EUROPEAN ASSESSMENT DOCUMENT

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KIT FOR ROCK AND SOIL ANCHORS USING PRESTRESSING STEEL STRAND

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This European Assessment Document (EAD) has been developed taking into account up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation (EU) No 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

Contents

1 Scope of the EAD

1.1 Description of the construction product

1.1.1 General description of the kit

The kit for rock and soil anchors using prestressing steel strand (in the following referred to as kit for rock and soil anchors) for geotechnical works is a grouted anchor in accordance with EN 1537[1] and comprises the following components, see Figure 1.1.1.1, Figure 1.1.1.2, Figure 1.1.1.3, Figure 1.1.1.4, Figure 1.1.1.5, Figure 1.1.1.6, and Figure 1.1.1.7:

- Tendon using 7-wire prestressing steel strand as tensile elements;
- Structural anchorage components for load transfer to the structure and for load transfer from the prestressing steel strand to compression pipe at the dead-end anchorage, where relevant;
- Corrosion protection systems;
- Ancillary components needed for assembly, installation and sealing of the rock and soil anchor.

Corrosion protection systems are combinations of cement grout, soft corrosion protection filling materials, individual PE or PP sheath, smooth and corrugated PE pipes:

- Distinction is made between internal grout – i.e., cement grout inside the PE pipe and in direct contact with prestressing steel – and external cement grout filling the void between anchor and borehole;
- Soft corrosion protection filling materials grease and wax;
- Individual PE or PP sheath for free length of prestressing steel strand;
- Smooth or, alternatively, corrugated PE pipes used for free length of anchor, if used;
- Corrugated PE pipes used for bond length of anchor, if used;
- Assembly for the free length consisting of 7-wire prestressing steel strand inside an individual PE or PP sheath filled with soft corrosion protection filling material. All seven wires of the prestressing steel strand are coated with soft corrosion protection filling material in the free length only. The assembly is assumed to be fabricated either by applying grease coating and pushing the strand into the sheath or, alternatively, by extruding the sheath onto the grease coated strand (monostrand).

The rock and soil anchor may be provided in the following options for corrosion protection (for terminology, see Figure 1.1.1.1, Figure 1.1.1.2, Figure 1.1.1.3, Figure 1.1.1.4, and Figure 1.1.1.5):

- Option with limited corrosion protection (PLL): For this option the tendon in the bond length is protected by external grout; in the free length the prestressing steel strands are encapsulated inside individual PE or PP sheaths or, alternatively, inside a PE pipe and all seven wires of the strands coated with soft corrosion protection filling material; the anchorage components and tendon in the anchorage zone are provided with corrosion protection in accordance with 1.1.2.3.
- Option with limited corrosion protection with extended working life (PLL+), see Figure 1.1.1.3: For this option the tendon in the bond length is protected by external grout; in the free length the prestressing steel strands are encapsulated inside individual PE or PP sheaths; the transition between free length to anchorage is sealed; the anchorage components and tendon in the anchorage zone are provided with corrosion protection in accordance with 1.1.2.3; and
- Options with enhanced corrosion protection (PLE1 and PLE2): For these options the tendon is encapsulated over the entire length in a PE pipe; in the bond length the PE pipe is filled with internal grout; for PLE2 crack width in internal grout is assessed; in the free length the prestressing steel strands are encapsulated inside individual PE or PP sheaths filled with soft corrosion protection filling material and the space to PE pipe is filled with internal grout or soft corrosion protection filling material; the borehole outside the PE pipe is filled with external cement grout, which acts as load transfer to rock or soil. The anchorage components are provided with corrosion protection in accordance with 1.1.2.3; and
- Options with comprehensive corrosion protection (PLC1 and PLC2): For these options the tendon is encapsulated over the entire length in a PE pipe and is electrically insulated from the ground and the anchored structure; in the bond length the PE pipe is filled with internal grout; for PLC2 crack width in internal grout is assessed; in the free length the prestressing steel strands are encapsulated inside individual PE or PP sheaths filled with soft corrosion protection filling material and the space to PE pipe is filled with internal grout or soft corrosion protection filling material; the borehole outside the PE pipe is filled with external cement grout, which

[1] All undated references to standards or to EADs in this EAD are to be understood as references to the dated versions listed in Clause 4.

acts as load transfer to rock or soil; the anchorage components are provided with corrosion protection in accordance with 1.1.2.3; the tendon is electrically insulated from the ground and the structure such as to provide for electrical resistance of at least 100 kΩ when tested in accordance with Annex B.1. These options permit monitoring of the corrosion protection system at the time of fabrication in the workshop, at the time of installation on site and at any time during the working life by electrical resistance measurement; and

The rock and soil anchors PLL and PLL+ may be provided in the following options for removability (for terminology, see Figure 1.1.1.6 and Figure 1.1.1.7):

