compliance with **EURO NORM EN 1537-2002 paragraph 6.6** or as otherwise stated by the Client's Technical Representative. The **DD-ED** (dynamic type) spacer guarantees a dynamic centring of the centralizer. As it deforms it centres itself in the entire section of the drilling hole and on the entire circumference of the section concerned.*

***DD-ED** (dynamic) spacer*

17.22.2 - DD-EF spacers (fixed)
*(**EURO NORM EN 1537-2002** paragraph 6.6)*

*The **DD-EF** (fixed) spacer guarantees the fixed spacing of the anchor from the hole walls at four points.*

***DD-EF** spacer (fixed)*

These spacers are almost never required in geotechnical applications; in offers, they are quoted separately and they are included in the variations to standard supply in the sheet of each anchor.
Handling and transport operations can damage them; we recommend fitting external spacers on site before insertion into the borehole.

17.22.3 - DD-ED external spacers applications
*(**EURO NORM EN 1537-2002** paragraph 6.6)*

DD-ED (dynamic) spacer

*On customer's request, anchors are supplied with centralizers that allow the anchor centering in the hole and a minimum of 10 mm grout cover to the borehole wall. Spacers and centralizers shall not impede grout flow and are manufactured from corrosion resistant materials. There are two types of centering systems in compliance with **EURO NORM EN 1537-2002 paragraph 6.6** or as otherwise stated by the Client's Technical Representative. The **DD-ED** (dynamic type) spacer guarantees a dynamic centring of the centralizer. As it deforms it centres itself in the entire section of the drilling hole and on the entire circumference of the section concerned.*

Application of DD-ED spacer on TPE 02 S

DD-ED spacers supplied in two halves

17.22.4 - DD-EF external spacers applications
*(**EURO NORM EN 1537-2002** paragraph 6.6)*

DD-EF spacer on corrugated sheath

*On customer's request, anchors are supplied with spacers that allow the anchor centering in the hole and a minimum of 10 mm grout cover to the borehole wall. Spacers and centralizers shall not impede grout flow and are manufactured from corrosion resistant materials. There are two types of centering systems in compliance with **EURO NORM EN 1537-2002 paragraph 6.6** or as otherwise stated by the Client's Technical Representative.*

Application of DD-EF spacer on TPE 02SP

*The **DD-EF** (fixed) spacer guarantees the fixed spacing of the anchor from the hole walls at four points.*

Application of DD-EF spacer

They are available in the following sizes:

DD-60-EF *(60-70 mm inside diameter);*
DD-70-EF *(70-85 mm inside diameter);*
DD-85-EF *(85-95 mm inside diameter);*
DD-95-EF *(95-110 mm inside diameter).*

17.22.5 - DD-CT centralizers (fixed centralizers for temporary ground anchors)
*(**EURO NORM EN 1537-2002** paragraph 6.6)*

(Centralizers for temporary ground anchors)

*On customer's request, anchors are supplied with **DD CT** centralizers that allow to detach the anchor from the borehole wall. The **DD CT** centralizer can be considered an internal/external spacer; its installation on temporary ground anchors allows to obtain the effect of both the external and internal spacer with only one component.*

DD CT centralizer mounted on rolled up anchors

DD CT centralizer mounted on a 6-strand bulb

*The **DD CT** centralizer is installed during its production directly, during assembly phases, and it allows to supply sites with the rolled up anchor ready for the insertion into the drilling hole.*

DD CT centralizer mounted on TPR 00 rolled up anchors

17.23 - Internal spacers

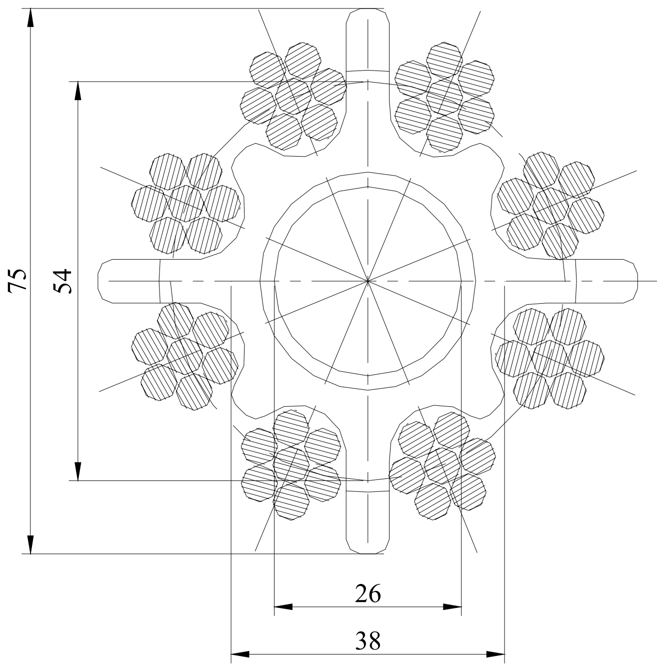
The internal spacers are made of H.D.P.E. and are designed to allow suitable strand distribution and sinusoid effect in the anchor. Fitting is executed with automatic and manual machines to guarantee a perfect assembly. The metal or tape straps allow a constant sinusoid pitch which is maintained when the rock anchorage is unrolled on site.

Fitted spacer

Spacer strapping on the bulb

The sinusoid effect of the strand is essential for correct bulb holding in the soil; this requires a careful execution for the success of an assembly.

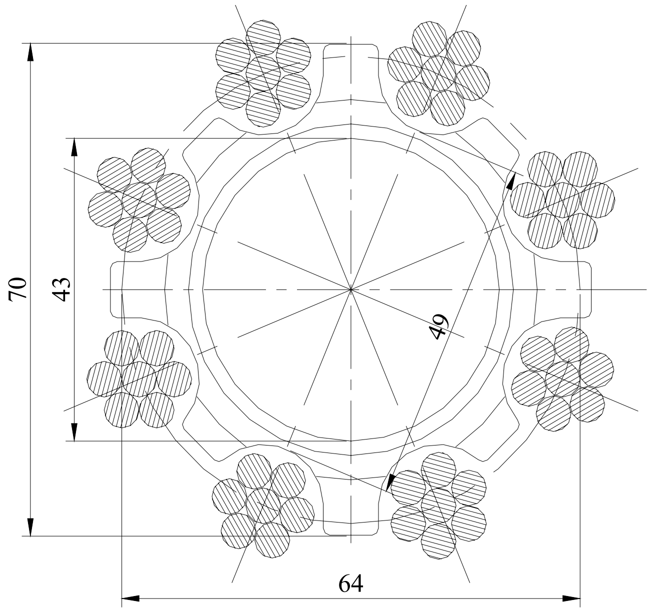
*The **8TRx20 DD 7002** spacer has a capacity of 8 seats per strand and an inside passage per tube with a diam. 26 mm.*



DD 7002 8TRx20 internal spacer

DD 7002 8TRx20 internal spacer

Strand installation external diameter: 38 mm.
Length: 60 mm.
Inside hole: 26 mm.
*The **8TRx40 DD 7001** spacer has a capacity of 8 seats per strand and an inside passage per tube with a diam. 27x34 mm. (use with valvate tubes)*

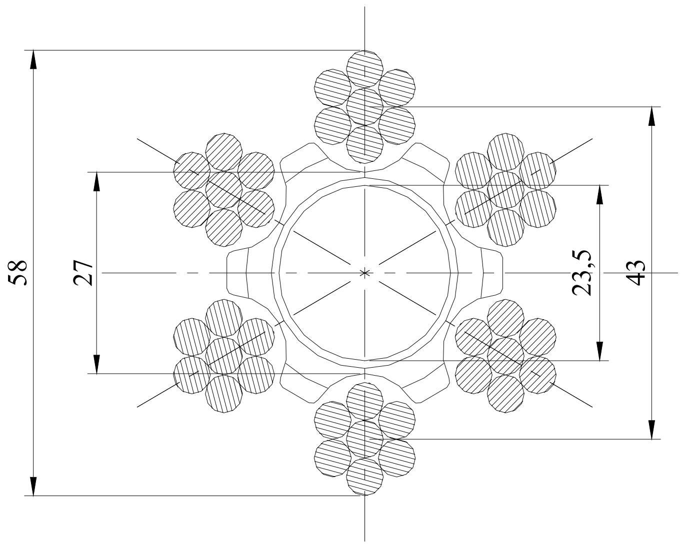


DD 7001 8TRx40 internal spacer

DD 7001 8TRx40 internal spacer

Strand installation external diameter: 49 mm.
Length: 55 mm.
Inside hole: 43 mm.

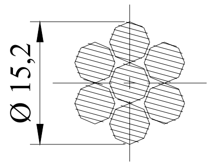
*The **6TRx20 DD 7003** spacer has a capacity of 6 seats per strand and an inside passage per tube with a diam. 23.5 mm.*

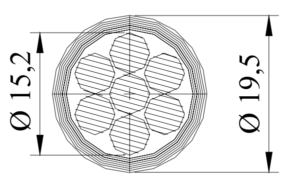


DD 7003 6Rx20 internal spacer

DD 7003 6Rx20 internal spacer

Strand installation external diameter: 27 mm.
Length: 60 mm.
Inside hole: 23.5 mm.



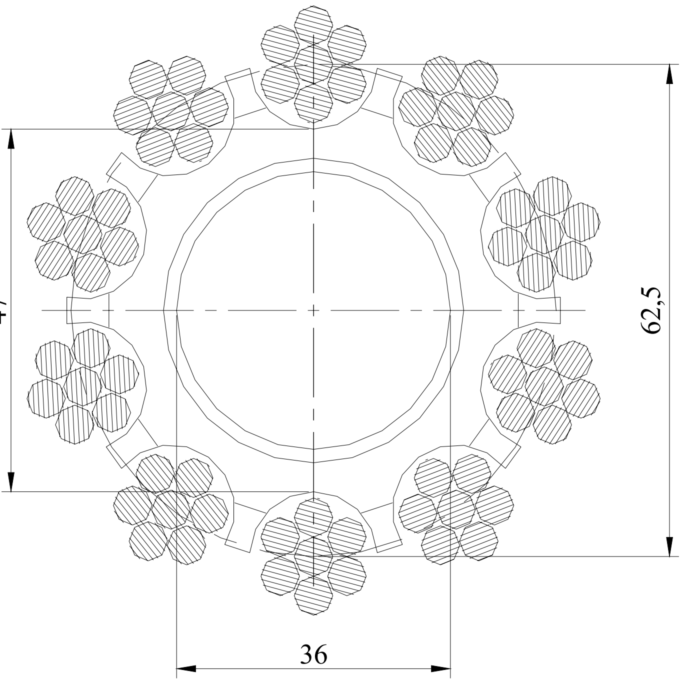


***Bare** strand nominal diameter:*

- *T15 normal 15.2 mm.*
- *T15S super 15.7 mm.*
- *T15C compact 15.2 mm.*

***Coated** strand nominal diameter:*

- *T15 normal 19.5 mm.*
- *T15S super 19.5 mm.*
- *T15C compact 19.5 mm.*

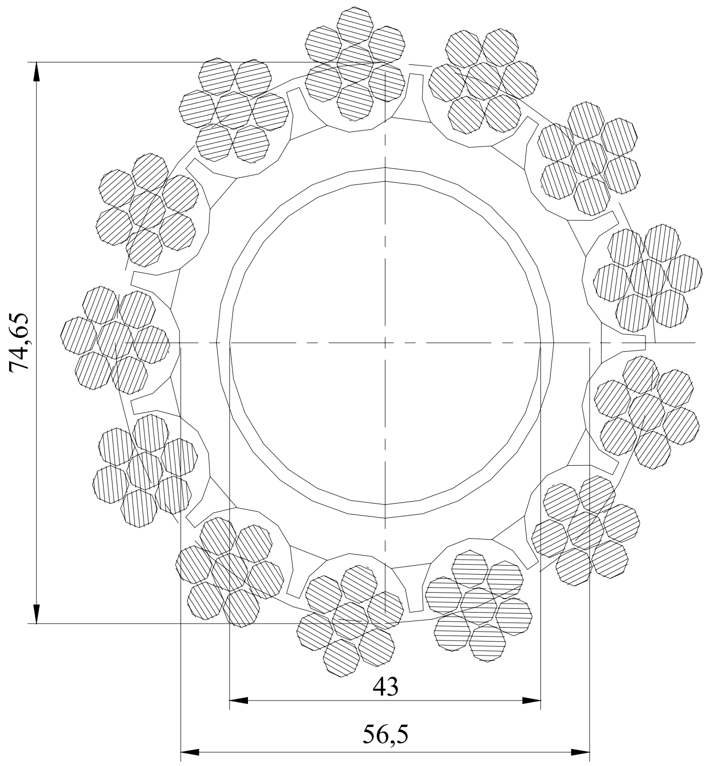


DD 7007 10Rx40 internal spacer

*The **10TRx40 DD 7007** spacer has a capacity of 10 seats per strand and an inside passage per tube with a diam. 36 mm.*

DD
7007 10Rx40 internal spacer

Strand installation external diameter: 47 mm.
Length: 60 mm.
Inside hole: 36 mm.



DD 7008 13Rx40 internal spacer

*The**13TRx40 DD 7008** spacer has a capacity of 13 seats per strand and an inside passage per tube with a diam. 43 mm.*

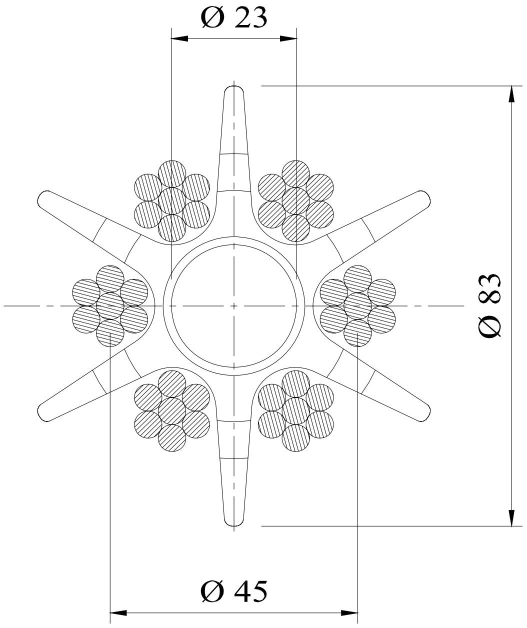
DD 7008 13Rx40 internal spacer

Strand installation external diameter: 56.5 mm.
Length: 60 mm.
Inside hole: 43 mm.

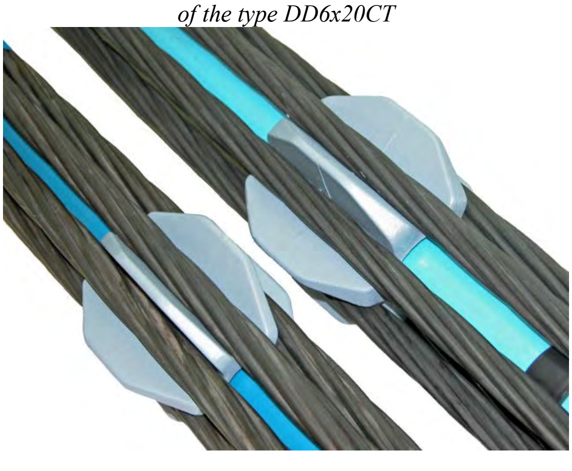
17.24 - DD-CT internal spacer/external internal centralizer

With the function of the internal spacer installed on the bulb, it also allows to obtain the function of an external centralizer, thus guaranteeing the correct spacing of the strands from the hole walls and the correct coverage of the tendon from the primary grouting.

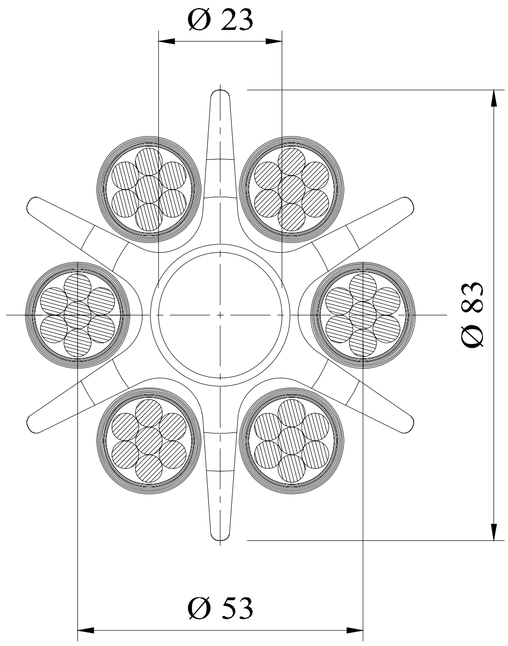
***DD-CT** centralizers allow to provide an anchor with external spacers directly from production, thus solving the problem of the cost of external spacers on permanent anchors. They can be used both on bare strands and on coated and grease strands.*



Internal spacer/external internal centralizer of the type DD6x20CT

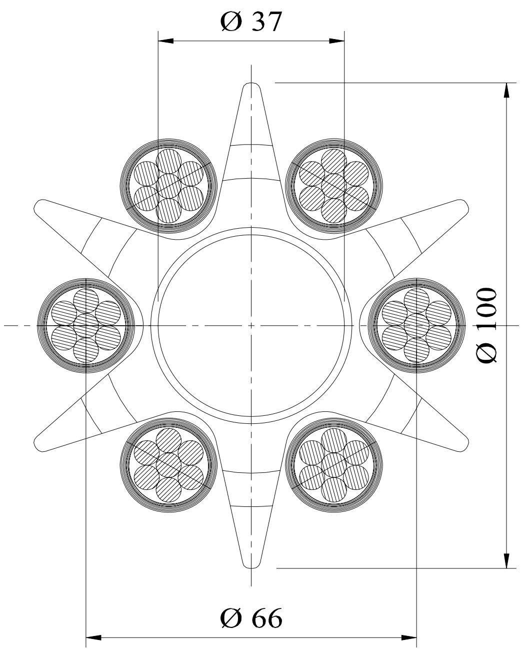


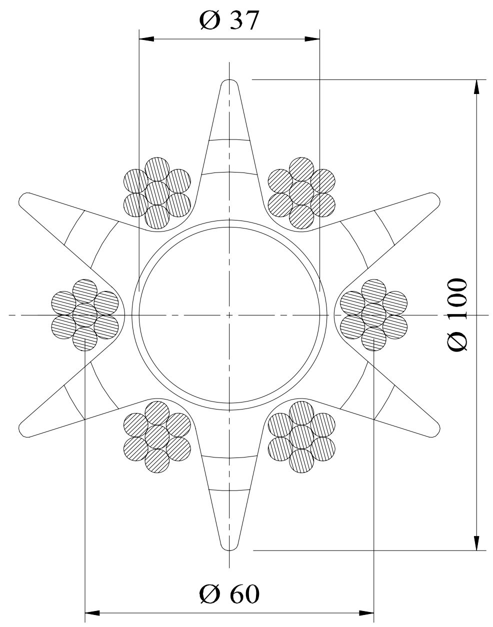
*The **DD6x20CT** internal spacer/ external internal centralizer has a capacity of max. 6 strands on the outside and a tube in the central hole.*

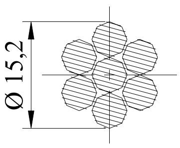


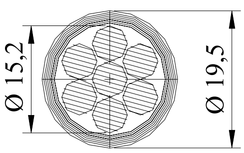
Internal spacer/external internal centralizer of the type DD6x20CT on coated strands

*The **DD6x34CT** internal spacer/ external internal centralizer has a capacity of max. 6 strands on the outside and a tube in the central hole of max. 37 mm.*









***Bare** strand nominal diameter:*

- *T15 normal 15.2 mm.*
- *T15S super 15.7 mm.*
- *T15C compact 15.2 mm.*

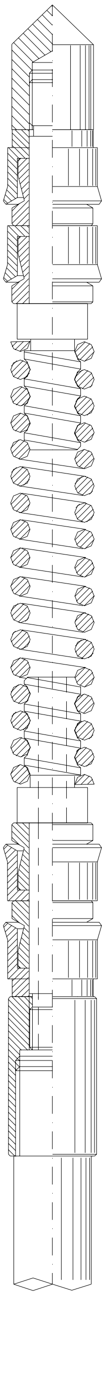
***Coated** strand nominal diameter:*

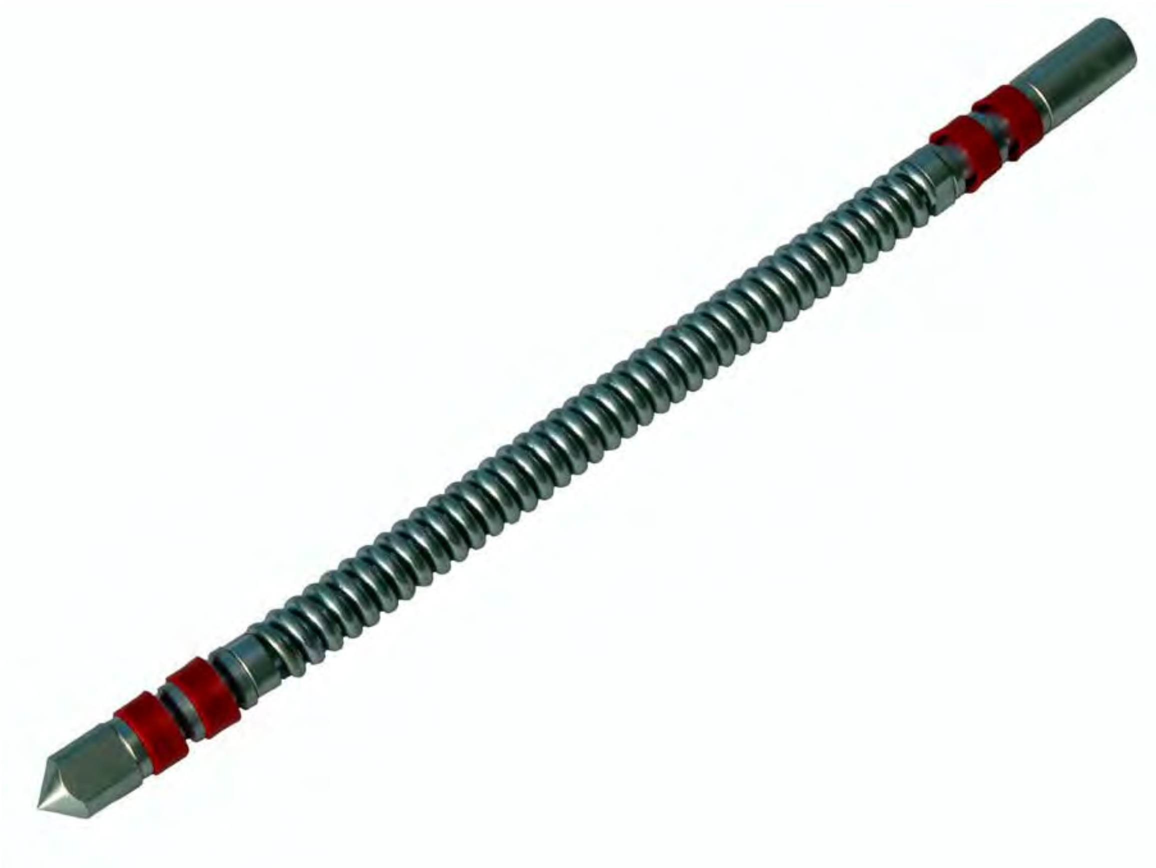
- *T15 normal 19.5 mm.*
- *T15S super 19.5 mm.*
- *T15C compact 19.5 mm.*

17.25 - XG27-600 double piston for selective grouting on the T001 tube

(On T-001 27/34 mm. valvate tube)

*The **XG27-600** double piston is produced with a highly resistant spring allowing flexibility; it compensates the natural deviations of the valvate tube and guarantees selective grouting of the manchette valves up to a max. pressure of 150 bar. **PO27** made of high abrasion resistance polyurethane, guarantee an extended life.*





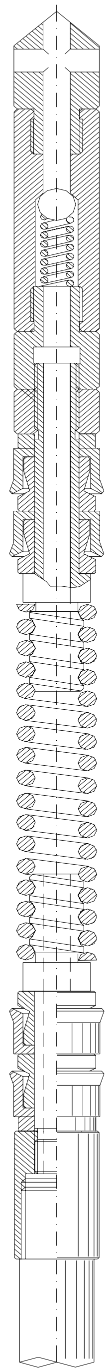
***XG27-600** flexible double piston tip with PO27 gaskets*

*Tip on **XG27-600 double piston***

17.26 - XG27-900 double piston for the cleaning of the T001 tube

(On T-001 27/34 mm. valvate tube)

*The **XG27-900** double piston is produced with a highly resistant spring allowing flexibility; it compensates the natural deviations of the valvate tube and guarantees selective grouting of the manchette valves up to a max. pressure of 150 bar. **PO27** made of high abrasion resistance polyurethane, guarantee an extended life. The double piston is supplied with fitted gaskets.*



***XG27-900** flexible double piston tip with PO27 gaskets*

Non return valve on XG27-900 double piston

*The **XG27-900** model is different from the **XG27-600** for a precalibrated valve placed on the tip that allows the reflowing of the fluids in the valvate tube as the double piston is inserted, which is used to clean the tube and empty the valvate tube.*

The special characteristic of this piston is its capacity to adapt to the deformations of the valvate tube, thus guaranteeing a perfect seal at grouting. It is also used for grouting on RRM valves or on T001 27/34 mm manchette valvate tubes.
***XG27-600** and **XG27-900** double pistons are made of a spring with two blocks with sealing gaskets at both ends; it allows the double piston to adapt to the curves of the valvate tube maintaining the seal even on out of shape tubes.*

PO27gaskets

XG27-600 flexible double piston tip

XG27-600 flexible double piston tip with PO27 gaskets

Selective or repeated regrouting can be carried out again at 12 hour intervals in case of non sealing of the foundation bulb.

15.33.2 - XG27-600 and XG27-900 double piston grouting

Filling of the casing with grouting mixture having a ratio water/dry mixture < 0.40.
After 12 hours since the insertion of the anchor, grouting can be carried out via the valves of the foundation bulb by 75 l per valve.

For a successful grouting we recommend:

- *an accurate cleaning after each phase of operation of the 27x34 mm T 001 tube;*
- *use of XG 27-600 double pistons only;*
- *for a better handling: of re-grouts, tube cleaning, re-insertion of 27x34 mm. T 001 tubes full of mixture or water, double pistons with XG 27-900 nonreturn valve on the tip;*
- *for primary grouts use 325 cement, 425 for the next ones;*
- *replace grouting caps on the double piston when worn out;*
- *carefully wash the double piston by disassembling it after each use.*

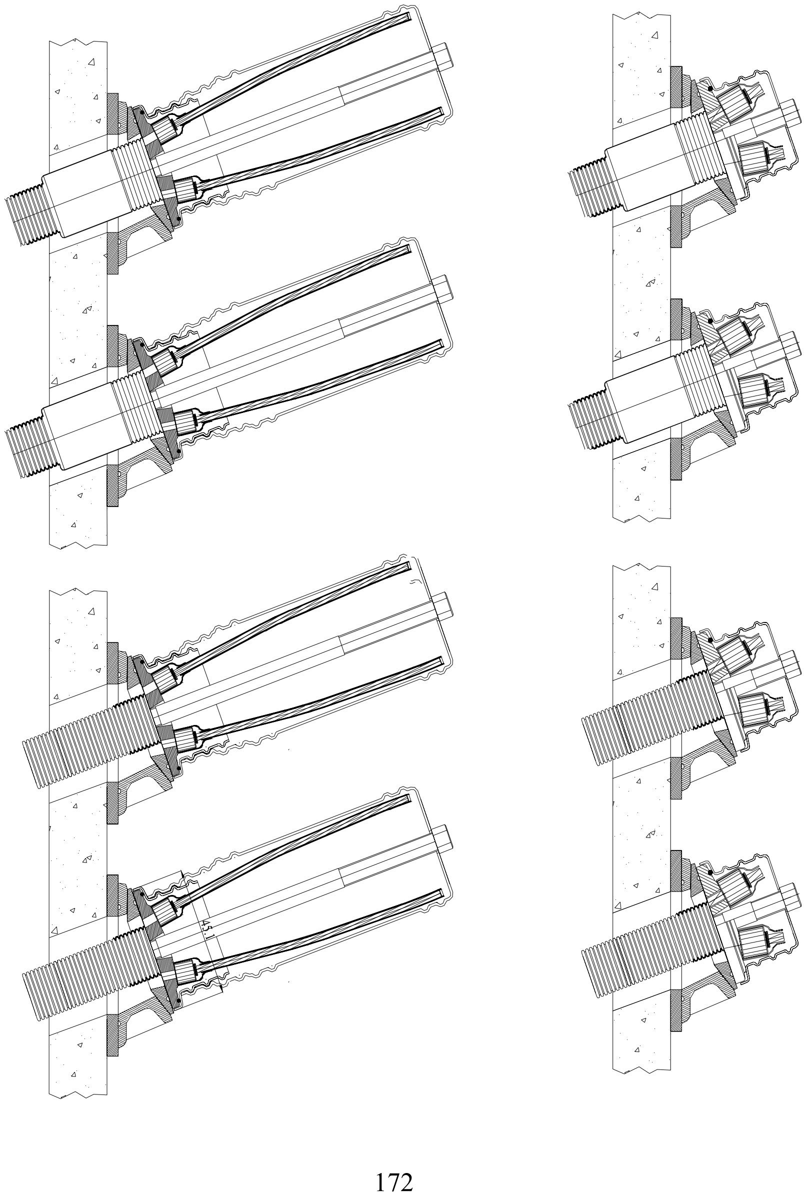
To ease grouting under high pressure conditions, the use of 325 cement is suggested at the opening of manchette valves.
The special characteristic of this piston is its capacity to adapt to the deformations of the valvate tube, thus guaranteeing a perfect seal at grouting. It is used for grouting on RRM valves or on 27/34 mm manchette valvate tubes.
The XG27-600 double piston are made of a spring with two blocks with sealing gaskets at both ends; it allows the double piston to adapt to the curves of the valvate tube maintaining the seal even on out of shape tubes.

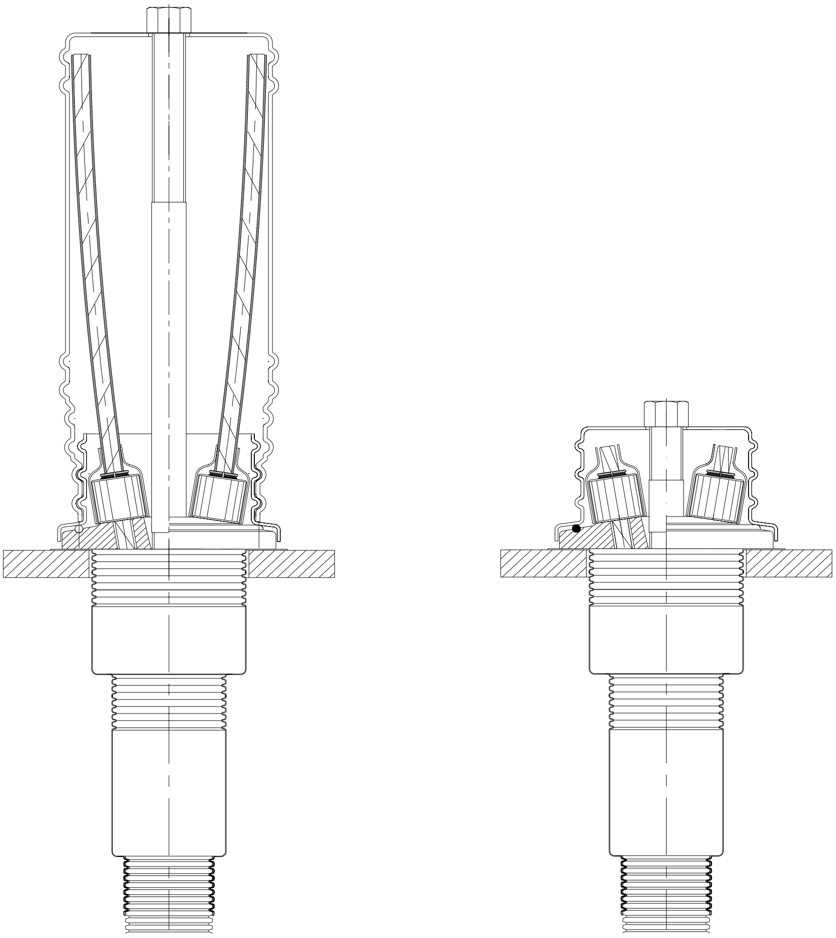
17.27- UNDER PLATE PROTECTION FOR PERMANENT GROUND ANCHORS

*(**EURO NORM EN 1537-2002** paragraph 6.10.1.)*

(DD200SP under plate protection)

- *The purpose of the under plate protection according to EURO NORM EN 1537-2002 paragraph 6.11.3 is to provide an effective connection/protection between the sheath of the free length and the anchorage.*
- *Its function consists in protecting the small section of tendon under the bearing plate and to guarantee the continuity of the plate. The application of the total protection requires the use of TTM corrugated sheaths, provided with a 100 mm long thread every 500 mm of sheath. In order to solve the problem of the continuity of the seal between free length and anchorage, the device was provided with a thread on the end part to connect it to the thread placed on the corrugated sheath. The DD200SP under plate connection is made for the coupling with the 110 mm sheath. Further reductions for a correct connection with the anchor sheath can be made by using DD-RC connections.*





*The **DD200SF** connection is made of polyethylene with a minimum thickness of 1.5 mm. It can be connected to a flange in the upper part to ensure connection with the TTR or TTM anchor plate.*
The upper flange must be placed between plate and contrast.

DD200SP under plate connection with protection cap

*The under plate protection according to **EURO NORM EN 1537-2002 paragraph 6.11.3** can be installed on site on all the anchors provided with a corrugated sheath on the free length. It can be installed to screw a **DD200SF connection.***

Examples of corrosion protection systems for permanent anchors
EURO NORM EN 1537-2002 paragraph 6.10.1
Table 3:

Table 3. Transition between anchor head and free length
A coated, grouted or cast-in metal sleeve or fixed plastic duct is sealed or welded to the anchor head. It is sealed to the free length sheath or duct and filled with corrosion protection compound, cement or resin.

Under plate protection with protection of elementary anchorages

Examples of corrosion protection systems for permanent anchors EURO NORM EN 1537-2002 paragraph 6.10.1 *Table 3:*

Table 3: Transition between anchor head and free length

A coated, grouted or cast-in metal sleeve or fixed plastic duct is sealed or welded to the anchor head. It is sealed to the free length sheath or duct and filled with corrosion protection compound, cement or resin.

Under plate protection with protection of elementary anchorages and long protection cap

DD200SP under plate connection

*The use of the **DD200SF** under plate protection with the TTR-100 or TTR-450 protection cap <u>allows the encapsulation</u> of the anchorage, thus guaranteeing the maximum protection for the TTR anchorage.*

DD200SP-78 under plate connection

The DD200SF connection is made of polyethylene with a minimum thickness of 1.5 mm. It can be connected to a flange in the upper part to ensure connection with the TTR or TTM anchor plate, it must be placed between plate and contrast.

The DD200SF-78 device is designed for the use on 7TTR15 and 8TTR15 anchor plates.

DD200SP-56 under plate connection

The DD200SF-56 device is designed for the use on 5TTR15 and 6TTR15 anchor plates.

DD200SP-234 under plate connection

The DD200SF-234 device is designed for the use on: 2TTR15, 3TTR15 and 4TTR15 anchor plates. In this version the flange directly connects with the corrugated sheath diam. 110 mm. which in its turn can be connected with a sheath diam. 75 mm.

DD-RC connections allow to connect sheaths between each other, reducing or increasing the application of corrugated sheaths: 75 mm., 90 mm. and 110 mm.

DD-RC connections for corrugated sheaths

17.28 – Application of corrosion protections
(EURO NORM EN 1537-2002 *paragraph 6.10.1.)*

Abstract from EURO NORM EN 1537-2002 *paragraph 6.11.1*

The principles of protection are the same for all parts of the anchor but different detailed treatments are necessary for the tendon bond length, the tendon free length and the anchor head.
The protective system shall not restrict any stressing or destressing operation nor be damaged by it. A lubricant or bond free contact shall be present within either the individual sheaths or the common sheath to ensure free movement of the tendon(s) during stressing.
Particular care shall be taken to seal transition points from one protection component to another and at end points. The ground anchor or any part of it shall be handled in such a way that the corrosion protection system is not damaged.

17.29 – Anchor head
(EURO NORM EN 1537-2002 *paragraph 6.10.1.)*

(sealing gasket between cap and anchor plate)

Abstract from EURO NORM EN 1537-2002 *paragraph 6.11.3*

Where the environment is aggressive, <u>early protection of the anchor head shall be applied to both temporary and permanent anchors</u>.
The purpose of the inner head protection is to provide an effective overlap with the free length protection, <u>to protect the short exposed length of tendon below and passing through the bearing plate.</u>

TTR *and* ***TTR-E*** *anchorages are provided with a gasket to seal the anchorage together with a mechanical closing of the cap.*
The strand whips are coated with low-saponification grease to maintain its properties over time.
The grout of the back part of the anchorage can be filled up from the central hole, which allows air to exit at the same time.
The back filling up of the anchorage, together with the containment offered by the under plate protection ***EURO NORM EN 1537-2002*** *paragraph 6.11.3, is the correct application to guarantee <u>the small section of the tendon below and through the bearing plate.</u>*

Where injection techniques are employed, a lower injection pipe and upper vent pipe should be used to ensure complete filling of the void. Where no access for injection of the inner head is provided, a prepacked corrosion protection compound may be used. Where restressability or load checking is not required, reins, grouts and other setting sealants may be used within the anchor cap.
<u>Where restressability or load checking is required the outer head protection including the anchor head</u>

cap and its contents shall be removable. It shall be possible to refill the cap with corrosion protection compound.

Sealing OR between plate and protection cap

A suitable seal and mechanical coupling shall be provided between the cap and the bearing plate.
*Where applied to permanent anchors the bearing plate and the other exposed steel components at the anchor head shall be protected in accordance with the relevant **EN** for the coating of steel structures prior to being brought onto site.*
Steel caps for permanent anchors shall have a minimum wall thickness of 3 mm. Reinforced plastic caps having a minimum wall thickness of 5 mm may be used, where approved by the Client's Technical Representative.
The protection system applied to the inner and outer anchor head shall be subjected to a system test (see 6.12).

17.30 – Corrosion protection testing for permanent anchors
***(EURO NORM EN 1537-2002** paragraph 6.12)*

(manual removal of the elementary protection for testing)

***Abstract from EURO NORM EN 1537-2002** paragraph 6.12*

All corrosion protection systems shall have been subjected to at least one system test to verify the competence of the system. The results of all tests shall be documented.
*The type of system test carried out for each anchor system shall be approved, in accordance with the principles stated herein, by the **Client's Technical Representative,** who shall assess the documented results of the corrosion system tests in order to verify that the protection offered by each barrier in the system has been achieved. The loading sequence shall comply with one or three types of suitability tests in clause 9 of the **EURO NORM EN 1537-2002**. The confinement conditions in the test bond length shall simulate those encountered in the ground, be it rock or soil.*

Note: Either insitu tests or simulated laboratory tests are performed. Laboratory tests may include uniform stressing of encapsulated tendons as well as simulating the load transfer in the bond length

Where an insitu test is undertaken the installation procedure shall simulate the procedure used with production anchors. After loading the test anchors shall be uncovered with care in order to observe the effect of the stressed condition on the corrosion protection system. The following properties of the corrosion protection system shall be assessed by inspection or measurement, where appropriate:

- *wall thickness and integrity of plastic ducts;*
- *integrity of joints and seals;*

- *grout cover and performance of spacers and centralizers;*
- *location and spacing of cracks in the cement grout where it serves as a corrosion protective barrier;*
- *degree of filling of grout, resin and corrosion protection compound in ducts and volumes of containment;*
- *damages to coatings;*
- *degree of bond or debonding along surfaces;*
- *dislocation of components during installation and loading.*

It should be noted that in certain systems the integrity of the inner protective barrier depends on the maintenance of the integrity of the outer barrier.
Where plastic duct(s) are used as a protection barrier in the bond length of a permanent anchor the system test should demonstrate the integrity of the pregrouted encapsulation. The test should simulate the loading condition by preloading in an environment which approximates the ground conditions. The inspection of the plastic after the loading should prove that protection has not impaired. A single documented test for a tendon arrangement in each particular duct size is sufficient in the simulated load condition (an example of a test is described in annex B).

Dez Dam IRAN Contractor: Iran Water Resources Development TPE 02SP permanent anchors according to EN 1537

The control of corrosion protection is fundamental in the application of permanent anchors where they have a static function to protect against geological instability.

18.0 - ANCHORAGE TYPES

Anchorages are devices that transmit the tensile load of elementary anchors to the anchorage. Permanent and temporary ground anchors can be provided with several anchorage systems based on the client's requests. The following systems may be installed: ***TTR, TTR-E, TTM-F, TTM, and TTR-DDSF.***

TTM-PE15 anchorages *(short cap) TTM-PE15 anchorages are designed for the application of permanent ground anchors, where the protection of the whole anchorage and of strands is required.*
The plate can be certified according to the ***Construction technical regulations of the Ministerial Decree of the 14.01.2008*** *and according to the Multi-**strand systems** European Technical approval* ***B.T.E. ETA-09-0013*** *and its relating marking* ***CE 0969-CPD-002/09-PT.***

TTM-PE15 anchorage with short cap

TTM-PE15 anchorages *(long cap). TTM-PE15 anchorages are designed for the application of permanent ground anchors, where the protection of the whole anchorage and of long strands is required to allow retensioning or a verification of the anchor tensioning values over time.*
The plate can be certified according to the ***Construction technical regulations of the Ministerial Decree of the 14.01.2008*** *and according to the Multi-**strand systems** European Technical approval* ***B.T.E. ETA-09-0013*** *and its relating marking* ***CE 0969-CPD-002/09-PT.***

TTM-PE15 anchorage with long cap

TTM-PR15 anchorages *(retensioning long strands) anchorages are designed for the application of temporary ground anchors, where no particular protection of the anchor and of long strands is required.*
The plate can be certified according to the ***Construction technical regulations of the Ministerial Decree of the 14.01.2008*** *and according to the Multi-**strand systems** European Technical approval* ***B.T.E. ETA-09-0013*** *and its relating marking* ***CE 0969-CPD-002/09-PT.***

TTM-PR15 anchorage with long strands

TTM-PE15 anchorages *(long cap). TTM-PE15 anchorages are designed for the application of permanent ground anchors, where the protection of the whole anchorage and of long strands is required to allow retensioning or a verification of the anchor tensioning values over time. On this anchorage further protection can be given to strands by inserting a 16x19.5 mm tube on each strand.*

The plate can be certified according to the ***Construction technical regulations of the Ministerial Decree of the 14.01.2008*** *and according to the Multi****-strand systems*** *European Technical approval* ***B.T.E. ETA-09-0013*** *and its relating marking* ***CE 0969-CPD-002/09-PT.***

TTM-PE15 anchorage with long cap and protected strands

TTM-F-PR15 anchorages *(short strands). TTM-F-PR15 anchorages are designed for the application of temporary ground anchors, where no particular protection of the anchor and of strands is required. The anchorage is provided with an external thread for hooking, for an applied load check with a lift-off operation.*

The plate can be certified according to the ***Construction technical regulations of the Ministerial Decree of the 14.01.2008*** *and according to the Multi****-strand systems*** *European Technical approval* ***B.T.E. ETA-09-0013*** *and its relating marking* ***CE 0969-CPD-002/09-PT.***

TTM-F-PR15 anchorage with threaded plate and short strands

TTM-F-PE15 anchorages (*short cap). TTM-F-PE15 anchorages are designed for the application of permanent ground anchors, where no particular protection of the anchor and of short-cap strands is required. The anchorage is provided with an external thread for hooking, for an applied load check with a lift-off operation. On this anchorage further protection can be given to strands by inserting a 16x19.5 mm tube on each strand.*

The plate can be certified according to the ***Construction technical regulations of the Ministerial Decree of the 14.01.2008*** *and according to the Multi****-strand systems*** *European Technical approval* ***B.T.E. ETA-09-0013*** *and its relating marking* ***CE 0969-CPD-002/09-PT.***

TTM-F-PE15 anchorage with short cap

TTM-F-PR15 anchorages *(retensioning long strands). TTM-F-PR15 anchorages are designed for the application of temporary ground anchors, where no particular protection of the anchor and of strands is required. Long strands allow the anchorage retensioning. The anchorage is provided with an external thread for hooking, for an applied load check with a lift-off operation.*

The plate can be certified according to the ***Construction technical regulations of the Ministerial Decree of the 14.01.2008*** *and according to the Multi**-strand systems*** *European Technical approval* ***B.T.E. ETA-09-0013*** *and its relating marking* ***CE 0969-CPD-002/09-PT.***

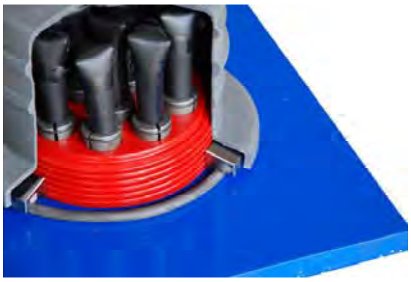
TTM-F-PR15 anchorage with threaded plate and long strands

TTM-F-PE15 anchorages *(long cap). TTM-F-PE15 anchorages are designed for the application of permanent ground anchors, where no particular protection of the anchor and of long-cap strands is required. The anchorage is provided with an external thread for hooking, for an applied load check with a lift-off operation. On this anchorage further protection can be given to strands by inserting a 16x19.5 mm tube on each strand.*

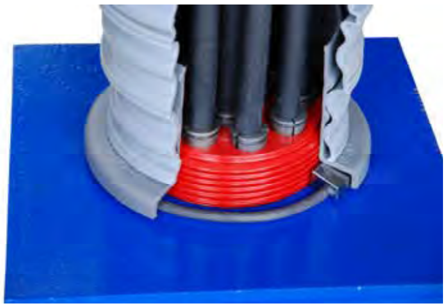
The plate can be certified according to the ***Construction technical regulations of the Ministerial Decree of the 14.01.2008*** *and according to the Multi**-strand systems*** *European Technical approval* ***B.T.E. ETA-09-0013*** *and its relating marking* ***CE 0969-CPD-002/09-PT.***

TTM-F-PE15 anchorage with long cap

On this anchorage further protection can be given to strands by inserting a 16x19.5 mm tube on each strand. We suggest to cover the strands with grease before applying the tube, thus allowing a further protection against corrosion.



TTM-F-PE15 anchorage with short cap with single strand protection



TTM-F-PE15 anchorage with long cap with single strand protection

TTR anchorages *(retensioning bare strands). TTR anchorages are designed for the application of temporary ground anchors, where no particular protection of the anchor and of strands is required. The anchorage allows its retensioning over time, provided the protection of elementary anchorages in order to guarantee their re-use.*

*The **TTR** plate cannot be certified according to an **"European Technical Approval"** but it is provided with qualification tests in compliance with the **Ministerial Memorandum dated 15th October 1996 no. 252 AA.GG./S.T.C. Paragraph F.** and qualified according to the **Construction technical regulations of the Ministerial Decree of 14.01.2008.** It is however going to obtain the **European Technical Approval** according to the **ETAG013 guidelines.***

TTR temporary anchorage with long strands for retensioning

TTR anchorages *(with long strands protected by elementary protections). TTR anchorages are designed for the application of temporary ground anchors, where no particular protection of the anchor and of strands is required. The anchorage allows its retensioning over time, provided the protection of elementary anchorages in order to guarantee their re-use.*

*The **TTR** plate cannot be certified according to an **"European Technical Approval"** but it is provided with qualification tests in compliance with the **Ministerial Memorandum dated 15th October 1996 no. 252 AA.GG./S.T.C. Paragraph F.** and qualified according to the **Construction technical regulations of the Ministerial Decree of 14.01.2008.** It is however going to obtain the **European Technical Approval** according to the **ETAG013 guidelines.***

TTR temporary anchorage with singularly protected long strands for retensioning

TTR anchorages *(with long strands protected by elementary protections and long cap). TTR anchorages are designed for the application of permanent ground anchors, where the protection of the anchor and of strands is required. The anchorage allows its retensioning over time, provided the protection of elementary anchorages in order to guarantee their re-use.*

*The **TTR** plate cannot be certified according to an **"European Technical Approval"** but it is provided with qualification tests in compliance with the **Ministerial Memorandum dated 15th October 1996 no. 252 AA.GG./S.T.C. Paragraph F.** and qualified according to the **Construction technical regulations of the Ministerial Decree of 14.01.2008.** It is however going to obtain the **European Technical Approval** according to the **ETAG013 guidelines.***

TTR permanent anchorage with individually protected long strands and long protection cap

TTR anchorages *(with short strands protected by elementary protections and short cap). TTR anchorages are designed for the application of permanent ground anchors, where the protection of the anchor and of strands is required. This anchorage does not allow its retensioning over time.*

*The **TTR** plate cannot be certified according to an **"European Technical Approval"** but it is provided with qualification tests in compliance with the **Ministerial Memorandum dated 15th October 1996 no. 252 AA.GG./S.T.C. Paragraph F.** and qualified according to the **Construction technical regulations of the Ministerial Decree of 14.01.2008.** It is however going to obtain the **European Technical Approval** according to the **ETAG013 guidelines.***

TTR permanent anchorage with individually protected short strands and short protection cap

TTM anchorage with short cap with single protection strands and OR for cap sealing

TTM anchorage with short cap and OR for cap sealing

TTS anchorages *(short strands protected by elementary protections and short protection cap). TTS anchorages are designed for the application of inclined surfaces up to max. 15° on permanent anchors, where no protection is required.*

*The **TTS** plate cannot be certified according to the **Construction technical regulations of the Ministerial Decree of 14.01.2008** or according to a **"European Technical Approval"***

TTS temporary anchorage with short strands where no protection cap can be installed.

TTS anchorage, application of spherical bushes

18.1 - TTR anchorages

TTR anchorages

TTR *anchorages represent most applications and allow to anchor* ***2 to 9 strands.*** *They can be used with both short and long caps and they are laboratory tested. On* ***TTR*** *anchorages, TTM250KN jacks can be simultaneously tensioned by using as many jacks as the strands. The tensioning of anchorages from 2 to 9 strands can be carried out manually without any mechanical lifting machine as the jacks used for tensioning are 23 Kg. /each. The* ***TTR*** *anchor plate has to be checked when transferring load. If proper values do not result, it will be necessary to install a suitable distribution plate. The most convenient protection to apply to single anchorages is the* ***DD0015-CV*** *bush cover, which is designed to protect single T15 anchorages against corrosion. The anchorage must be manually covered with grease and then covered with the* ***DD0015-CV*** *casing. The strand protruding from the casing is protected by a 16x20mm polyethylene tube that is cut to size and is such as to protect the strand on its whole length.*

Application of a 5TTS15 anchorage orthogonal to the wall

Application of a 5TTR15 anchorage orthogonal to the wall. TTR plates can be applied orthogonally only if there are orthogonal holes. If not, strands are subjected to a tangential strength causing them to fail.

The ***TTR*** *plate cannot be certified according to an* ***"European Technical Approval"*** *but it is provided with qualification tests in compliance with the* ***Ministerial Memorandum dated 15th October 1996 no. 252 AA.GG./S.T.C. Paragraph F.*** *and qualified according to the* ***Construction technical regulations of the Ministerial Decree of 14.01.2008***

Strands are fixed on the plate by means of conical trunk bushes made of ***C40-45 EN 10083/1*** *steel and with 7015-T15 clamps made of* ***16NiCr4Pb EN 10277-4*** *steel or 7017-T15 made of* ***9SMnP28 4838*** *steel.*

18.2 - TTR-E anchorages

TTR-E anchorages

***TTR-E** anchorages are produced according to the **ETAG013** guidelines and are going to obtain a qualification. They are made according to the norm **EN 1537-2002 paragraph 6.3** where a max deviation of the strand 3° is tolerated from the normal direction, and in compliance with the Eurocode 2. In **TTR-E** anchorages there are from 2 to 8 strands made of **C40-45 EN 10083/1,** that can be used with both short and long caps. **TTM250KN** jacks can be simultaneously tensioned by using as many jacks as the strands. The tensioning of **TTR-E** anchorages from 2 to 8 strands can be carried out manually without any mechanical lifting machine by moving one jack at a time as they are 23 Kg. /each.*

*The **TTR-E** anchor plate has to be checked when transferring load. If proper values do not result, it will be necessary to install a suitable distribution plate.*
*The application of the **TTR-E** anchorage requires a plain supporting surface that is orthogonal to the hole to prevent strands from being subjected to a tangential strength causing them to fail.*
*TTR plates are made of **C40-45 EN 10083/1.** Strands are fixed on the plate by means of conical trunk bushes made of **C40-45 EN 10083/1** steel and with 7015-T15 clamps made of **16NiCr4Pb EN 10277-4** steel.*

*The **TTR-E** plate can be certified according to the ETAG013 guidelines and the "**European Technical Approval"** and qualified according to **Construction technical regulations of the Ministerial Decree of 14.01.2008***

18.3 - TTS anchorages

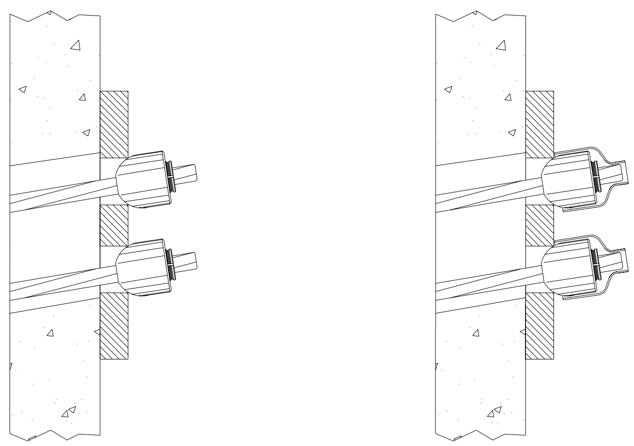
TTS anchorages

***TTS** anchorages represent a solution to anchor a ground anchor with an inclination up to 15°. They are available up to max. 6 strands, while bigger applications are not recommended as they cause:*

- *an increase in the borehole,*
- *an increase in the thickness of the plate,*
- *a decrease in the angular compensation reducing the max. value by 15°*

TTS anchorages cannot install caps, so they can only be used on temporary ground anchors.

Application of a 5TTS15 anchorage

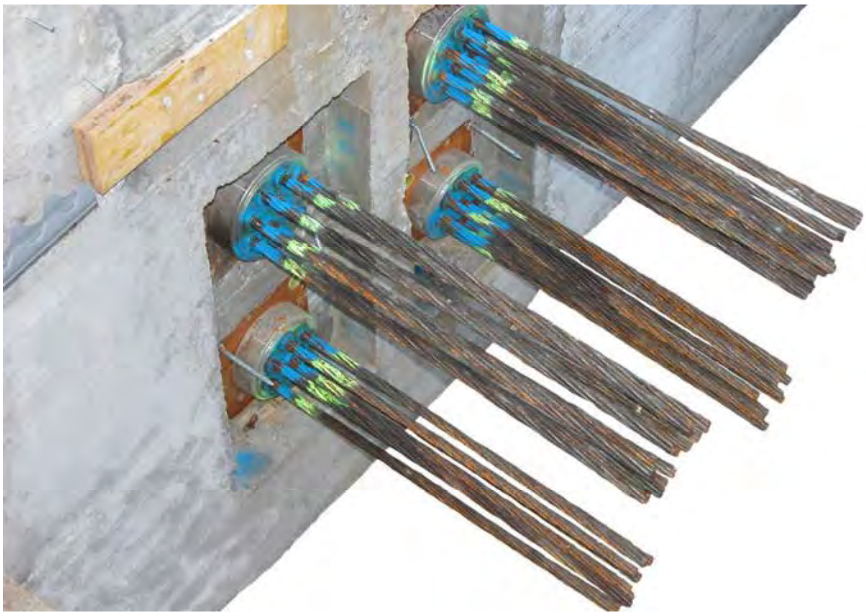


*In the application of a **4TTS15** anchorage, the spherical bushes are laid on an oxygen-cut hole allowing their rotation when tensioning.*
This application cannot be protected with a standard cap, but a special inclined-base cap must be made from carpentry production.
*The **TTS** plate <u>cannot be certified</u> according to the **Construction technical regulations of the Ministerial Decree of 14.01.2008** or according to a **"European Technical Approval"***

18.4 - TTM and TTM-F anchorages

12TTM-F15 anchorage

TTM *anchorages represent a small part of applications. They are generally used for tensioning with the multi-strand single jack which reduces the anchorage dimensions on the contrary of a M jack that must be handled with proper mechanical lifting machines due to its weight of 120-390 Kg/each.*



TTM-F *anchorages are externally equipped with a thread that allows on request to check the residual stress in the anchorage.*
TTM and TTM-F *anchorages must be provided with a suitable distribution plate at the installation which must take into consideration the borehole and the transfer surface of the load applied to the anchor.*

The plate can be certified according to the ***Construction technical regulations of the Ministerial Decree of the 14.01.2008*** *and according to the Multi-****strand systems*** *European Technical approval* ***B.T.E. ETA-09-0013*** *and its relating marking* ***CE 0969-CPD-002/09-PT***

18.5 - DD-SF spherical supports

DD-SF *spherical supports are recommended for the installation of temporary and permanent inclined ground anchors, offering the installer with:*

- *Correction of boring angles,*
- *No use of welded structures to guarantee square anchoring,*
- *Easy installation,*
- *Easy fixing to the bulkhead*

Angle compensation with spherical support DD-SF on TTM anchorage

The flexibility of ***DD-SF*** *supports allows the following angle possibilities:*

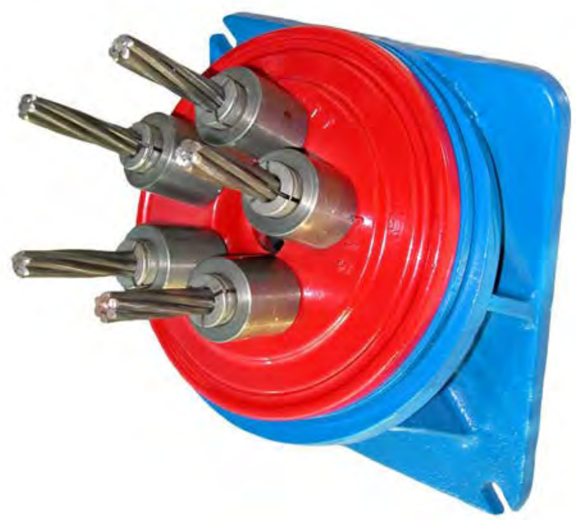
- ***DD 0525SF*** *installations with 20 to 30° of inclination*
- ***DD 0520SF*** *installations with 15 to 25° of inclination*

The ***DD-SF*** *spherical support allows the installation of temporary and permanent ground anchors.*

The spherical cap rests on a support that transfers the force to the bulkhead, reducing the load transfer coefficient.

The ***DD-SF*** *supports are designed for the installation of a transition tube by a thread located at the rear; this possibility guarantees boring continuity through bulkheads and supports.*

The inclination is given by a spherical support that guarantees a self-aligning effect to the boring axis.

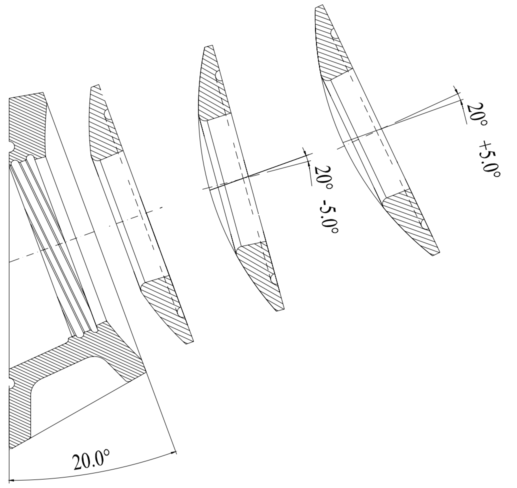


DD-SF spherical support with 5TTR plate applied

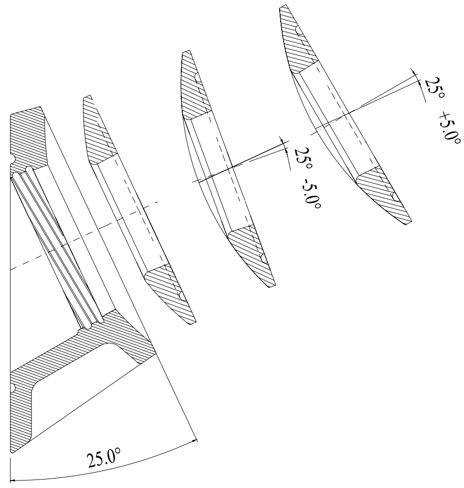
Installation from 15 to 25° of inclination +/- 5°

*TTR anchorage on spherical support: elementary anchorages are protected by elementary protections "****DD0015-CV bush covers****". These protections are designed to protect the single T15 anchorages covered with grease against corrosion.*

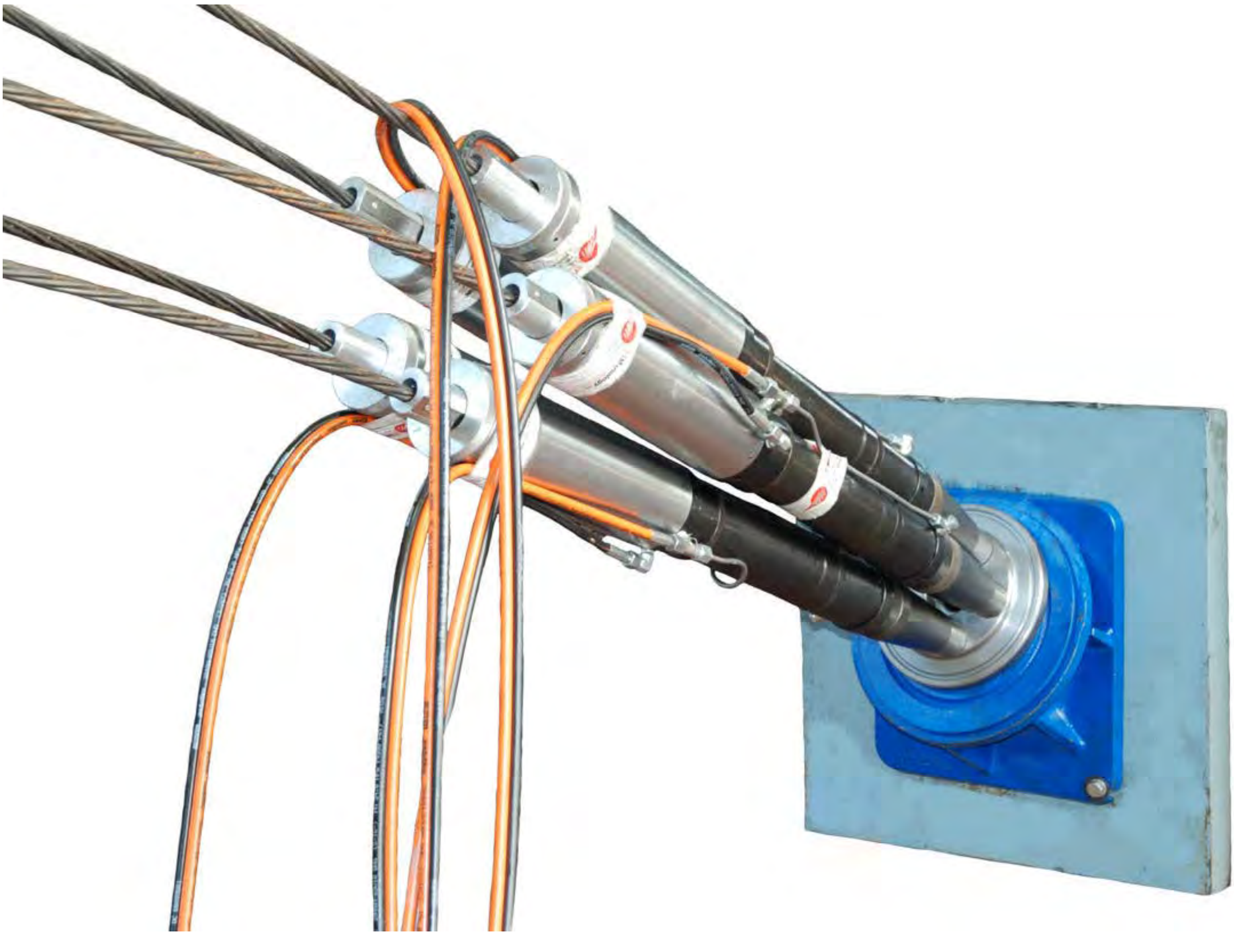
Installation from 20 to 30° of inclination +/- 5°



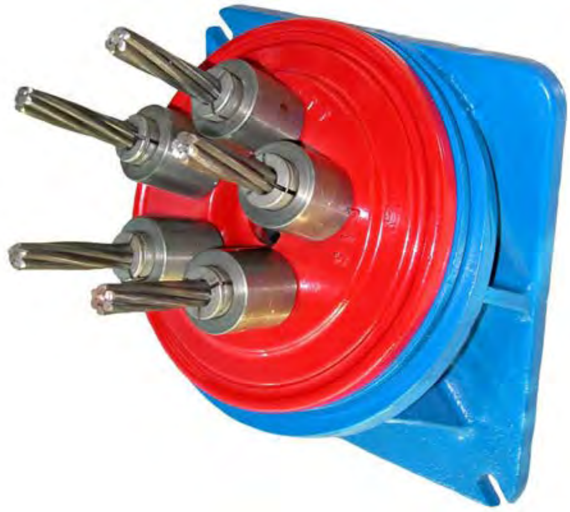
DD 0520SF spherical support



DD 0525SF spherical support



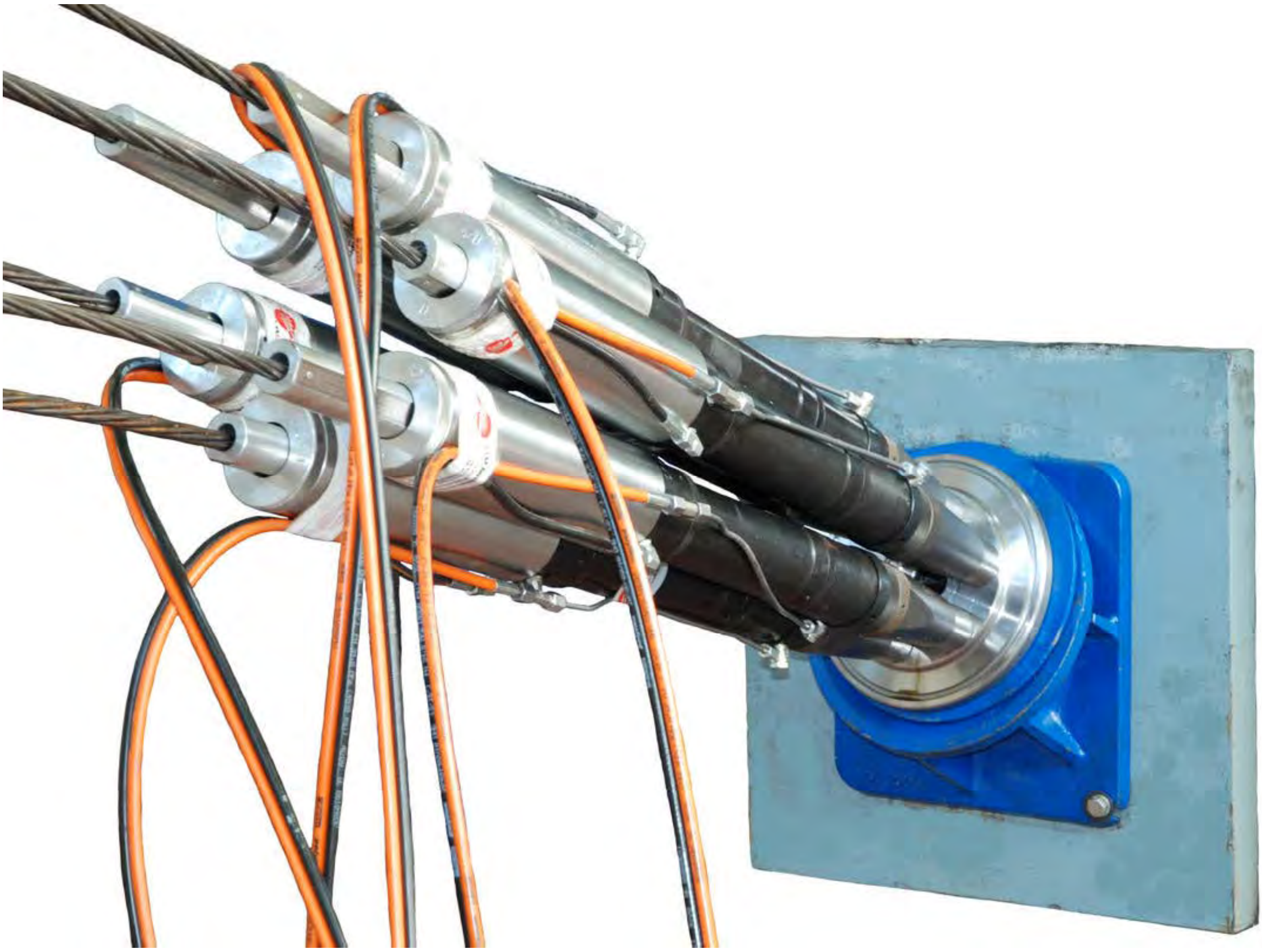
DD-SF spherical support with 5TTR15 plate and elementary protections on the single anchorages



DD-SF spherical support with 5TTR plate applied

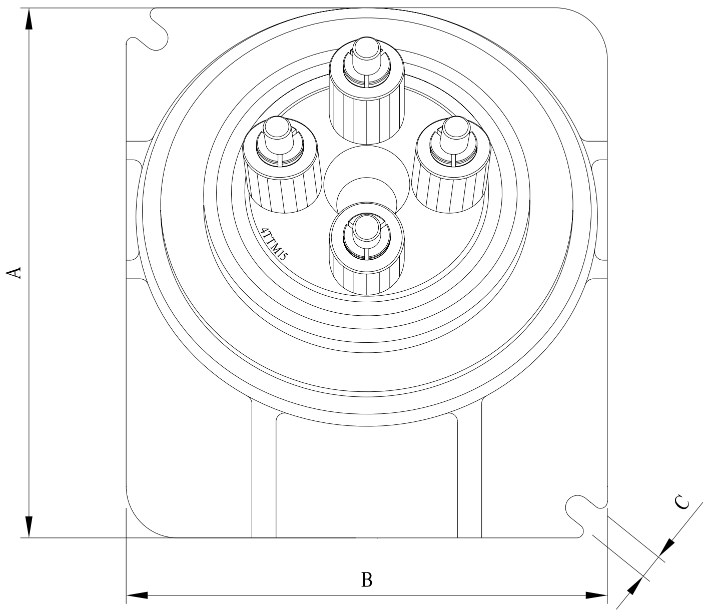
DD-SF spherical support

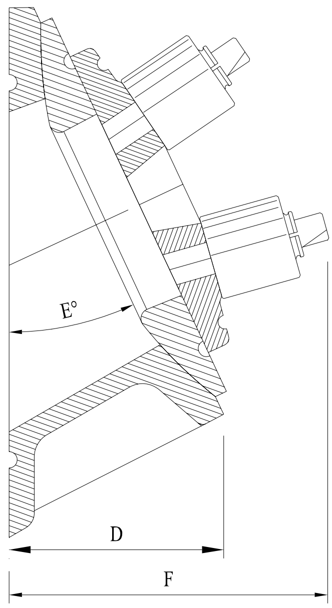
Application of a TTR anchorage on a DDSF spherical support with long and short cap



18.6 - DD-SF spherical supports

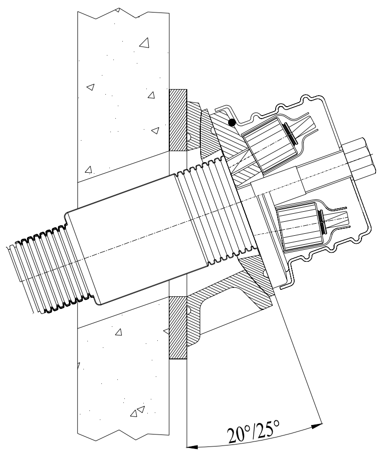
DD-SF spherical support

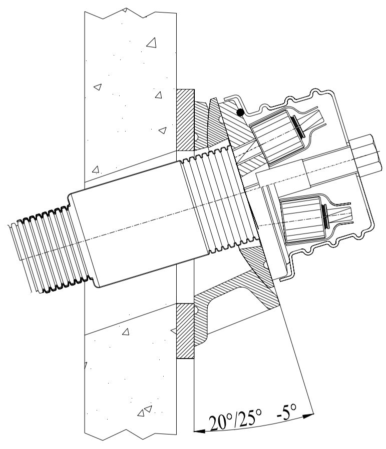


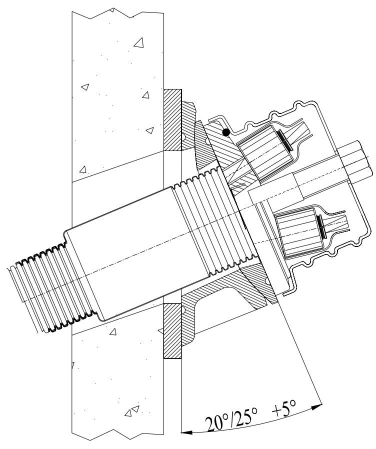


Support type	Strands min.	Strands max.	A (mm.)	B (mm.)	C (mm.)	D (mm.)	E (degrees)	F (mm.)
DD 0525-SF	2	5	310	280	14	143	**20-30 ± 5°**	209
DD 0520-SF	2	5	300	280	14	115	**15-25 ± 5°**	181
DD 0825-SF	6	8	390	350	18	180	**20-30 ± 5°**	246
DD 0820-SF	6	8	380	350	18	150	**15-25 ± 5°**	216

Drawing subject to modification without notice. Data related to TTR anchorages







18.7 - TT-F inclined supports

7TT15-F30 inclined support

TT-F *inclined supports, for tensioning of inclined ground anchors without using special devices. They allow to compensate inclinations up to 35°.*
The supports of the ***TT-F*** *series are especially designed for each application and inclination. Their best characteristics are: easy tensioning operations and precise anchor loading. The tensioning of these anchorages is carried out simultaneously with "M"series multiple stressing jacks.*

TT-F 30 inclined support

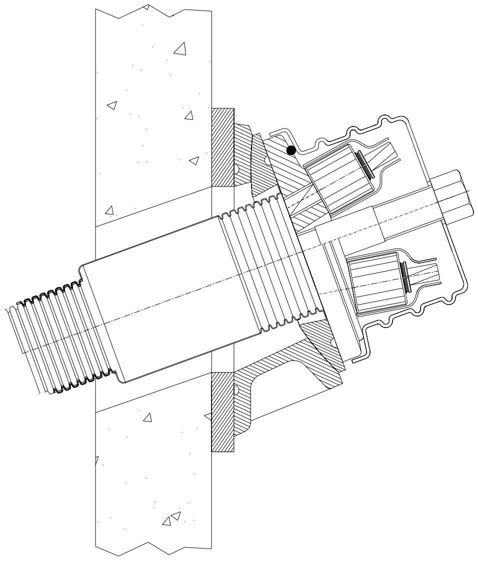
The plates of the ***TT-F*** *inclined supports are made of* ***S235JR EN 10025*** *steel, all the devices are made upon Client's order and request, provided the following characteristics:*

- *number of anchor strands,*
- *characteristics of the supporting surface,*
- *drilling diameter,*
- *inclination,*

They are fixed on the plate by means of ***TTM*** *plates with conical trunk holes made of* ***C40-45 EN 10083/1*** *steel and with**7015-T15*** *clamps made of* ***16NiCr4Pb EN 10277-4*** *steel or* ***7017-T15*** *made of* ***9SMnP28 4838*** *steel.*

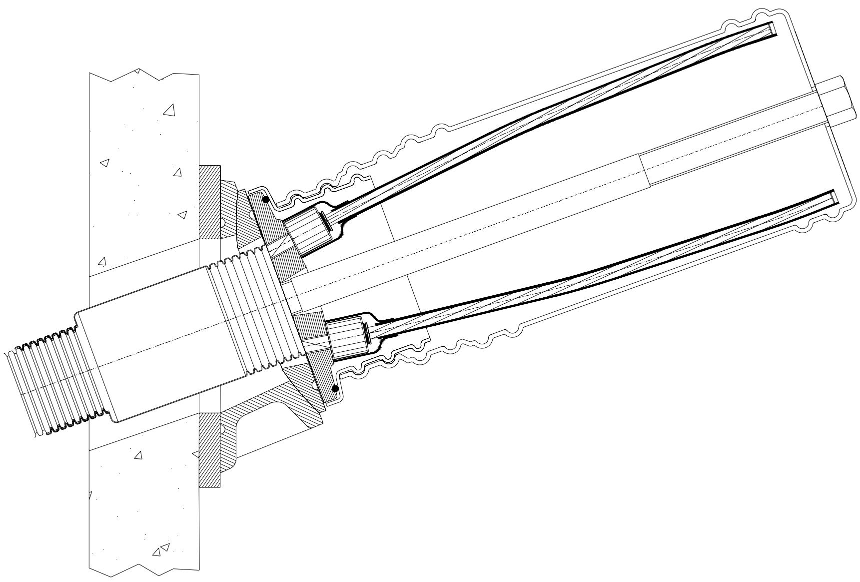
18.8 - DD-SF applied on TTR anchorages

*The **DD-SF** spherical support allows the installation of temporary and permanent ground anchors. The spherical cap rests on a support that transfers the force to the bulkhead, reducing the transfer* $\sigma_{transf.}$ *on the supporting surface.*



DD 0525SF spherical support with total protection

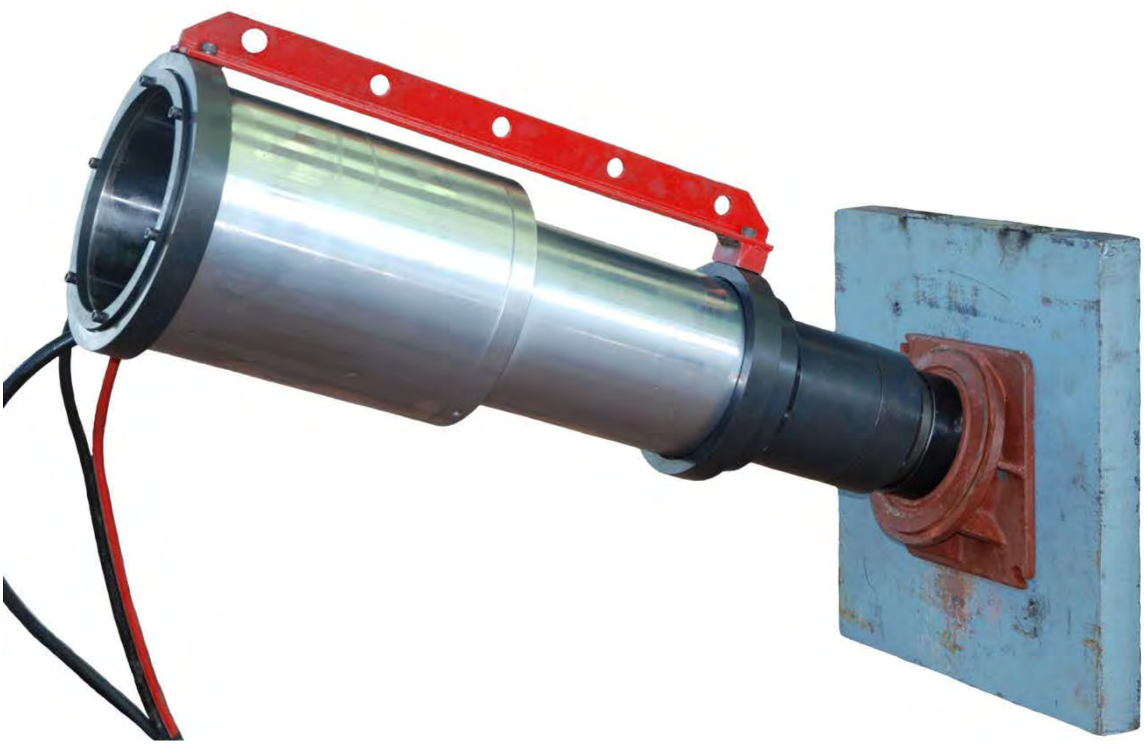
*Permanent ground anchors can be protected on **T15** elementary anchorages with **DD0015CV** protections, which guarantee that during the temporary life of the anchor the grease coverage of elementary anchorages and their retensioning over time, with no corrosion of the blocking elements.*



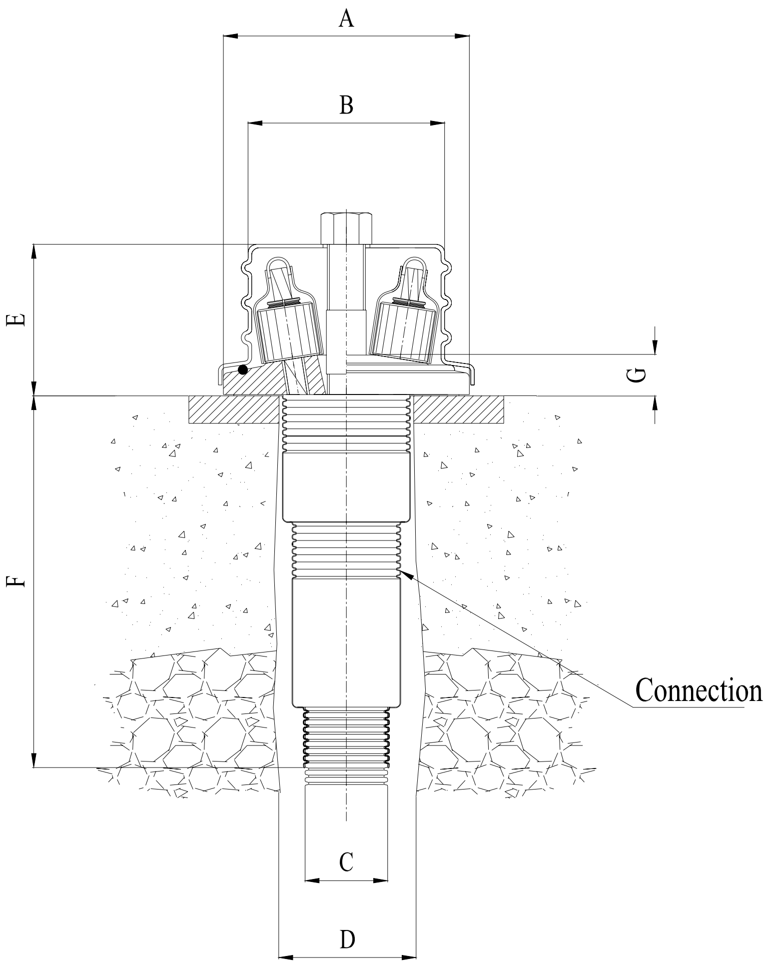
DD 0520SF spherical support with total protection

TTR 450 *caps are in polyethylene (H.D.P.E.) and guarantee a protection all around the anchor plate, entirely covering even its thickness.*
Permanent anchors can be protected on permanent anchorages via under plate protections.
TTR100 or TTR450 *protection caps complete the anchorage protection according to* ***EURO NORM EN 1537-2002 paragraph 6.11.3 and Table 3 ref. 4. Anchor head.***

DD0520SF spherical support with TTR-450 protection cap



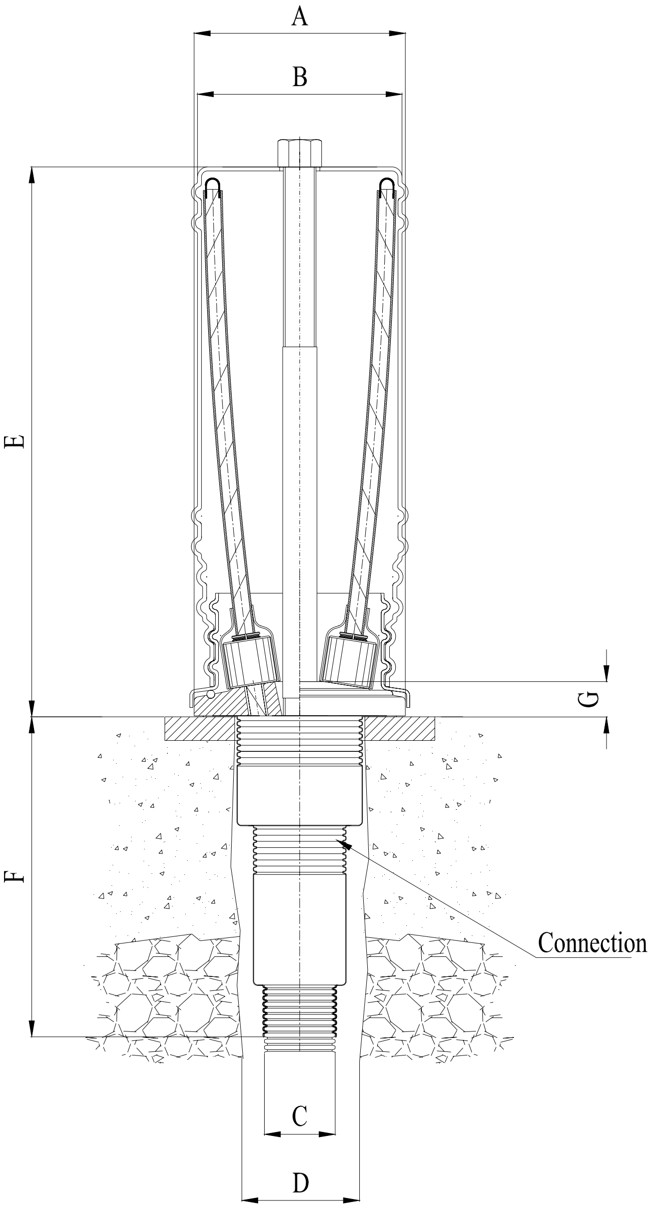
(Anchorage with TTR-100 short cap)



OR for cap sealing

Plate type	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*Connection*
	(mm.)	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*type*
2TTR15	*180*	*185*	*66-77*	*110*	*140*	*292*	*26*	***DD200SF-234***
3TTR15	*190*	*185*	*65-92*	*110*	*140*	*292*	*26*	***DD200SF-234***
4TTR15	*215*	*200*	*65-92*	*110*	*140*	*292*	*26*	***DD200SF-234***
5TTR15	*240*	*210*	*77-92*	*140*	*140*	*330*	*37*	***DD200SF-56***
6TTR15	*255*	*220*	*77-92*	*140*	*150*	*330*	*37*	***DD200SF-56***
7TTR15	*280*	*245*	*92-110*	*185*	*150*	*500*	*37*	***DD200SF-78***
8TTR15	*300*	*265*	*92-110*	*185*	*150*	*500*	*40*	***DD200SF-78***
9TTR15	*310*	*265*	*92-110*	***	*150*	***	*40*	******

Subject to modification *Further data is available on request*



Anchorage with TTR-450 long cap

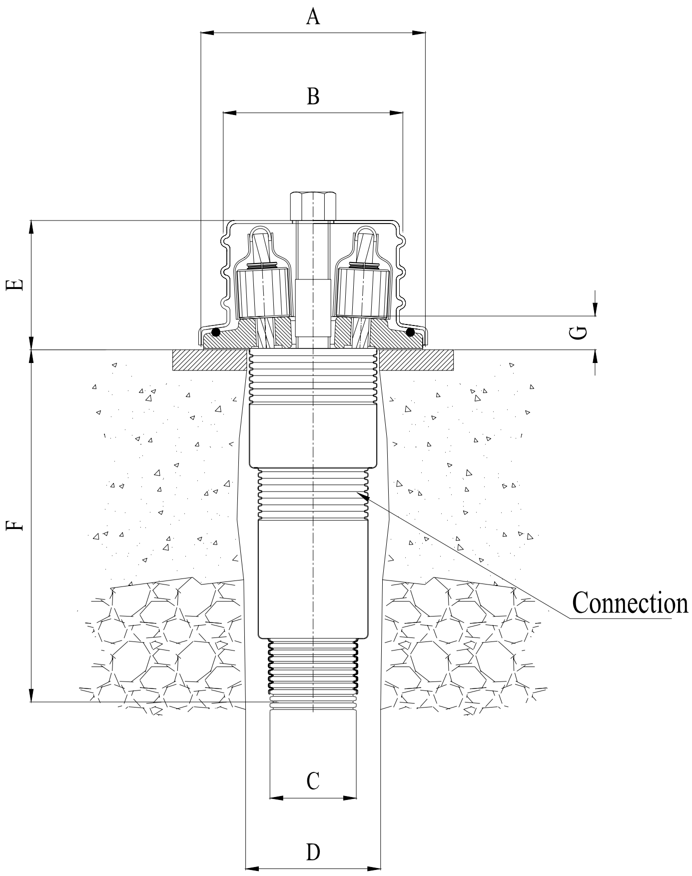
OR for cap sealing

Plate type	***A***	***B***	***C***	***D***	***E***	***F***	***G***	***Connection***
	(mm.)	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*type*
2TTR15	*180*	*200*	*66-77*	*110*	*540*	*292*	*26*	***DD200SF-234***
3TTR15	*190*	*200*	*65-92*	*110*	*540*	*292*	*26*	***DD200SF-234***
4TTR15	*215*	*200*	*65-92*	*110*	*540*	*292*	*26*	***DD200SF-234***
5TTR15	*240*	*200*	*77-92*	*140*	*480*	*330*	*37*	***DD200SF-56***
6TTR15	*255*	*200*	*77-92*	*140*	*420*	*330*	*37*	***DD200SF-56***
7TTR15	*280*	*270*	*92-110*	*185*	*540*	*500*	*37*	***DD200SF-78***
8TTR15	*300*	*270*	*92-110*	*185*	*480*	*500*	*40*	***DD200SF-78***
9TTR15	*310*	*270*	*92-110*	***	*420*	***	*40*	******