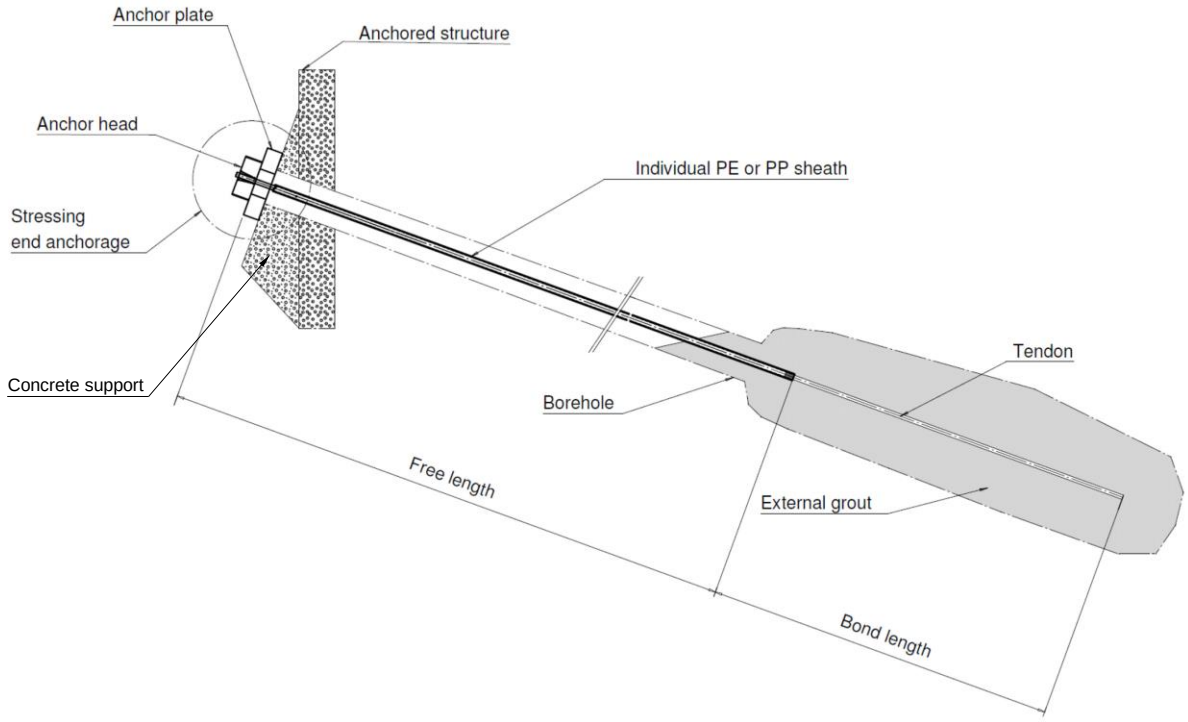
- Option conventional bond type anchor with detachment mechanism at transition from free length to bond length; and
- Option compression pipe anchor with detachment mechanism at end of dead-end anchorage unit.

The rock and soil anchor may be provided in the following options for anchor force adjustment and monitoring:

- With adjustment of anchor force increase only; or
- With adjustment of anchor force increase and reduction;
- With monitoring of anchor force.

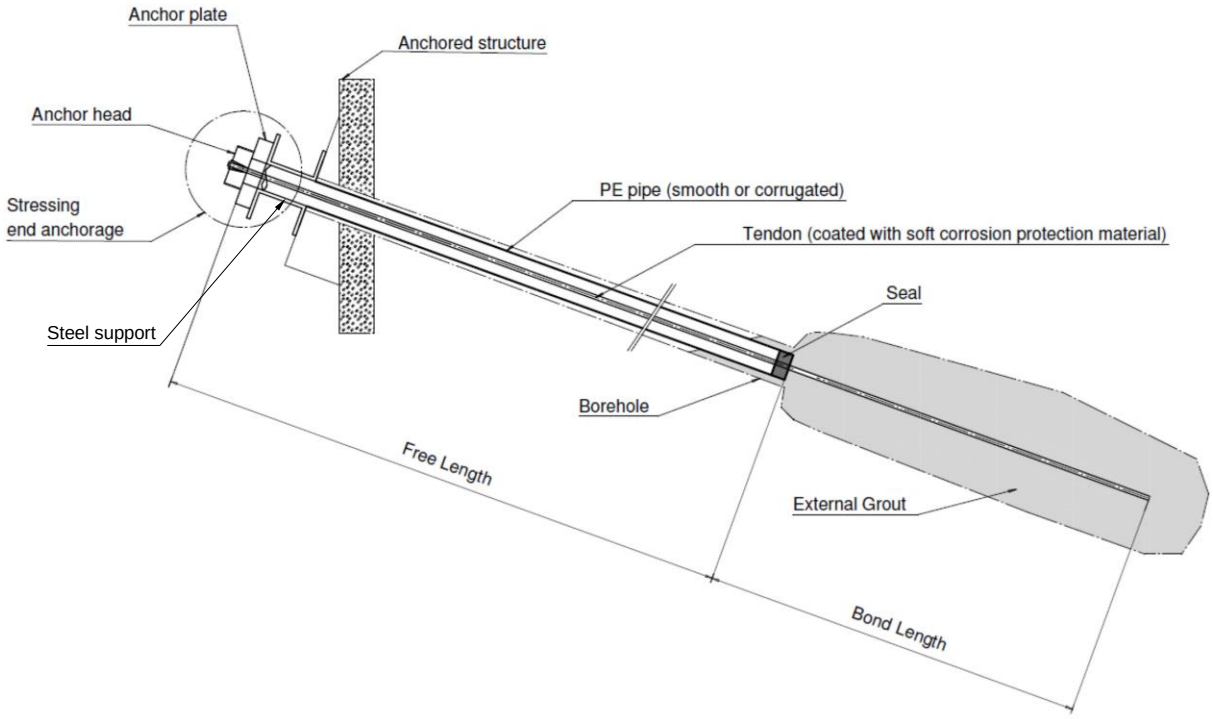
The kit for rock and soil anchor is intended to be used only in cases where the support of the stressing end anchorage of a rock and soil anchor on the anchored structure provides a capacity of ≥ 110 % of F_{pk} (where F_{pk} is the characteristic ultimate resisting force of the tensile elements of the tendon) which may be provided with different means:

- Support of stressing end anchorage on concrete, see Figure 1.1.1.1 as an example; and
- Support of stressing end anchorage on steel members, see Figure 1.1.1.2 as an example.