Subject to modification *Further data is available on request*

20.0 – TTR-E ANCHORAGES

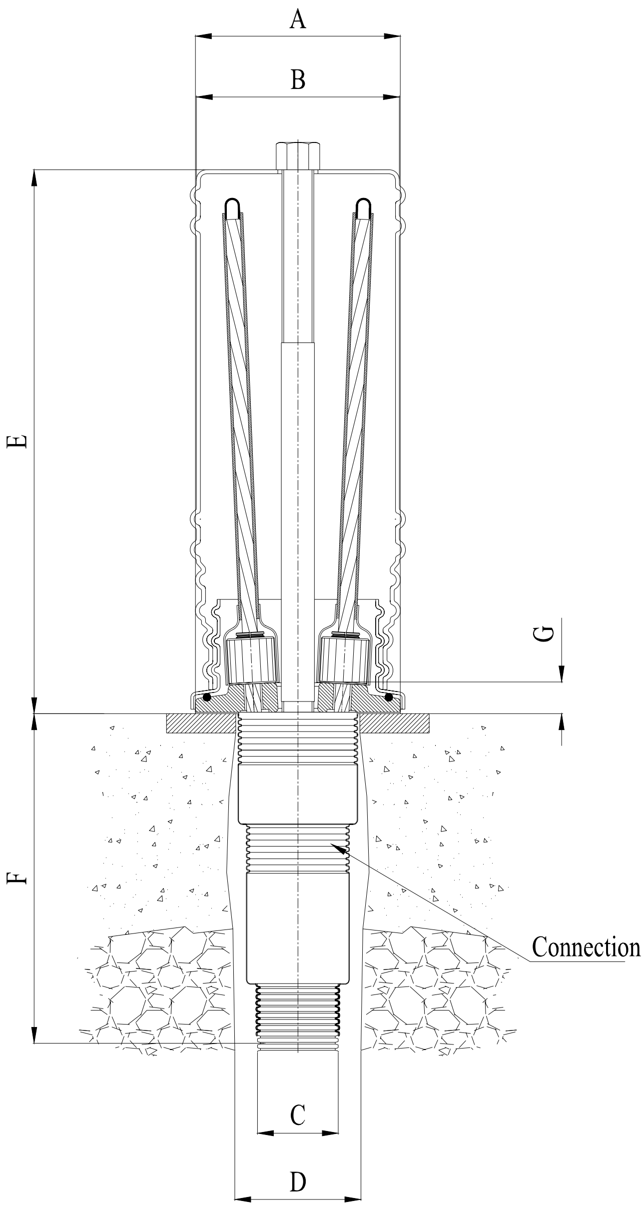
(Anchorage with TTR-100 short cap)



OR for cap sealing

Plate type	A	B	C	D	E	F	G	Connection
	(mm.)	(mm.)	(mm.)	(mm.)	(mm.)	(mm.)	(mm.)	type
2TTR-E15	215	185	92-110	130	140	330	31	**DD200SF-56**
3TTR-E15	215	185	92-110	130	140	330	31	**DD200SF-56**
4TTR-E15	215	185	92-110	130	140	330	31	**DD200SF-56**
5TTR-E15	240	200	92-110	160	140	330	37	**DD200SF-56**
6TTR-E15	275	220	92-110	190	150	500	37	**DD200SF-78**
7TTR-E15	300	245	92-110	200	150	500	37	**DD200SF-78**
8TTR-E15	310	275	92-110	220	150	***	37	******

Subject to modification *Further data is available on request*



Anchorage with TTR-450 long cap

OR for cap sealing

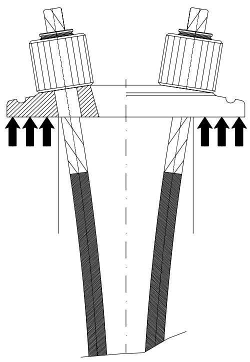
Plate type	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*Connection*
	(mm.)	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*type*
2TTR-E15	*215*	*200*	*92-110*	*130*	*540*	*330*	*31*	***DD200SF-56***
3TTR-E15	*215*	*200*	*92-110*	*130*	*540*	*330*	*31*	***DD200SF-56***
4TTR-E15	*215*	*200*	*92-110*	*130*	*540*	*330*	*31*	***DD200SF-56***
5TTR-E15	*240*	*200*	*92-110*	*160*	*480*	*330*	*37*	***DD200SF-56***
6TTR-E15	*275*	*270*	*92-110*	*190*	*540*	*500*	*37*	***DD200SF-78***
7TTR-E15	*300*	*270*	*92-110*	*200*	*540*	*500*	*37*	***DD200SF-78***
8TTR-E15	*310*	*270*	*92-110*	*220*	*480*	***	*37*	******

Subject to modification *Further data is available on request*

20.2 – Transfer for TTR anchorages

*(for temporary and permanent ground anchors according to **EURO NORM EN 1537 2002**)*

***TTR** anchor plates are calculated for a transfer σ of 250 Kg. /cm^2, for loads on the anchorage of 15,000 Kg. / strand. The transfer σ is evaluated on even supporting surfaces, orthogonal loads and anchorages centred on the drilling hole. Different conditions shall be properly evaluated.*
*As the drilling hole increases, beside the diameter reported in the table with the dimension B, the transfer σ must be checked again. If the condition σ transfer>σ allowable (resistance of the under plate concrete) is satisfied, under the **TTR** anchor a distribution plate must be placed which shall consider, beside the transferσ, also the cut induced on the **TTR** anchor plate.*
***TTR** plates are made of **C40-45 EN 10083/1** steel. Strands are fixed on the plate by means of conical trunk bushes made of C40-45 EN 10083/1 steel and with **7015-T15** clamps made of **16NiCr4Pb EN 10277-4** steel or **7017-T15** made of **9SMnP28 4838**steel.*



TTR anchorage

*The system offered is subjected to system testing that verifies its validity. The technical results of the tests are available to the Client's Technical Representative (Technical Manager of the company that installs the anchors) for approval and comply to the requirements of Standard **EURO NORM EN 1537-2002 paragraph 6.1**.*
*Abstract from **"EURO NORM EN 1537-2002 paragraph 6.1."** Anchor systems shall be used for which successful experience with respect to performance and durability has been documented. All anchor systems shall have been subjected to at least one system test to verify the competence of the system. The results of all tests shall be documented in detail. The documented system test shall be approved by the **Client's Technical Representative** in accordance with the principles stated in this Standard. All materials used must be mutually compatible. This applies in particular to adjacent materials with a common interface. Material properties shall not change during the design life of the ground anchor in such a way that the anchor loses its serviceability. Anchors involving the use of newly developed materials or methods of execution are permitted subject to the performance of the anchor and durability of the materials used being proven by system tests and approved by the **Client's Technical Representative**, to ensure that the serviceability of the anchor system is maintained for the design life of the anchored structure.*

Useful area
Au (useful area cm^2) = ((A2xπ)/4) - ((B2xπ)/4) = ***Au***

Determining the tensioning value according to EURO ***NORM EN 1537-2002 paragraphs 9.8 and 9.5***
Maximum lock-off load ***EURO NORM EN 1537-2002 paragraph 9.8***
The maximum lock-off load (Po) shall be limited to 0.6 Ptk   Po = 0,6 Ptk

Investigation tests ***EURO NORM EN 1537-2002 paragraph 9.5***
The anchor shall be loaded to failure (Ra) or to a proof load which shall be limited to 0.80 Ptk or 0.95 Pt0.1K., whichever is the lower.   Ra = 0.80 Ptk or 0,95 Pt0.1k

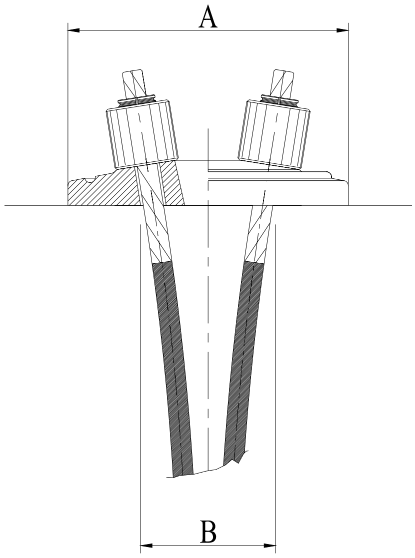


Plate type	A	B	Useful area*	Total load	σ transfer
	(mm.)	(mm.)	(cm^2)	(Kg.)	(Kg./ cm^2)
2TTR15	180	103	175,38	30.000	**175**
3TTR15	190	103	224,88	45.000	**225**
4TTR15	215	103	214,60	60.000	**215**
5TTR15	240	113	213,11	75.000	**213**
6TTR15	255	125	232,08	90.000	**232**
7TTR15	280	147	235,53	105.000	**236**
8TTR15	300	166	244,81	120.000	**245**
9TTR15	310	193	292,22	135.000	**292**

Elastic modulus = 196 +/- 10 KN / mm^2
Table subject to modification without notice

***** A_u *(useful area cm^2) = ((A2xπ)/4) - ((B2xπ)/4) =* A_u

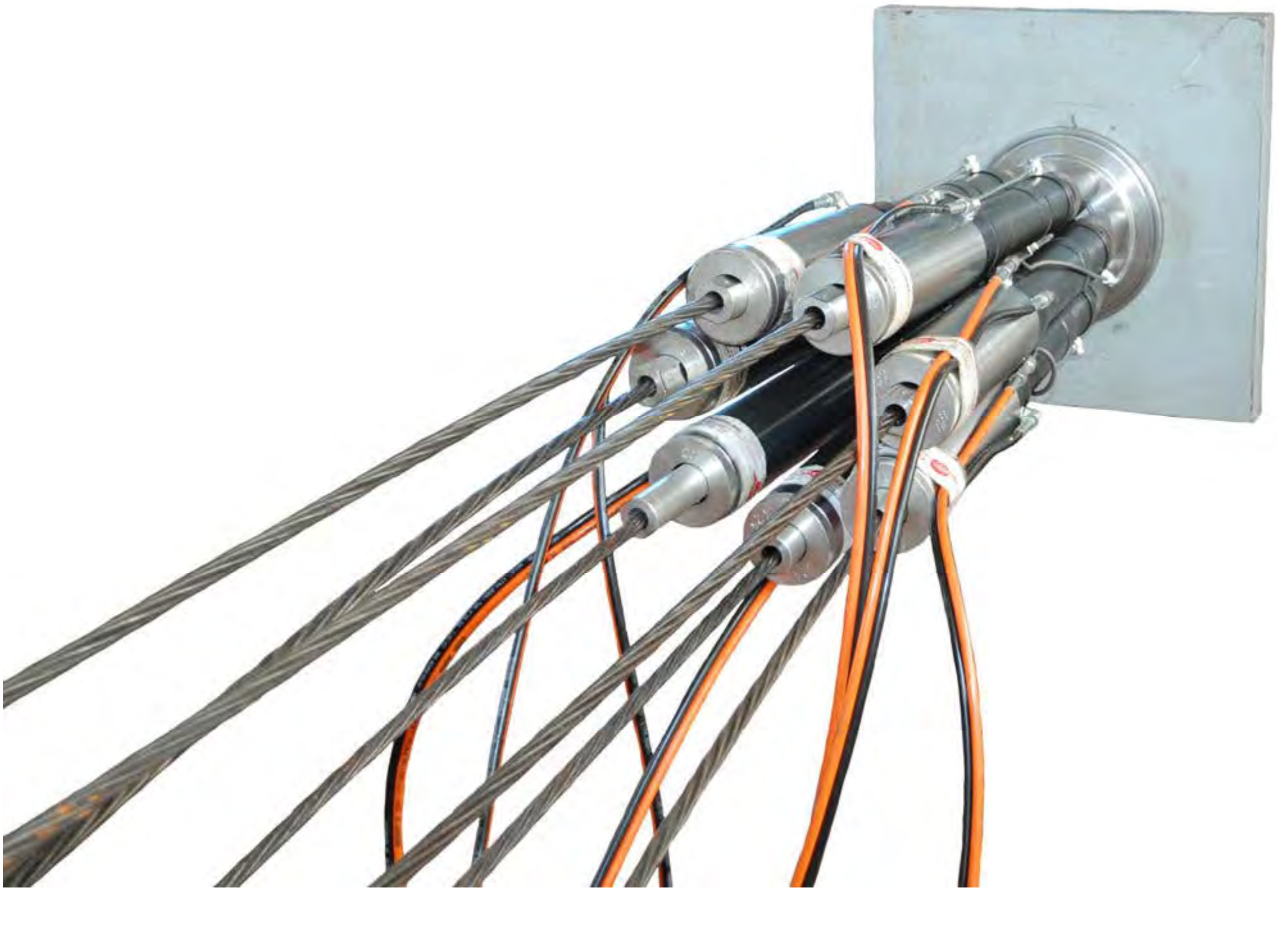
Characteristics of the strands:

Diameter	Standard	Type of strand	Nominal diameter	Nominal area	Mass	f_{tk}	Yield point (Ptk)	Elastic limit at 0.1% (Pt0,1k)	Relaxation after 1000 h.0.7 - 0.8 f_{pk}	
			mm.	mm^2	gr./m	N/mm^2	KN	KN	%	%
T15 /T15S	EN 10138	normal super	15,2 15,7	140 150	1095 1170	1860 1860	260 279	224 240	2.5 2.5	4.5 4.5
T15C	EN 10138	Compact	15,2	165	1290	1860	300	258	2.5	4.5

σ ***transfer***
σ *transfer at the max. lock-off load =* ***Po / Au***
σ *transfer at the max. failure load =* ***Po / Au***

Transfer verification

σ *transfer>σ allowable* ***distribution plate required,***
σ *transfer>σ allowable* ***no distribution plate required.***
σ *allowable, characteristic of the supporting plate of the TTR plate.*
N.b. *these evaluations apply to concrete works, supports on metallic structures or deviated supports, which shall be evaluated and studied case by case.*

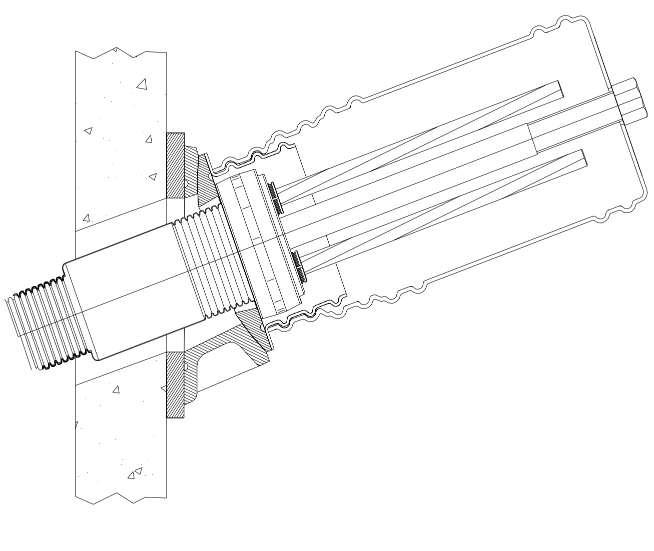


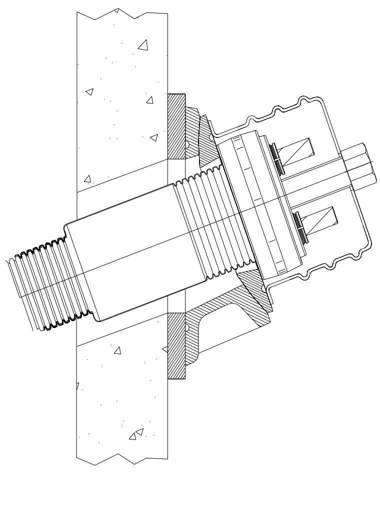
21.0 - TTM AND TTM-F ANCHORAGES (threaded plate)

*The **TTM** anchorage proves to be the most practical one for tensioning on anchors with more than 9 strands. This anchorage is more compact and allows lower load losses due to deviations in the anchoring zone.*
Special attention must be paid to the tensioning procedures as only one jack is used.
*It is important to reduce the slack cords of the free length before tensioning in order to avoid load losses. Tendons are fixed on the plate by means of conical trunk holes made of **C40-45 EN 10083/1 steel** and with **7015-T15** clamps made of **16NiCr4Pb EN 10277-4** steel or **7017-T15** made of **9SMnP28 4838** steel.*
*It may be supplied with a threaded plate for future stressing regulations in the **TTM-F** version. "M" jacks are employed for the loading of these anchors that because of their nature require the use of suitable lifting means.*

12TTM-PR15 anchorage

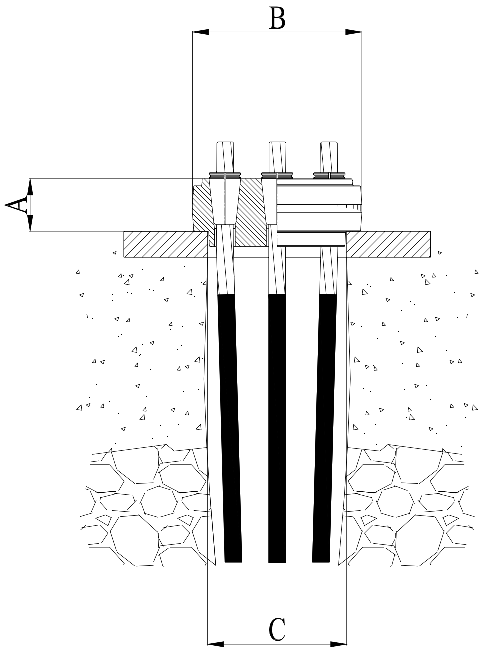
12TTM-F-PR15 anchorage

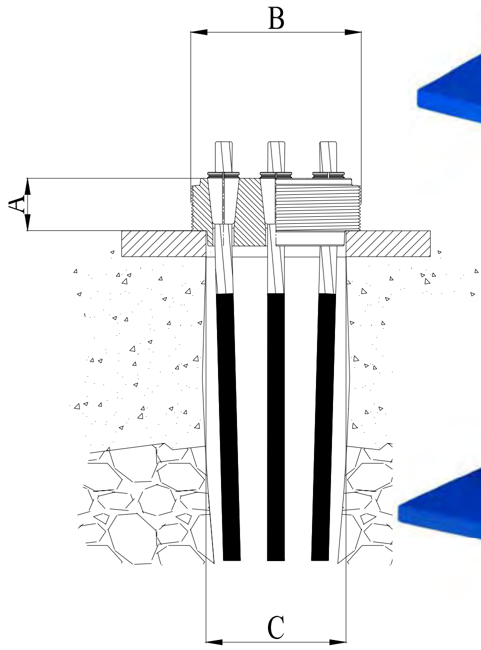




21.1 - TTM-PR and TTM-F-PR anchorages

(TTM-PR anchorage)

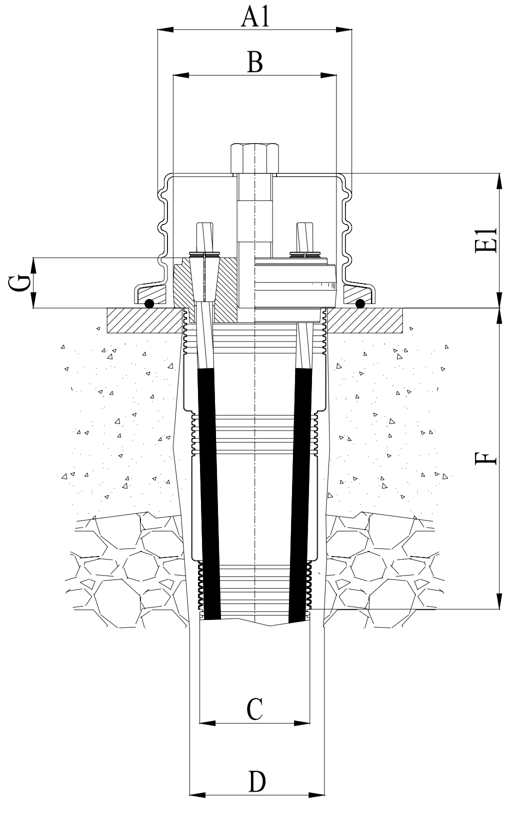


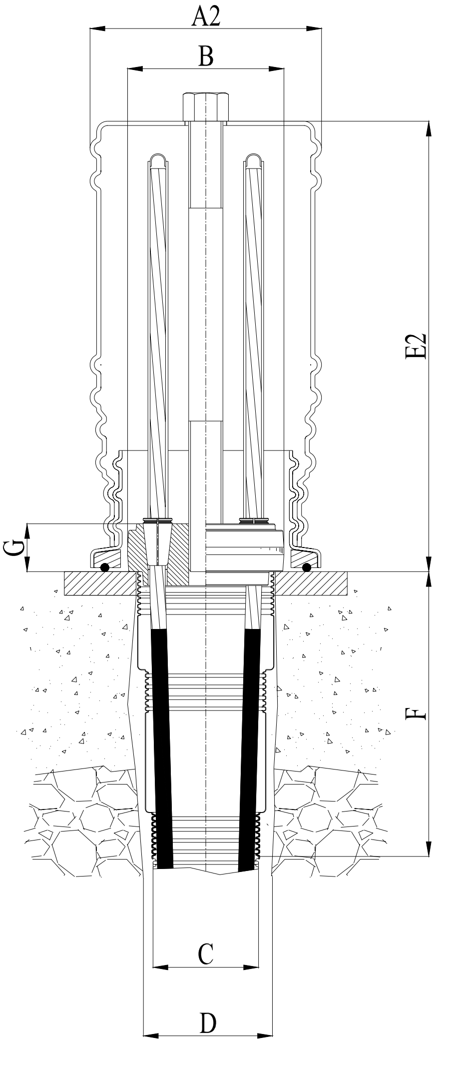


Anchorage type	***A***	***B***	***C***
TTM-PR	*(mm.)*	*(mm.)*	*(mm.)*
4TTM-PR15	*45*	*105*	*82*
7TTM-PR15	*45*	*125*	*102*
9TTM-PR15	*45*	*146*	*125*
12TTM-PR15	*45*	*160*	*140*
15TTM-PR15	*45*	*176*	*150*
19TTM-PR15	*56*	*200*	*163*

Anchorage type	***A***	***B***	***C***
TTM-F-PR	*(mm.)*	*(mm.)*	*(mm.)*
4TTM-F-PR15	*45*	*100*	*82*
7TTM-F-PR15	*45*	*120*	*102*
9TTM-F-PR15	*45*	*140*	*125*
12TTM-F-PR15	*45*	*155*	*140*
15TTM-F-PR15	*45*	*170*	*150*
19TTM-F-PR15	*56*	*195*	*163*

(TTM anchorage)

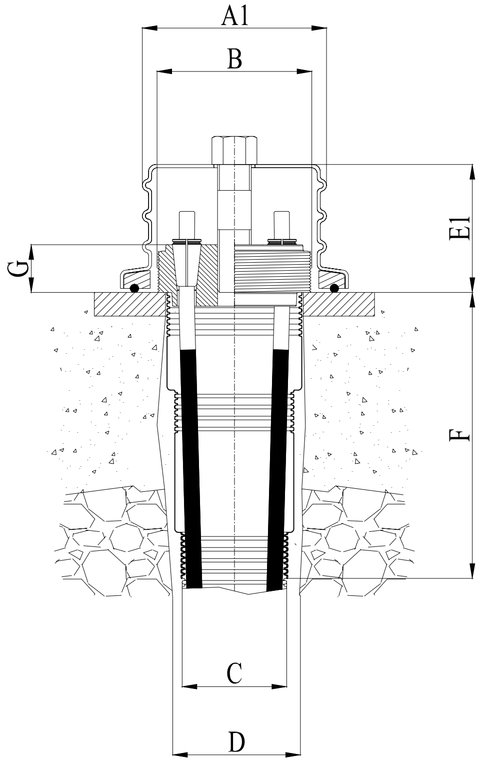


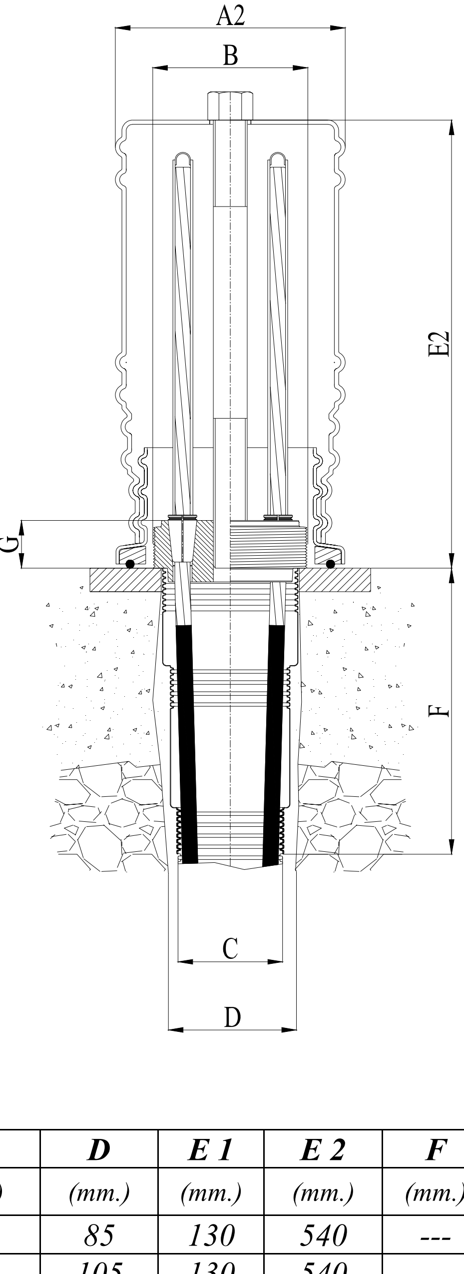


Anchorage type	*A 1*	*A 2*	*B*	*C*	*D*	*E 1*	*E 2*	*F*	*G*
	(mm.)	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*
4TTM -PE15	*180*	*200*	*105*	*110*	*85*	*130*	*540*	*---*	*45*
6TTM -PE15	*180*	*200*	*125*	*110*	*105*	*130*	*540*	*---*	*45*
8TTM -PE15	*180*	*200*	*146*	*110*	*130*	*130*	*540*	*---*	*45*
9TTM -PE15	*205*	*215*	*160*	*110*	*145*	*140*	*420*	*---*	*45*
10TTM -PE15	*205*	*215*	*176*	*110*	*155*	*140*	*420*	*---*	*45*
18TTM -PE15	*245*	*280*	*200*	*110*	*165*	*140*	*540*	*---*	*56*

Subject to modification *Further data is available on request*

(Threaded retensioning anchorage)





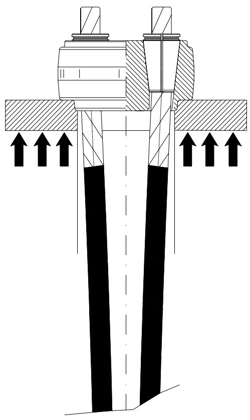
Anchorage type	*A 1*	*A 2*	*B*	*C*	*D*	*E 1*	*E 2*	*F*	*G*
	(mm.)	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*
4TTM-F-PE15	*180*	*200*	*100*	*110*	*85*	*130*	*540*	*---*	*45*
6TTM-F-PE15	*180*	*200*	*120*	*110*	*105*	*130*	*540*	*---*	*45*
8TTM-F-PE15	*180*	*200*	*140*	*110*	*130*	*130*	*540*	*---*	*45*
9TTM-F-PE15	*205*	*215*	*155*	*110*	*145*	*140*	*420*	*---*	*45*
10TTM-F-PE15	*205*	*215*	*170*	*110*	*155*	*140*	*420*	*---*	*45*
18TTM-F-PE15	*245*	*280*	*195*	*110*	*165*	*140*	*540*	*---*	*56*

Subject to modification *Further data is available on request*

21.4 – Transfer for TTM anchorages

(for temporary and permanent ground anchors according to ***EURO NORM EN 1537 2002****)*

TTR *anchor plates must be calculated from time to time since they are made of oxygen-cut steel. They are generally calculated for a transfer σ of 250 Kg. /cm^2, for loads on the anchorage of 15,000 Kg. / strand. The transfer σ is evaluated on even supporting surfaces, orthogonal loads and anchorages centred on the drilling hole. Different conditions shall be properly evaluated.*
As the drilling hole increases, beside the diameter reported in the table with the dimension B, the transfer σ must be checked again. If the condition: σ transfer>σ allowable (resistance of the under plate concrete) is satisfied, the dimensions of the plate under the ***TTM*** *anchorage shall be increased until the condition σ transfer<σ allowable is satisfied. Beside the transferσ, the punching stress induced by the* ***TTM*** *anchor plate on the oxygen-cut plate must also be checked; in this specific application special attention must be paid to the small transfer surface of the* ***TTM*** *plate on the distribution plate as well as its punching effect with low thickness.*
TTM *plates are made of* ***C40-45 EN 10083/1****steel. Strands are fixed on the* ***TTM*** *plate by means of* ***7015-T15*** *clamps made of* ***16NiCr4Pb EN 10277-4*** *steel or* ***7017-T15*** *made of* ***9SMnP28 4838****steel. The distribution plate is generally made of oxygen-cut* ***S235JR EN 10025****steel. The quality of steel may be increased or reduced based on its manufacturing conditions and on the punching stress it is subjected to.*



TTM anchorage

The system offered is subjected to system testing that verifies its validity. The technical results of the tests are available to the Client's Technical Representative (Technical Manager of the company that installs the anchors) for approval and comply to the requirements of Standard ***EURO NORM EN 1537-2002 paragraph 6.1****.*
The plate can be certified according to the ***Construction technical regulations of the Ministerial Decree of the 14.01.2008*** *and according to the Multi-****strand systems*** *European Technical approval* ***B.T.E. ETA-09-0013*** *and its relating marking* ***CE 0969-CPD-002/09-PT***
Abstract from ***"EURO NORM EN 1537-2002 paragraph 6.1."*** *Anchor systems shall be used for which successful experience with respect to performance and durability has been documented. All anchor systems shall have been subjected to at least one system test to verify the competence of the system. The results of all tests shall be documented in detail. The documented system test shall be approved by the* ***<u>Client's Technical Representative</u>*** *in accordance with the principles stated in this*

*Standard. All materials used must be mutually compatible. This applies in particular to adjacent materials with a common interface. Material properties shall not change during the design life of the ground anchor in such a way that the anchor loses its serviceability. Anchors involving the use of newly developed materials or methods of execution are permitted subject to the performance of the anchor and durability of the materials used being proven by system tests and approved by the **Client's Technical Representative**, to ensure that the serviceability of the anchor system is maintained for the design life of the anchored structure.*

Elements for the calculation of TTM anchorages

Useful area

Au (useful area cm^2) = (A x A) - ((B2 x π)/4) = ***Au***

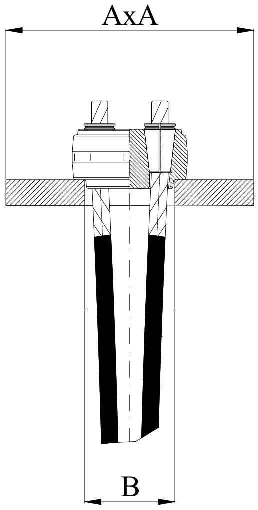
Determining the tensioning value according to EURO ***NORM EN 1537-2002 paragraphs 9.8 and 9.5***

Maximum lock-off load ***EURO NORM EN 1537-2002 paragraph 9.8***

The maximum lock-off load (Po) shall be limited to 0.6 Ptk   Po = 0.6 Ptk

Investigation tests ***EURO NORM EN 1537-2002 paragraph 9.5***

The anchor shall be loaded to failure (Ra) or to a proof load which shall be limited to 0.80 Ptk or 0.95 Pt0.1K., whichever is the lower.   Ra = 0.80 Ptk or 0,95 Pt0.1k



Permanent anchorage**	***AxA***	***B***	***Useful area****	***Total load***	***σ transfer***
	(mm.)	*(mm.)*	*(cm^2)*	*(Kg.)*	*(Kg./ cm^2)*
4TTM15	*170x170*	*82*	*234*	*60.000*	***250***
6TTM15	*210x210*	*102*	*359*	*90.000*	***250***
8TTM15	*245x245*	*125*	*477*	*120.000*	***250***
9TTM15	*260x260*	*140*	*522*	*135.000*	***250***
10TTM15	*275x275*	*150*	*579*	*150.000*	***250***
18TTM15	*360x360*	*165*	*1.087*	*270.000*	***250***
Temporary anchorage	*(mm.)*	*(mm.)*	*(cm^2)*	*(Kg.)*	*(Kg./ cm^2)*
4TTM15	*170x170*	*82*	*236*	*60.000*	***250***
7TTM15	*225x225*	*102*	*424*	*105.000*	***250***
9TTM15	*260x260*	*125*	*553*	*135.000*	***250***
12TTM15	*295x295*	*140*	*716*	*180.000*	***250***
15TTM15	*330x330*	*150*	*912*	*225.000*	***250***
19TTM15	*370x370*	*165*	*1.160*	*285.000*	***250***

Table subject to modification without notice

**** A_u*** *(useful area cm^2) = (A x A) - ((B2xπ)/4) = A_u*

*** Permanent anchorage with protection cap.*
Characteristics of the strands:

Diameter	***Standard***	***Type of strand***	***Nominal diameter***	***Nominal area***	***Mass***	f_{tk}	***Yield point (Ptk)***	***Elastic limit at 0.1% (Pt0,1k)***	***Relaxation after 1000 h.0.7 - 0.8*** f_{pk}	
			mm.	mm^2	***gr./m***	N/mm^2	***KN***	***KN***	***%***	***%***
T15 /T15S	*EN 10138*	*normal* *super*	*15.2* *15.7*	*140* *150*	*1095* *1170*	*1860* *1860*	*260* *279*	*224* *240*	*2.5* *2.5*	*4.5* *4.5*
T15C	*EN 10138*	*Compact*	*15.2*	*165*	*1290*	*1860*	*300*	*258*	*2.5*	*4.5*

Elastic modulus = 196 +/- 10 KN / mm^2

σ ***transfer***
σ *transfer at the max. lock-off load =* ***Po / Au***
σ *transfer at the max. failure load =* ***Po / Au***

Transfer verification

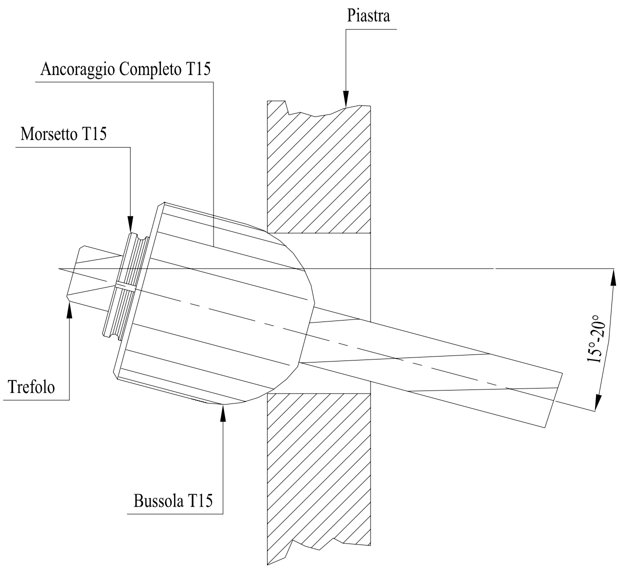
σ *transfer>σ allowable* ***bigger distribution plate required,***
σ *transfer>σ allowable* ***corrected distribution plate required.***
σ *allowable, characteristic of the supporting plate of the TTM plate.*
N.b. *these evaluations apply to concrete works, supports on metallic structures or deviated supports, which shall be evaluated and studied case by case.*

22.0 - TTS ANCHORAGES

*The **TTS** anchorage proves to be the most practical one for the tensioning of inclined anchors, with inclinations up to 15°, without using additional devices. The limit to the inclination of this anchorage is given by the thickness of the plate, which must always be verified before the installation. If an inclination mistake occurs on the drilling, the strand may risk to be subjected to cutting stress as it comes out of the plate.*
*The characteristics of this anchorage are: easy tensioning operations and precise anchor loading. **TTS anchorages** allow inclinations of a maximum of 15°; employing any greater degrees of inclination can lead to strands breaking under the plate due to interferences between plate and strand.*

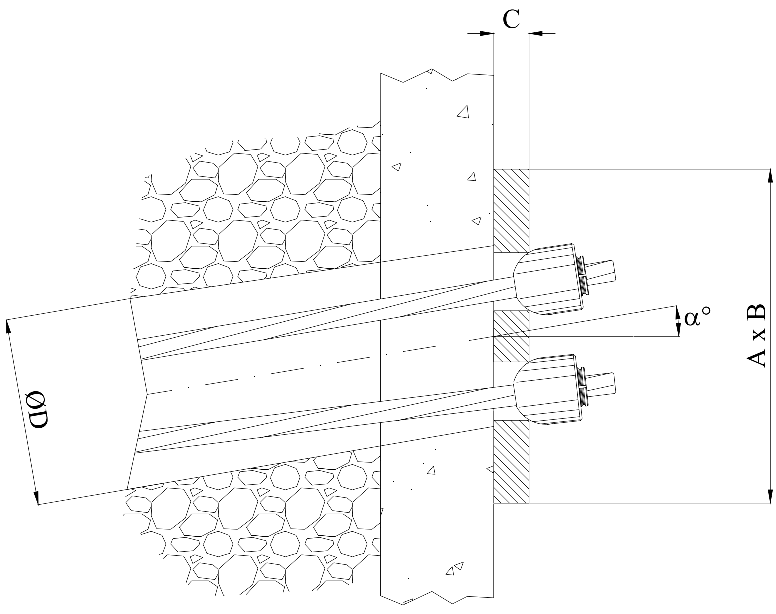
4TTS15 plate

This system allows to apply the same load to all strands, thus avoiding load unbalance due to slack cords.
***TTS** plates are made of **S235JR EN 10025** steel.*
*Strands are fixed on the plate by means of spherical conical trunk bushes made of **C40-45 EN 10083/1** steel and with **7015-T15** clamps made of **16NiCr4Pb EN 10277-4** steel or **7017-T15** made of **9SMnP28 4838 steel.***
TTS plates are made upon request and their dimensions are calculated from time to time based on the supporting conditions of the plate.



*For a correct installation of **TTS** anchorages, we suggest pretensioning the elementary anchorages one by one with a tensioning of 2 ton. per strand. This allows the spherical bushes to settle in the position required, thus facilitating the simultaneous tensioning to be carried out later on.*
Tensioning is carried out simultaneously (under isopressure) with TTR250KN jacks, in a number that is equal to the number of strands in the anchor.
*This anchorage cannot be certified according to the **Construction technical regulations of the Ministerial Decree of 14.01.2008** or a **"European Technical Approval"***
*When **using TTS anchorages anchors we always recommend** consulting our technical office.*

22.1 - TTS anchorages



Anchorage type	A	B	C	α	D
	(mm.)	(mm.)	(mm.)	(degrees)	(mm.)
2TTS15	190	190	30	max. 15°	Variable
2TTSL15	300	160	25	max. 15°	Variable
3TTS15	200	200	30	max. 15°	Variable
3TTSL15	300	160	30	max. 15°	Variable
4TTS15	250	250	30	max. 15°	Variable
4TTSL15	300	180	40	max. 15°	Variable
5TTS15	320	260	40	max. 15°	Variable
6TTS15			40	max. 15°	Variable

Subject to modification *Further data is available on request*

23.0 – ANCHORAGE SYSTEMS

All the systems offered are subjected to system testing that verifies their validity. The technical results of the tests are available to the Client's Technical Representative for approval/looking up and comply to the requirements of Standard ***EURO NORM EN 1537-2002 paragraph 6.1.***
For TTM and TTM-F systems, anchorages are provided with the ***European Technical Approval*** *and comply with* ***Construction technical regulations of the Ministerial Decree of the 14.01.2008***

- Tendon EURO NORM EN 1537-2002 paragraph 6.2
All tendons used in the production of the anchor comply with the Standard ***EURO NORM EN 1537-2002 paragraph 6.2*** *and the Standard* ***EURO NORM EN 10138 (Design of prestressing steel)***

- Anchor head EURO NORM EN 1537-2002 paragraph 6.3
The anchor head shall allow the tendon to be stressed, proof loaded and locked-off and, if required, released, destressed and restressed. It shall be able to carry the characteristic tensile load of the tendon of 97% Ptk. The anchor head shall distribute the tendon load to the anchored structure through tested components, in accordance with ***EURO NORM EN 1537-2002 paragraph 6.3***

24.0 - DETERMINING THE TENSIONING VALUES

The Italian and European Standard ***"Execution of special geotechnical work: GROUND ANCHORS EURO NORM EN 1537-2002"*** *establishes and defines principles with regard to anchor technology. This Standard is applicable to the installation, testing and monitoring of permanent and temporary ground anchors where the load capacity is tested.*

24.1 - Tensioning values on strand anchorages for geotechnical applications
(EURO NORM EN 1537-2002 *paragraph 9.8)*

- Maximum lock-off load EURO NORM EN 1537-2002 paragraph 9.8
The maximum lock-off load (Po) shall be limited to 0.6 Ptk.

Po = 0.6 Ptk

- Investigation tests EURO NORM EN 1537-2002 paragraph 9.5
The anchor shall be loaded to failure (Ra) or to a proof load which shall be limited to 0.80 Ptk or 0.95 Pt0.1K., whichever is the lower.

Ra = 0.80 Ptk or 0,95 Pt0.1k

Technical characteristics of the strands

Diameter	Standard	Type of strand	Nominal diameter	Nominal area	Mass	f_{tk}	Yield point (Ptk)	Elastic limit at 0.1% (Pt0.1k)	Relaxation after 000 h.0.7 - 0.8 f_{pk}	
			mm	mm^2	gr/m	N/mm^2	KN	KN	%	%
(T15)	EN 10138	normal super	15.2 15.7	140 150	1095 1170	1860 1860	260 279	224 240	2.5 2.5	4.5 4.5
(T15)	EN 10138	Compact	15.2	165	1290	1860	300	258	2.5	4.5

Elastic modulus = 196 +/- 10 KN / mm^2

25.0 – TENDONS
(strand)

Diameter	Standard	Type of strand	Nominal diameter	Nominal area	Mass	Yield point (Ptk)	Elastic limit at 1% (Pt0,1k)	Relaxation after 1000 h.0.7 - 0.8 f_{pk}	
			mm.	mm^2	g/m.	KN	KN	%	%
0.6" (T15)	EN 10138	normal super	15.2 15.7	140 150	1095 1170	260 279	230 248	2.5 2.5	4.5 4.5
0.6" (T15)	BS 5896/80	normal super	15.2 15.7	139 150	1090 1180	232 265	197 225	2.5 2.5	4.5 4.5
0.6" (T15)	ASTM A416/98	Grade 270	15.24	140	1102	260.7	221	2.5	3.5
0.6" (T15)	ONORM B 4258	standard super	15.2 15.7	140 150	1095 1170	248 265	220 236	2.5 2.5	4.5 4.5
0.6" (T15)	EN 10138	Compact	15.2	165	1290	300	264	2.5	4.5
Elastic modulus = 196 +/- 10 KN / mm^2									

26.0 – ELEMENTARY ANCHORAGES

This clamp is designed for anchoring single or multiple strands on anchor plates. It is for disposable use and it is available in different versions.

Clamps for post-tensioning on anchorages for disposable use.
7015-T15 *clamps made of* ***16NiCr4Pb***
EN 10277-4 steel
7017-T15 *clamps made of* ***9SMnP28***
4838 steel,

T15 clamps

Conical bushes complete with marking for post-tensioning uses for tensioning strands measuring between 15.2 mm and 15.7 mm.
7010-T15*bushes* ***C40-45 EN 10083/1***

T15 bushes

T15 spherical bushes

Spherical conical bushes complete with marking for post-tensioning uses for tensioning strands measuring between 15.2 mm and 15.7 mm.
7020-T15*bushes* ***C40-45 EN 10083/1,***

Sleeves for post-tensioning used on strand connections.
7030-T15 *sleeve with steel clamps*
16NiCr4Pb EN 10277-4,
7034-T15 sleeve with steel clamps
9SMnP28 4838.

T15 sleeves for strand connection

27.0 – PACKAGING

Elementary anchorages are supplied packaged and with identification and traceability.
These products are tested with: T15, T15S and T15C strand according to <u>Ministerial Memorandum dated 15th October 1996 no. 252 AA.GG./S.T.C.</u> This clamp is designed for anchoring single or multiple strands on anchor plates. It is for disposable use and it is available for different applications. The sleeve uses clamps and bushes with mechanical and geometrical characteristics tested at the Politecnico di Torino with Certified ***protocol 8681 no. 8545/16/A***

Clamps are supplied oiled in plastic cans with hermetic seal in order to prevent oxidation.
All the cans are provided with:

- *lot identification,*
- *traceability,*
- *product identification,*

T15 bushes packaged in a box

All bushes and clamps are provided with traceability on the transport document with lot identification.

T15 clamps packaged in 100 piece cans

Bushes are supplied in cardboard boxes in order to prevent oxidation.
All boxes are provided with:

- *lot identification,*
- *traceability,*
- *product identification,*

DI packaging

D2 packaging

All packaging is provided with identification and designed to guarantee the material protection during transport and storage on site.

28.0 – TENSIONING EQUIPMENT

(EURO NORM EN 1537-2002** paragraph 8.4**)

*The Italian and European Standard **"Execution of special geotechnical work: GROUND ANCHORS EURO NORM EN 1537-2002"** establishes and defines principles with regard to anchor technology. This Standard is applicable to the installation, testing and monitoring of permanent and temporary ground anchors where the load capacity is tested.*

28.1 – Anchor loading

(EURO NORM EN 1537-2002** paragraph 8.4**)

Anchor loading must be carried out by using a proper equipment to fulfil the following functions:

- *to tension the tendon and anchor it as its lock-off load,*
- *to ascertain and record the load carrying behaviour of the anchor,*

*The tensioning and adjustment must be carried out by trained personnel, under the control of a properly qualified supervisor, preferably from a company specialized in rock anchorages or a supplier of stressing equipment, in compliance with **EURO NORM EN 1537-2002 paragraph 8.4.1.***

28.2 – Equipment/Calibration

(EURO NORM EN 1537-2002** paragraph 8.4.2.**)

*The equipment is supplied with operating instructions and **CE** marking, it is identified by a part number and a type of construction for each component. It is supplied calibrated according to **EURO NORM EN 1537-2002 paragraph 8.4.2.** and the calibration has a six-month validity; the calibration is provided for both the machine and the tensioning jacks.*

The jacks-pump system allows to snub the whole wire simultaneously by applying the same load to all the strands of the tendon.

Maximum lock-off load (EURO NORM EN 1537-2002 paragraph 9.8)

The maximum lock-off load (Po) shall be limited to 0.6 Ptk.

Investigation tests (EURO NORM EN 1537-2002 paragraph 9.5)

The anchor shall be loaded to failure (Ra) or to a proof load which shall be limited to 0.80 Ptk or 0.95 Pt0.1K, whichever is the lower.

28.3 – Characteristics of the tensioning equipment for TTR and TTS anchorages

- *Hydraulic pump: power supply **380 Volt 50Hz. 16 A 3P+T**, max. pressure **550 bar,***
- ***TTM 450-A** hydraulic pump equipped with: button strip L=10 m, wheeled carriage, double control gauge, electric controls, differentiated pressure regulation on stressing and return, pressure release (safety valve), complete with oil, everything complying with the standards in force and in full respect of **EURO NORM EN 1537-2002.***
- *250-300 KN maximum jack capacity (suitable for anchor extraction tests to failure), all **TTM250KN** jacks have a stressing section of 47.2 cm^2, and are available with these strokes: 100, 200 and 400 depending on use,*
- *Calibration is carried out with a dynamometer calibrated at the Politecnico di Milano or S.I.T. centre on the hydraulic pump-hydraulic extension-distributor-jack assembly,*

28.4 - Characteristics of the tensioning equipment for TTM and TTM-F anchorages

- *Hydraulic pump: power supply **380 Volt 50Hz. 32 A 3P+T**, max. pressure **650 bar,***
- ***TTM 1000-E** hydraulic pump equipped with: button strip L=10 m, wheeled carriage, double control gauge, electric controls, differentiated pressure regulation on stressing and return, pressure release (safety valve), complete with oil, everything complying with the standards in force and in full respect of **EURO NORM EN 1537-2002.***
- *Jacks for tensioning anchorages from 1 to 27 strands (suitable for anchor extraction tests to failure). All M jacks have a declared section, and are available with these strokes: 250 to 300 depending on use,*
- *Calibration is carried out with a dynamometer calibrated at the Politecnico di Milano or S.I.T. centre on the hydraulic pump-hydraulic extension-jack assembly,*

29.0 - CALIBRATION OF TTR EQUIPMENT
*(**EURO NORM EN 1537-2002** paragraph 8.4.2)*

*The **TTR** equipment is calibrated via the **S1000** dynamometer box and the **S300KN** hydraulic transducer, which allows to verify the load applied by the TTM 250KN jack to the anchorage as the pressure applied by the pump to the jack varies.*
*The **S1000** dynamometer box and the **S300KN** hydraulic transducer are calibrated at a **SIT** centre or **authorized Polytechnic**. The dynamometer allows to consider all the system losses, which can be considered as continuous and accidental and found in a tensioning equipment in:*

- *all hydraulic pumps suffer from internal losses due to the circuit and due to the plant decay caused by its use over time,*
- *losses in the hydraulic extension that are directly proportional to their length and to their decay caused by use over time,*
- *losses in the manifold, which is part of the circuit and suffers from internal losses,*
- *losses in the jack, which suffers from internal losses due to internal friction and from mechanical decay caused by use over time,*

Equipment being calibrated with S1000 gauge box and S300KN hydraulic transducer

*The **S300KN** hydraulic transducer allows to survey the load applied by a tensioning jack to the anchorage and to calibrate the system. The value is read on the **S1000** dynamometer box that allows to assess the load value in Kg. or dN applied to the anchorage.*
*The **S1000** dynamometer box consists of digital gauges with a 1 bar precision, which can survey pressure in a circuit with a high-level precision. They can be used together with the hydraulic transducer, but also with a hydraulic circuit where they can work as a digital sample gauge.*
With this function, they have a reading capacity of max. 700 bar.

The use of the instrument as a sample gauge does not allow to calibrate the tensioning equipment, but only to check pressure at several points in the circuit, thus assessing whether the previously read values have changed. The system is calibrated on the anchorage assembly, not on pressure.
Simple analogue-reading analogue gauges are also available calibrated, which are easier to insert in the circuit for checking, but which are less direct in reading with respect to a digital reading.

S1000 gauge box

S300KN hydraulic transducer

S300KN hydraulic transducer

29.1 – Calibration of TTM equipment
*(**EURO NORM EN 1537-2002** paragraph 8.4.2)*

*The **TTM** equipment is calibrated via a calibrated electrical cell, which is designed to survey the load applied by a jack bucked by a proper metallic structure, which allows to compare the load applied by the jack and the load read on the sample cell.*

This mechanism allows by means of a data acquisition electronic system to calibrate the jack, by surveying the correct comparison between load applied and pressure read by the pump.

29.2 - Equipment
*(**EURO NORM EN 1537-2002** paragraph 8.4.2)*

Stressing equipment and dynamometers in regular use shall be calibrated at intervals not exceeding 6 months, and the calibration certificate shall be made available for inspection on site at all times. Stressing equipment for bar and strand tendon should tension the complete tendon as a single unit.
It should be provided with or be supplemented by measuring devices which establish the total load in the multiple strands at any time during testing. Alternatively, an accurate control of the release of the wedge should be carried out.
The equipment should be able to snub the steel reinforcement safely up to the test stressing specified, remaining under the maximum pressure allowed by the pump.

***TTM 450-A** hydraulic pump used with a digital **S1000** gauge box to check the stability of the pump when in use.*
During the six month validity of calibration, by using of a connected gauge it is possible to check whether the pump has lost its initial calibration.

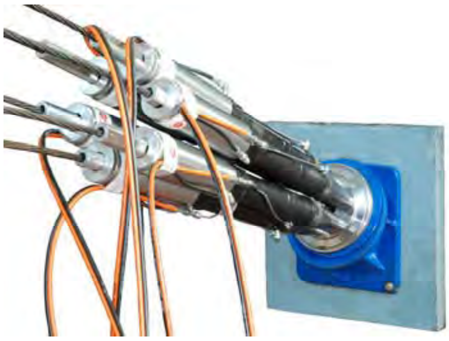
Pressure calibration on a TTM hydraulic pump

Calibration of TTM jack and related pump.

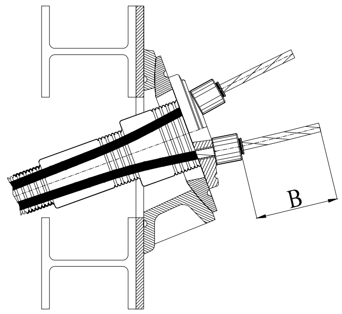
Pressure can also be checked via an analogue gauge applied to the downstream output, which allows to survey the pressure loss in the circuit inside the pump.

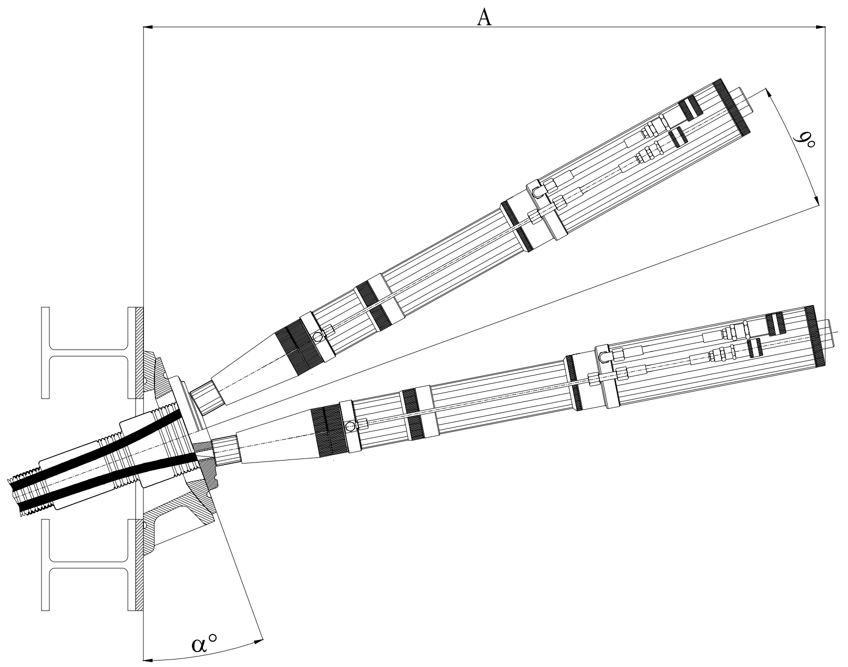
Calibration of a M jack

30.0 - TENSIONING ON TTR ANCHORAGES - DIMENSIONS OF JACKS



*Tensioning of **TTR** anchorages with **TTM250KN** jacks must take into consideration the dimensions of the jacks which may suffer from deviation up to 9°. This implies dimensions to consider during the production phase. **TTM** offers jacks with different strokes to allow tensioning even with limited space available.*





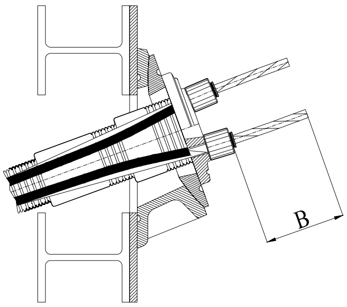
TTM250KN jacks dimensions on TTR heads:

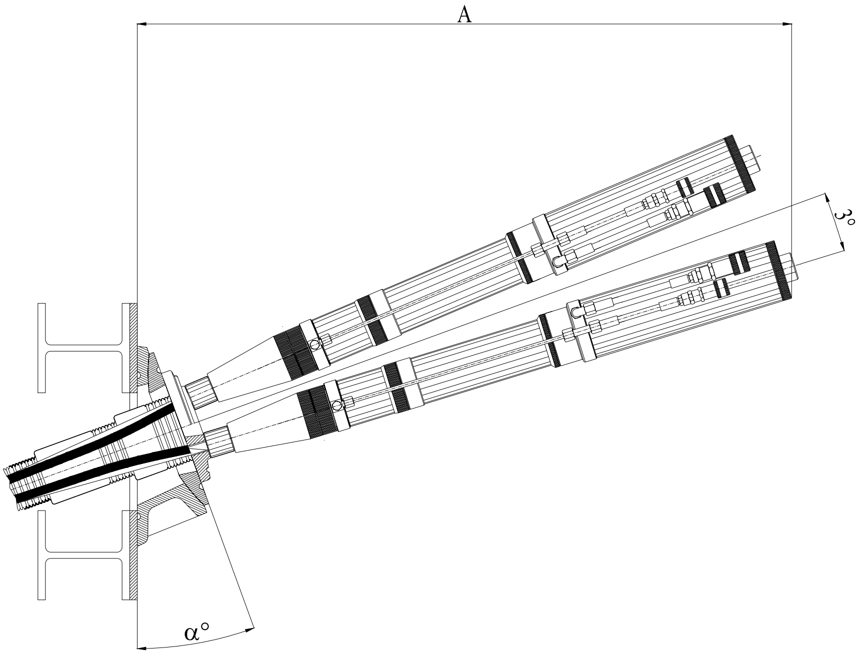
Jack type	*α°*	*A*	*B*	*α°*	*A*	*B*
	(degrees)	*(mm.)*	*(mm.)*	*(degrees)*	*(mm.)*	*(mm.)*
TTM250KN-200	*20°*	*1.100*	*350*	*30°*	*1.080*	*350*
TTM250KN-100	*20°*	*900*	*350*	*30°*	*890*	*350*
TTM250KN-60	*20°*	*820*	*350*	*30°*	*810*	*350*
TTM250KN-40	*20°*	*450*	*350*	*30°*	*440*	*350*

Subject to modification *Further data is available on request*

30.1 - Tensioning on TTR-E anchorages - dimensions of jacks

*Tensioning of **TTR-E** anchorages with **TTM250KN** jacks must take into consideration the dimensions of the jacks which may suffer from deviation up to 3° as required by the **EURO NORM EN 1537-2002 paragraph 6.3.**This implies dimensions to consider during the production phase. **TTM** offers jacks with different strokes to allow tensioning even with limited space available.*



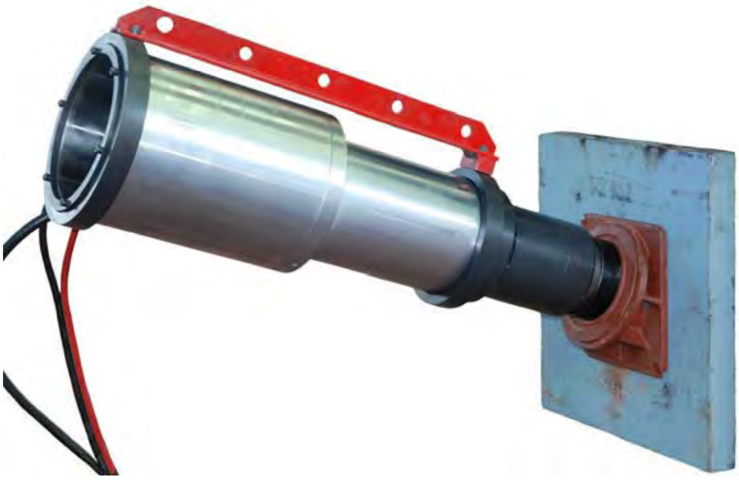


TTM250KN jacks dimensions on TTR E15 heads:

Jack type	*α°*	*A*	*B*	*α°*	*A*	*B*
	(degrees)	*(mm.)*	*(mm.)*	*(degrees)*	*(mm.)*	*(mm.)*
TTM250KN-200	*20°*	*1.090*	*350*	*30°*	*1.050*	*350*
TTM250KN-100	*20°*	*890*	*350*	*30°*	*850*	*350*
TTM250KN-60	*20°*	*760*	*350*	*30°*	*730*	*350*
TTM250KN-40	*20°*	*450*	*350*	*30°*	*440*	*350*

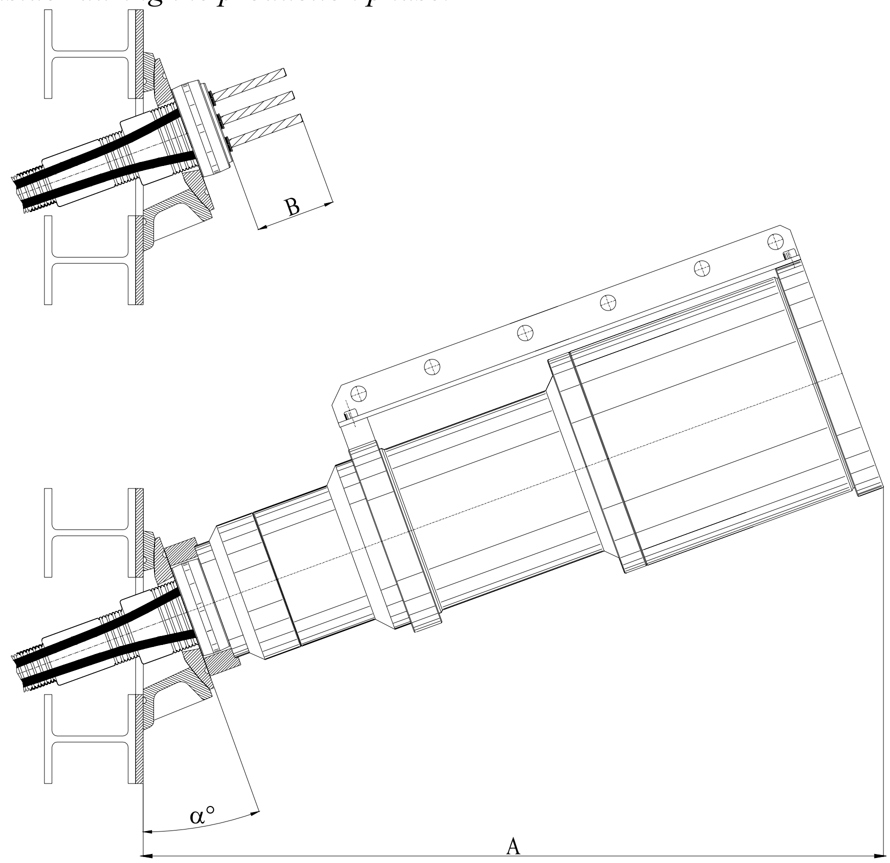
Subject to modification *Further data is available on request*

30.2 - Tensioning on TTM anchorages - dimensions of jacks



M1800KN jack

*Tensioning of **TTM** anchorages with **M** jacks must take into consideration the dimensions of the jacks which may suffer from deviation up to 3° as required by the **EURO NORM EN 1537-2002 paragraph 6.3.**, as well as of their weight that requires mechanical lifting means. The application implies dimensions to consider during the production phase.*



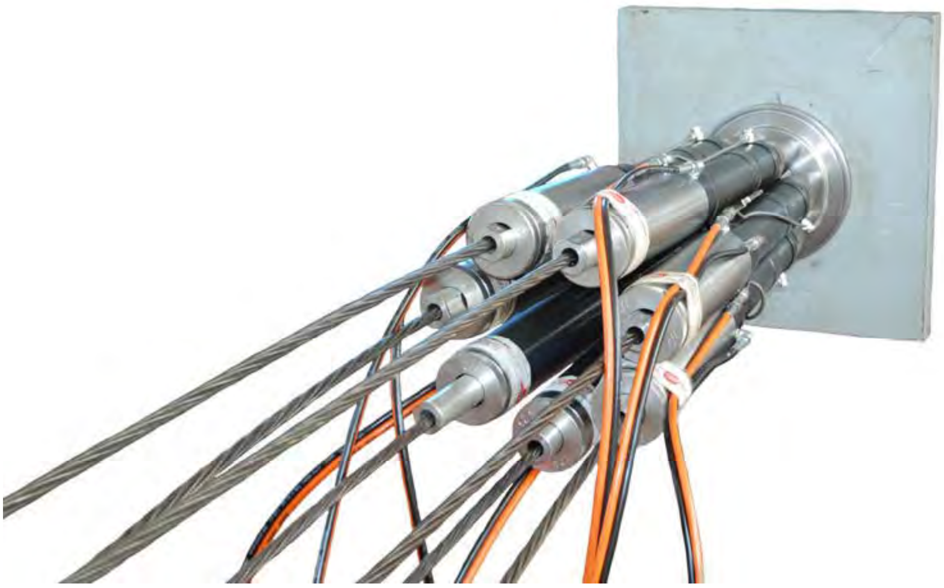
M jacks dimensions:

Jack type	*α*	*A*	*B*	*α*	*A*	*B*
	(degrees)	*(mm.)*	*(mm.)*	*(degrees)*	*(mm.)*	*(mm.)*
M1600KN	*20°*	*1070*	*650*	*30°*	*1040*	*650*
M1800KN	*20°*	*1150*	*650*	*30°*	*1120*	*650*
M3000KN	*20°*	*1200*	*650*	*30°*	*1180*	*650*
M3600KN	*20°*	*1250*	*650*	*30°*	*1220*	*650*
M4800KN	*20°*	*1250*	*650*	*30°*	*1220*	*650*
M6800KN	*20°*	*1470*	*650*	*30°*	*1450*	*650*

Subject to modification *Further data is available on request*

31.0 - THE ANCHOR LOADING PROCESS
***(EURO NORM EN 1537-2002** paragraph 8.4.3)*

If the loading on the structure is required to control the sequence or the phase loading of the anchors, then this shall be specified at the design stage.
*The anchored structure should be designed to provide reaction to allow load testing of the ground anchors in accordance with **EURO NORM EN 1537-2002 paragraph 9**.*
The methods of stressing and load recording to be used in each testing or stressing operation should be detailed prior to any tensioning work.
The equipment should be used strictly in accordance with the manufacturer's operating instructions. Stressing or testing should not be carried out until sufficient hardening of the grout in the fixed length has been achieved, which normally requires seven days.
In sensitive cohesive soils it may be appropriate to stipulate a minimum time period for soil recovery after completion of the ground anchor installation and prior to stressing.
During the testing or stressing of production anchors no indents resulting from tendon gripping should be formed in the tendon below the anchor head and no damage should be allowed to the corrosion protection.

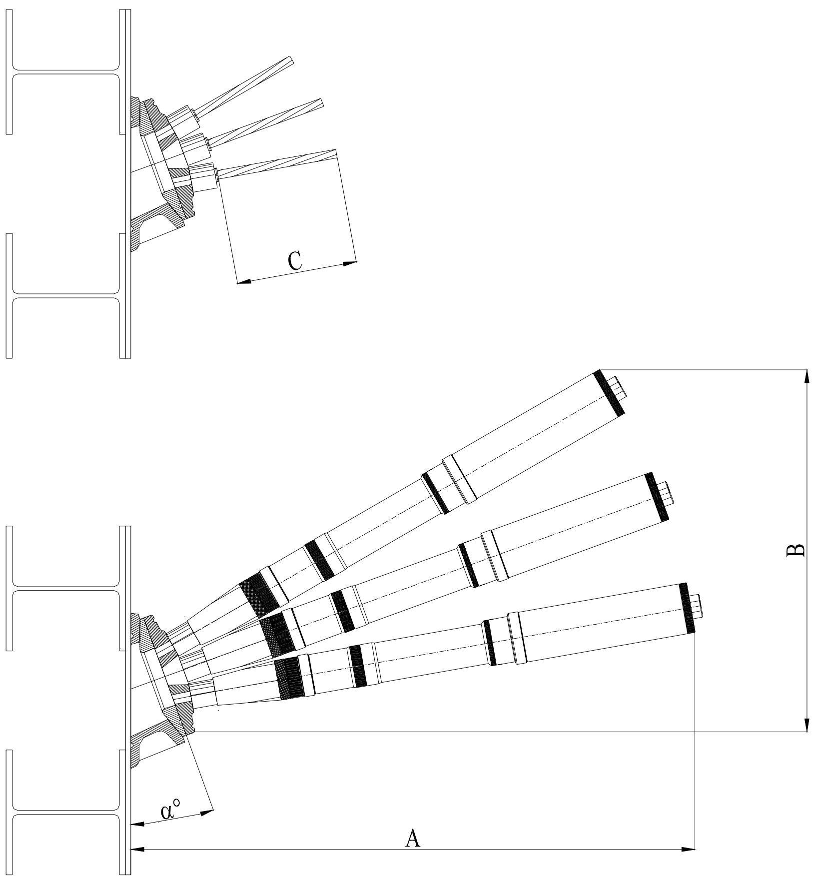


31.1 - Dimensions of TTM jacks under tensioning on TTR anchorages

TTM jacks are available with different strokes to offer several dimensions for tensioning. They shall be considered indicative and for jack applications where tensioning is carried out simultaneously on all the strands under isopressure.

31.1.1 - TTM250KN-200 jacks dimensions on TTR heads

TTM 250KN-200 jack

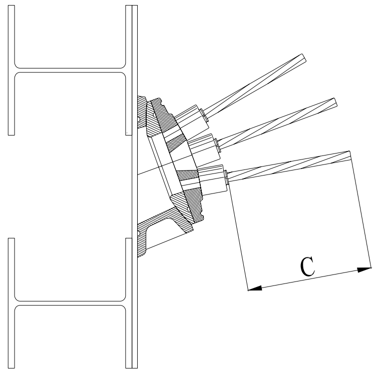


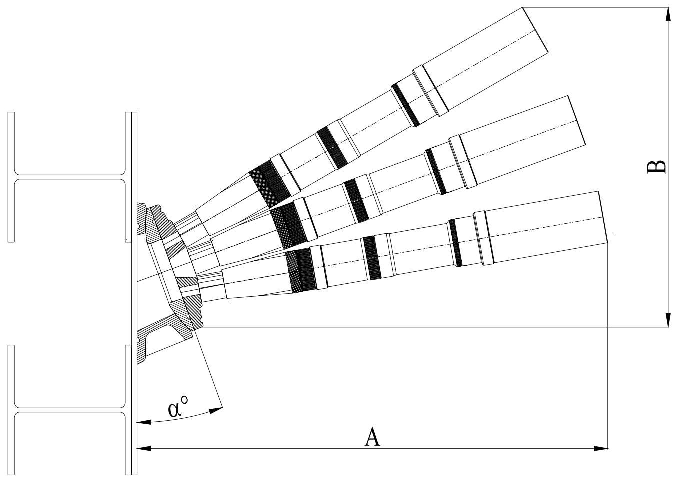
Jack type	*α°*	*A*	*B*	*C*	*α°*	*A*	*B*	*C*
	(degrees)	*(mm.)*	*(mm.)*	*(mm.)*	*(degrees)*	*(mm.)*	*(mm.)*	*(mm.)*
TTM250KN-200	*20°*	*1.100*	*700*	*350*	*30°*	*1.080*	*730*	*350*

Subject to modification *Further data is available on request*

31.1.2 - TTM250KN-100 jacks dimensions on TTR heads

TTM 250KN-100 jack



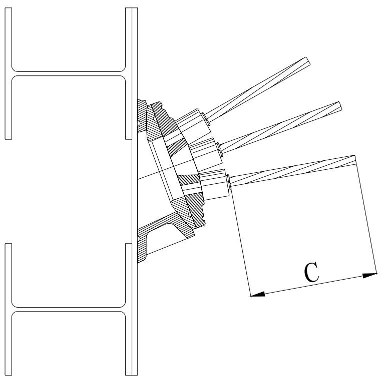


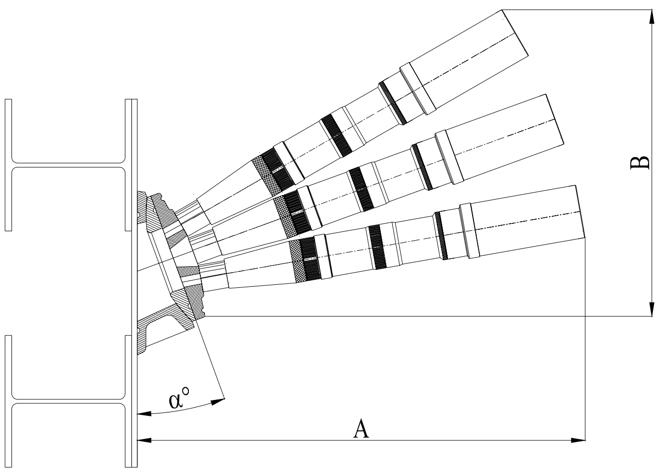
Jack type	*α°*	*A*	*B*	*C*	*α°*	*A*	*B*	*C*
	(degrees)	*(mm.)*	*(mm.)*	*(mm.)*	*(degrees)*	*(mm.)*	*(mm.)*	*(mm.)*
TTM250KN-100	*20°*	*900*	*600*	*350*	*30°*	*890*	*630*	*350*

Subject to modification *Further data is available on request*

31.1.3 - TTM250KN-60 jacks dimensions on TTR heads

TTM 250KN-60 jack



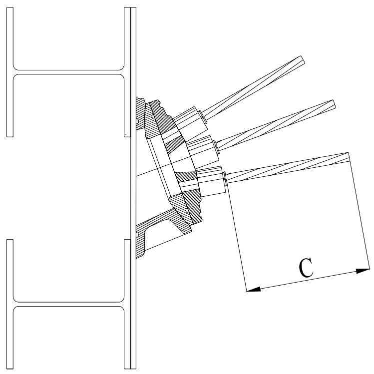


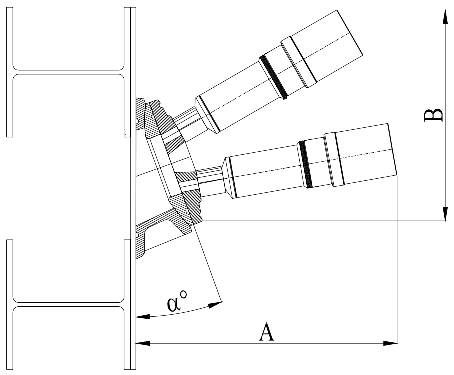
Jack type	***α°***	***A***	***B***	***C***	***α°***	***A***	***B***	***C***
	(degrees)	*(mm.)*	*(mm.)*	*(mm.)*	*(degrees)*	*(mm.)*	*(mm.)*	*(mm.)*
TTM250KN-60	*20°*	*820*	*550*	*350*	*30°*	*810*	*580*	*350*

Subject to modification *Further data is available on request*

31.1.4 - TTM250KN-C-40 jacks dimensions on TTR heads

TTM 250KN-C-40 jack





Jack type	*α°*	*A*	*B*	*C*	*α°*	*A*	*B*	*C*
	(degrees)	*(mm.)*	*(mm.)*	*(mm.)*	*(degrees)*	*(mm.)*	*(mm.)*	*(mm.)*
TTM250KN-C-40	*20°*	*450*	*400*	*120/150*	*30°*	*440*	*420*	*80-100*

Subject to modification *Further data is available on request*

TTM250KN-C-40 *jacks are designed for tensioning on short whips. Their use cannot be considered simultaneous on the anchorage, but only for strand by strand use or for tensioning on anchorages with alternate strands.*

32.0 - MEDIUM RESISTANCE BARS

*Medium resistance bars are used for post-tensioning and geotechnical applications: they have continuous threads, a diameter between 26.5 and 47 mm and working loads between **568 KN and 1,820 KN**.*

The main applications are:
- *Continuous structures or prefabricated elements made of reinforced prefabricated concrete*
- *Additional reinforcement for reinforced concrete works*
- *Permanent and temporary anchors,*
- *Temporary or permanent single ground anchors with corrosion protection*

Medium resistance bar technical characteristics:

Diameter	**18**	**26,5**	**32**	**36**	**40**	**47**
Area (cm^2)	2,41	5,55	8,04	10,20	12,57	17,35
Mass (Kg/m)	1,96	4,48	6,53	8,27	10,21	14,10
Fpyk (KN)	230	525	760	970	1190	1650
Fptk (KN)	255	580	850	1070	1320	1820
f_{pyt} / f_{ptk}	950/1050	950/1050	950/1050	950/1050	950/1050	950/1050
Type	**Y 1050**	**Y 1050**	**Y 1050**	**Y 1050**	**Y 1050**	**Y 1050**

32.1 – Accessories for the assembly of ground anchors in bars

Rubber accessories for bars

The grouting accessories are divided into the following types:

"PU" tips
DD26,5-PU *tips for Ø 26.5 mm bars*
DD32-PU *tips for Ø 32 mm bars*
DD36-PU *tips for Ø 36 mm bars*
DD40-PU *tips for Ø 40 mm bars*
DD47-PU *tips for Ø 47 mm bars*
DD50-PU *tips for Ø 50 mm bars*

"TA" buffers
DD26,5-TA *buffers for Ø 26.5 mm bars*
DD32-TA *buffers for Ø 32 mm bars*
DD36-TA *buffers for Ø 36 mm bars*
DD40-TA *buffers for Ø 40 mm bars*
DD47-TA *buffers for Ø 47 mm bars*
DD50-TA *buffers for Ø 50 mm bars*
All the end-pieces are made of NBR rubber and are designed for use with their sheaths via interference fitting.
The end-pieces have special external templates that guarantee the grouting seal on sliding PVC sleeves.

DD-TA buffer

DD-PU buffer

Accessory coupling on bars can be carried out:
- ***DD-TA - DD-TA*** *(intermediate part)*
- ***DD-TA - DD-PU*** *(end part)*

The end-pieces are designed with a threaded hole on the body for injection.

Internal ***DD-IN*** *spacers for bars*

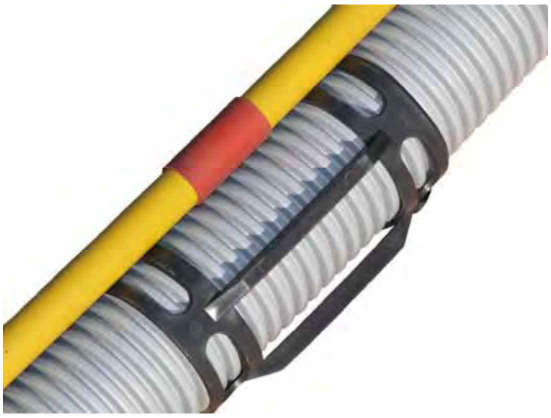
"IN" internal spacers
Internal ***DD26,5-IN*** *spacers Ø 26.5 mm.*
Internal ***DD32-IN*** *spacers Ø 32 mm.*
Internal ***DD36-IN*** *spacers Ø 36 mm.*
Internal ***DD40-IN*** *spacers Ø 40 mm.*
Internal ***DD47-IN*** *spacers Ø 47 mm.*

Internal spacers guarantee suitable bar centering inside the corrugated sheath. The internal spacers are made of nylon for easier sheath sliding after assembly.

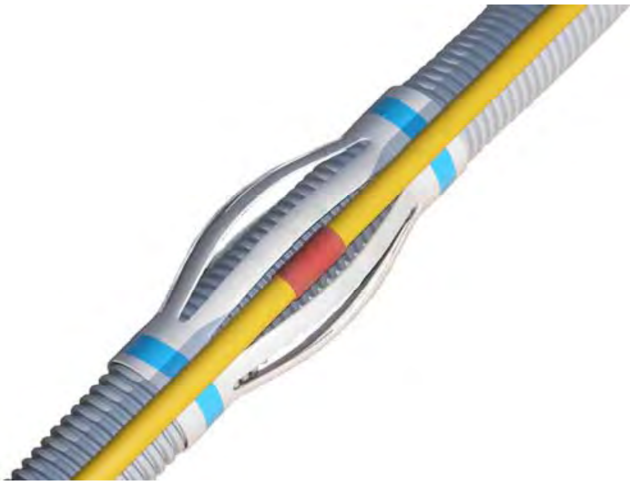
Application of DD-TA buffer

Buffer on pre-grouted bar; the protrusion of the bar allows sleeve joint connection.
After inserting the sleeve, the PVC tube sliding on the buffers guarantees its protection.

PVC tube on pre-grouted ground anchor

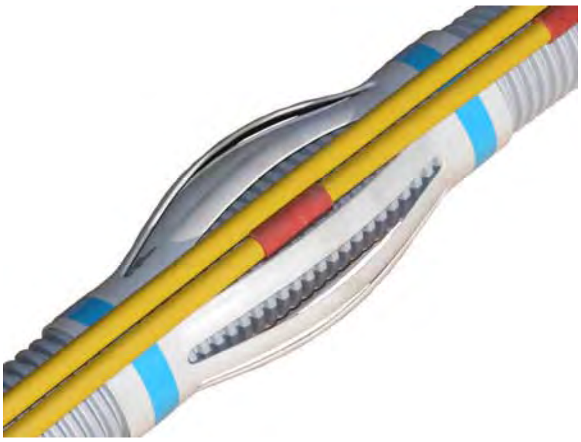


Bar ground anchor with DD-EF spacer and tube for external grouting



Bar ground anchor with DD-ED spacer and tube for external grouting

Bar ground anchor with DD-EF spacer and tube for repeated external grouting



Bar ground anchor with DD-ED spacer and tube for repeated external grouting

Fitting of rubber buffers on 32 mm diameter bars and preparing of corrugated tube grouting.

Taping of rubber tips on bars complete with corrugated tube for grouting.

Upper vent of bar internal grouting; the corrugated tube allows a natural venting for the cement mix.

Taping of rubber buffers on bars complete with corrugated tube for grouting.

Prepared bar grouting on an inclined plane: grouting is from below upwards, with the vent on the upper part.

The kind of material is identified by painting the bars on the cutting zone. The following colours are used for the respective kinds:

- *Green: 950/1050,*

33.0 – GROUND ANCHORS IN BARS

33.1 - TBR-00 temporary ground anchors

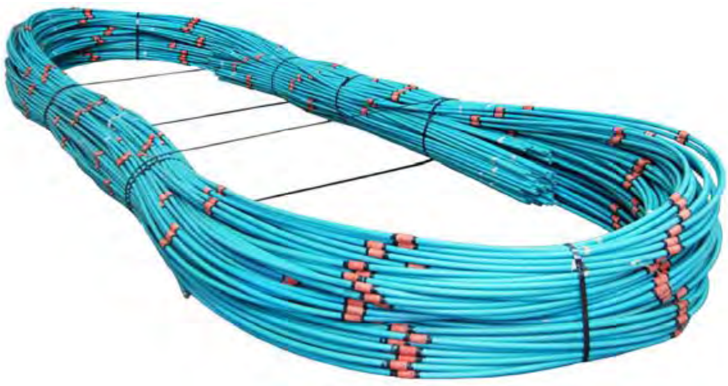
TRB-00 temporary *ground anchors are produced in compliance with the European and Italian Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" paragraph 6.9.3*** *and they are made of harmonic steel bars.*
The ***TRB-00 temporary*** *ground anchor is usually used in the construction of bulkheads and diaphragms, where the type of ground does not have any particular geo-technical problems and where temporary ground anchors are needed.*

The anchor is made as follows:

- *In the active part, the bar is bare and by exploiting the adhesion provided by the continuous thread, it guarantees the anchorage to the foundation.*
- *The free length is protected by greasing and sheathing. The separation of the free length from the active part is achieved by way of a buffer of sealing material, which allows both parts to be perfectly hermetic.*

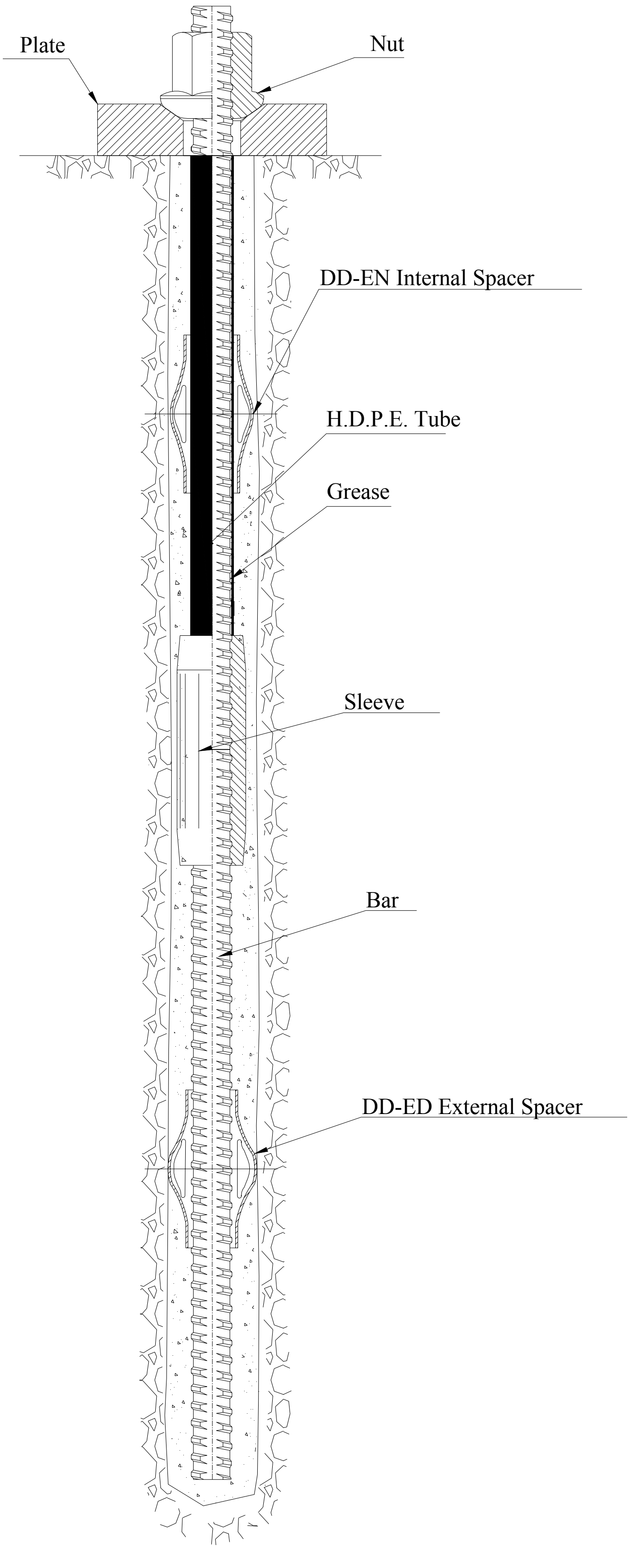
Variations to the standard version:
- *Packer insertion;*
- *External tube for repeated grouting, type* ***T-004-U*** *U-shaped double tube with valves spaced at 0.5 m, dimensions 10x14 mm;*
- *External tube for grouting, type* ***T-004-S*** *single tube with valves spaced at 0.5 m, dimensions 10x14 mm;*
- *External tube for grouting, type* ***T-005-S*** *single tube with valves spaced at 0.5 m, dimensions 15x21 mm;*
- *External tube for repeated grouting, type* ***T-005-U*** *U-shaped double tube with valves spaced at 0.5 m, dimensions 15x21 mm;*
- *Extra grouting tubes;*
- *External spacers;*
- *Protection caps.*

T001 27x34 mm valvate tube



T003 U-shaped 15x21 mm double valve tube

33.1.1 - TRB-00 temporary ground anchor diagram



33.2 - TRB-01 temporary ground anchors

TRB-01 temporary *ground anchors are produced in compliance with the European and Italian Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" paragraph 6.9.3*** *and they are made of harmonic steel bars.*
The ***TRB-00 temporary*** *ground anchor is usually used in the construction of bulkheads and diaphragms, where the type of ground does not have any particular geo-technical problems and where temporary ground anchors are needed with the free length having a double protection.*

The anchor is made as follows:

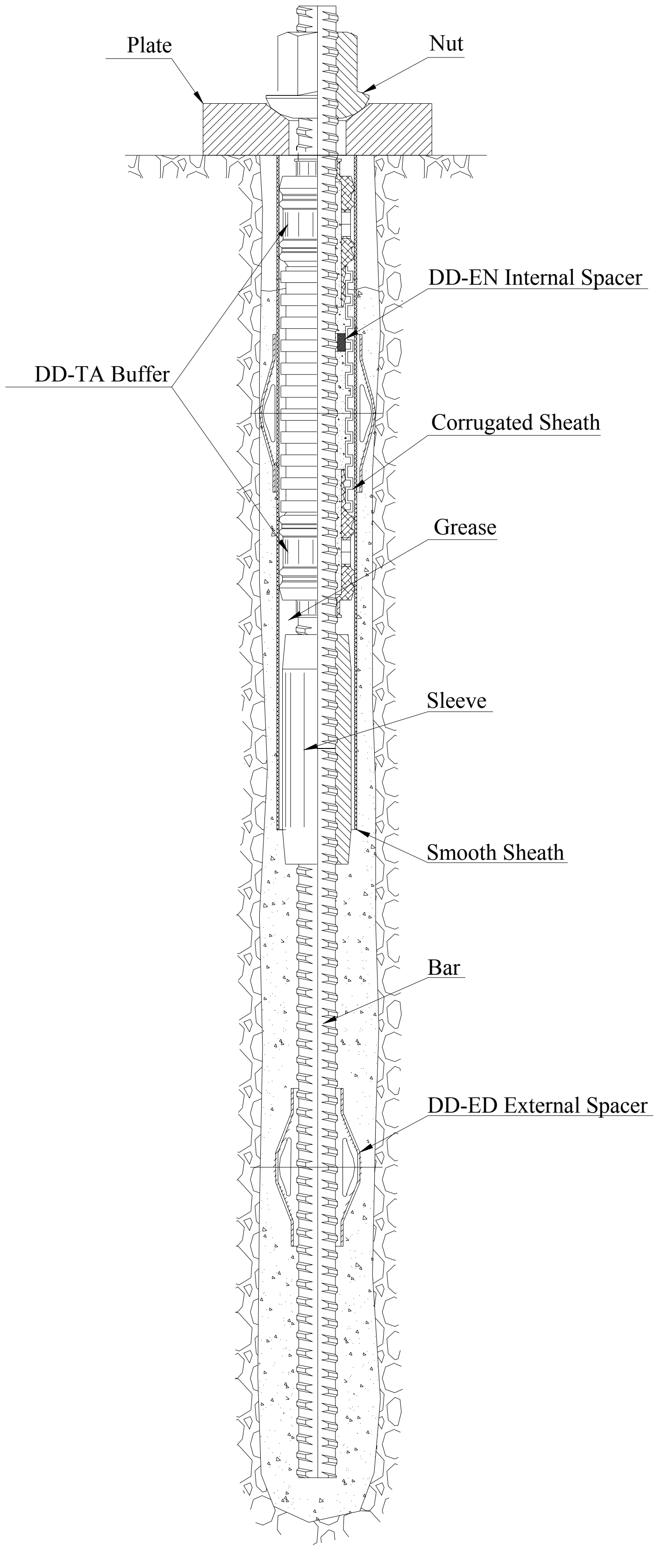
- *In the active part, the bar is bare and by exploiting the adhesion provided by the continuous thread, it guarantees the anchorage to the foundation.*
- *The free length is protected by inserting a corrugated sheath in H.D.P.E. The separation of the free length from the active part is achieved by way of NBR rubber buffers, which allow both parts to be perfectly hermetic. A smooth external PVC sheath guarantees the sliding of the anchor free length during tensioning.*