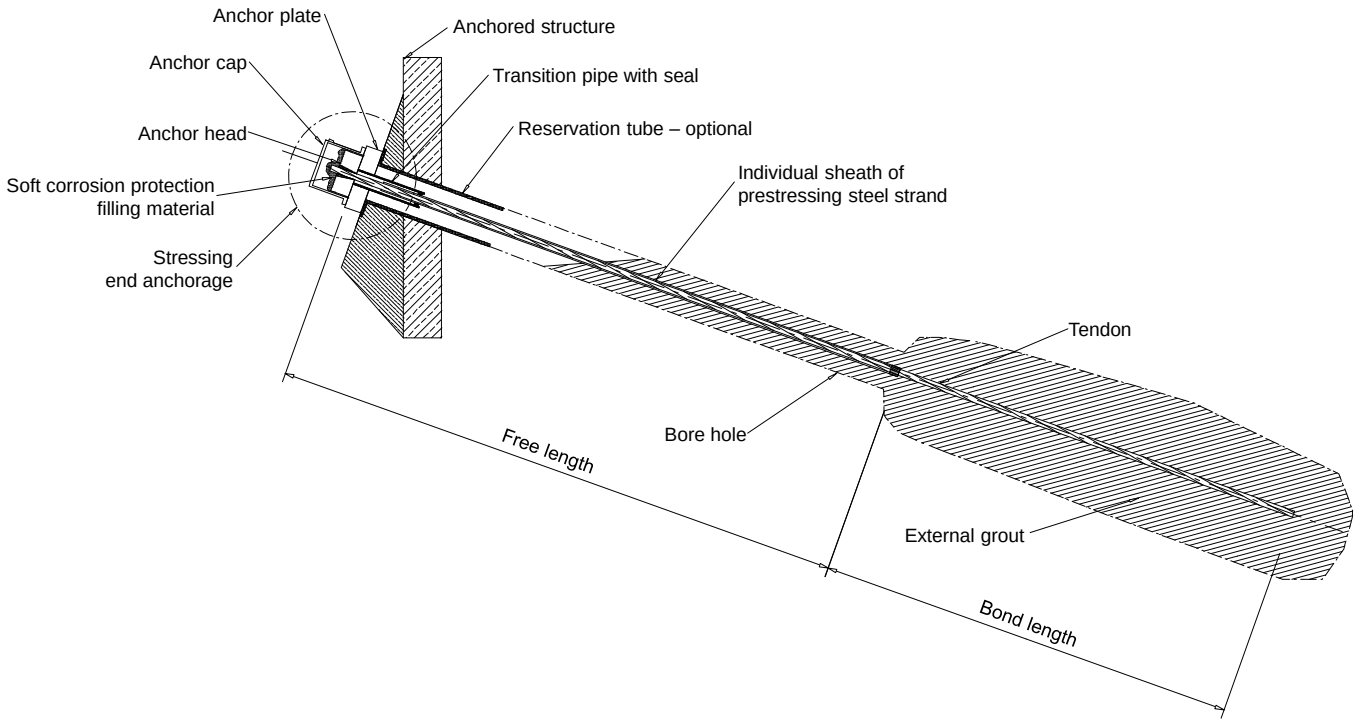
PLL – Limited corrosion protection (strands inside individual PE or PP sheaths in free length): support of stressing end anchorage on concrete shown

Figure 1.1.1.1 Rock and soil anchor – General schematic and terminology for PLL – Support on concrete



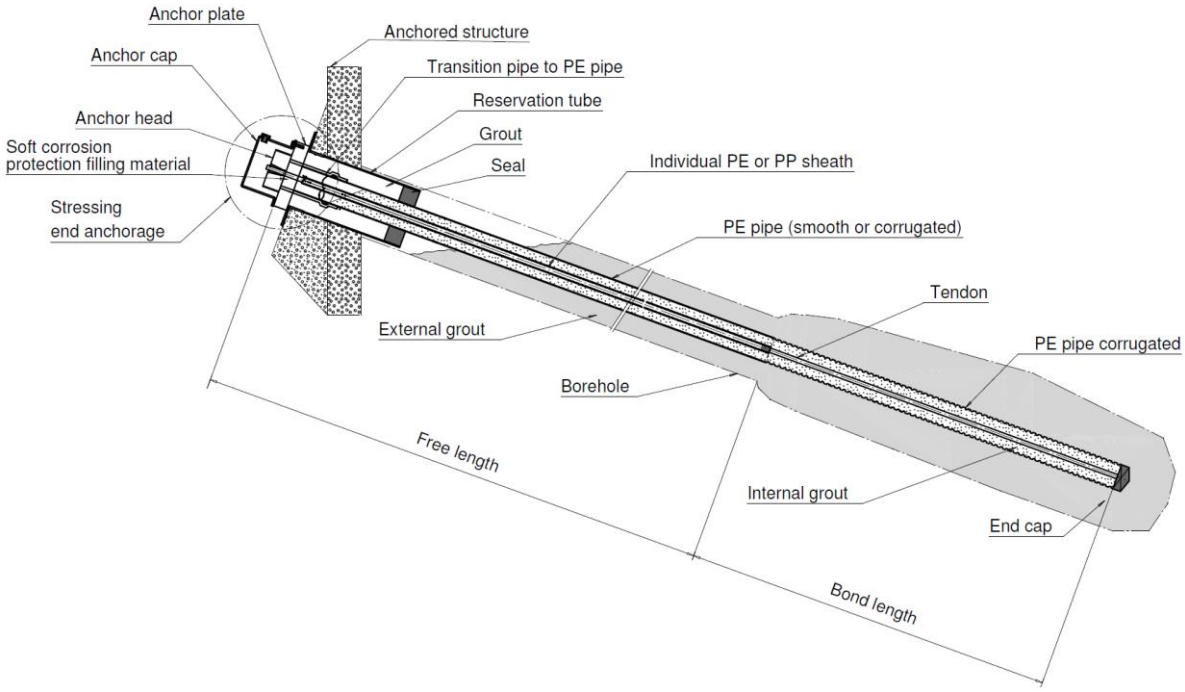
PLL – Limited corrosion protection (strands inside PE pipe in free length): support of stressing end anchorage on steel members shown