Free length of TRB-01 temporary ground anchors with PVC sheath

Variations to the standard version:
- *Packer insertion;*
- *Bar free length part greased and protected by a polyethylene tube.*
- *External tube for repeated grouting, type* ***T-004-U*** *U-shaped double tube with valves spaced at 0.5 m, dimensions 10x14 mm;*
- *External tube for grouting, type* ***T-004-S****single tube with valves spaced at 0.5 m, dimensions 10x14 mm;*
- *External tube for grouting, type* ***T-005-S****single tube with valves spaced at 0.5 m, dimensions 15x21 mm;*
- *External tube for repeated grouting, type* ***T-005-U*** *U-shaped double tube with valves spaced at 0.5 m, dimensions 15x21 mm;*
- *Extra grouting tubes;*
- *External spacers;*
- *Protection caps.*

Accessories for assembling pre-grouted bars with double protection

33.2.1 - TRB-01 temporary ground anchor diagram



33.3 - TPB-02 permanent ground anchors

TRB-02 permanent *ground anchors are produced in compliance with the European and Italian Standard* ***"Execution of special geo-technical works: GROUND ANCHORS EURO NORM EN 1537-2002" paragraph 6.9.3*** *and they are made of harmonic steel bars.*
The ***TPB-02 permanent*** *ground anchor is usually used in the construction of bulkheads and diaphragms, where the type of ground does not have any particular geo-technical problems and where temporary ground anchors are needed with the free length having a double protection.*

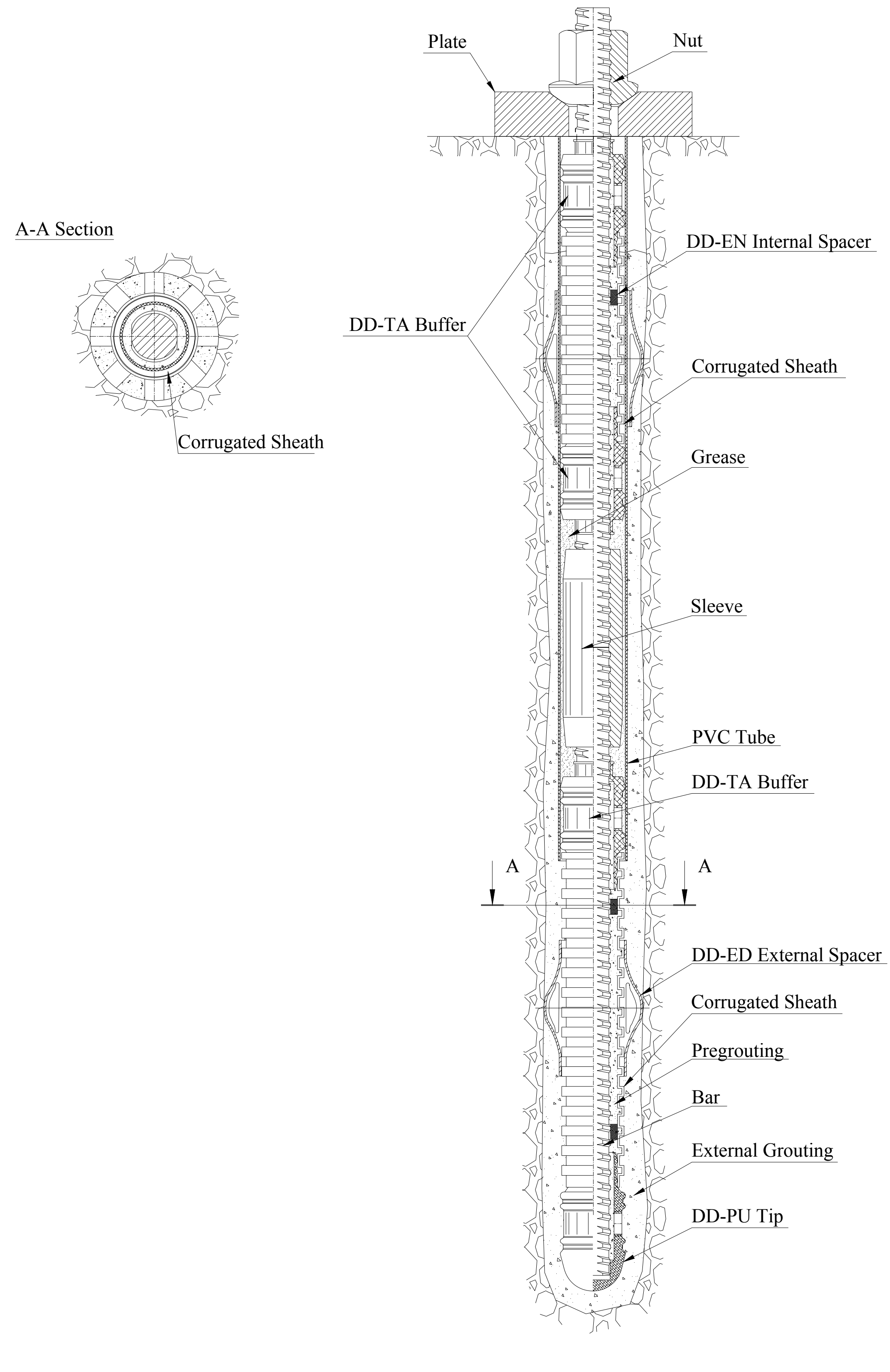
The anchor is made as follows:

- *In the active part, the bar is separated from the corrugated sheath by special spacers/centralizers arranged radially to the bar itself,*
- *The free length is protected by inserting a corrugated sheath in H.D.P.E. The separation of the free length from the active part is achieved by way of NBR rubber buffers, which allow both parts to be perfectly hermetic. A smooth external PVC sheath guarantees the sliding of the anchor free length during tensioning.*

TPB-02 permanent ground anchor bulb with DD-ED external spacer

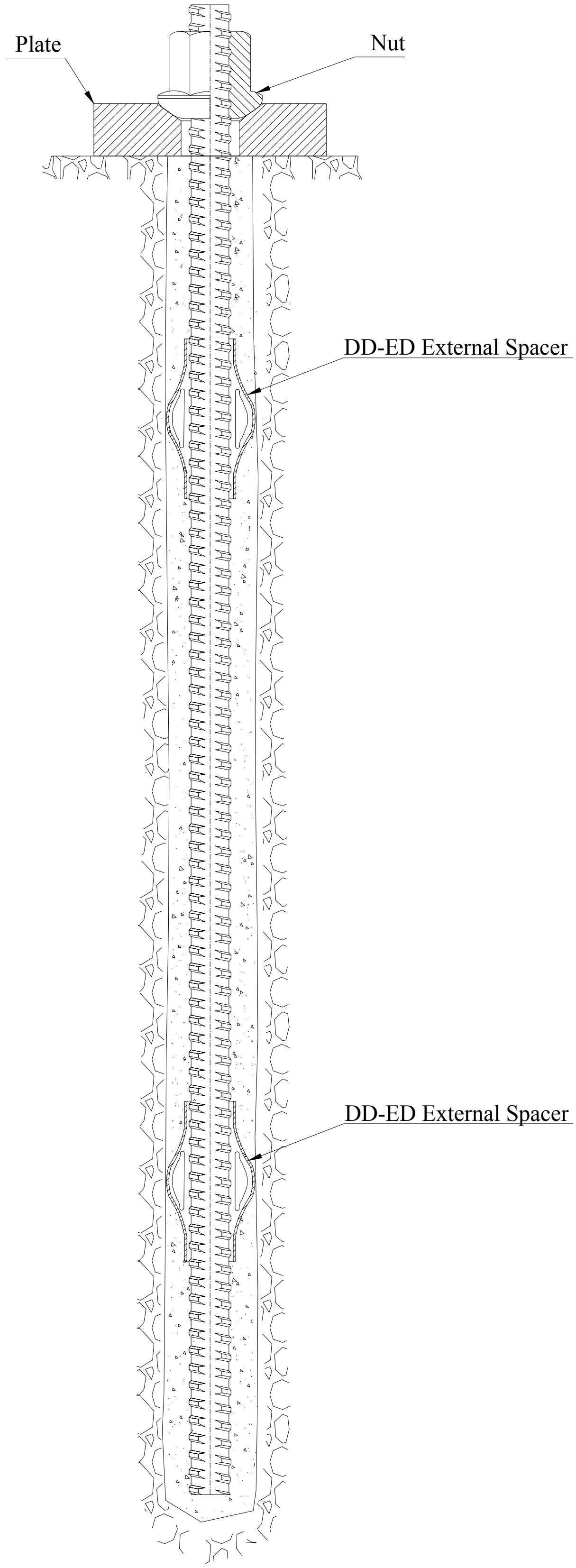
Variations to the standard version:
- *Packer insertion;*
- ***T 001*** *27/34 mm external tube for selective grouting;*
- ***T 002*** *27/34 mm external tube for grouting;*
- *External tube for repeated grouting, type* ***T-005-U*** *U-shaped double tube with valves spaced at 1 m, dimensions 15x21 mm;*
- *External tube for repeated grouting, type* ***T-004-U*** *U-shaped double tube with valves spaced at 0.5 m, dimensions 10x14 mm;*
- *External tube for grouting, type* ***T-004-S****single tube with valves spaced at 0.5 m, dimensions 10x14 mm;*
- *External tube for grouting, type* ***T-005-S****single tube with valves spaced at 0.5 m, dimensions 15x21 mm;*
- *External tube for repeated grouting, type* ***T-005-U*** *U-shaped double tube with valves spaced at 0.5 m, dimensions 15x21 mm;*
- *Extra grouting tubes;*
- *External spacers;*
- *Protection caps.*

33.3.1 - TPB-02 permanent ground anchor diagram



33.4 - T-00 passive bars

T-00 *passive bars are usually used for constructing bulkheads and diaphragms where the type of ground does not have any particular geo-technical problems and where the device does not have to be tensioned; its application is therefore passive.*



33.5 - Tensioning values on bar anchorages for geo-technical applications

***(EURO NORM EN 1537-2002** paragraph 9.8)*

Maximum lock-off load EURO NORM EN 1537-2002 paragraph 9.8

The maximum lock-off load (Po) shall be limited to 0.6 Ptk.$_{tk}$

Po = 0.6 P_{tk}

Investigation tests EURO NORM EN 1537-2002 paragraph 9.5

The anchor shall be loaded to failure (Ra) or to a proof load which shall be limited to 0.80 P_{tk} or 0.95 $P_{t0.1K,}$ whichever is the lower

Ra=0.80 P_{tk} or 0.95 $P_{t0.1K}$

Ptk *Characteristic load capacity of the tendon,*

Pt0.1K *Characteristic tensile load at which there is a permanent strain of 0.1 %*

Medium resistance bar technical characteristics:

Diameter	*18*	*26,5*	*32*	*36*	*40*	*47*
Area (cm^2)	*2,41*	*5,55*	*8,04*	*10,20*	*12,57*	*17,35*
Mass (Kg/m)	*1,96*	*4,48*	*6,53*	*8,27*	*10,21*	*14,10*
$P_{t0,1K}$ (KN)	*230*	*525*	*760*	*970*	*1190*	*1650*
P_{tk} (KN)	*255*	*580*	*850*	*1070*	*1320*	*1820*
f_{pyk} / f_{ptk}	*950/1050*	*950/1050*	*950/1050*	*950/1050*	*950/1050*	*950/1050*
Type	***Y 1050***	***Y 1050***	***Y 1050***	***Y 1050***	***Y 1050***	***Y 1050***

33.6 - Low resistance bars

Low resistance bars are used for geo-technical applications, have continuous threading and diameters from 12 to 50 mm.

The main applications are:

- *Micropiles*
- *Soil nails*

Low resistance bar technical characteristics:

Diameter	*12*	*16*	*20*	*25*	*26*	*28*
Area (cm^2)	*1,13*	*2,01*	*3,14*	*4,91*	*5,31*	*6,16*
Mass (Kg/m)	*0,89*	*1,58*	*2,47*	*3,85*	*4,17*	*4,83*
Fpyk (KN)	*57*	*100*	*160*	*245*	*265*	*310*
Fptk (KN)	*65*	*110*	*175*	*270*	*290*	*340*
f_{pyt} / f_{ptk}	*500/550*	*500/550*	*500/550*	*500/550*	*500/550*	*500/550*
Type	***B500***	***B500***	***B500***	***B500***	***B500***	***B500***

Diameter	*30*	*32*	*36*	*40*	*50*	
Area (cm^2)	*7,07*	*8,04*	*10,20*	*12,60*	*19,60*	
Mass (Kg/m)	*5,55*	*6,31*	*7,99*	*9,87*	*15,40*	
Fpyk (KN)	*355*	*405*	*510*	*630*	*980*	
Fptk (KN)	*390*	*440*	*560*	*690*	*1080*	
f_{pyt} / f_{ptk}	*500/550*	*500/550*	*500/550*	*500/550*	*500/550*	
Type	***B500***	***B500***	***B500***	***B500***	***B500***	

Low resistance bars cannot be tensioned, they do not guarantee a low relaxation over time, they are to be used as passive nails to resist cutting stress.

34.0 – EQUIPMENT

All the equipment is manufactured in full respect of the "Machinery regulations", they are provided with CE marking and button strip for drive operation at 24 Volt. 50Hz. to allow use even in difficult conditions.
All the machine are provided with onboard electrical protections and are supplied as follows: 3 poles plus earth 3P+T with supply at 380 Volt. 50Hz. and 16, 32 and 63 Amp supply base on the machine absorption.
Where a direction of rotation must be observed, machines are provided with a change-over switch to allow the phase inversion automatically without any manual intervention on the circuit.
All the hydraulic circuits are provided with safety valves to limit overpressure or mistakes in the operation of regulation valves. A metallic label identifies the machine and its part number.
All the machines are provided with operating and maintenance manuals, and with the CE marking upon request.

34.1 - Anchor loading

*(**EURO NORM EN 1537-2002** paragraph 8.4)*

"The tensioning and recording shall be carried out by experienced personnel, under the control of a suitably qualified supervisor, provided preferably by a specialist anchor contractor or stressing equipment supplier".
The use of the equipment for site activities is carried out by qualified and trained personnel.

34.2 - Maintenance

The maintenance of the equipment is defined as:

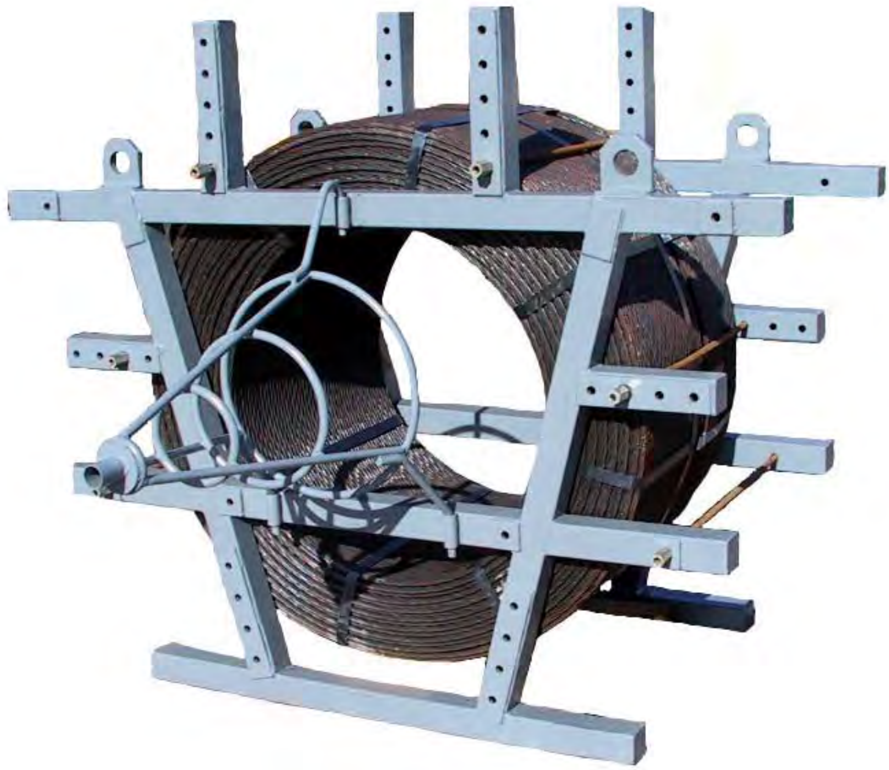
- *planned maintenance, (maintenance caused by wear due to the use of the machine)*
- *upkeep, (maintenance caused by a permanent damage of the machine)*

All maintenance operations aim at restoring the efficiency of the equipment. Any modification carried out on site or by operators make void the CE marking of the equipment void. Restoring it by removing such modifications is considered as upkeep.

34.3 - “B1500” uncoiler

(Uncoiler from 3 to 5 ton.)

*The **B1500** uncoiler was designed to ease threading operations of the strand into the sheaths on building sites. It is usually used in combination with a strand forcing machine and guarantees the unwinding of the strand without tangling even at a high speed.*
It is set up to host coils of different dimensions and diameters.



B1500 uncoiler

The B1500 uncoiler does not require any special anchorage to the ground, its own weight is sufficient to guarantee its stability when used. The coil of strand is inserted between the two shoulders, before cutting the metal band straps, the correct tightening of the closing anchors, which guarantee the correct blocking and the safety of the operations, must be checked.
While cutting the metal band straps, the unwinding direction shown inside the coil must be complied with to guarantee the strand will unwind smoothly.

Type	***Weight***	***Max. capacity***	***Loaded weight***	***Dimensions***	
	(Kg.)	*(mm.)*	*(Kg.)*	*mm.*	
B1500	*180*	*1.000*	*220*	*2500x2500*	

Subject to modification *Further data is available on request*

34.4 – “F2300-E” turntable

(single strand winding turntable)

*The turntable for wire winding allows to handle precut single strands, which are cut to measure and preincised on the polyethylene protection. The **F2300-E** turntable winds them up on a 2.2 m diameter to ease handling on site.*

Type	***Weight***	***Diam. max.***	***Height***	***AxB dimensions***	***Max. capacity***
	(Kg.)	*(mm.)*	*(mm.)*	*(mm.)*	*(Kg.)*
F2300-E	*250*	*2200*	*1250*	*1500x1500*	*160*

Subject to modification *Further data is available on request*

34.5 – "F3000-E turntable"

(single strand winding turntable)

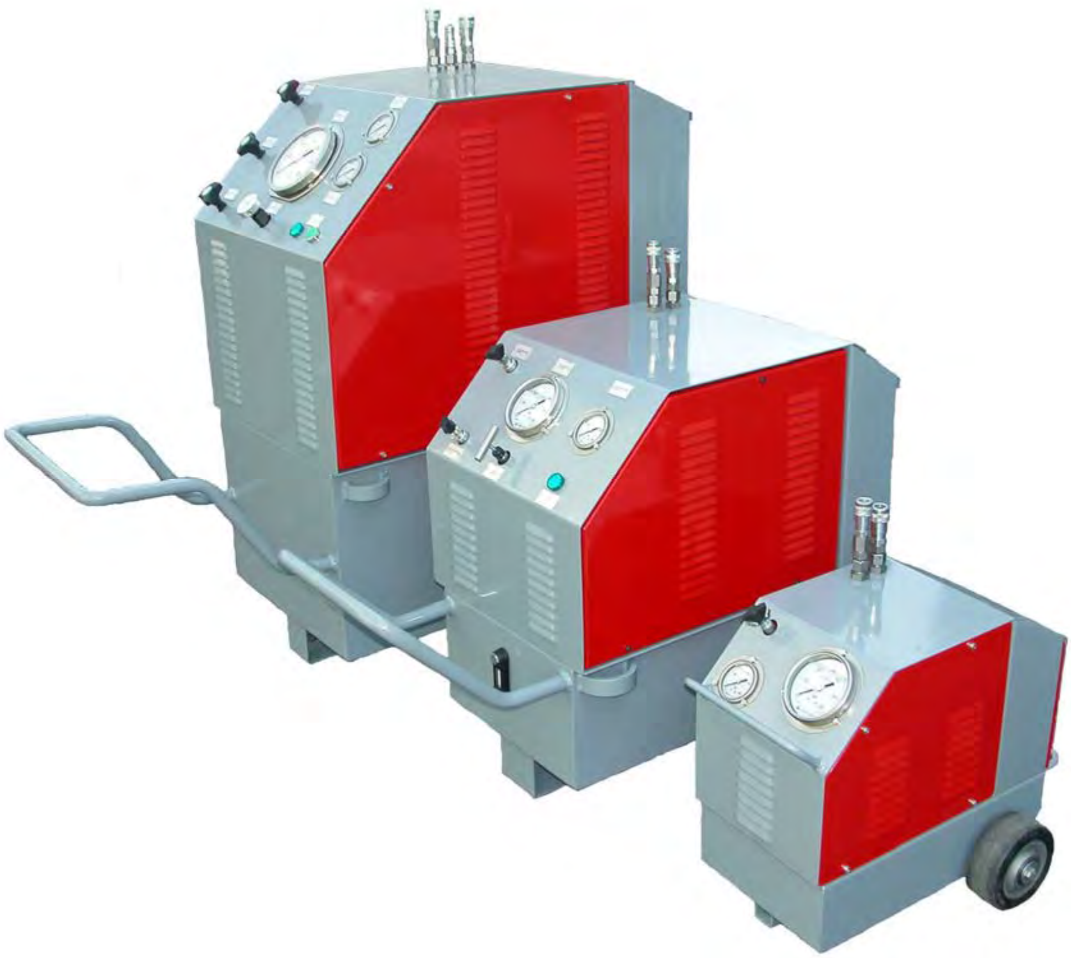
*This turntable is designed for anchor winding. It allows to wind up ground anchors that are assembled with several strands by sliding them on a roller table. Strands are cut and assembled and then wound up on rolls. The **F3000-E** turntable then winds them up on a 2.2 diameter to ease handling them when loading on trucks.*

Type	*Weight*	*Diam. max.*	*Height*	*AxB dimensions*	*Max. capacity*
	(Kg.)	*(mm.)*	*(mm.)*	*(mm.)*	*(Kg.)*
F3000-E	*350*	*2.500*	*2.000*	*2.500x2.500*	*400*

Subject to modification *Further data is available on request*

34.6 - TTM-A hydraulic pumps

All the machines are equipped with a button strip L=10 m which allows all the operating phases of the machine to be controlled. Special calibration valves enable the operator to manually adjust pressure very easily and precisely in the two machine circuits.
The equipment supplied is manufactured in compliance with the EC Directive and has CE markings according to the machinery regulations, as well as a calibration with a six month validity.



Hydraulic pumps: TTM1000-E, TTM 450-A and TTM 250-A

Type	***Weight***	***Max. pressure***	***Capacity***	***Voltage/ Amperes***	***Use***
	(Kg.)	*bar.*	*KW*		
TTM 250-A	*85*	*450-500*	*2,5*	*380/16*	*TTM*
TTM 450-A	*200*	*450-500*	*4.5*	*380/16*	*TTM*
TTM 550-A	*175*	*550-700*	*7.5*	*380/32*	*TTM*

Subject to modification *Further data is available on request*

All the circuits are supplied with calibration valves and safety valves to avoid overpressure.
The control gauges installed are analogue, but can be coupled to a digital gauge with 1 bar precision.

TTM 250-A, TTM 450-A and TTM 550-A are made for use with TTM250KN jacks.
650, 700 and 750 hydraulic pumps are made for use with DD jacks, for tensioning bars or simple jacks and are not equipped for the locking circuit.

TTM 450-A pump

***TTM 450-A** pump, designed for small operations with max. 8 TTM250KN jacks or DD series bar tensioning for all types of jacks. The limited size makes it an excellent machine for tensioning ground anchors.*
The machine is made for intermittent operations and can reach max pressures of 600 bar and 550 bar for continuous services.

***TTM250-A** pump, designed for small operations with single TTM250KN jack or DD series bar tensioning jacks.*
The limited sizes and weight together with an operating pressure of 550 bar make it a simple and practical means for small operations.

TTM 250-A pump

TTM 550-A pump

***TTM550-A** pump, designed for heavy duty with TTM250KN jack where continuous operating is required.*
Its characteristics make it flexible and robust and usable for draw out tests and tensioning of post-tensioned structures, it can work with a maximum of 19 TTM250KN or 12 TTM250KN-400 jacks.
The machine is made for heavy duty and can reach max. pressures of 700 bar and pressures for continuous operating services of 550 bar.

34.7 - TTM450-A hydraulic pump

(Tensioning of TTR anchors)

TTM450-A pump

***TTM 450-A** pumps are designed for tensioning with TTM jacks. They are the most used type, they are compact and suitable for tensioning anchors up to 8 strands.*

The pump is provided with all the protections to guarantee a safe tensioning. The button strip allows the operator to control drive, stressing, locking and return at a distance of 10 m from the machine.

T-R-I button strip L=10 m for: stressing, locking and return

T-R button strip L=10 m for stressing and return only

The button strip, by precalibrating the stressing and return valves allows to change functions and the carry out the tensioning cycle by controlling the anchor. The button strip characterises all the machines produced by TTM, it is easy to replace, independent of the equipment, easy to use, it can be removed after use and it is maintenance friendly.

34.8 – Release cones

TR-15 *release cone for single strand T15 anchorages, to be used on TTM250-KN jacks.*

TR-15 release cone

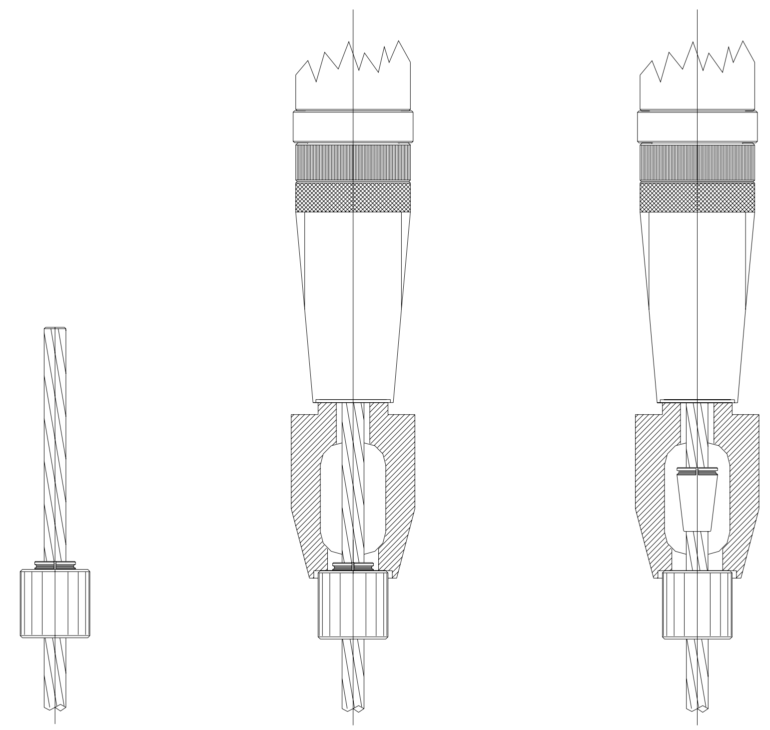
TM-15 release cone

TM-15 *release cone for single strand T15 anchorages, to be used on TTM250-KN-M jacks.*
It can operate only on anchorages of the series:

- *TTM,*
- *M*
- *G*

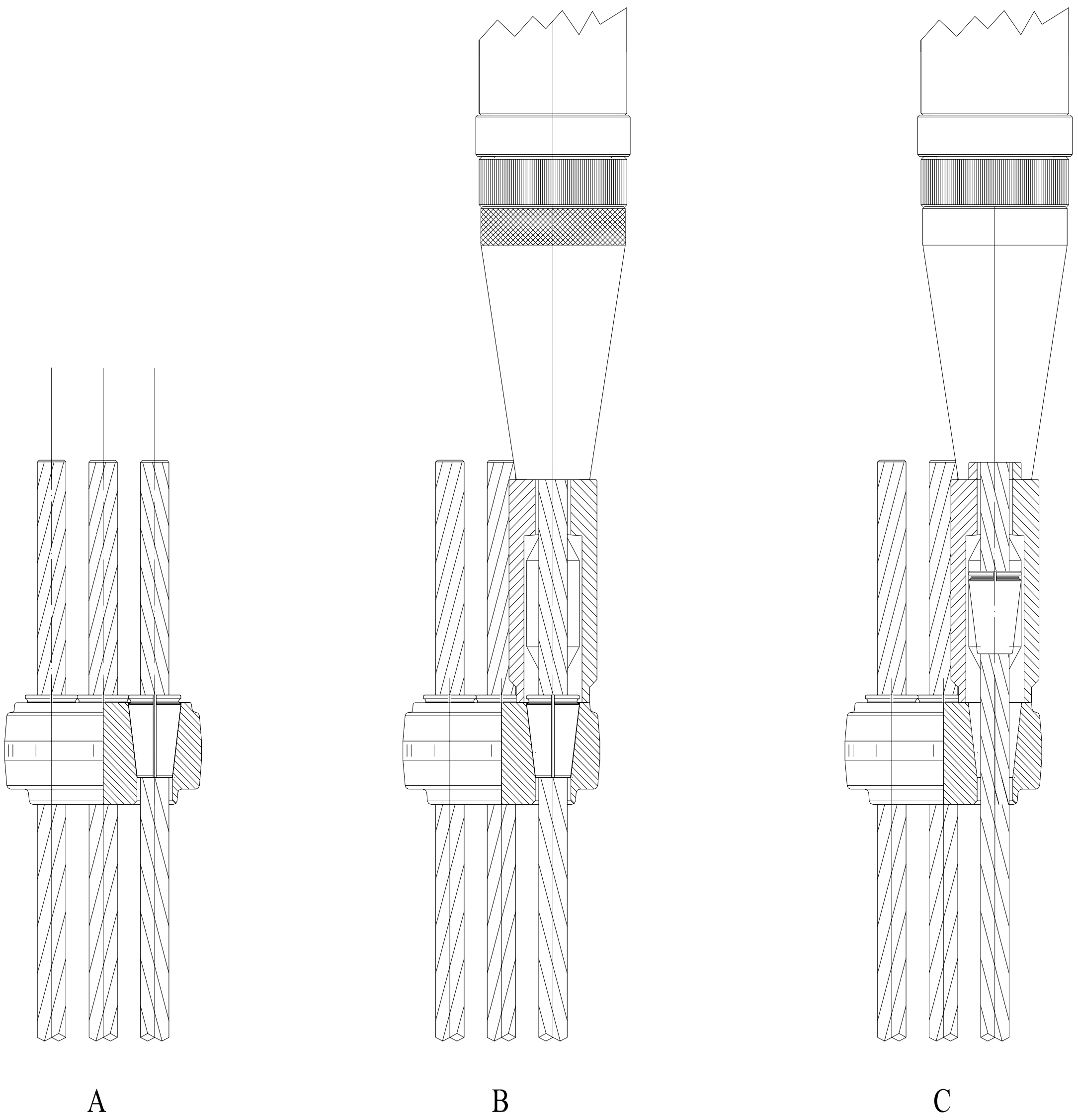
On all multiple strand anchorages.

The releasing of clamps on TTM anchorages is carried out by means of TTM 2500KN-200-M jacks and of a TR 15 release cone.



A B C

The releasing of clamps on M anchorages is carried out by means of TTM 2500KN-200-M jacks and of a TM 15 release cone.
The TTM 2500KN-200 jack must be provided with a suitable special end part for tensioning on M anchorages.



During the phase B the TTM 250KN-200 jack with the TM 15 release cone is inserted onto the strand in the return position. The stressing function is carried out thus releasing the clamp (phase B). Releasing usually occurs at a higher value than the stressing one, the clamp requires a greater stressing to overcome the friction of the clamp self-locking. The clamp must be released with the TTM jack at half stroke (mechanical dimensioning). Once released, the clamp must be moved into the release cone by lifting it with a screwdriver in the slit of the release cone as high as possible (phase C).

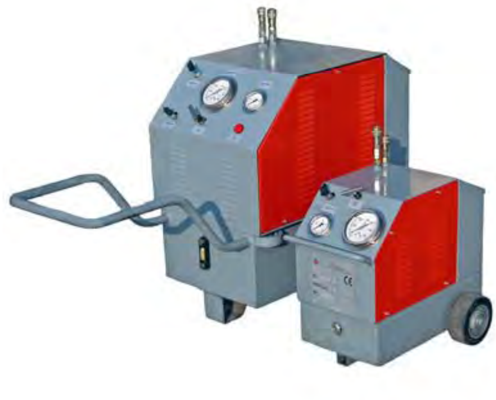
With the TTM 250KN-200 jack, by means of the release valve, decrease pressure in the oil hydraulic circuit and tension the wire. The cycle must be repeated until the tension of the strand is zero in order to remove the clamp.

Pay attention not to break the metallic ring that joins the three sectors of the clamp, as breaking it means losing control over the three sectors of the clamp which therefore cannot be moved simultaneously any longer.

Moving the clamp with a screwdriver must be done with a particular attention, wearing proper gloves and using a screwdriver with the handle sufficiently external to the release cone. In order to make releasing easier, do not strew the anchorage with oil as, while releasing, it could prevent the clamp from self-locking.

All activities must be carried out dry with no lubricants.

34.9 – “TTM 450-A” hydraulic pump
(Tensioning of TTR anchors)



TTM450-A and TTM250-A pumps

TTM 450-A pump

Button strip for T-R stressing and return only

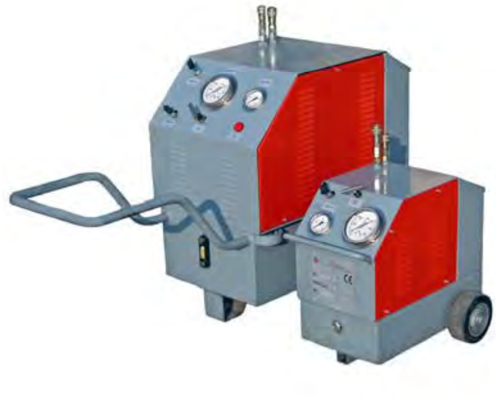
T-R-I button strip for: stressing, locking and return

*The **“TTM-A”** series of pumps is available in two models which differ according to use required and characteristics. They are set up with a two-tube exit for driving the **TTM** and **DD** series of tensioning jacks. All the machines are equipped with three control circuits: stressing, locking and return.*
All the circuits are supplied with calibration valves and safety valves to avoid overpressure.
All the pumps are provided with a button strip to electrically control these functions: stressing, locking and return. The control gauges installed are analogue, but can be coupled to a digital gauge with 1 bar precision.

Type	*Weight*	*Max. pressure*	*Capacity*	*Voltage/ Amperes*	*Use*
	(Kg.)	*bar.*	*KW*		
TTM450-A	*170*	*450-500*	*4.5*	*380/16*	*TTR*

Subject to modification *Further data is available on request*

34.10 – “TTM 250-A” hydraulic pump
(Tensioning of TTR anchors)



TTM450-A and TTM250-A pumps

TTM 250-A pump

Button strip for T-R stressing and return only

T-R-I button strip for: stressing, locking and return

*The **“TTM-A”** series of pumps is available in several models which differ according to use required and characteristics. They are set up with a two-tube exit for driving the **TTM** and **DD** series of tensioning jacks. All the machines are equipped with three control circuits: stressing, locking and return.*
All the circuits are supplied with calibration valves and safety valves to avoid overpressure.
All the pumps are provided with a button strip to electrically control these functions: stressing, locking and return.
The control gauges installed are analogue, but can be coupled to a digital gauge with 1 bar precision.

Type	***Weight***	***Max. pressure***	***Capacity***	***Voltage/ Amp***	***Dimensions***	***Use***
	(Kg)	*bar.*	*KW*		*(mm)*	
TTM 250-A	*60*	*450-550*	*1,5*	*380/16*	*600x500x300*	*TTR-DD*

Subject to modification *Further data is available on request*

34.11 – "TTM 550-A" hydraulic pump
(Tensioning of TTR anchors)

TTM550 hydraulic pump

*This type of pump is set up with a two-tube exit for driving the **TTM and DD** series of tensioning jacks. All the machines are equipped with three control circuits: stressing, locking and return. All the circuits are supplied with calibration valves and safety valves to avoid overpressure.*

TTM550-A pump

TTM 550-A pumps are designed to use up to 12 single strand jacks at the same time. They are made for use with DD jacks or simple jacks.

Type	***Weight***	***Max. pressure***	***Capacity***	***Voltage/ Amp***	***Dimensions***	***Use***
	(Kg)	*bar.*	*KW*		*(mm)*	
TTM 550-A	*290*	*550-600*	*7,5*	*380/16*	*1200x650x1200*	*TTR-DD*

Subject to modification *Further data is available on request*

34.12 – “TTM 650-E” hydraulic pump

(Tensioning of TTM and M multi-strand anchorages)

TTM 650-E pump

*The **“TTM-E”** series of pumps is available in six models which differ according to use required and characteristics.*
They are set up with a three-tube exit for driving the M series of jacks. All the machines are equipped with three control circuits: stressing, locking and return.
All the circuits are supplied with calibration valves and safety valves to avoid overpressure.
The control gauges installed are analogue, but can be coupled to a portable digital gauge.

Type	***Weight***	***Max. pressure***	***Capacity***	***Voltage/ Amperes***	***Use***
	(Kg.)	*bar.*	*KW*		
TTM 650-E	*290*	*600*	*7,5*	*380/16-32*	*TTM - M*

Subject to modification *Further data is available on request*

34.13 – "TTM-E" hydraulic pump

(Tensioning of TTM and M multi-strand anchorages)

*The **"TTM-E"** series of pumps is available in two models which differ according to use required and characteristics. They are set up with a three-tube exit for driving the M series of jacks. The pumps are equipped with three control circuits: stressing, locking and return. All the services are supplied with calibration valve.*
The control gauges installed are analogue, but can be coupled to a digital gauge with 1 bar precision.
All the machines are equipped with a button strip (wire L=10 m) which allows all the operating phases of the machine to be controlled. Special calibration valves enable the operator to manually adjust pressure very easily and precisely in the three machine circuits.

TTM 2000-E pump

All the machines are equipped with three control gauges to check pressure in the single circuits. They are supplied with release valve and safety valves to avoid overpressure.
All the equipment supplied is manufactured in compliance with the machinery regulations and has CE markings.

Type	***Weight***	***Max. pressure***	***Capacity***	***Voltage/ Amperes***	***Use***
	(Kg.)	*bar.*	*KW*		
TTM 1000-E	*380*	*700*	*10*	*380/32*	*TTM - M*
TTM 2000-E	*470*	*700*	*22*	*380/32*	*TTM - M*

Subject to modification *Further data is available on request*

34.14 - “DD-MF” manifold

(Tensioning of single strand anchorages with several TTM jacks)

*By means of a manifold, all the hydraulic pumps can be connected to several tensioning jacks. The **DD-MF** manifold is designed with 4, 6 or 10 hydraulic outputs under isopressure, it is made of galvanized steel and can be completely disassembled. The upper connections are for jacks, the side connections are for **TTM pumps***

*The **DD-MF** manifold is arranged for connecting a sample gauge for pressure checks during the tensioning activities and is created for maximum working pressures of 700 bar.*
The manifolds are available in the following types where the number indicates the pressure outputs available for jack connection:

- *DD04-MF,*
- *DD06-MF,*
- *DD10-MF,*

Different arrangements can be obtained by series connecting several manifolds.

Type	***Weight***	***Max. pressure***	***Height from ground***	***Dim. AxB***	***No. outputs***
	(Kg.)	*(bar.)*	*(mm.)*	*(mm.)*	*number*
DD 04-MF	*20*	*450-500*	*40*	*500x500*	*4*
DD 06-MF	*28*	*450-500*	*40*	*900x500*	*6*
DD 10-MF	*35*	*450-500*	*40*	*1200x500*	*10*

Subject to modification *Further data is available on request*

34.15 - “S 1000/S3000” dynamometer

(Dynamometer for jack calibration)

*The digital-reading **S1000/S3000** dynamometer, if used with a hydraulic pump allows to check the stress applied by the tensioning jack to a passive anchorage used to calibrate TTM 250KN and TTM300KN tensioning jacks. It is supplied calibrated by a S.I.T. centre or an authorized laboratory.*

The dynamometer is provided with a calibration certificate issued by a S.I.T. centre or an authorized laboratory with a six month validity.
*The gauge box requires a single phase supply 220 Volt. 16 Amp 2P+T 50 Hz., for calibration on site where power is supplied by generator sets. Always check the tension (voltage) and frequency calibration. If they are not within the tolerated range, they may damage the instrument. The **S1000** gauge box allows to calibrate jacks and check pressure at the same time.*
*The instrument can be supplied with different certifications on request, sample gauges are set up for use at max. 300KN. They are provided with **CE** marking.*

Type	***Weight***	***Capacity***	***Power supply***	***Dimensions***	***Use***
	(Kg.)	*KN*	*Volt.*	*mm.*	
S1000/S3000	*24*	*300*	*220*	*320x430x250*	*TTM*

Subject to modification *Further data is available on request*

34.16 - TTM series tensioning jacks

TTM 250KN-200 jack

TTM 250KN-200 *jack for tensioning on anchorages: E, EX and TTR provided with 200 mm actual stroke, hydraulic locking and tubes with 4 m quick joints.*

TTM 250KN-100 jack

TTM 250KN-100 *jack for tensioning on anchorages: E, EX and TTR provided with 100 mm actual stroke, hydraulic locking and tubes with 4 m quick joints.*

TTM 250KN-60 jack

TTM 250KN-60 *jack for tensioning on anchorages: E, EX and TTR provided with 60 mm actual stroke, hydraulic locking and tubes with 4 m quick joints.*

TTM 250KN-M-100 jack

TTM 250KN-M-100 *jack for tensioning on anchorages: M and TTM provided with 100 mm actual stroke, hydraulic locking and tubes with 4 m quick joints.*

TTM 250KN-400 *jack for tensioning on anchorages: E, EX and TTR provided with 400 mm actual stroke, hydraulic locking and tubes with 4 m quick joints.*

TTM 250KN-400 jack

TTM 250KN-C-100 jack

TTM 250KN-C-100 *jack for tensioning on anchorages: E, EX and TTR with 100 mm. stroke.*
The jack without locking for tensioning of short strands is provided with tubes with 4 m quick joints.

TTM 300KN-M-100 jack

TTM300KN-M-100 *jack for tensioning on anchorages: M and TTM provided with 100 mm actual stroke, hydraulic locking and tubes with 4 m quick joints.*

TTM 300KN-100 jack

TTM300KN-200 *jack for tensioning on TTM anchorages provided with 200 mm actual stroke, hydraulic locking and tubes with 4 m quick joints.*

Head for tensioning on anchorages: E, EX and TTR

Head for tensioning on anchorages: E, EX and TTR, all the heads of this series are provided with internal hydraulic locking.

Head for tensioning on M and TTM anchorages

Head for tensioning on anchorages: M and TTM, all the heads of this series are provided with internal hydraulic locking.

34.17 - "TTM 250KN-200" tensioning jack
(Tensioning of TTR and TTS anchors)

TTM jacks are available in three models which differ according to use characteristics. They are provided with an automatic locking circuit and 4 meter long flexible tubes. The main use of ***TTM250KN*** *jacks is for tensioning on single strand heads on TTM anchorages. They are available with strokes: 400 mm., 200 mm., 100 mm. and 60 mm., the stroke reduction allows smaller dimensions of the jack.*

Type	*Weight*	*Stroke*	*Max. diameter*	*Length*	*Grip*	*Section*	*Capacity*
	(Kg.)	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(cm^2)*	*(KN)*
TTM 250KN-200 jack	*26*	*200*	*100*	*930*	*300*	*47,2*	*250*

Subject to modification *Further data is available on request*

34.18 - "TTM 250KN-100" tensioning jack

(Tensioning of TTR and TTS anchors)

TTM 250KN-100 jack

*TTM jacks are available in three models which differ according to use characteristics. They are provided with an automatic locking circuit and 4 meter long flexible tubes. The main use of **TTM250KN** jacks is for tensioning on single strand heads on TTM anchorages. They are available with strokes: 400 mm., 200 mm., 100 mm. and 60 mm., the stroke reduction allows smaller dimensions of the jack.*

Type	***Weight***	***Stroke***	***Max. diameter***	***Length***	***Grip***	***Section***	***Capacity***
	(Kg.)	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(cm^2)*	*(KN)*
TTM 250KN-100 jack	*24*	*100*	*100*	*720*	*300*	*47,2*	*250*

Subject to modification *Further data is available on request*

34.19 - "TTM 250KN-60" tensioning jack

(Tensioning of TTR and TTS anchors)

TTM 250KN-60 jack

*TTM jacks are available in three models which differ according to use characteristics. All the jacks are provided with an automatic locking circuit and 4 meter long flexible tubes. The main use of **TTM250KN** jacks is for tensioning on single strand heads on TTM anchorages. They are available with strokes: 400 mm., 200 mm., 100 mm. and 60 mm., the stroke reduction allows smaller dimensions of the jack.*

Type	***Weight***	***Stroke***	***Max. diameter***	***Length***	***Grip***	***Section***	***Capacity***
	(Kg.)	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(cm^2)*	*(KN)*
TTM 250KN-60 jack	*22*	*60*	*100*	*640*	*300*	*47,2*	*250*

Subject to modification *Further data is available on request*

34.20 - "TTM 250KN-400" tensioning jack
(Tensioning of TTR and TTS anchors)

TTM 250KN-400 jack

*TTM jacks are available in three models which differ according to use characteristics. All the jacks are provided with an automatic locking circuit and 4 meter long flexible tubes. The main use of **TTM250KN** jacks is for tensioning on single strand heads on TTM anchorages. They are available with strokes: 400 mm., 200 mm., 100 mm. and 60 mm., the stroke reduction allows smaller dimensions of the jack.*

Type	*Weight*	*Stroke*	*Max. diameter*	*Length*	*Grip*	*Section*	*Capacity*
	(Kg.)	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(cm^2)*	*(KN)*
TTM 250KN-400 jack	*32*	*400*	*100*	*1.035*	*300*	*47,2*	*250*

Subject to modification *Further data is available on request*

34.21 - "TTM 300KN-200" tensioning jack

(For tensioning of T15C strands on TTR and TTS anchorages)

TTM 300KN-200 jack

TTM jacks are available in two models which differ according to use characteristics. They are provided with an automatic locking circuit and 4 meter long flexible thermoplastic tubes with quick joints.