Figure 1.1.1.2 Rock and soil anchor – General schematic and terminology for PLL – Support on steel



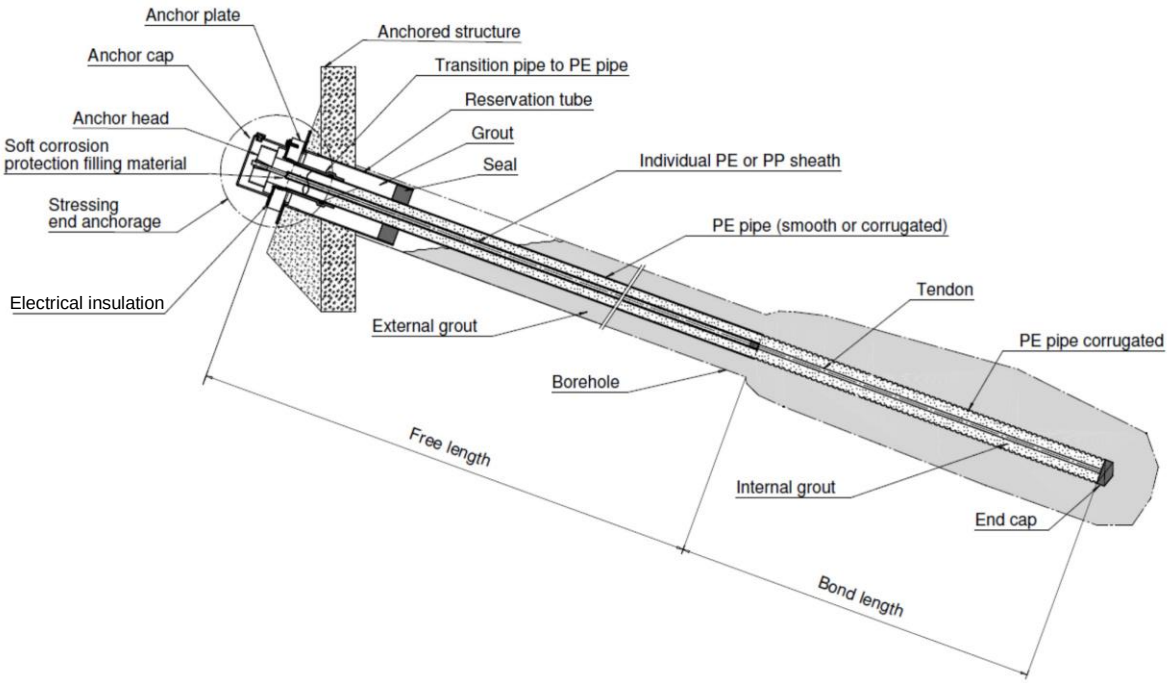
PLL+ – Limited corrosion protection with extended working life (strands inside individual PE or PP sheaths in free length with sealing at transition anchorage to free length): support of stressing end anchorage on concrete shown

Figure 1.1.1.3 Rock and soil anchor – General schematic and terminology for PLL+



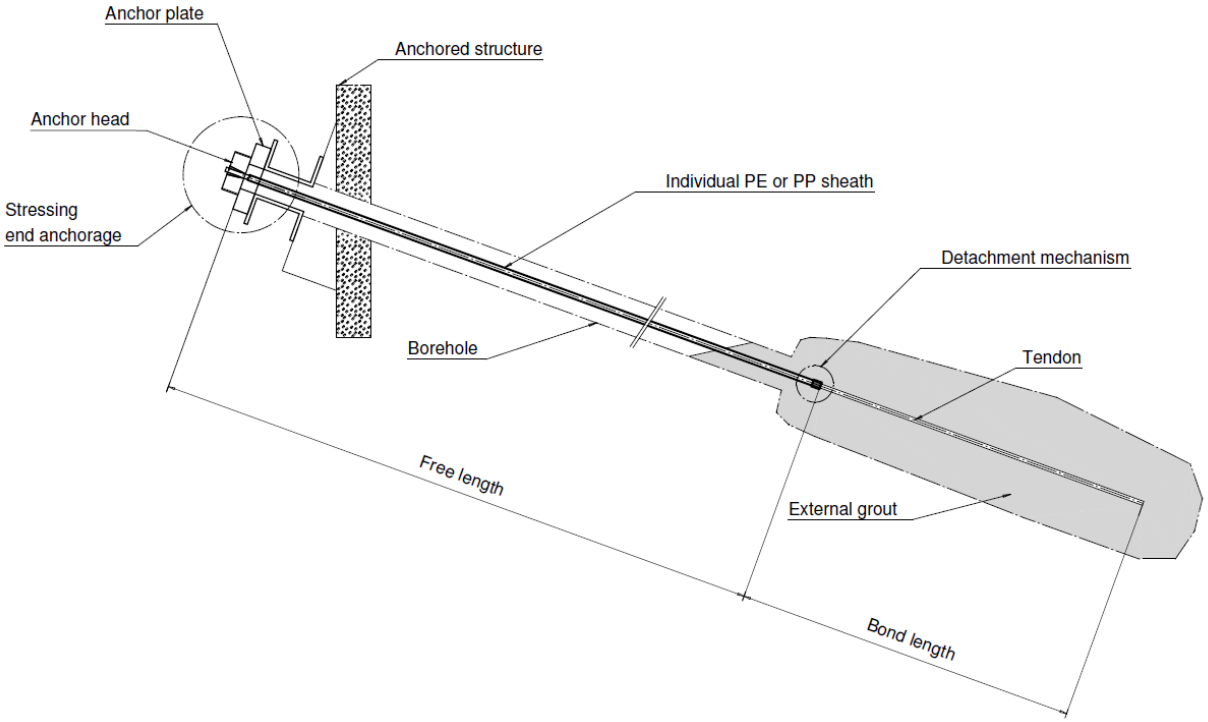
PLE1 and PLE2 – Enhanced corrosion protection: support of stressing end anchorage on concrete shown

Figure 1.1.1.4 Rock and soil anchor – General schematic and terminology for PLE1 and PLE2



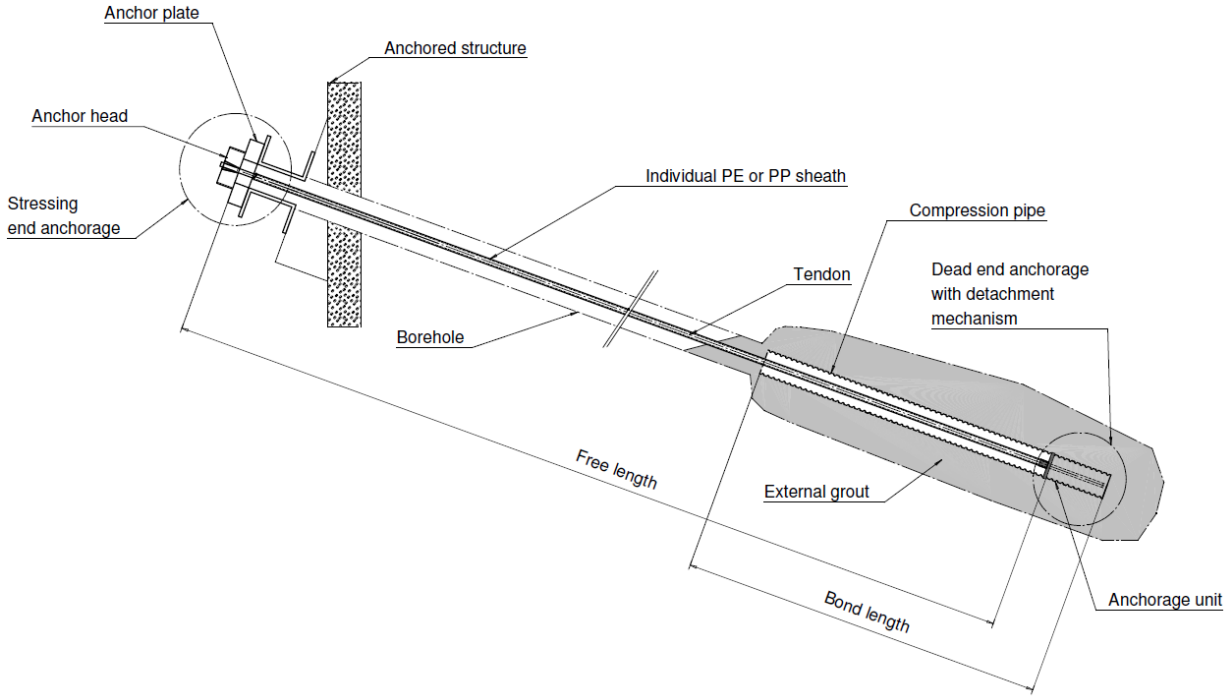
PLC1 and PLC2 – Comprehensive corrosion protection: support of stressing end anchorage on concrete shown

Figure 1.1.1.5 Rock and soil anchor – General schematic and terminology for PLC1 and PLC2



Options: Conventional bond type anchor with detachment mechanism at transition from free length to bond length (PLL and PLL+): support of stressing end anchorage on steel members shown

Figure 1.1.1.6 Rock and soil anchor – Anchor with detachment mechanism



Options: Compression pipe anchor with detachment mechanism in dead-end anchorage unit (PLL and PLL+): support of stressing end anchorage on steel members shown

Figure 1.1.1.7 Rock and soil anchor – Compression pipe anchor with detachment mechanism

1.1.2 Kit components

1.1.2.1 Tensile element

The tendon is using 7-wire prestressing steel strand as tensile elements. Only 7-wire prestressing steel strands as defined in EAD 160004-00-0301, clause 1.1, in terms of geometry and characteristic force are covered by this EAD. No essential characteristics are assessed for tensile elements in the EAD.

1.1.2.2 Structural anchorage components

Structural anchorage components are for load transfer from the tendon to the structure and for load transfer from the tendon to the rock or soil at the dead-end anchorage (anchorage unit and compression pipe), where relevant. Structural anchorage components made of steel are covered in this EAD.