*The main use of **TTM300KN-200** jacks is for tensioning on single strand or TTR heads where the T15C compact strand is used.*

Type	***Weight***	***Stroke***	***Max. diameter***	***Length***	***Grip***	***Section***	***Capacity***
	(Kg.)	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(cm^2)*	*(KN)*
TTM300KN-200	*30*	*200*	*110*	*930*	*300*	*68.80*	*300*

Subject to modification *Further data is available on request*

34.22 - "TTM 300KN-100" tensioning jack

(For tensioning of T15C strands on TTR and TTS anchorages)

TTM 300KN-100 jack

TTM jacks are available in two models which differ according to use characteristics. They are provided with an automatic locking circuit and 4 meter long flexible thermoplastic tubes with quick joints.
*The main use of **TTM300KN-100** jacks is for tensioning on single strand or TTR heads where the T15C compact strand is used.*

Type	*Weight*	*Stroke*	*Max. diameter*	*Length*	*Grip*	*Section*	*Capacity*
	(Kg.)	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(cm^2)*	*(KN)*
TTM300KN-100	*25*	*100*	*110*	*730*	*300*	*68.80*	*300*

Subject to modification *Further data is available on request*

34.23 - “TTM 250KN-C-60” tensioning jack

(Tensioning on short strands)

TTM 250KN-C-60 jack

TTM 250KN-C-100 jack

TTM250KN-C *jacks are designed for tensioning on short strands. Their main characteristic is the short strand grip to guarantee the grip of the jack on strand protrusions between 80 – 100 mm. They are without locking and are only used on single strand interventions on anchorages: TTR, E, EX, TTS with minimum support for the jacks of 48 mm. Two different strokes are available to guarantee their use in small spaces, they are provided with L=4 m hydraulic tubes as well as quick joints.*

Type	***Weight***	***Stroke***	***Max. diameter***	***Length***	***Grip***	***Section***	***Capacity***
	(Kg.)	*(mm.)*	*(mm.)*	*(mm.)*	*(mm.)*	*(cm^2)*	*(KN)*
TTM 250KN-C-60	*15,5*	*60*	*100*	*470*	*80-100*	*47,2*	*250*
TTM 250KN-C-100	*18*	*100*	*100*	*560*	*80-100*	*47,2*	*250*

Subject to modification *Further data is available on request*

34.24 - “S 1000” sample gauge

(Digital gauge to check pressure)

*The **S 1000** dynamometer (with digital reading) if used with a hydraulic pump or manifold allows to check the pressure in the circuit it is connected to. It is used to monitor the testing and operating pressure applied to jacks via manifolds. It can be supplied calibrated with factory or certified laboratory calibration.*

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S1000 sample gauge

The dynamometer is provided with a calibration certificate issued by a University of Polytechnic which certifies its validity. It is valid for six months since the date of issue.
*The dynamometer requires a single phase supply 220 Volt. 2P+T 50 Hz., for calibration on site where power is supplied by generator sets. Always check the tension (voltage) and frequency calibration. If they are not within the tolerated range, they may damage the instrument. The **S1000** sample gauge allows calibration by comparison with the hydraulic system in use, via coupling before and after the circuit. It is supplied in a suitable insulated aluminium box containing a digital gauge with four digit reading, precise to 1 bar. The instrument can be supplied with different certifications on request: The sample gauges are set up for use at max. 1.000 bar. They are provided with **CE** marking, completely protected and bear identification serial numbers for the controls performed periodically by our technical service.*

Type	***Weight***	***Max. pressure***	***Power supply***	***Dimensions***	***Use***
	(Kg.)	*bar.*	*Volt.*	*mm.*	
S1000	*15*	*1.000*	*220*	*320x430x250*	*TTM*

Subject to modification *Further data is available on request*

34.25 - "S 900" analogue sample gauge

(Analogue gauge to check pressure)

The S 900 sample gauge (analogue reading), if installed on a circuit allows to check pressure at the connection point.
It is used to monitor the testing and operating pressure applied to jacks via manifolds and flexible tubes. It can be supplied calibrated with factory or certified laboratory calibration.

S 900 analogue sample gauge

It is valid for six months since the date of issue. The S 900 sample gauge allows calibration by comparison with the hydraulic system in use, via couplings before and after the circuit. It is supplied in a suitable insulated aluminium box, complete with coupling devices on both fixed and flexible circuits.

Type	***Weight***	***Max. pressure***	***Accuracy class***	***Dimensions***	***Overpressure***
	(Kg.)	*bar.*		*mm.*	
S 900	*2.4*	*1.000*	*+/- 0.25% VFS*	*320x160x50*	*30% of VFS*

Subject to modification *Further data is available on request*

The gauge is provided with part number and can operate with process fluid from -40 to +150 C° . It is provided with PI 65 protection class according to IEC 529 8896. It has an aluminium dial on white background, with rating and numbers in black with anti-parallax band.
The instrument can be installed on hydraulic circuits on site to check pressure falls or the actual pressure on a required point.

The sample gauge cannot be considered as an equipment calibration instrument, but only a system to check pressure by means of a measurement obtained via calibrated instrument.
The sample gauge can also be used to check in load tests, according to EURO NORM EN 1537-2002, annex E the decrease in pressure on the circuit after the hydraulic pump at its closure.

34.26 - " T " grouting pump
(Pump for wire grouting)

The "T" grouting pump is designed to guarantee maximum versatility with regard to site requirements and use in severe conditions. It is supplied on wheels with robust tyres, it can be towed on-site and is equipped with all the safety devices necessary for use. The machine has two tanks: one for mixing the colloidal mix and one as a tank for the mix. The turbo mixer has a turbine capable of mixing material at 1500 rpm/min.
All the injection pumps are fitted as standard with a gauge, gauge protector and button strip L=10 m. Quick joints, litre-counters, plastic accessories, grouting tubes of various lengths, syringe and the Saunders flow closing valve are considered to be accessories.

T 500 grouting pump

Characteristics	**T500 model**	**T400 model**
Weight (Kg.)	900	900
Dimensions (mm.)	1900x1500x1900 mm	1900x1500x1900 mm
Mixer capacity (litres)	190 litres	190 litres
Mixing time (sec.)	40"	40"
Agitator capacity (litres)	200 litres	200 litres
Max. grouting pressure (bar.)	10-20 bar.	10-20 bar.
Max. grouting capacity	25-40 litres/minute	15-25 litres/minute
Agitator power (KW)	10 KW	10 KW
Pump power (KW)	7.5 KW	7.5 KW

Subject to modification *Further data is available on request*

Saunders valves are membrane closing valves recommended for intercepting mud and cement mixes. They are self-cleaning and, if cleaned frequently they do not become encrusted. The litre counter, *considered as an accessory is a simple mechanical, turbine fluid measuring device; it is made of plastic and is applied on client's request. All the pumps have button strip control, they are equipped with a 10 metre long wire, but wires up to 50 m. can be requested. The extension for the button strip is necessary in all those cases where the operator has to control the machine from a distance, supervising the injection zone.*

DD5001 *gauge protector for T500 pumps. The device allows a proper protection of the gauge against the grouting mix. This device is made of two parts separated by a membrane that ensures pressure transmission to the valve via oil. When the mix depresses the membrane transmits pressure to the oil that in its turn transmits it to the gauge.*
The gauge protector can be supplied with a bronze quick joint that facilitates its insertion into pressurised hoses, its removal and washing.
It is essential to wash the device correctly for it to operate properly.
I is provided with a lateral hole for washing the device where it comes into contact with the cement mix; a water pipe can be attached to this joint.
The ***DD7169-B*** *rubber gasket allows to divide the two mix-oil parts of the gauge protector.*

DD5001 gauge protector with gauge

DD5001 gauge protector

Saunders valve

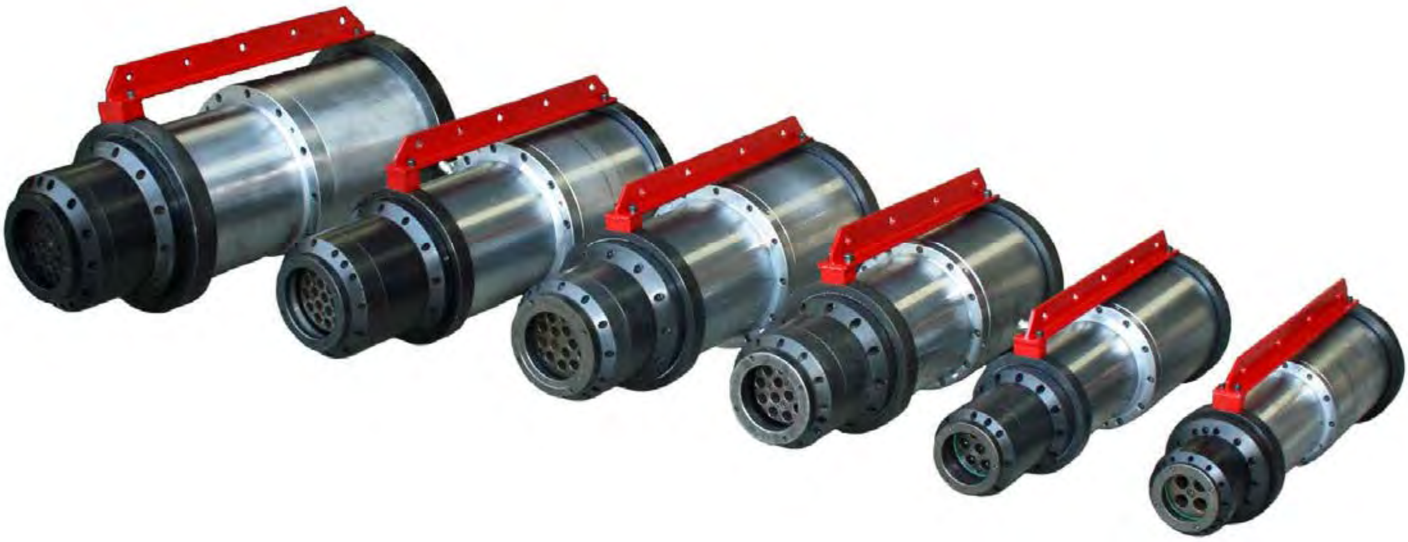
The 1" Saunders valves are the only element that guarantees a safe fluid interception. Closing takes place via a rubber gasket that guarantees a self-cleaning effect of the seat.

DD7169-B rubber gasket

34.27 - "M" tensioning jack

(Tensioning of TTM multi-strand anchorages)

The "M" series of jacks is available in nine models which differ according to use characteristics. They are provided with an automatic locking circuit and 10 metre long flexible tubes; they are also equipped with a device rotating on an axis, restricted tensioning extension, low operating pressure.
The jacks are equipped with a metal support, designed in particular to achieve the required inclinations during tensioning operations.
The support is integral with two bearings which enable the jack to turn on its axis, facilitating insertion of the strands protruding from the head. The restricted tensioning extension, the rotation of the jack on its axis and the support allow quick operations and a limited effort during handling.



M series jacks

Characteristics	***U.M.***	***M 1600 KN***	***M 1800 KN***	***M 3000 KN***	***M 3600 KN***	***M 4800 KN***
Capacity	KN	1600	1800	3000	3600	4800
Strand max. capacity	No.	1-4	4-7	7-12	12-15	15-19
Stroke	mm	250	250	250	250	250
Weight	Kg	180	210	280	390	490
Stressing section	cm^2	155,51	302,20	424,49	564,21	725,71
Max. stressing pressure	bar	700	700	700	700	700
Max. return pressure	bar	250	250	250	250	250
Max. locking pressure	bar	250	250	250	250	250
Tensioning extension	mm	400	400	400	450	500
Max. diameter	Mm	290	330	400	470	520
Length	mm	950	1.050	1.000	1.150	1.150

Subject to modification *Further data is available on request*

All the jacks in the M series are supplied complete with internal parts and accessories

for tensioning.
The jacks in the M series are classified according to types, ex. **M6800KN** and the inside, if different from standard, indicates **M6800KN-22** (22 strands)
The jacks are powered by three tubes which guarantee the following functions:

- stressing,
- return,
- locking,

All the jacks require a comb for correct use to ease the insertion of the jack on the cable.

M1600KN-4 jack

27 strand comb

For tensioning of active anchorages, all the jacks require a belt that allows the jack to rest correctly against the anchorage.
Only on G joints does the jack rest directly on the steel plate.
The main characteristics of the M series jacks are:

- 350° rotation on an axis,
- reduced grip extension,
- automatic locking by means of a hydraulic circuit,
- small dimensions,
- front grip,
- easy to manoeuvre,
- maintenance friendly,
- easy inspection/cleaning of the engagement clamps,

The jacks are identified by a serial number and equipped with certificate of calibration upon user's request.

M1800KN-7 jack

M4800KN-19 jack

M6800KN-27 jack

M3000KN-12 jack

34.28 - “DD” series tensioning jacks

*The **“DD”** series of jacks is available in four models which differ according to use characteristics. They are equipped with 10 m long flexible tubes and spanners of different sizes for all the types of bars from 26.5mm to 50mm. They are set up for automatic tightening. When the special spanner is inserted in the jack, the nut can be tightened keeping the bar under tension. This avoids the use of seatings and manual tightening operations.*
***“DD”** jacks have two robust handles for easy handling. The jacks operate with all the pumps with the following characteristics:*

- *Working pressure of 550 bar,*
- *Switch-over oil hydraulic circuit, flow and return (with return discharge).*

DD2000KN jack

The equipment is supplied with operating instructions and CE marking, it is identified by a part number and a type of construction for each component.
DD jacks are supplied with the following components:

- *Tensioning cylinder,*
- *10 m hydraulic extensions,*
- *Additional spanners for nuts associated with the bar capacity,*
- *Nut for nut pretightening,*
- *Connection sleeve.*

Tightening is by way of chain transmission (inside the jack) driven by a special lever.
The lever is supplied with a special device that permits both nut unscrewing and screwing. the chain connects the gears that allow the tightening of the nut; the assembly is protected by a robust casing.

34.29 - Characteristics of the "DD" jacks

(Jacks for tensioning bars with tightening)

DD1200KN jack

Characteristics	*U.M.*	*DD700KN*	*DD1200KN*	*DD2000KN*	*DD2600KN*
Capacity	*KN*	*700*	*1.200*	*2.000*	*2.600*
Stroke	*mm*	*50*	*50*	*50*	*50*
Weight	*Kg*	*42*	*54*	*95*	*135*
Stressing section	cm^2	*132,47*	*235,5*	*439,60*	*521,5*
Max. stressing pressure	*bar*	*550*	*550*	*550*	*550*
Max. return pressure	*bar*	*100*	*100*	*100*	*100*
Tensioning extension	*mm.*				
Max. diameter	*mm.*				
Length	*mm.*				

Subject to modification *Further data is available on request*

34.30 - “DX” series tensioning jacks

(Jacks for tensioning bars without tightening)

DX700KN jack

Characteristics	***U.M.***	***DX700KN***	***DX1200KN***	***DX2000KN***	***DX2600KN***
Capacity	*KN*	*700*	*1.200*	*2.000*	*2.600*
Stroke	*mm*	*50*	*50*	*50*	*50*
Weight	*Kg*	*35*	*43*	*68*	*95*
Stressing section	*cm^2*	*132,47*	*235,5*	*439,60*	*521,5*
Max. stressing pressure	*bar*	*550*	*550*	*550*	*550*
Max. return pressure	*bar*	*100*	*100*	*100*	*100*
Tensioning extension	*mm.*	*150*	*150*	*150*	*150*
Max. diameter	*mm.*	*200*	*270*	*360*	*430*
Length	*mm.*	*230*	*300*	*370*	*490*

Subject to modification *Further data is available on request*

DX jacks are supplied with the following components:
- *Tensioning cylinder,*
- *10 m hydraulic extensions,*

DX jacks are supplied without mechanical tightening and are used for tensioning on dressed stones where the nut is manually screwed through its entire minimum length.

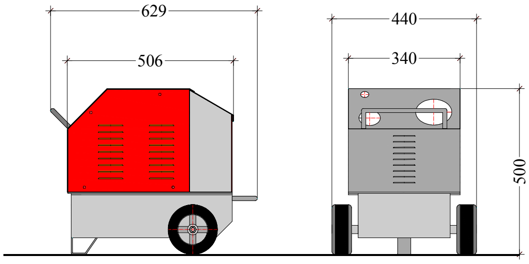
Bar tensioning with DD2000KN jack

Bar tensioning of diam. 40 mm with DD2000KN jack and TTM250-A pump

35.0 – EQUIPMENT DIMENSIONS – WEIGHT

35.1 - TTM-A hydraulic pumps

35.1.1 - TTM 250-A hydraulic pump

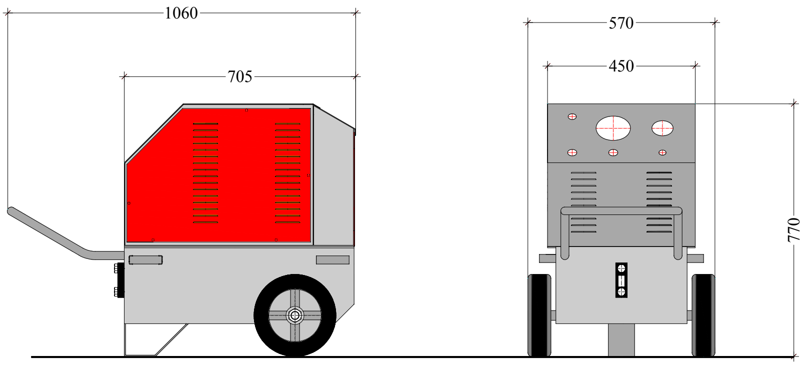


TTM250-A pump

Weight: 85 Kg./piece

Measures in mm.

35.1.2 - TTM 450-A hydraulic pump

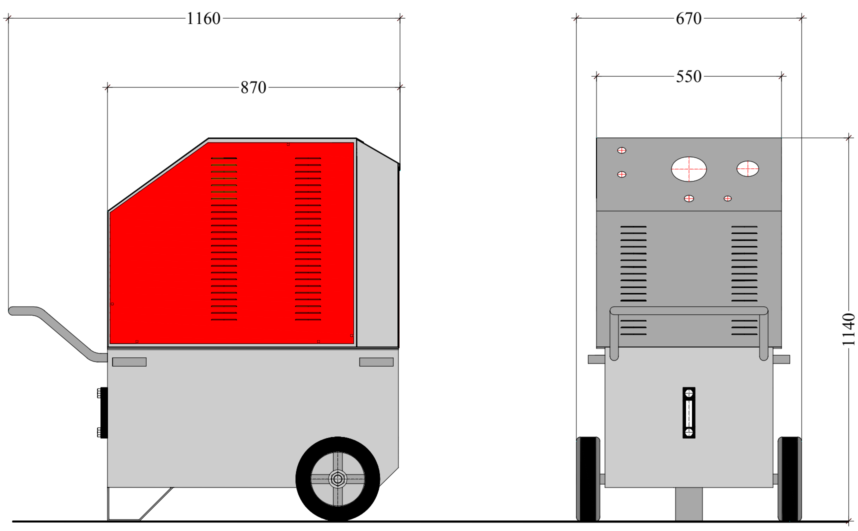


TTM450-A pump

Measures in mm.

Weight: 200 Kg./piece

35.1.3 - TTM 550-A hydraulic pump



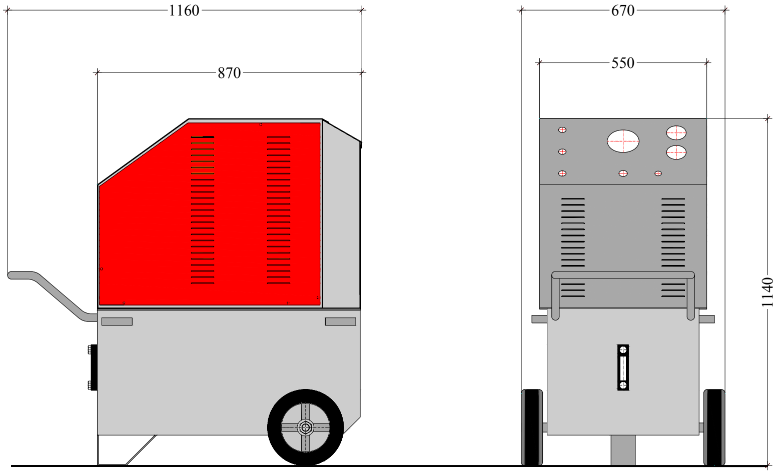
TTM550-A pump

Measures in mm.

Weight: 290 Kg./piece

35.2 - TTM-E hydraulic pumps

35.2.1 - TTM 1000-E pump

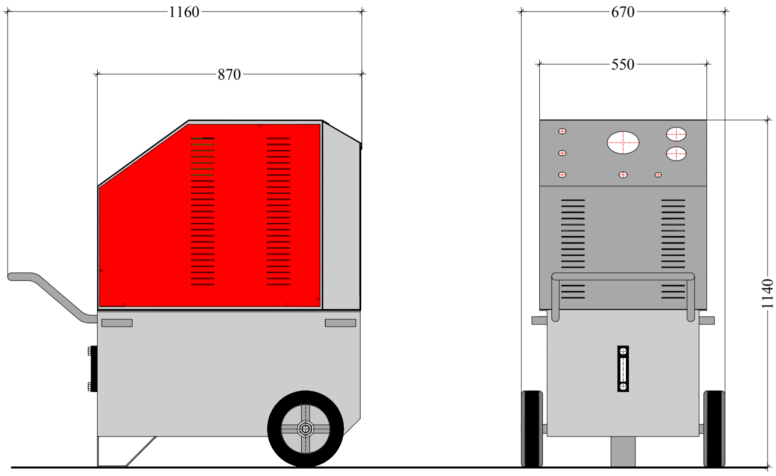


Measures in mm.

TTM1000-E hydraulic pump

Weight: 380 Kg./piece

35.2.1 - TTM 2000-E pump



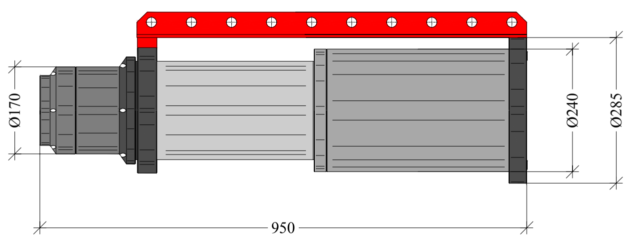
Measures in mm.

TTM2000-E hydraulic pump

Weight: 470 Kg./piece

35.3 - M series jacks

35.3.1 – M1600KN jack

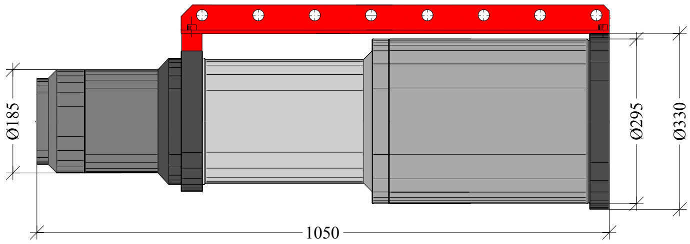


Measures in mm.

M1600KN jack

Weight: 180Kg./piece
Stressing section: 155.51 cm^2

35.3.2– M1800KN jack

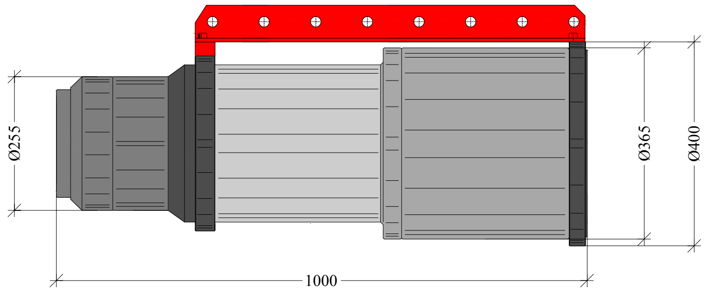


Measures in mm.

M1800KN jack

Weight: 210 Kg./piece
Stressing section: 302.20 cm^2

35.3.3 – M3000KN jack

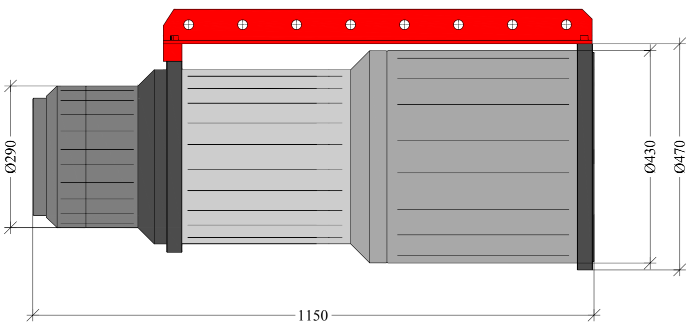


Measures in mm.

M3000KN jack

Weight: 280 Kg./piece
Stressing section: 424.49 cm^2

35.3.4 – M3600KN jack

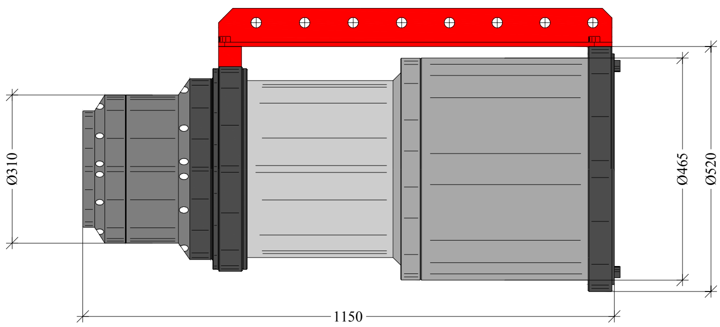


Measures in mm.

M3600KN jack

Weight: 390 Kg./piece
Stressing section: 564.21 cm^2

35.3.5 – M4800KN jack

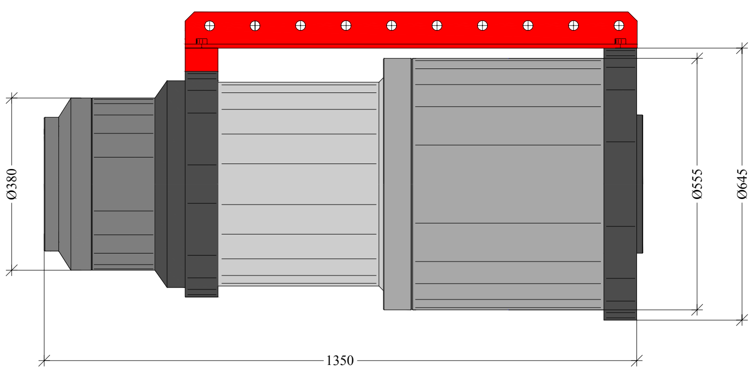


Measures in mm.

M4800KN jack

Weight: 490 Kg./piece
Stressing section: 725.71 cm^2

35.3.6 – M6800KN jack



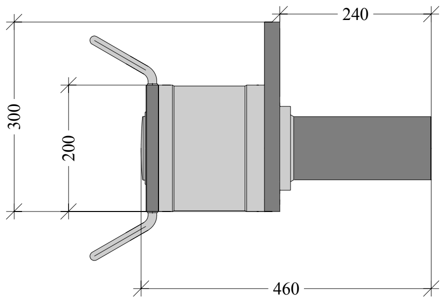
Measures in mm.

M6800KN jack

Weight: 650 Kg./piece
Stressing section: 879.20 cm^2

35.4 – Jacks for bars with tightening

35.4.1 – DD700KN jack

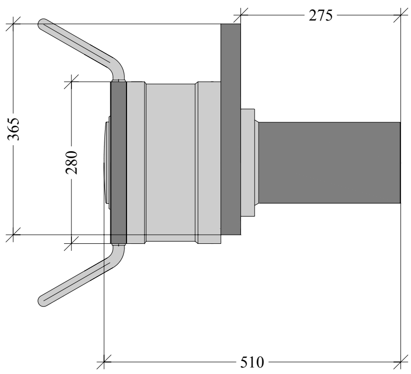


Measures in mm.

DD700KN jack

Weight: 42 Kg./piece
Stressing section: 132.47 cm^2

35.4.2 – DD1200KN jack

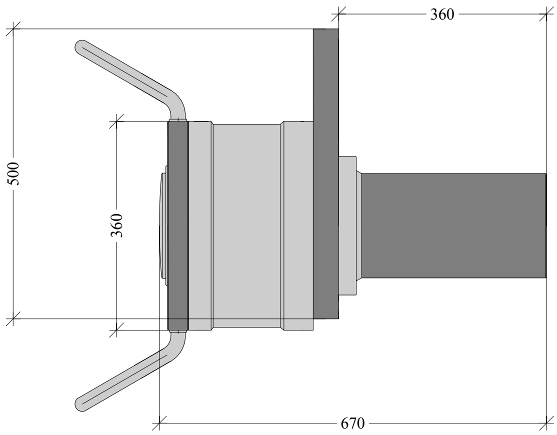


DD1200KN jack

Weight: 54 Kg./piece
Stressing section: 235.50 cm^2

Measures in mm.

35.4.3 – DD2000KN jack



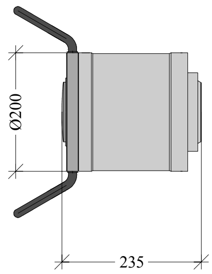
Measures in mm.

DD2000KN jack

Weight: 95 Kg./piece
Stressing section: 439.60 cm^2

35.5 - Jacks for bars without tightening

35.5.1 – DX700KN jack

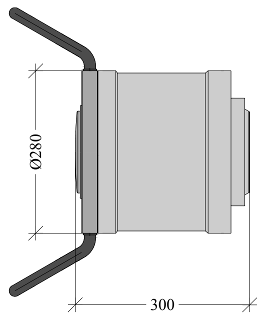


DX700KN jack

Measures in mm.

Weight: 35 Kg./piece
Stressing section: 132.47 cm^2

35.5.2 – DX1200KN jack

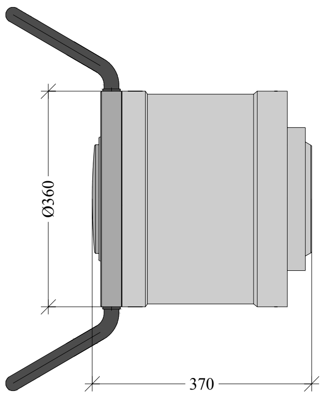


DX1200KN jack

Measures in mm.

Weight: 43 Kg./piece
Stressing section: 235.50 cm^2

35.5.3 – DX2000KN jack



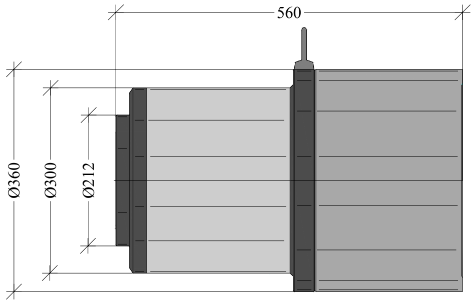
DX2000KN jack

Measures in mm.

Weight: 68 Kg./piece
Stressing section: 439.60 cm^2

35.6 - Tensioning jacks for special M anchorages

35.6.1 – MX3600KN jack



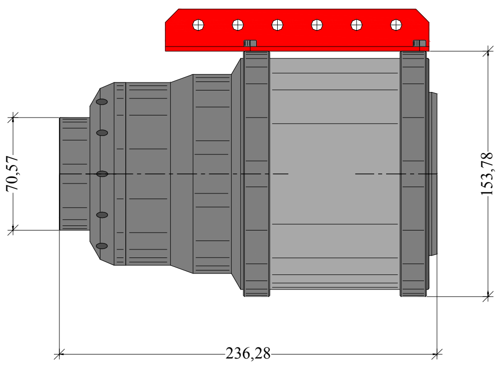
MX3600KN jack

Measures in

mm.

Weight: 250 Kg./piece
Stressing section: 424.49 *cm*^{2}

35.6.2 – MC3000KN jack

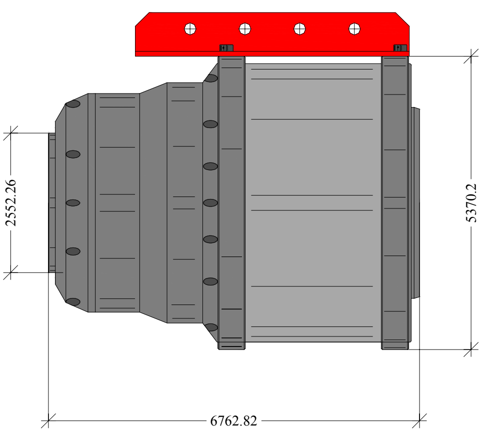


MC3000KN jack

Weight: 350Kg./piece
Stressing section: 564.50 *cm*^{2}

Measures in mm.

35.6.3 – MC4800KN jack



MC4800KN jack

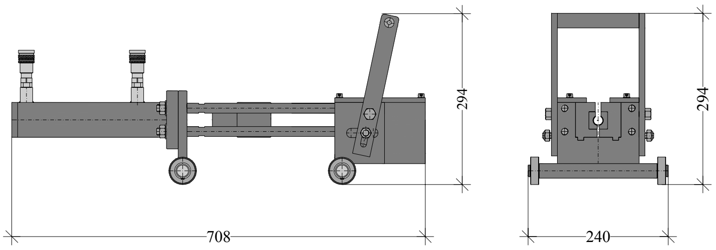
Measures in

nm.

Weight: 490Kg./piece
Stressing section: 636.76 *cm*^{2}

35.7 - Special jacks for single strands

35.7.1– S4000 strand breaking jack

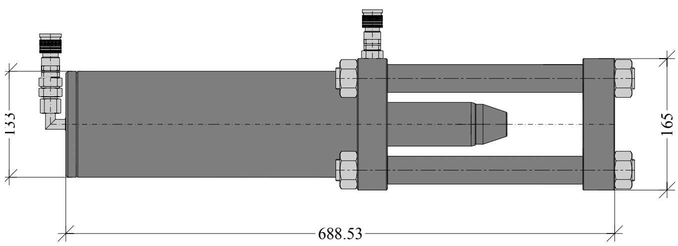


S4000 strand breaking jack

Measures in mm.

Weight: 30 Kg./piece

35.7.2 – B300 locking jack

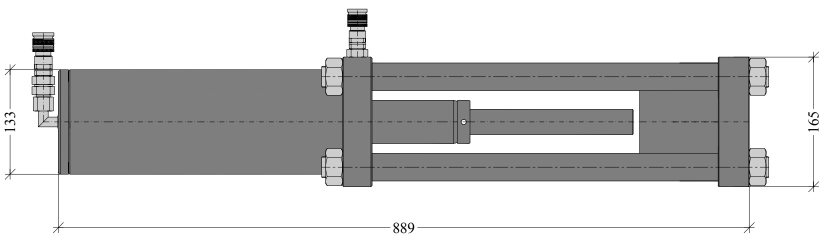


B300 locking jack

Measures in mm.

Weight: 60 Kg./piece

35.7.3 – M300 jack for extruded anchorages



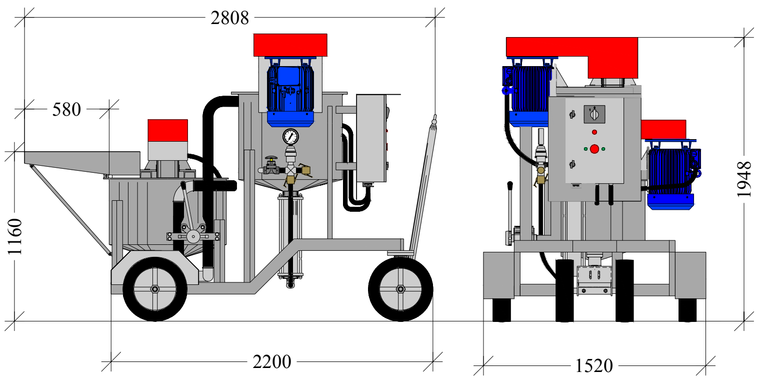
M300 jack for extruded anchorages

Measures in mm.

Weight: 60 Kg./piece

35.8 – Grouting pump

35.8.1 – T500 pump



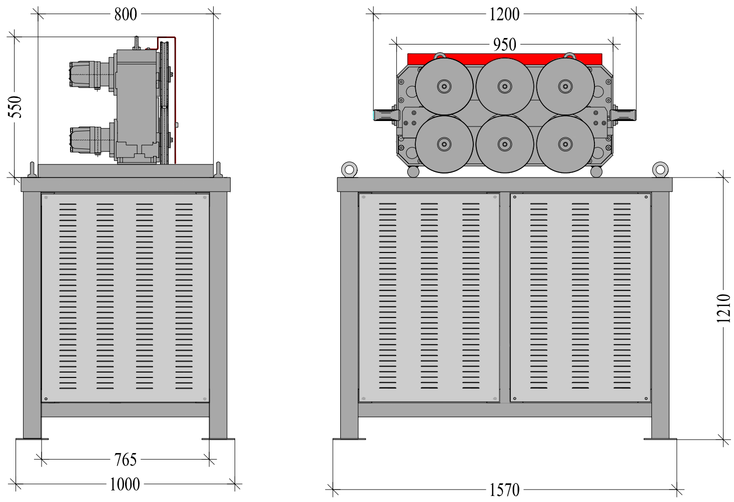
Measures in mm.

T 500 pump

Weight: 930 Kg./piece

35.9 - Strand forcing machines

35.9.1 – T61 strand forcing machine

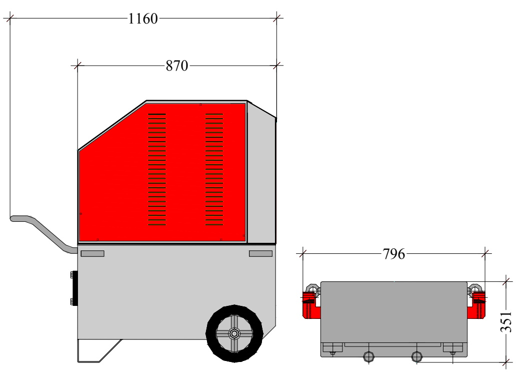


Measures in mm.

T61 strand forcing machine

Pump weight: 490 Kg./piece
Strand forcing machine weight: 160 Kg./piece

35.9.2 – TM S4 strand forcing machine

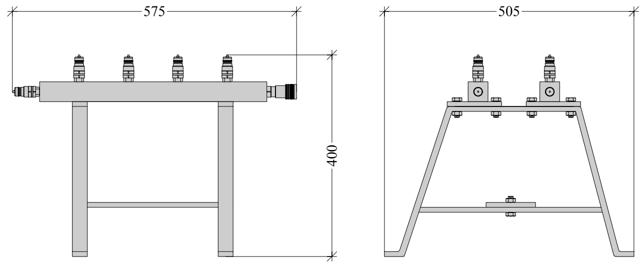


Measures in mm.

TM S4 strand forcing machine

Pump weight: 380 Kg./piece
Strand forcing machine weight: 80 Kg./piece

35.10.1 – DD 04-MF manifold

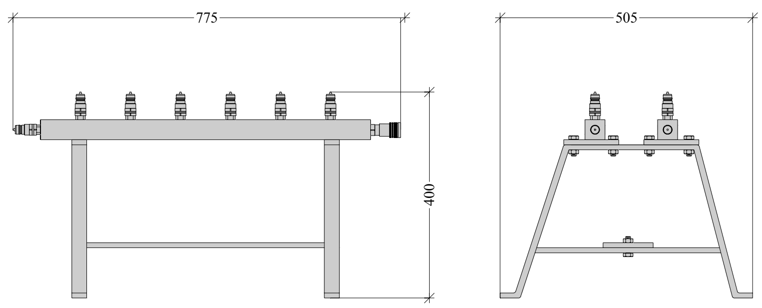


DD 04-MF manifold

Measures in mm.

Weight: 20 Kg./piece

35.10.2 – DD 06-MF manifold

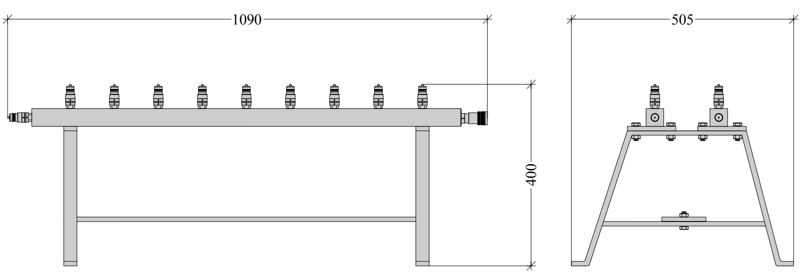


DD 06-MF manifold

Weight: 25 Kg./piece

Measures in mm.

35.10.3 – DD 10-MF manifold



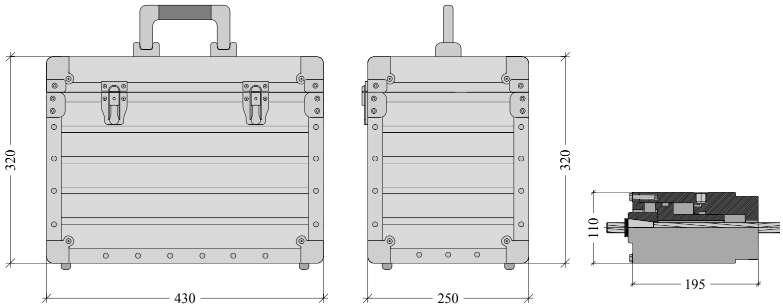
DD 10-MF manifold

Measures in mm.

Weight: 34 Kg./piece

35.11 – Calibration and control instruments

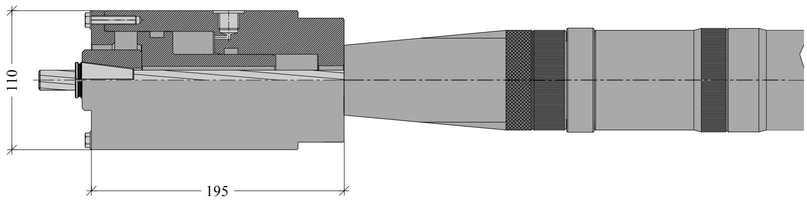
35.11.1 – Complete dynamometer box



Complete dynamometer box

Measures in mm.

35.11.2 – S3000 dynamometer

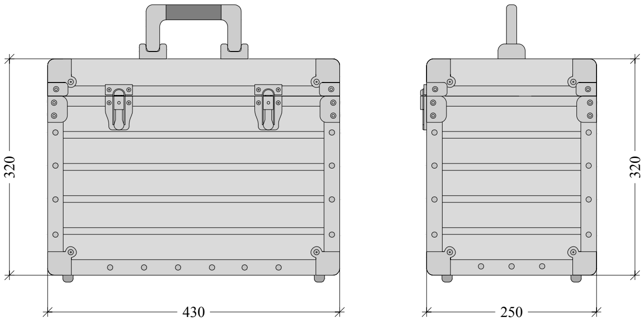


Dynamometer

Measures in mm.

Weight: 8 Kg./piece

35.11.3 – S1000 gauge box

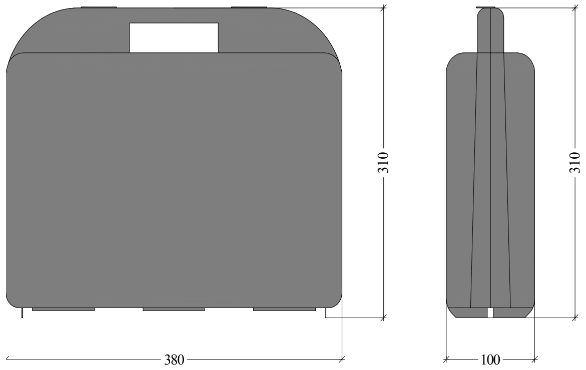


Gauge box

Measures in mm.