Structural anchorage components for load transfer to the structure at the stressing end anchorage include:

- Anchor head;
- Wedges;
- Anchor plate;
- Local anchorage zone reinforcement, if required;
- Electrically insulating plate, placed such as to electrically insulate the tendon from the structure and ground (PLC1 and PLC2).

Structural anchorage components for load transfer from the tensile elements to the rock or soil at the dead-end anchorage (compression pipe anchors only) include:

- Anchorage unit (for load transfer from tensile elements to compression pipe): Proprietary mechanical components such as anchor head and wedges or compression fittings attached to tensile elements may be used in anchorage unit for load transfer from tensile element to compression pipe or, alternatively, load transfer may be provided by bond through cement grout inside the anchorage unit; a combination of the two alternatives may also be used;
- Corrugated compression pipe.

No additional structural anchorage components are necessary for load transfer from the tensile elements to the ground in conventional bond type anchors.

1.1.2.3 Corrosion protection components

The EAD covers the kit for rock and soil anchors with corrosion protection components consisting of:

- Internal cement grout in contact with prestressing steel in accordance with EN 447;
- External cement grout filling the void between anchor and borehole in accordance with EN 1537;
- Cement grout in contact with prestressing steel inside dead-end anchorage unit of compression pipe anchor in accordance with EN 447;
- Soft corrosion protection filling materials;
- Smooth PE pipes and smooth PE or PP sheath;
- Corrugated PE pipes in accordance with EN 1537;
- Monostrand, if used as PE or PP sheath and prestressing steel assembly for the free length;
- Individual PE or PP sheath and prestressing steel strand assembly filled with soft corrosion protection filling material for free length of tendon;
- Transition pipe at stressing end anchorage between anchor head or anchor plate and free length PE pipe;
- Particular sealing and electrically insulating systems required to provide leak tight and / or electrically insulating encapsulation to the tendon;
- Metallic coating in accordance with EN ISO 1461 or coating satisfying requirements of EN ISO 12944-2 for the corrosivity Category C4 for protection of steel components directly exposed to the atmosphere;
- Grout for protection of steel components directly exposed to the ground;
- Either a layer of cement grout or soft corrosion protection filling material for protection of steel components not directly exposed to the atmosphere or ground. The corrosion protection is assumed to be renewable or, if not renewable, to provide protection for the working life. Alternatively, corrosion resistant materials may be used for these steel components.

1.1.2.4 Ancillary components

Ancillary components in accordance with the manufacturer’s specifications as the following, needed for assembly, installation, and sealing of the rock and soil anchor, are covered under this EAD and shall be detailed in the ETA:

- Reservation tube as may be required to provide reservation for anchors passing through concrete members;
- Spacers as required to provide intended cover to prestressing steel strand or PE pipe;
- Individual sealing components such as heat shrink sleeves;
- Anchor caps for stressing end or dead-end of anchor;
- Vents and tubes for injection of anchor.

1.1.3 Further product related aspects

The kit for rock and soil anchors is not covered by a harmonised European standard (hEN).

EN 1537 is not a harmonised standard but provides a reference to some methods and criteria for the assessment.

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

It is assumed that the kit for rock and soil anchors will be installed according to the manufacturer's instructions or (in absence of such instructions) according to the regulations valid at the place of use.

Relevant manufacturer's stipulations having influence on the performance of the kit for rock and soil anchors covered by this European Assessment Document shall be considered for the determination of the performance and detailed in the ETA.

1.2 Information on the intended use(s) of the construction product

1.2.1 Intended use(s)

The kit for rock and soil anchors is intended to be used for the anchoring of structures and to stabilise rock and soil by active introduction of prestressing forces. Depending on the corrosion protection needs the rock and soil anchor is intended to be used with:

- Limited corrosion protection (PLL) in non-aggressive ground conditions and without exposure to critical stray currents: for temporary use;
- Option limited corrosion protection with extended working life (PLL+) in non-aggressive ground conditions and without exposure to critical stray currents: for temporary use with extended working life;
- Options enhanced corrosion protection (PLE1 and PLE2) in non-aggressive and in aggressive ground conditions but without exposure to critical stray currents: for temporary and permanent use;
- Options comprehensive corrosion protection (PLC1 and PLC2) in non-aggressive and in aggressive ground conditions and/or exposure to critical stray currents: for temporary and permanent use.

1.2.2 Working life/Durability

The assessment methods included or referred to in this EAD have been written based on the manufacturer's request to take into account a working life of the kit for rock and soil anchors of:

- up to 2 years for temporary use;
- up to 7 years for temporary use with extended working life
- more than 2 years and up to 100 years for permanent use

when installed in the works, provided that the kit for rock and soil anchors is subject to appropriate transport, storage, and installation (see 1.1). These provisions are based upon the current state of the art and the available knowledge and experience.

When assessing the kit for rock and soil anchors, the intended use as foreseen by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works[2].

The indications given as to the working life of the kit for rock and soil anchors cannot be interpreted as a guarantee neither given by the product manufacturer or his representative nor by EOTA when drafting this EAD nor by the

[2] The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works is subject, as well as on the particular conditions of the design, execution, use and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than referred to above.

Technical Assessment Body issuing an ETA based on this EAD but are regarded only as a means for expressing the expected economically reasonable working life of the product.

1.3 Specific terms used in this EAD

1.3.1 Temporary anchors

Temporary anchors are rock and soil anchors that are in use for up to 2 years in accordance with EN 1537. Temporary anchors with extended working life are rock and soil anchors that are in use for up to 7 years.

1.3.2 Permanent anchors

Permanent anchors are rock and soil anchors that are in use for more than 2 years in accordance with EN 1537 and up to 100 years.