Weight: 9.40 Kg./piece

35.11.4 – S900 analogue sample gauge



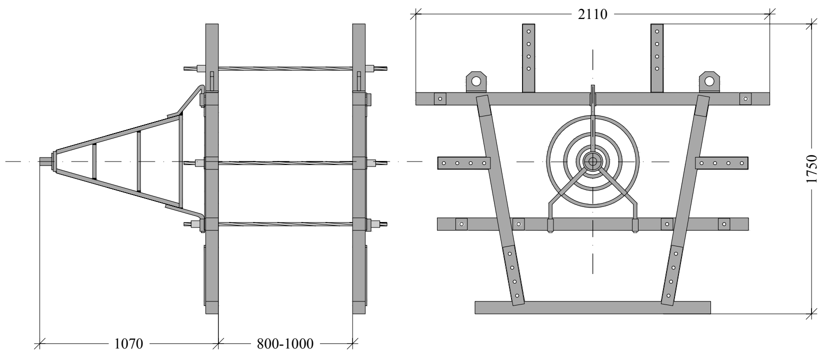
Analogue gauge box

Weight: 2.40 Kg./piece

Measures in mm.

35.12 – Uncoilers

35.12.1 – B1500 uncoiler



Measures in mm.

B1500 uncoiler

Weight: 180 Kg./piece

36.0 – CHARACTERISTICS OF THE EQUIPMENT
36.1 – TTM 250KN jack

36.1.1 – TTM 250KN-40 jack

TTM 250KN-40 jack

Weight: 16.40 Kg./piece
Stressing section: 47.2 cm^2
Length: 350 mm.
Max. diameter: 100 mm.
Max. capacity: 250 KN
Tensioning extension: 80-100 mm.
Stroke: 40 mm.
Without locking
Type: ***TTM 250KN-40****
**(jack for tensioning short strands)*

36.1.2 – TTM 250KN-60 jack

TTM 250KN-60 jack

Weight: 19.2 Kg./piece
Stressing section: 47.2 cm^2
Length: 630 mm.
Max. diameter: 100 mm.
Max. capacity: 250 KN
Tensioning extension: 270 mm.
Stroke: 60 mm.
Provided with locking
Type: ***TTM 250KN-60 jack***

36.1.3 – TTM 250KN-100 jack

TTM 250KN-100 jack

Weight: 21.5 Kg./piece
Stressing section: 47.2 cm^2
Length: 720 mm.
Max. diameter: 100 mm.
Max. capacity: 250 KN
Tensioning extension: 270 mm.
Stroke: 100 mm.
Provided with locking
Type: ***TTM 250KN-100***

36.1.4 – TTM 250KN-200 jack

TTM 250KN-200 jack

Weight: 26 Kg./piece
Stressing section: 47.2 cm^2
Length: 950 mm.
Max. diameter: 100 mm.
Max. capacity: 250 KN
Tensioning extension: 270 mm.
Stroke: 200 mm.
Provided with locking
Type: ***TTM 250KN-200***

36.1.5 – TTM 250KN-400 jack

Weight: 35.00 Kg./piece
Stressing section: 47.2 cm^2
Length: 1.350 mm.
Max. diameter: 110 mm.
Max. capacity: 250 KN
Tensioning extension: 300 mm.
Stroke: 400 mm.
Provided with locking
*Type: **TTM 250KN-400****

**(jack for extraction tests to failure)*

TTM 250KN-400 jack

36.1.6 – TTM 250KN-M-100 jack

TTM 250KN-M-100 jack

Weight: 21.5 Kg./piece
Stressing section: 47.2 cm^2
Length: 720 mm.
Max. diameter: 100 mm.
Max. capacity: 250 KN
Tensioning extension: 270 mm.
Stroke: 100 mm.
Provided with locking
*Type: **TTM 250KN-M-100***

36.1.7 – TTM 250KN-M-60 jack

TTM 250KN-M-60 jack

Weight: 19.2 Kg./piece
Stressing section: 47.2 cm^2
Length: 630 mm.
Max. diameter: 100 mm.
Max. capacity: 250 KN
Tensioning extension: 270 mm.
Stroke: 60 mm.
Provided with locking
*Type: **TTM 250KN-M-60***

36.1.8 – TTM 250KN-C-100 jack

TTM 250KN-C-100 jack

Weight: 18 Kg./piece
Stressing section: 47.2 cm^2
Length: 560 mm.
Max. diameter: 100 mm.
Max. capacity: 250 KN
Tensioning extension: 90-100 mm.
Stroke: 100 mm.
Without locking
*Type: **TTM 250KN-C-100****

**(jack for tensioning short strands)*

36.1.9 – TTM 250KN-C-60 jack

TTM 250KN-C-60 jack

Weight: 16.40 Kg./piece
Stressing section: 47.2 cm^2
Length: 510 mm.
Max. diameter: 100 mm.
Max. capacity: 250 KN
Tensioning extension: 90-100 mm.
Stroke: 60 mm.
Without locking
*Type: **TTM 250KN-C-60****
**(jack for tensioning short strands)*

36.1.10 – TTM 250KN-K-100 jack

TTM 250KN-K-100 jack

Weight: 21 Kg./piece
Stressing section: 47.2 cm^2
Length: 1.000 mm.
Max. diameter: 100 mm.
Max. capacity: 250 KN
Tensioning extension: 650 mm.
Stroke: 100 mm.
Without locking
*Type: **TTM 250KN-K-100***

36.1.11 – TTM 250KN-K-60 jack

TTM 250KN-K-60 jack

Weight: 19 Kg./piece
Stressing section: 47.2 cm^2
Length: 650 mm.
Max. diameter: 100 mm.
Max. capacity: 250 KN
Tensioning extension: 650 mm.
Stroke: 60 mm.
Without locking
*Type: **TTM 250KN-K-60***

36.2 – TTM 300KN jack

36.2.1 – TTM 300KN-M-100 jack

TTM 300KN-M-100 jack

Weight: 24 Kg./piece
Stressing section: 68.80 cm^2
Length: 730 mm.
Max. diameter: 110 mm.
Max. capacity: 300 KN
Tensioning extension: 270 mm.
Stroke: 100 mm.
Provided with locking
*Type: **TTM 300KN-M-100****

(jack for tensioning **T15C compact strands with sect. 165 mm^2)*

36.2.2 – TTM 300KN-100 jack

TTM 300KN-100 jack

Weight: 24 Kg./piece
Stressing section: 68.80 cm^2
Length: 730 mm.
Max. diameter: 110 mm.
Max. capacity: 300 KN
Tensioning extension: 270 mm.
Stroke: 100 mm.
Provided with locking
*Type: **TTM 300KN-100****
(jack for tensioning **T15C compact strands with sect. 165 mm^2)*

36.2.3 – TTM 300KN-200 jack

TTM 300KN-200 jack

Weight: 27.70 Kg./piece
Stressing section: 68.80 cm^2
Length: 650 mm.
Max. diameter: 110 mm.
Max. capacity: 300 KN
Tensioning extension: 270 mm.
Stroke: 200 mm.
Provided with locking
*Type: **TTM 300KN-200****

(jack for tensioning **T15C compact strands with sect. 165 mm^2)*

36.2.4 – TTM 300KN-K-100 jack

TTM 300KN-K-100 jack

Weight: 26 Kg./piece
Stressing section: 68.80 cm^2
Length: 1.000 mm.
Max. diameter: 100 mm.
Max. capacity: 300 KN
Tensioning extension: 650 mm.
Stroke: 100 mm.
Without locking
*Type: **TTM 300KN-K-60***

36.3 – TTM 280KN jack

36.3.1 – TTM 280KN-200 jack

TTM 280KN-200 jack

Weight: 28 Kg./piece
Stressing section: 51.30 cm^2
Length: 270x500x220 mm.
*Max. diameter: ******
Max. capacity: 280 KN
Tensioning extension: 300 mm.
Stroke: 200 mm.
Provided with locking
*Type: **TTM 280KN-200***
**(jack for tensioning through strands)*

36.4 - M series TTM jacks

36.4.1 – M1600 KN jack

M1600KN jack

Capacity: 1600 KN
Strand max. capacity: 1 - 4
Stroke: 250 mm.
Weight: 180 Kg./piece
Stressing section: 155.51 cm^2
Max. stressing pressure: 700 bar
Max. return pressure: 250 bar
Max. locking pressure: 250 bar
Tensioning extension: 400 mm.
Max. diameter: 285 mm.
Length: 950 mm.

36.4.2 – M1800 KN jack

M1800KN jack

Capacity: 1800 KN
Strand max. capacity: 7
Stroke: 250 mm.
Weight: 210 Kg./piece
Stressing section: 302.20 cm^2
Max. stressing pressure: 700 bar
Max. return pressure: 250 bar
Max. locking pressure: 250 bar
Tensioning extension: 400 mm.
Max. diameter: 330 mm.
Length: 1.050 mm.

36.4.3 – M3000 KN jack

M3000KN jack

Capacity: 3000 KN
Strand max. capacity: 9 - 12
Stroke: 250 mm.
Weight: 280 Kg./piece
Stressing section: 424.49 cm^2
Max. stressing pressure: 700 bar
Max. return pressure: 250 bar
Max. locking pressure: 250 bar
Tensioning extension: 400 mm.
Max. diameter: 400 mm.
Length: 1.000 mm.

36.4.4 – M3600 KN jack

M3600KN jack

Capacity: 3600 KN
Strand max. capacity: 12-15
Stroke: 250 mm.
Weight: 390 Kg./piece
Stressing section: 564,21 cm^2
Max. stressing pressure: 700 bar
Max. return pressure: 250 bar
Max. locking pressure: 250 bar
Tensioning extension: 450 mm.
Max. diameter: 470 mm.
Length: 1.150 mm.

36.4.5 – M4800 KN jack

M4800KN jack

Capacity: 4800 KN
Strand max. capacity: 19
Stroke: 250 mm.
Weight: 490 Kg./piece
Stressing section: 725.71 cm^2
Max. stressing pressure: 700 bar
Max. return pressure: 250 bar
Max. locking pressure: 250 bar
Tensioning extension: 500 mm.
Max. diameter: 520 mm.
Length: 1.150 mm.

36.4.6 – M6800 KN jack

M6800KN jack

Capacity: 6800 KN
Strand max. capacity: 22 - 27
Stroke: 250 mm.
Weight: 650 Kg./piece
Stressing section: 879.20 cm^2
Max. stressing pressure: 700 bar
Max. return pressure: 250 bar
Max. locking pressure: 250 bar
Tensioning extension: 600 mm.
Max. diameter: 650 mm.
Length: 1.350 mm.

36.5 – Jacks for bars with tightening

36.5.1 – DD700 KN jack

DD700KN jack

Capacity: 700 KN
Stroke: 50 mm.
Weight: 42 Kg./piece
Stressing section: 132.47 cm^2
Max. stressing pressure: 550 bar
Max. return pressure: 100 bar
Tensioning extension: 100 mm.
Max. diameter: 200 mm.
Length: 460 mm.

36.5.2 – DD1200 KN jack

DD1200KN jack

Capacity: 1200 KN
Stroke: 50 mm.
Weight: 54 Kg./piece
Stressing section: 235,50 cm^2
Max. stressing pressure: 550 bar
Max. return pressure: 100 bar
Tensioning extension: 120 mm.
Max. diameter: 280 mm.
Length: 510 mm.

36.5.3 – DD2000 KN jack

DD2000KN jack

Capacity: 2000 KN
Stroke: 50 mm.
Weight: 95 Kg./piece
Stressing section: 439,60 cm^2
Max. stressing pressure: 550 bar
Max. return pressure: 100 bar
Tensioning extension: 150 mm.
Max. diameter: 360 mm.
Length: 670 mm.

36.6 - Jacks for bars without tightening

36.6.1 – DX700 KN jack

DX700KN jack

Capacity: 700 KN
Stroke: 50 mm.
Weight: 35 Kg./piece
Stressing section: 132,47 cm^2
Max. stressing pressure: 550 bar
Max. return pressure: 100 bar
Tensioning extension: 150 mm.
Max. diameter: 200 mm.
Length: 235 mm.

36.6.2 – DX1200 KN jack

DX1200KN jack

Capacity: 1200 KN
Stroke: 50 mm.
Weight: 43 Kg./piece
Stressing section: 236.50 cm^2
Max. stressing pressure: 550 bar
Max. return pressure: 100 bar
Tensioning extension: 150 mm.
Max. diameter: 280 mm.
Length: 300 mm.

36.6.3 – DX2000 KN jack

DX2000KN jack

Capacity: 2000 KN
Stroke: 50 mm.
Weight: 68 Kg./piece
Stressing section: 439.60 cm^2
Max. stressing pressure: 550 bar
Max. return pressure: 100 bar
Tensioning extension: 150 mm.
Max. diameter: 360 mm.
Length: 360 mm.

36.7 - Tensioning jacks for special M anchorages

36.7.1 – MX 3600 KN jack

MX3600KN jack

Capacity: 3600 KN
Stroke: 100 mm.
Weight: 250 Kg./piece
Stressing section: 424.49 cm^2
Max. stressing pressure: 700 bar
Max. return pressure: 250 bar
Tensioning extension: 500 mm.
Max. diameter: 360 mm.
Length: 560 mm.

36.7.2 – MC 3000 KN jack

MC3000KN jack

Capacity: 3000 KN
Stroke: 100 mm.
Weight: 350 Kg./piece
Stressing section: 564.50 cm^2
Max. stressing pressure: 700 bar
Max. return pressure: 250 bar
Max. locking pressure: 250 bar
Tensioning extension: 450 mm.
Max. diameter: 153,78 mm.
Length: 236,28 mm.

36.7.3 – MC4800 KN jack

MC4800KN jack

Capacity: 4800 KN
Stroke: 100 mm.
Weight: 490 Kg./piece
Stressing section: 636.76 cm2
Max. stressing pressure: 700 bar
Max. return pressure: 250 bar
Max. locking pressure: 250 bar
Tensioning extension: 400 mm.
Max. diameter: 536,02 mm.
Length: 676.28 mm.

36.8 – Special jacks for single strands

36.8.1 – S4000 strand breaking jack

S4000 strand breaking jack

Capacity: 300 KN
Stroke: 125 mm.
Weight: 30 Kg./piece
Pushing section: 19.63 cm^2
Max. pushing pressure: 450 bar
Max. return pressure: 100 bar
Max. height: 293 mm.
Max. length: 240 mm.
Length: 708 mm.

36.8.2 – B300 locking jack

B300 locking jack

Capacity: 300 KN
Stroke: 200 mm.
Weight: 60 Kg./piece
Pushing section: 78.53 cm^2
Max. pushing pressure: 100 bar
Max. return pressure: 100 bar
Max. height: 165 mm.
Max. length: 210 mm.
Length: 688,33 mm.

36.8.3 – M300 jack for extruded anchorages

M300 jack for extruded anchorages

Capacity: 300 KN
Stroke: 200 mm.
Weight: 60 Kg./piece
Pushing section: 78.53 cm^2
Max. pushing pressure: 100 bar
Max. return pressure: 100 bar
Max. height: 165 mm.
Max. length: 210 mm.
Length: 889 mm.

36.9 – TTM-A hydraulic pumps

36.9.1 – TTM 250-A hydraulic pump

TTM250-A pump

Installed power capacity: 1.5 KW
Power supply: 3P+T 380 Volt. 16 Amp
Weight: 85 Kg./piece
Control: with button strip
Functions: stressing-locking-return
Max. stressing pressure: 550 bar.
Max. locking pressure: 150 bar.
Max. return pressure: 150 bar.
Dimensions: 600x440x630 mm
Hydraulic tubes: two

36.9.2 – TTM 450-A hydraulic pump

TTM450-A pump

Installed power capacity: 4.5 KW
Power supply: 3P+T 380 Volt. 16 Amp
Weight: 200 Kg./piece
Control: with button strip
Functions: stressing-locking-return
Max. stressing pressure: 550 bar.
Max. locking pressure: 150 bar.
Max. return pressure: 150 bar.
Dimensions: 1050x560x910 mm
Hydraulic tubes: two

36.9.3 – TTM 550-A hydraulic pump

TTM550-A pump

Installed power capacity: 4.5 KW
Power supply: 3P+T 380 Volt. 32 Amp
Weight: 500-600 Kg./piece
Control: with button strip
Functions: stressing-locking-return
Max. stressing pressure: 550 bar.
Max. locking pressure: 150 bar.
Max. return pressure: 150 bar.
Dimensions: 1400x730x1400 mm.
Hydraulic tubes: two

36.10 - TTM-E hydraulic pumps

36.10.1 – TTM 1000-E pump

TTM1000-E hydraulic pump

Installed power capacity: 10 KW
Power supply: 3P+T 380 Volt. 32 Amp
Weight: 380 Kg./piece
Control: with button strip
Functions: stressing-locking-return
Max. stressing pressure: 550 bar.
Max. locking pressure: 150 bar.
Max. return pressure: 150 bar.
Dimensions: 1400x730x1400 mm
Hydraulic tubes: three

36.10.2 – TTM 2000-E pump

TTM2000-E hydraulic pump

Installed power capacity: 22 KW
Power supply: 3P+T 380 Volt. 32 Amp
Weight: 470 Kg./piece
Control: with button strip
Functions: stressing-locking-return
Max. stressing pressure: 550 bar.
Max. locking pressure: 150 bar.
Max. return pressure: 150 bar.
Dimensions: 1400x730x1400 mm
Hydraulic tubes: three

36.10.3 – TTM 650-E pump

TTM650-E hydraulic pump

Installed power capacity: 7.5 KW
Power supply: 3P+T 380 Volt. 32 Amp
Weight: 290 Kg./piece
Control: with button strip
Functions: stressing-locking-return
Max. stressing pressure: 550 bar.
Max. locking pressure: 150 bar.
Max. return pressure: 150 bar.
Dimensions: 1500x900x700 mm
Hydraulic tubes: three

36.11 – Grouting pump

36.11.1 – T500 pump

T 500 pump

Installed power capacity: 20 KW
Power supply: 3P+T 380 Volt. 63 Amp
Weight: 930 Kg./piece
Control: with button strip
Functions: pump-turbo mixer
Max. grouting pressure: 20 bar.
Max. locking pressure: 150 bar.
Max. return pressure: 150 bar.
Width: 1.930 mm.
Length: 1.930 mm.
Height: 1.450 mm.
Mixer capacity: 190 litres
Agitator/turbo capacity: 200 litres

36.12 – Strand forcing machines

36.12.1 – T61 strand forcing machine

T61 strand forcing machine

Installed power: 22 KW
Pump weight: 490 Kg./piece
Strand forcing machine weight: 160 Kg./piece
Control: with button strips
Drive: proportional control
Max. speed: 10 m/sec.
Max. pushing pressure: 120 bar
Starting torque: 280 Nm
Average insertion: 350 m.
*Max. insertion: 500 mm.**
Hydraulic pump dimensions: 1600x1000x1300 mm.
Head dimensions: 800x1200x550 mm.
Hydraulic pump type: T61
Strand forcing machine type: T61

** depending on the trend of the strand seating wire*

36.12.2 – TM S4 strand forcing machine

TM S4 strand forcing machine

Installed power: 7.5 KW
Pump weight: 380 Kg./piece
Strand forcing machine weight: 80 Kg./piece
Control: with button strips
Drive: on/off control
Max. speed: 3 m/sec.
Max. pushing pressure: 230 bar
Starting torque: 175 Nm
Average insertion: 80 m.
*Max. insertion: 120 mm.**
Hydraulic pump dimensions: 1400x730x1400 mm.
Head dimensions: 950x410x530 mm.
Hydraulic pump type: TM
Strand forcing machine type: S4

** depending on the trend of the strand seating wire*

36.13 – Uncoilers

36.13.1 – B1500 uncoiler

B1500 uncoiler

Capacity: 1.000 Kg.
Loaded weight: 220 Kg
Equipment weight: 180 Kg./piece
Dimensions: 2500x2500 mm

36.14.1 – DD 04-MF manifold

DD 04-MF manifold

Useful positions: 4 outputs + gauge joint
Weight: 20 Kg./piece
Dimensions: 600x500x410 mm
Max. operating pressure: 450-500 bar.

36.14.2 – DD 06-MF manifold

DD 06-MF manifold

Useful positions: 6 outputs + gauge joint
Weight: 25 Kg./piece
Dimensions: 800x500x410 mm
Max. operating pressure: 450-500 bar.

36.14.3 – DD 10-MF manifold

DD 10-MF manifold

Useful positions: 10 outputs + gauge joint
Weight: 34 Kg./piece
Dimensions: 600x500x410 mm
Max. operating pressure: 450-500 bar.

36.15 – Calibration and control instruments

36.15.1 – S 1000 gauge box

Gauge box

Capacity: 999 bar.
Weight: 9.40 Kg./piece
Power supply: 3P+T 220 Volt 16 Amp
Max. pressure: 900 bar
Dimensions: 320x430x250 mm.

36.15.2 – S900 analogue sample gauge

S900 analogue sample gauge

Capacity: ??? KN
Weight: ??? Kg./piece
Useful section: ??? cm^2
Max pressure: ???bar
Reading with translator: ??? mA
Reading: ???bar
Length: ??? mm.
Diameter: ??? mm.

36.15.3 – Complete dynamometer box

Complete dynamometer box

Dynamometer hydraulic transducer

Capacity: 350 KN
Weight: 8 Kg./piece
Useful section: 34.36 cm^2
Max. pressure: 900 bar
Reading with translator: 4-20 mA
Reading: 1 bar
Length: 210 mm.
Diameter: 110 mm.

Dynamometer box

Capacity: 999 bar.
Weight: 9.40 Kg./piece
Power supply: 3P+T 220 Volt 16 Amp
Max. pressure: 900 bar
Dimensions: 320x430x250 mm.

37.00 – CALCULATION OF FOUNDATIONS FOR GROUND ANCHORS

*This calculation must always be checked by carrying out a removal on site, according to **EURO NORM EN 1536-2002 paragraph 9.4.***

37.1 – Anchor tendon		*Measurement unit*
Section of a T15 strand diam. 15,2 mm.	*Area = 139 mm^2*	*[mm^2)*
Limit tensile creep:	$f_{0,1k} = 1670$	*[N/mm^2]*
Limit tensile stress:	$f_{tk} = 1860$	*[N/mm^2]*
Limit creep load:	$N_{ys} = n_t \cdot A \cdot f_{0,1k}$	*[N]*
Limit stress load:	$N_{ts} = n_t \cdot A \cdot f_{tk}$	*[N]*
Allowable load:	$N_{amm} = N_{ys} /1,45$	*[N]*
Prestress load:	$N_{ys} = 0,9 \cdot N_{amm}$	*[N]*
Working load (derived from the calculation)	$N_Q \le N_{amm}$	*[N]*
37.2 – Classification of anchors		
Prestressed:	$N_i > N_Q$	*[N]*
Partially prestressed:	$N_i \le N_Q$	*[N]*
Not prestressed:	$N_i = 0$	*[N]*
37.3 – Determining the anchor bulb *(The Bustamante-Doix 1985 criterion is applied)*		
Ultimate foundation limit strength	$N_{fu} = \dfrac{\alpha \cdot \pi \cdot D_f \cdot q_f \cdot L_f}{\gamma_f} \ge \begin{cases} N_Q \\ N_{amm} \end{cases}$	*[N]*

where :	
$\boldsymbol{\alpha}$	*Improving coefficient depending on the type of mortar grouting*
$\boldsymbol{D_f}$	*Diameter of the foundation*
$\boldsymbol{g_f}$	*Side friction limit stress between bulb and ground*
$\boldsymbol{L_f}$	*Length of the foundation*
$\boldsymbol{\gamma_f}$	*Safety coefficient (2.0 for temporary anchors; 2.5 for permanent anchors)*

Anchorage minimum length	$L_{f,\min} = \dfrac{N_{amm} \cdot \gamma_f}{\alpha \cdot \pi \cdot D_f \cdot q_f}$	*[m]*
Anchorage minimum length	$L_{f,\min} = \dfrac{N_Q \cdot \gamma_f}{\alpha \cdot \pi \cdot D_f \cdot q_f}$	*[m]*

37.4 - Determining the anchor bulb *(The Bowles criterion is applied)*			
Ultimate foundation limit strength		$N_{fu} = \dfrac{\pi \cdot D_f \cdot \tau_f \cdot L_f}{\gamma_f} \geq \begin{cases} N_Q \\ N_{amm} \end{cases}$	*[N]*
		$\tau_f = \gamma_t \cdot h_f \cdot K \cdot \tan(\delta) + c_a$	
where:			
D_f	*Diameter of the foundation*		
τ_f	*Side friction limit stress between bulb and ground*		
L_f	*Length of the foundation*		
γ_f	*Safety coefficient (2.0 for temporary anchors; 2.5 for permanent anchors)*		
γ_t	*Specific weight of the ground above the foundation*		
h_f	*Average depth of the foundation*		
K	*Active thrust, resting thrust*		
δ	*Side friction limit stress between bulb and ground*		
c_a	*Adhesion:* $0{,}7 \div 0{,}9 \cdot c_u$		
Anchorage minimum length		$L_{f,\min} = \dfrac{N_{amm} \cdot \gamma_f}{\pi \cdot D_f \cdot \tau_f}$	*[N]*

where:

Coefficient α

	I.R.S.	***I.***
Gravel	*1.8*	*1.3 ÷ 1.4*
All-in ballast	*1.6 ÷ 1.8*	*1.2÷ 1.4*
Gravel-sand mixture	*1.5 ÷ 1.6*	*1.2÷ 1.3*
Coarse sand	*1.4 ÷ 1.5*	*1.1÷ 1.2*
Medium sand	*1.4 ÷ 1.5*	*1.1÷ 1.2*
Fine sand	*1.4 ÷ 1.5*	*1.1÷ 1.2*
Silty sand	*1.4 ÷ 1.5*	*1.1÷ 1.2*
Silt	*1.4 ÷ 1.6*	*1.1÷ 1.2*
Clay	*1.8 ÷ 2.0*	*1.2*
Marl	*1.8*	*1.1÷ 1.2*
Calcareous marl	*1.8*	*1.1÷ 1.2*
Altered or fractured sandstone	*1.8*	*1.1÷ 1.2*
Altered or fractured rock	*1.2*	*1.2*

I.R.S. *= repeated and selective grouting*
I *= simple grouting*

c_u = not drained cohesion [N/mm^2] that is determined via the Mohr's circle				
Typical values of cohesion, of the friction angle and of the volume weight in some types of ground				
Type	***Description***	***Volume weight***	***Friction angle***	***Cohesion***
		(dry/saturated) [kN/m³]	*[°]*	*[kPa]*
Sand	*Not thickened and well selected sand*	*19/14*	*28 ÷ 34*	
	Thickened and well selected sand	*21/17*	*32 ÷ 40*	
	Not thickened and badly selected sand	*20/16*	*34 ÷ 40*	
	Thickened and badly selected sand	*21/18*	*38 ÷ 46*	
Gravel				
	Well selected gravel	*22/20*	*34 ÷ 36*	
	Sand and gravel	*19/17*	*45 ÷ 48*	
Clay	*Soft bentonite*	*13/6*	*7 ÷ 13*	*10 ÷ 20*
	Very soft organic clay	*14/6*	*12 ÷ 16*	*10 ÷ 30*
	Soft glacial clay	*17/12*	*27 ÷ 32*	*30 ÷ 70*
	Hard glacial clay	*20/17*	*30 ÷ 32*	*70 ÷ 150*
	Badly selected glacial tillites	*23/20*	*32 ÷ 35*	*150 ÷ 250*

38.0 – DETERMINING THE THEORETICAL STRESSING OF A JACK

The stressing section of a jack, except for losses, allows to define its stressing capacity.
The stressing section of a jack must be determined, which does not always result full, but greater section minus smaller section.

***Stressing section (A_1)**: 47.2 cm^2*
*Stressing **pressure (P_1)** usually displayed in bar on the gauge,*

*Stressing = A_1 x P_1 = 47.2 cm^2 x 350 Kg/cm^2 = **16.520 Kg.***

This value is theoretical and does not take into account the losses of each circuit that cause a stressing reduction. Losses are: ΣP_1 accidental losses and ΣP_2 continuous losses.
***Losses$_{Tot.}$** = $\Sigma P_1 + \Sigma P_2$ these losses can be surveyed on a circuit only experimentally. They depend on several factors, ex.: deterioration of the circuit, tubes and valves, losses on components (accidental losses related to the component), deterioration of the jack sliding surfaces (friction)*

39.0 – UNIT OF MEASUREMENT AND CONVERSIONS

1 bar = 0.9869 atm = 1.0197 Kg/cm^2
1 atm = 1.0332 Kg/cm^2 = 1.0132 bar.
1 Kg/cm^2 = 0.9807 bar = 0.9678 atm.
1 Kg. = 0.001 Ton. = 0.0098 KN
1KN = 0.102 Ton. = 101.9716 Kg.
Ex. stressing 16.520 Kg. = 16.52 Ton. = 161.89 KN

40.0 – EVALUATION OF LOAD LOSSES DURING TENSIONING

*Load losses of each anchor of the **TTM Tension Technology s.r.l.** system, made of a coated and greased strand, are evaluated based on the procedures defined in the **EN 1536-2002**. They are divided into the following types.*

40.1 - Losses due to friction

a) strand-polyvinyl chloride, due to the not intentional angular deviation of the anchor inside the hole in the ground;
b) strand-anchor plate, due to the deviation of the single strands in the holes of the anchor plate;
c) losses due to the re-entering of the clamps;
d) losses due to bond length creep and anchor head displacement at lock-off load.

Calculation of losses due to friction (Pfriction)
Losses mentioned in paragraph 1) are calculated based in the following theoretical expression, if the curve of the anchor inside the hole is known.

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

Friction phenomena are evaluated based on the curve of hysteresis typical behaviour of steel between a load curve and an unload one, and for subsequent test cycles. From this curve the following variables result: "elastic elongation", "permanent plastic elongation" and "apparent tendon length".

40.2 - Immediate losses
Eurocode 2, 5.10.3

According to paragraph 5.10.3 (3) of the European Standard EN 1992-1-1:2005 (EC2), in order to determine immediate losses, $\Delta P_i(x)$ the following immediate effects for post-tensioning shall be considered, where applicable:

:

1. *Losses due to friction strand / sheath,* $\Delta\sigma_{\mu}$
2. *Losses due to the anchorage re-entering (re-entering of wedges),* $\Delta\sigma_{sl}$
3. *Losses due to the elastic deformation of concrete,* $\Delta\sigma_{el}$

Immediate losses occur in the tensioning phase, reducing the tension generated by the jack.

40.3 – Losses of tension due to friction
Eurocode 2, 5.10.5.2

According to ***EC2, 5.10.5.2,*** *tension losses* $\Delta\sigma_{\mu}(x)$ *in post-tensioned tendons due to friction can be evaluated with the expression:*

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

where:

θ - *is the sum of angular deviations on a length x (independent of direction and sign);*

μ - *is the friction coefficient between the strand and its sheath [rad^{-1}];*

k - *is a non intentional angular deviation for internal wires (per length unit, rad/m);*

x - *is the distance of the section under consideration along the tension from the point where the precompression force is equal to Pmax (force at the active end during the anchor loading).*

The value μ depends on the characteristics of the surface of tendons and of the sheath, on the presence of rust, on the elongation and profile of the tendon. The value k, for the non intentional angular deviation, depends on the quality of execution, on the distance between the supporting points of the tendons, on the type of duct or sheath used and on the level of vibration used in the concrete laying.

TTM recommends to apply the following values for μ *and* k *:*

- *coated and greased strand (HDPE sheath):*

0,05 rad^{-1} < μ *< 0,07rad^{-1} and 0,004 rad/m <* k *< 0,008 rad/m*

- *adherent single strand in a metallic sheath:*

μ *= 0,19 rad^{-1} and k=0,005 rad/m*

40.4 - Evaluations of the elongations during tensioning of wires

During the tensioning of wires it is necessary to compare the actual elongations with the theoretical elongations envisaged in the calculations to which the corrective terms must be added in order to obtain the actual elongations. The elongations registered on site are the sum of the following elements:

$$\Delta L_o = \Delta L_a + \Delta L_b + \Delta L_c + \Delta L_d + \Delta L_e$$

where:

ΔL_a *elongation of the strand calculated considering the extra length necessary for the jack to grip it;*

ΔL_b *elastic deformation of the concrete. Usually, the elongation measured on the jack included the elastic shrinkage of the concrete;*

ΔL_c *sum of the deformations of the anchoring devices and re-entry of the clamps in the conical seats;*

ΔL_d *re-entry of gripper clamps;*

ΔL_e *internal deformation of the jack.*

40.5 – Re-entry of clamps on the active anchorage

The loss of elongation due to re-entering of the clamps occurs during their locking phase following tensioning.
*According to the reports of the "**Static Load Tests, EMPA",*** ΔL_d *is evaluated as follows:*

ΔL_d *= 5 mm for tensioning with jacks equipped with locking system*
ΔL_d *= 10 mm for tensioning with jacks not equipped with locking system.*

40.6 - Re-entry of clamps and deformation of fixed anchoring

*According to the reports of the "**Static Load Tests, EMPA**", deformation of anchorings under load is always limited to and does not exceed 1 mm.*
Usually, deformation of anchorings under load is always limited to and does not exceed 1mm.
The re-entry of the clamps on passive anchorages causes a translation of the wire towards the tensioning jack. The values remain about 4-5 mm.

40.7 - Deformation of jacks

These deformations must be assumed from the measure of the elongation of the strand when the readings are taken on the piston of the jack.
The internal losses at the jacks are considered:

TTM series jacks = 8 mm

When the elongations are taken directly on the strand these values must not be taken into consideration.

40.8 – Losses due to the re-entry of clamps ($P_{re\text{-}entry}$)

The loss of elongation due to the re-entry of the clamps in TTM jacks with locking is evaluated in 5 mm., for jacks without locking, ex. the TTM250KN-C-100 model, the loss to consider for re-entry of the clamps is 10 mm.

40.9 – Losses due to the creep of the bond length and moving of the anchor head at the lock-off load (*Pdeformation*)

During cyclic tests, in order to determine the percent load loss, this is surveyed while controlling the stressing loss of the jack in "stand by", at the end of each time interval stated.
At the lock-off load, the transfer of the anchor head and the creep of the bond length with respect to the structure should be kept constant. In order to determine the cumulative percent load loss, the anchor head must be mounted on a load cell, controlling the stressing loss at the end of each time interval until 10 days.
The losses stated above and all the behaviour curves surveyed depend on the anchor-ground assembly. Curves may provide the design engineer with further information about the ground and the behaviour of the anchor components in the ground.

40.10 – Total losses ($P_{Tot.}$)

$(P_{Tot.}) = (P_{re\text{-}entry}) + (P_{re\text{-}entry}) + (P_{deformation})$

41.00 – CEMENT GROUT AND ADMIXTURES
*(**EURO NORM EN 1536-2002** paragraph 6.7)*

Cement grouts used in the encapsulation and in contact with prestressing steel tendons shall conform in general with prEN 445, prEN 446 and prEN 447. Where there is conflict between the provisions of this standard and prEN 445, prEN 446 and prEN 447, the provisions of this standard shall be adopted. For cement grout used to encase a tendon within an encapsulation or to protect steel tubes, the properties should be controlled to prevent bleed and shrinkage. Water/cement ratios for anchor grouts outside the encapsulation but within the borehole should be chosen appropriate to the ground conditions.
High sulphide content cements shall not be used in contact with prestressing steel.
When selecting the type of cement for grout placed in contact with the surrounding ground, account shall be taken of the presence of aggressive substances in the environment, e.g. carbonic acid and sulphates, of the permeability of the ground and of the design life of the anchor. The aggressivity of the environment shall be defined in accordance with ENV 206.
Admictures may be used for improving workability or durability, for reducing bleed or shrinkage, or for increasing rate of strength development. The use of admixtures with prestressing steel shall be approved by the Client's Technical Representative. Admixtures shall be free from any product liable to damage prestressing steel or the grout itself. No admixture that contains more than 0.1% (by mass) of chlorides, sulphides or nitrates shall be used.
Where appropriate, inert fillers (i.e. sand) may be incorporated within the grout mix to reduce leakage away from the borehole.
Laboratory and field tests should be undertaken to verify mixture, mixing efficiency, setting times and performance. These tests should be undertaken in accordance with prEN 445, where applicable.

42.00 - RECORDS
*(**EURO NORM EN 1536-2002** paragraph 10)*

An anchor installation plan shall be prepared and shall be available on site containing the technical specification related to the anchor system to be used.

Note: An anchor installation plan may contain the following information, as appropriate:

- *the anchor type with designation;*
- *number of anchors;*
- *the location and orientation of each anchor and tolerances in position;*
- *free anchor length and fixed anchor length;*
- *required anchor load carrying capacity and lock-off load;*
- *installation technique (drilling, placing, grouting and stressing);*
- *known obstructions;*
- *any other constraints on anchoring activities.*

Records of anchor construction shall be compiled in accordance with ENV 1997-1-1, for future reference.

These shall cover:

- *the sequence of deliveries of all cementitious materials, resins and hardeners, cement and resin grouts;*
- *site investigation;*
- *drilling technique;*
- *installation and geometry of anchor elements;*
- *date and time of installation of each anchor;*
- *for grouted anchors: material, pressure, grouted volume, grouting length, grouting time;*
- *installation of the chosen corrosion protection;*
- *grouting;*
- *stressing;*

- *anchor testing.*

A signed record shall be kept for each anchor installation. This record shall include any special features of construction. All installation and testing records shall be kept after the completion of the works.
As-built plans shall be compiled after completion of the anchors and kept with the construction records. Any acceptance certificates issued by regulatory authorities for materials used in the anchor installation shall be held with the construction records. Copies of all records described in this clause should be deposited such that they may be consulted by interested parties in the future.

43.00 -** SPECIAL **REQUIREMENTS
***(EURO NORM EN 1536-2002** paragraph 11)*

When executing anchor works all national standards, specifications or statutory requirements regarding:

- *security of the site;*
- *safety of the working procedures; and*
- *operational safety of drilling and auxiliary equipment and tools shall be complied with.*

Particular attention shall be drawn to all the processes requiring personnel operating alongside heavy equipment and heavy tools.
Nuisance and/or environmental damage that can be caused by the anchor work shall be kept to a minimum.

Such nuisance and/or environmental damage can be caused by:

- *noise;*
- *ground vibration;*
- *ground pollution;*
- *surface water pollution;*
- *groundwater pollution;*
- *air pollution.*

During stressing safety precautions are essential. Operatives and observers should stand to one side of the tensioning equipment and never pass behind when it is under load. Notices should be displayed stating 'DANGER – Tensioning in Progress' or something similar.

44.0 – CORROSION PROTECTION SYSTEMS ON PERMANENT ANCHORS
(EURO NORM EN 1537-2002** paragraph 6.9.1**)

EURO NORM EN 1537-2002 paragraph 6.9.1 *Permanent ground anchors are defined as those which are to have a design life of more than two years.*
Table 3 (*page 13)* ***EURO NORM EN 1537-2002 paragraph 6.10.*** *Examples of corrosion protection systems for permanent anchors.*

Verification of protection offered:

a) *All corrosion protection systems shall have been subjected to test(s) to verify the competence of the system. The results of all tests shall be well documented;*

b) *The* ***Client's Technical Representative*** *will carry out a technical assessment of the results of the corrosion protection system tests in order to verify that the protection offered by each barrier in the system is achieved. It should be noted that in certain systems the integrity of the inner protective barrier itself depends on the maintenance of the integrity of the outer barrier;*

c) *where only a single protective barrier is provided in the tendon bond length the integrity of this barrier may be checked by an insitu test such as an electrical resistivity test.*

1. Tendon bond length	***Protective barriers offered insitu***
The encapsulation may consist of one of the following:	
a) *a single corrugated plastic duct containing the tendon(s) and cement grout;*	***a)*** *one plastic duct;*
b) *two concentric corrugated plastic ducts containing the tendon(s), fully pregrouted (with cement or resin) within the core and the annulus between the ducts prior to installation;*	***b)*** *two plastic ducts;*
c) *a single corrugated plastic duct containing a bar tendon or tendons and pregrouted with cement grout. A minimum cover of 5 mm is provided between the duct and the bar. The bar tendon(s) have a continuous ribbed outer surface. The crack width of the cement grout between the duct and the bar does not exceed 0.1 mm under service loading;*	***c)*** *internal cement grout and surrounding plastic duct;*
d) *a single steel or corrugated plastic tube-a-manchette duct not less than 3 mm thick, surrounded by a minimum of 20 mm grout cover injected under a pressure of not less than 500 KPa at intervals along the tube-a-manchette no greater than 1 m. A minimum cover of 5 mm is provided between the duct and the tendons. The crack width of this cement grout does not exceed 0.2 mm under service loading;*	***d)*** *internal cement grout and surrounding steel or plastic duct;*
e) *a single corrugated steel duct (compression tube) closely surrounding a greased steel tendon. The duct and plastic cap at the restraining nut are protected by the surrounding cement grout having a thickness of not less than 10 mm, and where the crack widths do not exceed 0.1 mm under service loading.*	***e)*** *steel duct and surrounding cement grout.*

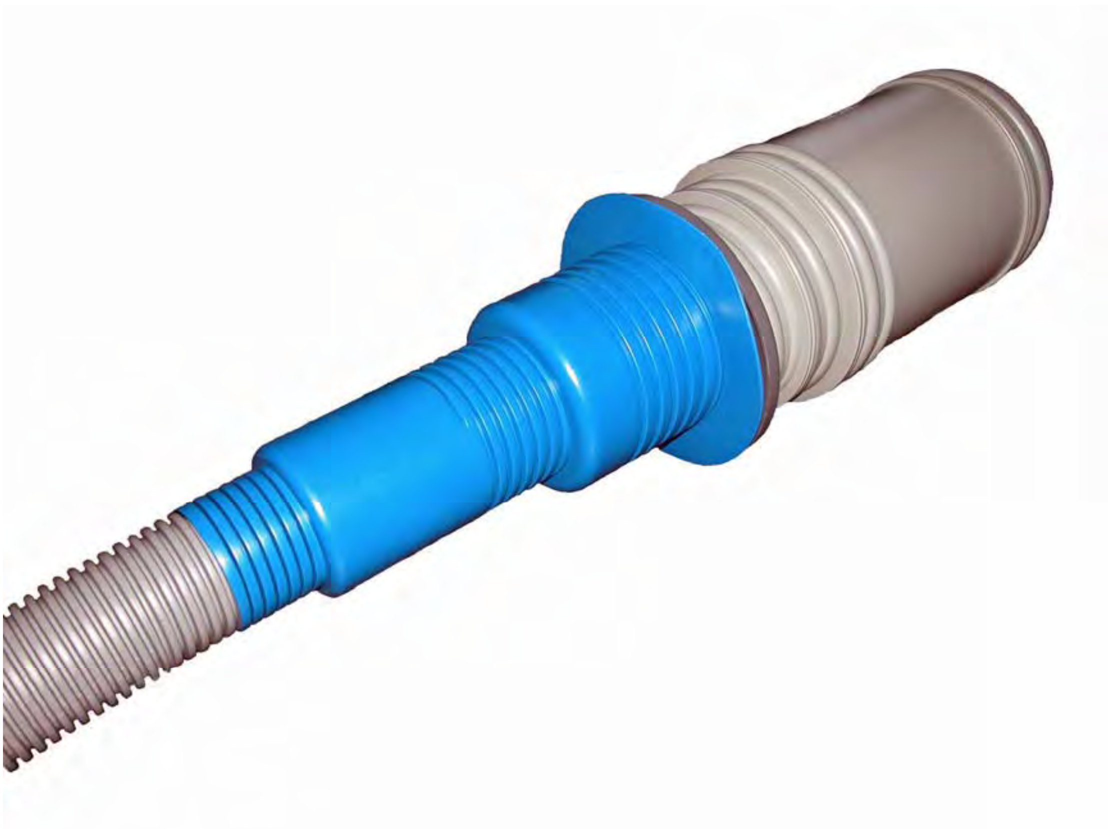
2. Tendon free length EURO NORM EN 1537-2002 paragraph 6.10.

The protection system allows free movement of the tendon within the borehole. This may be achieved by one of the following:

a) *a plastic sheath to individual tendon(s) filled completely with flexible corrosion protection compound plus the inclusion of A, B, C or D below;*
b) *a plastic sheath to individual tendon(s) filled completely with cement grout plus A or B below;*
c) *a common plastic sheath for multiple tendon(s) completely with cement grout plus B.*
a *Common plastic sheath or duct filled with flexible corrosion protection compound;*
b *Common plastic sheath or duct filled at the ends against ingress of water;*
c *Common plastic sheath or duct filled with cement grout;*
d *Common steel duct filled with dense cement grout.*
A lubricant or bond free contact is present within either the individual sheaths or the common sheath to ensure free movement of the tendon(s) during stressing.

3. Transition between anchor head and free length EURO NORM EN 1537-2002 paragraph 6.10.

A coated, grouted or cast-in metal sleeve or fixed plastic duct is sealed is sealed or welded to the anchor head. It is sealed to the free length sheath or duct and filled with corrosion protection compound, cement or resin.



The purpose of the under plate protection, according to ***EURO NORM EN 1537-2002 paragraph 6.11.3*** *s to provide an effective connection/protection between the sheath of the free length and the anchorage.*
It protects the small section of tendon under the bearing plate and to guarantee the continuity of the plate.

4. Anchor head EURO NORM EN 1537-2002 paragraph 6.10.

A coated and/or galvanized metal cap with a minimum 3 mm wall thickness or a rigid plastic cap a minimum 5 mm wall thickness is connected with the bearing plate and if removable, it is filled with a flexible corrosion protection compound and sealed with a gasket. If non-removable it may be filled with cement or resin.

TTR-100 short cap installed complete with accessories

TTR-450 long cap installed complete with accessories

45.0 - CORROSION PROTECTION SYSTEMS ON DOUBLE PROTECTION PERMANENT ANCHORS
(EURO NORM EN 1537-2002** paragraph 6.9.1**)

EURO NORM EN 1537-2002 paragraph 6.9.1 *Permanent ground anchors are defined as those which are to have a design life of more than two years.*

Table 3 (*page 13)* ***EURO NORM EN 1537-2002 paragraph 6.10.*** *Examples of corrosion protection systems for permanent anchors.*

Verification of protection offered:

a) *All corrosion protection systems shall have been subjected to test(s) to verify the competence of the system. The results of all tests shall be well documented;*
b) *The **Client's Technical Representative** will carry out a technical assessment of the results of the corrosion protection system tests in order to verify that the protection offered by each barrier in the system is achieved. It should be noted that in certain systems the integrity of the inner protective barrier itself depends on the maintenance of the integrity of the outer barrier;*
c) *where only a single protective barrier is provided in the tendon bond length the integrity of this barrier may be checked by an insitu test such as an electrical resistivity test.*

1. Tendon bond length	***Protective barriers offered insitu***
The encapsulation may consist of one of the following:	
a) *a single corrugated plastic duct containing the tendon(s) and cement grout;*	***a)*** *one plastic duct;*
b) *two concentric corrugated plastic ducts containing the tendon(s), fully pregrouted (with cement or resin) within the core and the annulus between the ducts prior to installation;*	***b)*** *two plastic ducts;*
c) *a single corrugated plastic duct containing a bar tendon or tendons and pregrouted with cement grout. A minimum cover of 5 mm is provided between the duct and the bar. The bar tendon(s) have a continuous ribbed outer surface. The crack width of the cement grout between the duct and the bar does not exceed 0.1 mm under service loading;*	***c)*** *internal cement grout and surrounding plastic duct;*
d) *a single steel or corrugated plastic tube-a-manchette duct not less than 3 mm thick, surrounded by a minimum of 20 mm grout cover injected under a pressure of not less than 500 KPa at intervals along the tube-a-manchette no greater than 1 m. A minimum cover of 5 mm is provided between the duct and the tendons. The crack width of this cement grout does not exceed 0.2 mm under service loading;*	***d)*** *internal cement grout and surrounding steel or plastic duct;*
e) *a single corrugated steel duct (compression tube) closely surrounding a greased steel tendon. The duct and plastic cap at the restraining nut are protected by the surrounding cement grout having a thickness of not less than 10 mm, and where the crack widths do not exceed 0.1 mm under service loading.*	***e)*** *steel duct and surrounding cement grout.*

Two concentric corrugated plastic ducts containing the tendon

Application of a double protection to bulbs on permanent anchors:

1. Anchor bond length *(protective barriers offered insitu) solution b) "two plastic ducts"Table* ***3 (****page 13)* ***EURO NORM EN 1537-2002 paragraph 6.10.1***

b) two concentric corrugated plastic ducts *containing the tendon(s), fully pregrouted (with cement or resin) within the core and the annulus between the ducts prior to installation;*
This solution requires the use of two corrugated tubes on the foundation/bulb part, which must be grouted into the annulus with cement grout.

2. Anchor free length EURO NORM EN 1537-2002 paragraph 6.10.1

The protection system allows free movement of the tendon within the borehole. This may be achieved by one of the following:
a) *a plastic sheath to individual tendon(s) filled completely with flexible corrosion protection compound plus the inclusion of A, B, C or D below;*
b) *a plastic sheath to individual tendon(s) filled completely with cement grout plus A or B below;*
c) *a common plastic sheath for multiple tendon(s) completely with cement grout plus B.*
a *Common plastic sheath or duct filled with flexible corrosion protection compound;*
b *Common plastic sheath or duct filled at the ends against ingress of water;*
c *Common plastic sheath or duct filled with cement grout;*
d *Common steel duct filled with dense cement grout.*
A lubricant or bond free contact is present within either the individual sheaths or the common sheath to ensure free movement of the tendon(s) during stressing.

3. Transition between anchor head and free length EURO NORM EN 1537-2002 paragraph 6.10.1

A coated, grouted or cast-in metal sleeve or fixed plastic duct is sealed or welded to the anchor head. It is sealed to the free length sheath or duct and filled with corrosion protection compound, cement or resin.

4. Anchor head EURO NORM EN 1537-2002 paragraph 6.10.

A coated and/or galvanized metal cap with a minimum 3 mm wall thickness or a rigid plastic cap a minimum 5 mm wall thickness is connected with the bearing plate and if removable, it is filled with a flexible corrosion protection compound and sealed with a gasket. If non-removable it may be filled with cement or resin.

46.0 - CORROSION PROTECTION SYSTEMS ON TEMPORARY ANCHORS

(EURO NORM EN 1537-2002 *paragraph 6.9.1)*

EURO NORM EN 1537-2002 paragraph 6.9.1 *Temporary ground anchors are defined as those which are required to be in service no longer than two years.*
Table 2 (*page 11)* ***EURO NORM EN 1537-2002 paragraph 6.10****. Examples of corrosion protection systems for temporary anchors.*

1. Tendon bond length

All installed tendons shall be provided with a minimum 10 mm cement grout cover to the borehole wall. Where aggressive ground conditions are known to exist, it may be appropriate to enhance the protection for example by the use of a single corrugated duct around the tendon(s).

Spacers EURO NORM EN 1537-2002 paragraph 6.6

On customer's request, anchors are supplied with centralizers/spacers that allow the anchor centering in the hole and a minimum of 10 mm grout cover to the borehole wall. Spacers and centralizers shall not impede grout flow and are manufactured from corrosion resistant materials.
There are two types of centering systems in compliance with ***EURO NORM EN 1537-2002 paragraph 6.6*** *or as otherwise stated by the* ***Client's Technical Representative.***
The ***DD-EF (****fixed type) spacer only guarantees the fixed spacing of the anchor from the hole walls at four points.*

*The **DD-ED** (dynamic type) spacer guarantees a dynamic centring of the centralizer. As it deforms it centres itself in the entire section of the drilling hole and on the entire circumference of the section concerned.*

***DD-ED** (dynamic) type*

***DD-EF** (fixed) type*

2. Tendon free length

The protection system shall have low frictional properties and allow movement of the tendon within the borehole. This may be achieved by the provision of one of the following:

***a)** Plastic sheath surrounding each individual tendon, end sealed against ingress of water;*

***b)** Plastic sheath surrounding each individual tendon, completely filled with corrosion protection compound;*

***c)** Plastic or steel sheath or duct common to all tendons, end sealed against ingress of water;*

***d)** Plastic or steel sheath or duct common to all tendons, completely filled with corrosion protection compound;*

b) or d) is appropriate for extended temporary use or in aggressive conditions.

***3. Transition between anchor head and free length** (inner anchor head)*

The free length sheath or duct may be sealed to the bearing plate/anchor head, or a metal sleeve or plastic duct may be sealed or welded to the bearing plate. It shall overlap the free length sheath or duct and for extended temporary use with corrosion protection compound, cement or resin which is contained at the lower end.

Under plate protection

4. Anchor head

Where the anchor head is accessible for inspection and possible re-coating the following protection is acceptable:

***a)** a coating of non-fluid corrosion protection compound; or*

***b)** a combination of corrosion protection compound and tape which is impregnated with corrosion protection compound.*

Where the anchor head is not accessible, a metal or plastic cap shall be fitted and filled corrosion protection compound for extended use.

Where aggressive conditions are known to exist, a metal or plastic cap shall be fitted and filled corrosion protection compound.

The protection of single strands on temporary anchors is achieved in two phases:

- *Greasing of the strands and their anchorages,*
- *Coverage in polyethylene, strand by strand,*

Temporary ground anchors EURO NORM EN 1537-2002 paragraph 6.9.2

Steel components of a temporary ground anchor shall be provided with protection which will inhibit or prevent corrosion over a minimum design life of two years.
*If there is a possibility that the design life of a temporary ground anchor is to be extended on a temporary basis, or if the ground anchor is installed in soil conditions known to be corrosive, then measures approved by the **Client's Technical Representative** shall be taken to protect all parts of the anchor from corrosion.*
Examples of corrosion protection which may be considered to satisfy the above principles of protection to temporary anchors are described in Table 2.

TPR 00 temporary ground anchors

TPR-00 temporary ground anchors

47.0 - EQUIPMENT/CALIBRATION EURO NORM EN 1537-2002 paragraph 8.4.2.

The equipment is supplied with operating instructions and CE marking, it is identified by a part number and a type of construction for each component.

48.0 – ANCHOR LOADING

Anchor loading is necessary to fulfil the two following functions:

- *to ascertain and record the load carrying behaviour of the anchor;*
- *to tension the tendon and anchor it as its lock-off load.*

The tensioning and adjustment must be carried out by trained personnel, under the control of a properly qualified supervisor, preferably from a company specialized in rock anchorages or a supplier of stressing equipment.

48.1 - Equipment

Stressing equipment and dynamometers in regular use shall be calibrated at intervals not exceeding 6 months, and the calibration certificate shall be made available for inspection on site at all times. Stressing equipment for bar and strand tendon should tension the complete tendon as a single unit. A stressing equipment not to stress single strands simultaneously should be provided or integrated with measurement devices that at every moment of the test indicate the total stressing in multiple strands. Alternatively, an accurate control of the release of the wedge should be carried out.

Note: *The equipment should be able to snub the steel reinforcement safely up to the test stressing specified, remaining under the maximum pressure allowed by the pump.*

48.2 - The anchor loading process

If the loading on the structure is required to control the sequence or the phase loading of the anchors, then this shall be specified at the design stage. The anchored structure should be designed to provide reaction to allow load testing of the ground anchors in accordance with the present Standard, paragraph 9.

The methods of stressing and load recording to be used in each testing or stressing operation should be detailed prior to any tensioning work.

The equipment should be used strictly in accordance with the manufacturer's operating instructions. Stressing or testing should not be carried out until sufficient hardening of the grout in the fixed length has been achieved, which normally requires seven days.

In sensitive cohesive soils it may be appropriate to stipulate a minimum time period for soil recovery after completion of the ground anchor installation and prior to stressing.

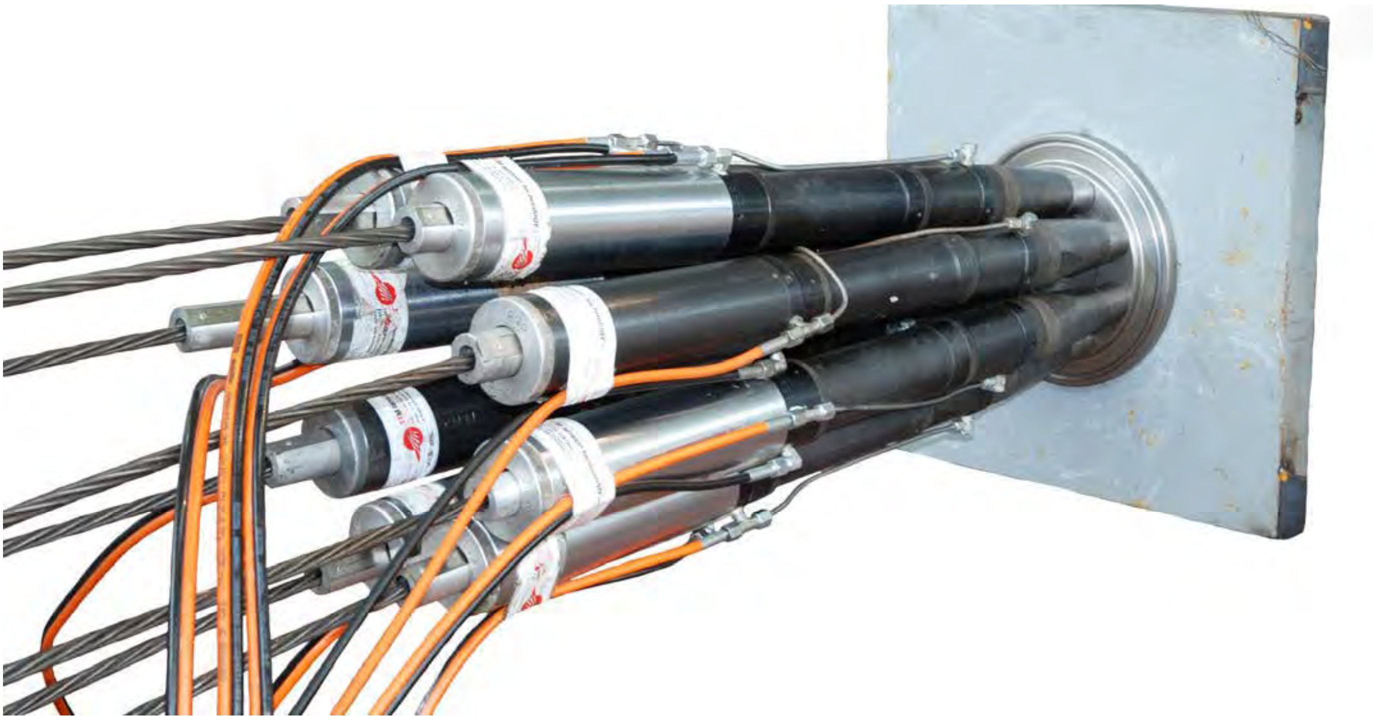
During the testing or stressing of production anchors no indents resulting from tendon gripping should be formed in the tendon below the anchor head and no damage should be allowed to the corrosion protection.

Equipment/calibration EURO NORM EN 1537-2002 paragraph 8.4.2.

The equipment is supplied with operating instructions and CE marking, it is identified by a part number and a type of construction for each component.

*It is supplied according to **EURO NORM EN 1537-2002 paragraph 8.4.2.** and calibration has a six month validity for the machine and the tensioning jacks.*

The jacks-pump system allows to snub the whole wire simultaneously by applying the same load to all the strands of the tendon.



49.0 – TESTING METHODS FOR PERMANENT AND TEMPORARY GROUND ANCHORS

*(Abstract from "**EURO NORM EN 1537-2002 Annex E")***

1 – Anchor testing methods

*Abstract from "**EURO NORM EN 1537-2002, Annex E"***

1.1 - General

*a) **Method 1**: The anchor is loaded in incremental cycles from a datum load to a maximum test load. Displacement of the anchor head is measured over a time period at the maximum load in each incremental cycle;*
*b) **Method 2**: The anchor is loaded in incremental cycles from a datum load to a maximum test load or to failure. The loss of load at the anchor head is measured over a time at the lock-off load and at the maximum load in each incremental cycle;*
*c) **Method 3**: The anchor is loaded in incremental cycles from a datum load to a maximum test load Displacement of the anchor head is measured under maintained load at each loading step.*
The essential loading procedures for Test Methods 1, 2 and 3 are shown in Figures E.1, E.2 and E.3.

E.2 Test Method 1

E.2.1 Investigation test – Loading procedure

The anchor should be loaded to failure (R_a) or to a proof load (P_p) which should be limited to 0.80 P_{tk} or 0.95 $P_{t0.1k}$, whichever is the lower.
The anchor should be loaded to the maximum test load in a minimum of six cycles.
The load cycles and minimum periods of observation are given in Table E.1
Where creep displacements are monitored the maximum load in each cycle should be held for a minimum of 15 min for loads less than P_p and 60 min at P_p in non-cohesive soils or 180 min in cohesive soils. This time should be extended until the creep displacement rate at that load is approximately constant.

E.2.2 Suitability test—Loading procedure

The proof load required for the working anchor should be: $P_p \geq 1{,}25\ P_0$ or $P_p \geq R_d$ whichever is greater. The load in the tendon should not exceed 0.95 $P_{t0.1k}$.
The load cycles and minimum periods of observation are given in Table E.1.
The anchor may be loaded to the maximum test load in a minimum of five load cycles by the omission of the first cycle in Table E.1.
The maximum displacement rate k_s at proof load should be no greater than 1 m, where investigation tests have been carried out. Where failure (defined as k_s = 2 mm) has not been confirmed by investigation tests then the value of k_s at proof load should not exceed 0.8 mm.

E.2.3 Acceptance test—Loading procedure

The anchor should be loaded to proof load (P_p) by a minimum of three equal increments. The anchor should then be unloaded to a datum load (P_a) and again reloaded to lock-off load (P_0). The proof load should be a minimum of 1.25 P_0 but should be no greater than 0.9 $P_{t0,1k}$., the monitoring period not less than 5 min.
The following limit should apply:
The creep displacement rate k_s should not exceed 0.8 mm at proof load and 0.5 mm at lock-off load.
Higher values of k_s (up to 1 mm at proof load) are recommended if they have been proven to be acceptable by previous investigation tests.

E.2.4 Measurement of creep characteristics

The increment of anchor head displacement relative to a fixed point should be measured at the end of specified time intervals for load increments indicated in Table E.1. The creep rate should be determined after a constant displacement rate (k_s) is measured over two time intervals.

k_s is defined as follows:

$$k_s = (s_2 - s_1) / \log (t_2 / t_1)$$

where:

s_1 is the head displacement at time t_1;

s_2 is the head displacement at time t_2;

t is the time after application of load increment.

The creep rate limit is the maximum displacement creep rate at the specified load level.

Measurements of anchor head displacement should be made at the times indicated below while maintaining a constant load.

The successive monitoring times (in minutes) at the maximum cycle load levels are as follows:

1 > 2 > 3 > 5 > 10 > 15 >20 > 30 > 45 > 60.

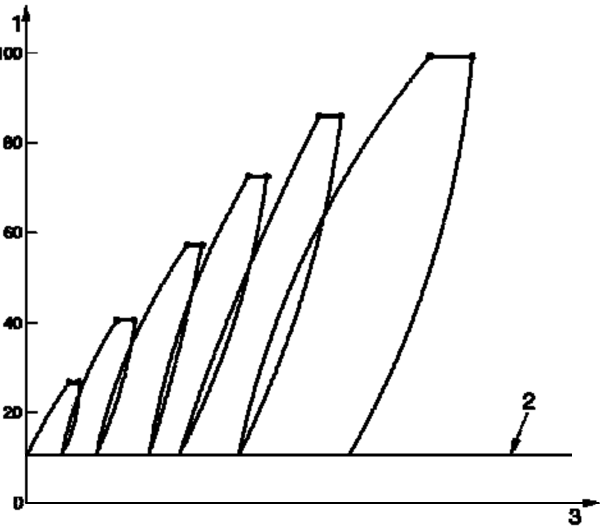
Where periods of observation are shorter than 60 min., the sequence is curtailed as indicated in Table E.1.

Loading procedure for Test Method 1

***1** Applied load in % P_p*

***2** Datum load P_a*

***3** Anchor displacement*



E.3 Test Method 2

E.3.1 Investigation test – Loading procedure

The anchor should be loaded to failure (R_a) or to a proof load (P_p) which should be limited to 0.80 P_{tk} or 0.95 $P_{to,\,1k}$, and loaded to the maximum test load in a minimum of six cycles.

The load cycles and minimum periods of observation are given in Tables E.1 and E.2.

If the cumulative load loss, at the proposed lock-off load, after 7 time periods (3 days) does not exceed the allowable and the load loss per time interval is not increasing then the test may terminate and the load cycling of the anchor may be continued to Pp or to failure.

Should the allowable loss of load be exceeded and/or the load loss per time interval be increasing the observation period may be extended to the eight period (10 days) or longer until stability is achieved.

If stability is not achieved the applied load is too high for a serviceability condition but the test should be continued to determine the failure load.

E3.2 Suitability test—Loading procedure

The proof load required for the working anchor should be:

$P_p \geq 1{,}25\ P_0$ *or* $P_p \geq R_d$

whichever is greater.

The load in the tendon should not exceed 0.95 $P_{t0,1k}$

The anchor may be loaded to the maximum test load in two cycles of approximately 10% P_p *- 25%* P_p *- 50%* P_p *- 75%* P_p *- 100%* P_p *- 75%* P_p *- 50%* P_p *- 10%* P_p *and then to the lock-off load* P_0*. Periods of observation are given in Table E.2.*

The load loss (kl) at the lock-off load P_0 *should not exceed the limits specified in Table E.2 over 7 time periods (3 days).*

E3.3 Acceptance test—Loading procedure

The anchor should be loaded to proof load (P_p) *by a minimum of three equal increment. The anchor should then be unloaded to a datum load* (P_a) *and again reloaded to lock-off load* (P_0)*. The proof load should be a minimum of 1.25* P_0*, but should be no greater than 0.9* $P_{t0,1k}$*.*

Behaviour under lock-off load should be observed over 3 time periods (50 min) and the load loss should exceed the cumulative figure shown in Table E.2. If the loss is greater than the limit of the test should be extended until stability is achieved and acceptable load loss is measured.

If the monitoring system accuracy does not comply to 9.2 in terms of load loss tests but does comply with clause 9.2 using lift-off tests then acceptance may be established by lift-off after 6 time periods (1 day) showing cumulative load loss k_l *less than 6%.*

The following limit should apply at the lock-off load:

a) the load loss k_l *should not exceed 3%* P_0 *in 50 min;*

or b) the load loss k_l *should not exceed 6%* P_0 *in 24 h.*

E3.4 Measurement of load loss characteristics

At lock-off load, the anchor displacement relative to the structure should be held constant and the load should be monitored. The anchor head should be fixed against a load cell or an inactive jack and the load loss should be monitored at the end of each time interval up to ten days to determine k_l*, the percentage load loss.*

The load loss limit is the maximum cumulative load loss recommended at the specified load level at the end of a number of time periods.

Measurement of load loss as required in E.3.4 should be made at times shown in Table E.2.

The minimum duration of observation is as follows:

- *investigation test - 7 periods (3 days);*
- *suitability test - 7 periods (3 days);*
- *acceptance test - 3 periods (50 min).*

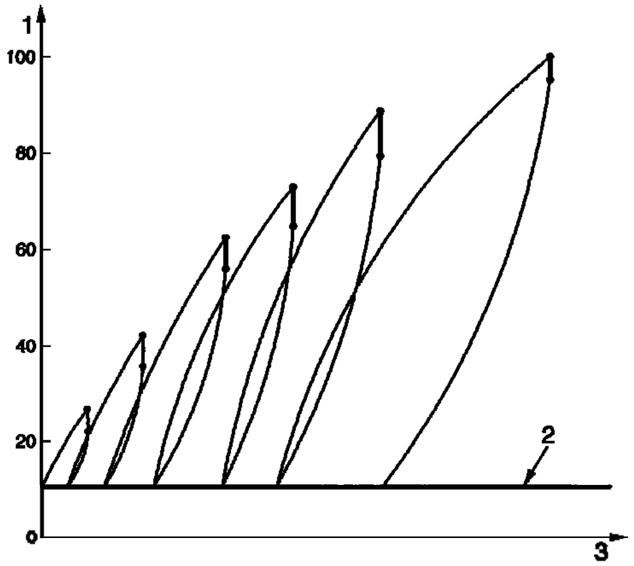
Load loss characteristics are representative of true load loss as applied to the structure via the anchor head. If used to interpret actual creep displacement of the fixed anchor then *allowance must be made for the influence of the free anchor length, i.e. the longer the free length the smaller the load loss effect from the same absolute creep displacement of the fixed anchor.*

Loading procedure for Test Method 2

1 *Applied load in %* P_p

2 *Datum load* P_a

3 *Anchor displacement*



E.4. Test method 3

E.4.1 Investigation test – Loading procedure

The anchor should be loaded to failure (R_a) *or to a proof load* (P_p) *which shall be limited to 0.80* P_{tk} *or 0.90* $P_{t0.1k}$*, whichever is the lower, to the maximum test load by a minimum of six load steps.*
The load steps and minimum periods of observation are given in Table E.3.
The minimum periods of observation can be reduced to 30 min if no significant creep occurs.

E.4.2 Suitability test—Loading procedure

The proof load required for the working anchor should be:
$P_p \geq 1.25\, P_0$ *or* $P_p \geq R_d$
whichever is greater.
The load in the tendon should not exceed 0.90 $P_{t0.1k}$.
The anchor may be loaded to the maximum test load in a minimum of five steps by omission of the first step.
The load steps and minimum periods of observation are given in Table E.4.
The minimum creep displacement (α) at the proof load level of Suitability Tests should be less than 0.8 mm per log.cycle of time where investigation tests have not been carried out (see Figure E.4).
Where tests have been carried out then α at the proof load level of the suitability test should be less than:

- 1.2 mm/log time for a temporary anchor;
- 1.0 mm/log time for a permanent anchor.

In any case the proof load level of the suitability test for the project anchors should be not greater than P_c.

E4.3 Acceptance test—Loading procedure

The anchor should be loaded from the datum load P_a to proof load P_p of 1.25 P_0 or R_d in a minimum of 4 increments. Then the proof load is maintained constant for at least 15 min.
After the proof load has been maintained for the desired period the contractor can carry out a partial or total unloading-loading cycle.
Where test method 3 is used in accordance with 9.4, the apparent tendon free length may be calculated from the datum load to the proof load curve using the method shown in Figure E.3 c). Where there is significant friction in the free length a partial cycle may be performed and the apparent tendon free length calculated from the established no-friction curve to determine ΔP and ΔS.
The displacement due to creep at proof load should be measured between the 3rd and 15th minute.

The corresponding α should be less than:

- 1.2 mm for permanent or temporary anchors without investigation tests;
- 1.5 mm for permanent anchors without investigation tests;
- 1.8 mm for temporary anchors without investigation tests.

E4.4 Measurement of creep and characteristic load

Creep and characteristic loads should be measured and evaluated as follows:
- the increment of anchor head displacement relative to a fixed point should be measured at each step of loading at different times;
- the creep displacement α should be determined at each step of loading as indicated in Figure E.4. The creep displacement α is defined as the slope of the anchor head displacement versus log.time curve at the end of each loading step.
- the anchor resistance R_a is the load corresponding to the vertical asymptote of the α versus load curve. If the asymptote cannot be determined, it is considered that R_a is the load corresponding to an α value equal to 5 mm.
- the critical creep load P_c should be determined as indicated on Figure E.5. The critical creep load is the load corresponding to the end of the first linear part of the α versus load curve. Where it is difficult to determine P_c accurately an alternative resistance $P_{c'}$ is determined as indicated in Figure E.5 and P_c is defined by:

$$P_c = 0.9\ P_{c'}$$

Measurement of creep displacement should be made at the times indicated below, after each change in load. The periods of observation for each step are:
- investigation test - 30 min. or 60 min.;
- suitability test - 30 min. or 60 min.;
- acceptance test – not less than 15 min. at proof load.

The successive monitoring times (in minutes) at each step are as follows:

$$1 > 2 > 3 > 4 > 5 > 7 > 10 > 15 > 20 > 30 > 45 > 60.$$

Loading procedures for Test Method 3

Key a) and b)

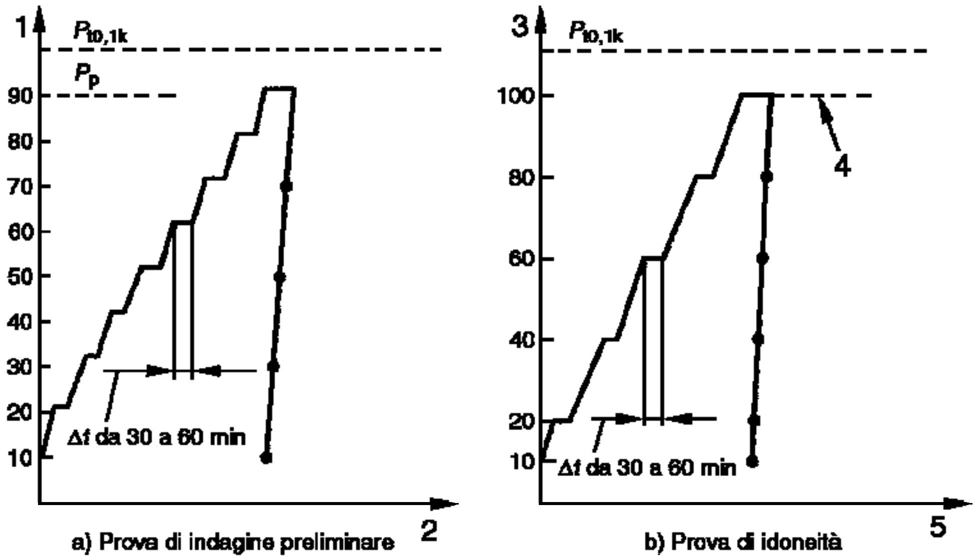
Applied load in % of $P_{t0.1k}$
Anchor displacement

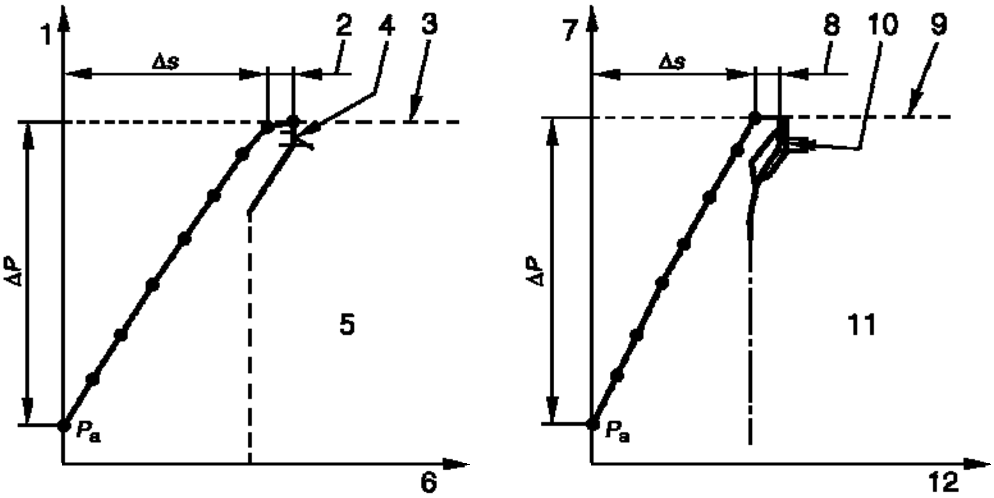
Key c)

Applied load
Creep

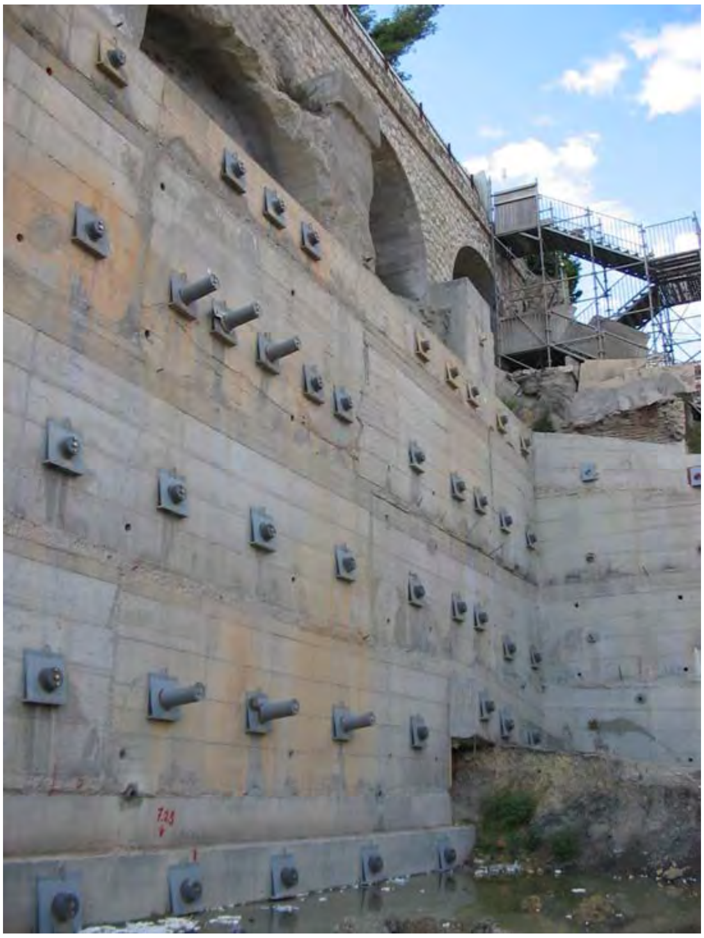
Applied load in % of P_p
Proof load
Anchor displacement

Proof load
Friction f as proportion p_f P_p
Without cycle
Anchor displacement
Applied load
Creep
Proof load
Friction f as proportion p_f P_p
With partial cycle
Anchor displacement





c) Acceptance test
Papp = At Et ΔS/ΔP (1-f)




CAT
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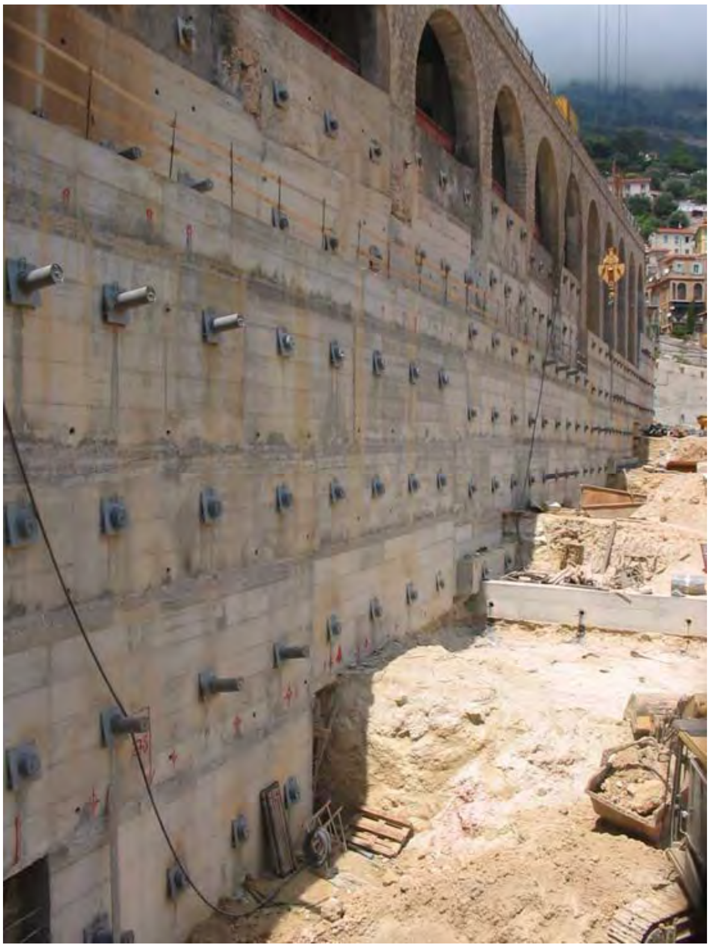
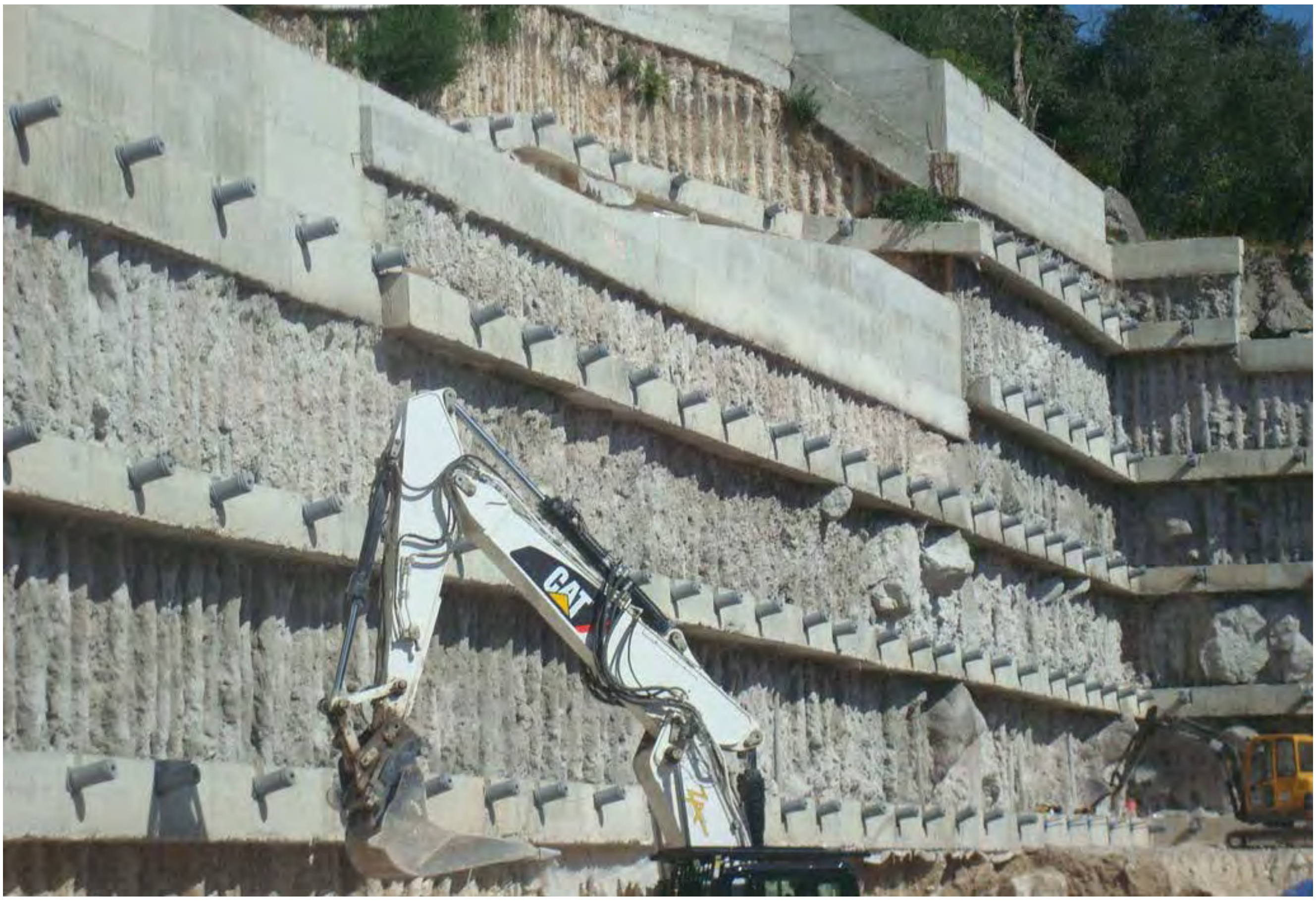
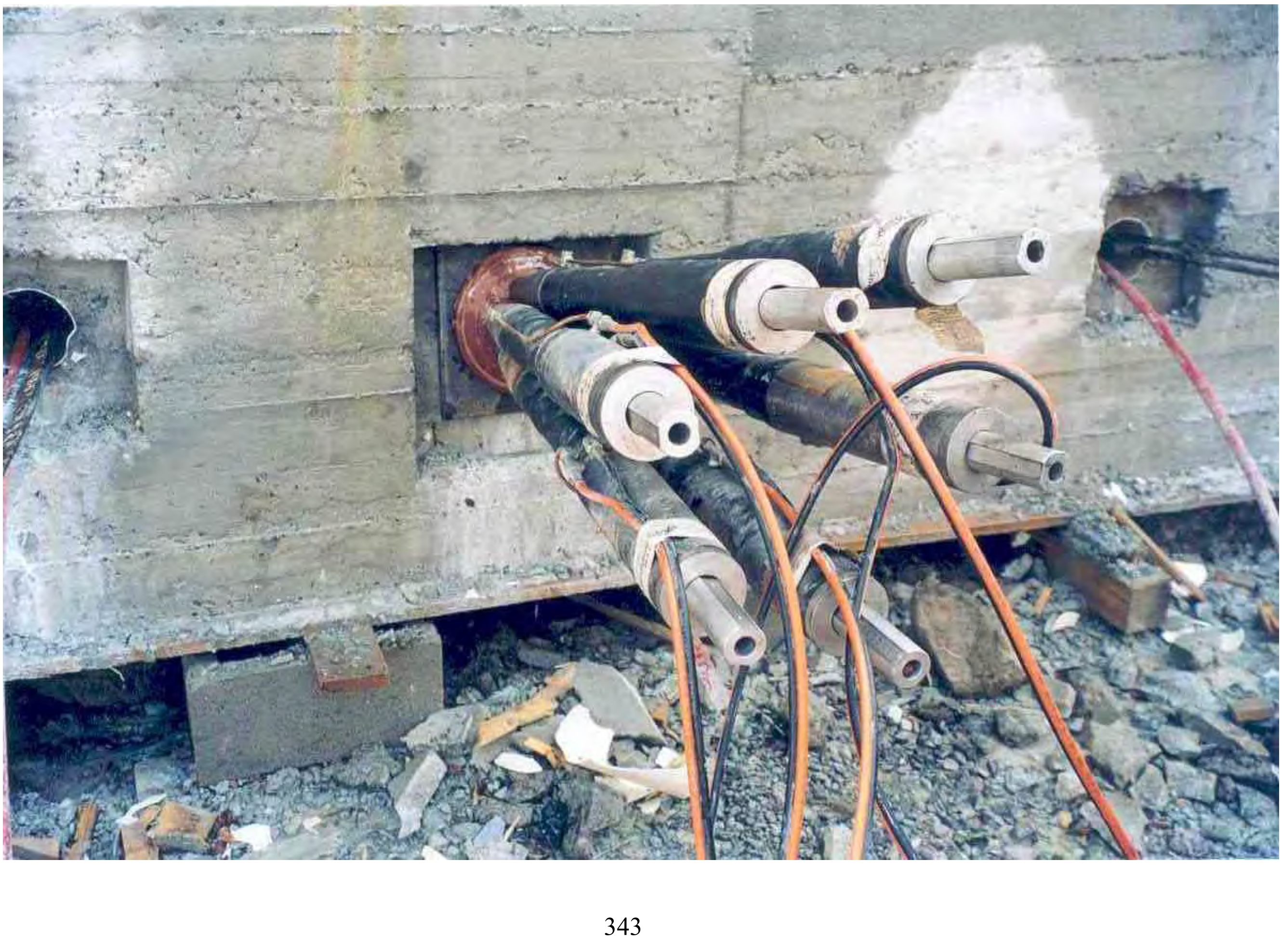




-5.32
75
72 -5.55


VOLVO


CAT



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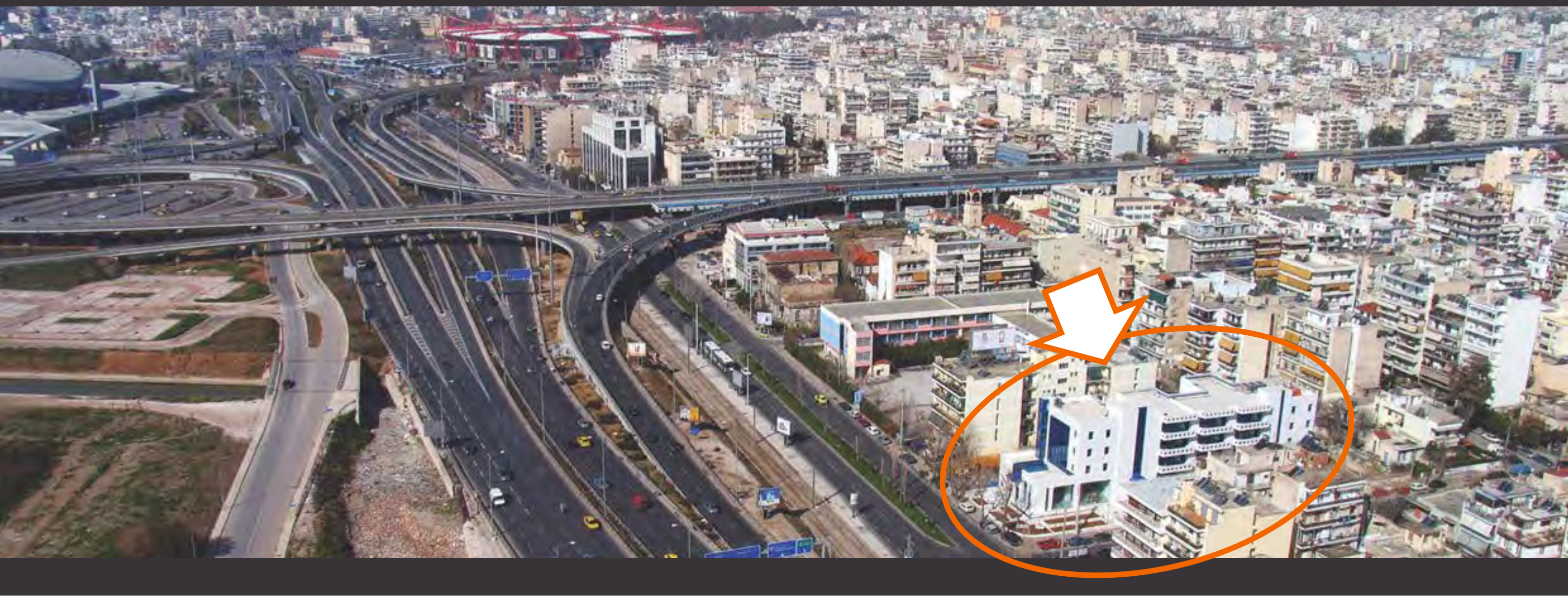

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