1.3.3 Monostrand

A single prestressing steel strand with its individual protection by grease or wax and HDPE sheath, c.f. EAD 160004-00-0301.

1.3.4 Ring nut

Structural anchorage component with inner thread to facilitate anchor force adjustment, see Figure 1.3.4.1.

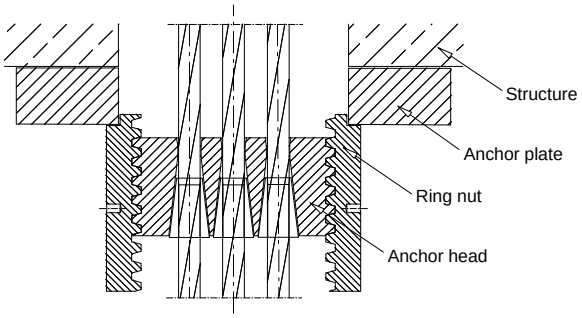


Figure 1.3.4.1 Stressing end anchorage with ring nut – Example

2 Essential characteristics and relevant assessment methods and criteria

2.1 Essential characteristics of the product

Table 2.1.1 shows how the performance of the kit for rock and soil anchors is assessed in relation to the essential characteristics. Annex A, Table A.1 summarises which essential characteristics can be considered as relevant to each of the intended uses.

Table 2.1.1 Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics – Kit for rock and soil anchors

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 1: Mechanical resistance and stability			
1	Resistance to static load	2.2.1	Level
2	Resistance to fatigue	2.2.2	Level
3	Load transfer to structure	2.2.3	Level
4	Comprehensive corrosion protection (PLC1 and PLC2)	2.2.4	Description, level
5	Enhanced corrosion protection (PLE1)	2.2.5	Description
6	Enhanced corrosion protection (PLE2)	2.2.6	Description
7	Limited corrosion protection with extended working life (PLL+)	2.2.7	Description
8	Limited corrosion protection (PLL)	2.2.8	Description
9	Effect of removability of anchor on resistance	2.2.9	Level
10	Effect of means for adjustment and monitoring of anchor force on resistance	2.2.10	Level
11	Individual PE or PP sheath and prestressing steel strand assembly filled with soft corrosion protection filling material – Mass of soft filling material per metre (filling degree) (PLL+, PLC1, PLC2, PLE1, and PLE2)	2.2.11	Description, level
12	Individual PE or PP sheath and prestressing steel strand assembly filled with soft corrosion protection filling material – Maximum pull-out force for strand from sheath of manufactured assembly (PLL+, PLC1, PLC2, PLE1, and PLE2)	2.2.12	Level
13	Individual PE or PP sheath and prestressing steel strand assembly filled with soft corrosion protection filling material – Sealing of end of individual smooth PE or PP sheath (PLL+, PLC1, PLC2, PLE1, and PLE2)	2.2.13	Level
14	Individual PE sheath and prestressing steel strand assembly filled with soft corrosion protection filling material – Monostrand	2.2.14	Description, level

No	Essential characteristic	Assessment method	Type of expression of product performance
15	Particular sealing and electrically insulating systems – Resistance of corrugated PE pipe under internal pressure (PLC1, PLC2, and PLE1)	2.2.15	Level
16	Particular sealing and electrically insulating systems – Resistance of transition from smooth PE pipe to corrugated PE pipe and of end cap on corrugated PE pipe (PLC1, PLC2, and PLE1)	2.2.16	Level
17	Particular sealing – Tightness of transition from smooth PE pipe to corrugated PE pipe and of end cap on corrugated PE pipe (PLE2)	2.2.17	Description, level
18	Particular sealing and electrically insulating systems – Resistance of sealing of free length PE pipe to anchorage under external pressure (PLC1, PLC2, and PLE1)	2.2.18	Level
19	Particular sealing – Tightness of sealing of free length PE pipe to anchorage under external pressure (PLE2)	2.2.19	Description, level
20	Individual PE or PP sheath and prestressing steel strand assembly filled with soft corrosion protection filling material – Tightness of transition free length to anchorage (PLL+ and PLE2)	2.2.20	Description, level
21	Crack width of grout within corrugated PE pipe in bond length (PLC2 and PLE2)	2.2.21	Description, level
22	Particular sealing and electrically insulating systems – Electrical resistance of insulating plate between anchor head and anchor plate (PLC1 and PLC2)	2.2.22	Level
23	Particular sealing and electrically insulating systems – Filling of space outside of transition pipe from anchorage to free length for corrosion protection by cement grout (PLC1 and PLE1)	2.2.23	Description

2.2 Methods and criteria for assessing the performance of the product in relation to essential characteristics of the product

Testing will be limited only to the essential characteristics which the manufacturer intends to declare. If for any components covered by harmonised standards or European Technical Assessments the manufacturer of the component has included the performance regarding the relevant characteristic in the Declaration of Performance, retesting of that component for issuing the ETA under the current EAD is not required except for reasonable cases given under specified clauses in 2.2.

This clause is intended to provide instructions for TABs. Therefore, the use of wordings such as “shall be stated in the ETA” or “it has to be given in the ETA” shall be understood only as such instructions for TABs on how results of assessments shall be presented in the ETA. Such wordings do not impose any obligations for the manufacturer and the TAB shall not carry out the assessment of the performance in relation to a given essential characteristic when the manufacturer does not wish to declare this performance in the Declaration of Performance.

2.2.1 Resistance to static load

Assessment of resistance to static load of mechanical anchorages at the stressing end of the anchor and at the dead-end of the anchor (anchorage unit assembly), where applicable, shall be based on testing in accordance with EAD 160004-00-0301, Annex C.2.1, for external tendons. Both stressing end anchorages and dead-end anchorage units, where applicable, shall be tested. When testing dead-end anchorage units, the support of the dead-end anchorage unit on the test frame shall be provided only along the end face of the compression pipe, the cross-section inside the compression pipe / anchorage unit shall not be supported directly on the test frame.

The feasibility of ring nut adjustment after loading to 80 % F_{pk} shall be assessed for stressing end anchor heads with ring nuts.

NOTE: See Clause 1.3.4 with an example of stressing end anchorage with ring nut.

The number and size of test specimens and the required performance shall be in accordance with EAD 160004-00-0301, Clause 2.2.1.

2.2.2 Resistance to fatigue

Assessment of resistance to fatigue of mechanical anchorages at the stressing end of the anchor and at the dead-end of the anchor (anchorage unit assembly), where applicable, shall be based on testing in accordance with EAD 160004-00-0301, Annex C.3.1. Both stressing end anchorages and dead-end anchorage units, where applicable, shall be tested. When testing dead-end anchorage units, the support of the dead-end anchorage unit on the test frame shall be provided only along the end face of the compression pipe, the cross-section inside the compression pipe / anchorage unit shall not be supported directly on the test frame.

The number and size of test specimens and the required performance shall be in accordance with EAD 160004-00-0301, Clause 2.2.2.

2.2.3 Load transfer to structure

Assessment of load transfer to structure of mechanical anchorages at the stressing end of the anchor supported on concrete members shall be based on testing in accordance with EAD 160004-00-0301, Annex C.4.1.

The number and size of test specimens and the required performance shall be in accordance with EAD 160004-00-0301, Clause 2.2.3.

2.2.4 Comprehensive corrosion protection (PLC1 and PLC2)

Comprehensive corrosion protection components are assessed for the following aspects in accordance with EN 1537, Table C.2, and actual corrosion protection details of the kit shall be stated in the ETA:

- Tendon bond length for PLC1: A single corrugated PE pipe, containing the 7-wire prestressing steel strands, and filled with internal grout. The end of the PE pipe is sealed with a cap (EN 1537, Table C.2, Item 1a));
- Tendon bond length for PLC2: A single corrugated PE pipe, containing the 7-wire prestressing steel strands, and filled with internal grout. In addition, crack width of internal grout under service loading is such that 2 protective barriers are created, see Clause 2.2.21. The end of the PE pipe is sealed with a cap (EN 1537, Table C.2, Item 1c));
- Tendon free length: A single smooth or corrugated PE pipe, containing the individual PE or PP sheath and prestressing steel strand assemblies filled with soft corrosion protection filling material, and filled with internal grout (EN 1537, Table C.2, Item 2, first option combined with C);
- Tendon transition from bond length to free length: Sealing system between corrugated and smooth PE pipes, if applicable;
- Tendon transition from free length to anchorage: Transition pipe between anchor plate and PE pipe, connected to anchor plate, with sealing device between transition pipe and PE pipe, filled with soft corrosion protection filling material (EN 1537, Table C.2, Item 3);
- Stressing end anchorage: 7-wire prestressing steel strand coated with a layer of soft corrosion protection filling material, anchor head and anchor plate inside cap coated with a layer of soft corrosion protection filling material or, alternatively, the inside of the cap completely filled; anchor cap, anchor plate and steel transition pipe protected against corrosion in accordance with EN ISO 1461 or provided with coating type and thickness satisfying requirements of EN ISO 12944-2 for corrosivity Category C4, if the coating is renewable or, if not renewable, relevant components provided in corrosion resistant material providing at least equivalent protection when compared with EN ISO 12944-2 for corrosivity Category C4. Anchor caps not completely filled with soft corrosion protection filling material with drainage at lowest point of the cap. Protection of structural

steel surfaces exposed to ground by cement grout is considered suitable such as, e.g., for the external surface of the transition pipe from the anchorage to the free length.

Assessment of the performance of comprehensive corrosion protection system (PLC1 and PLC2) shall be based on testing in accordance with Annex B.1, test procedures in the Clauses B.1.2.1 and B.1.2.3.

Five fully assembled kits of intermediate size out of the series of available anchor sizes of the kit shall be used for testing.

The required performance for site tests (B.1.2.3) is a minimum electrical resistance of ≥ 100 kΩ. If one out of the five tested kits does not comply other five kits shall be tested. At least 9 of the 10 tested anchors shall comply with the specified minimum electrical resistance. For factory tests (B.1.2.1) the actual electrical resistance shall be stated in the ETA. An electrical resistance of ≥ 100 MΩ is suggested.

NOTE: The required performance originates from the scope of this EAD, see 1.1.1.

2.2.5 Enhanced corrosion protection (PLE1)

Enhanced corrosion protection components are assessed for the following aspects in accordance with EN 1537, Table C.2, and actual corrosion protection details of the kit shall be stated in the ETA:

- Tendon bond length: A single corrugated PE pipe, containing the 7-wire prestressing steel strands, and filled with internal grout. The end of the PE pipe is sealed with a cap (EN 1537, Table C.2, Item 1a));
- Tendon free length: A single smooth or corrugated PE pipe, containing the individual PE or PP sheath and prestressing steel strand assemblies filled with soft corrosion protection filling material, and filled with internal grout (EN 1537, Table C.2, Item 2, first option combined with C);
- Tendon transition from bond length to free length: Sealing system between corrugated and smooth PE pipes, if applicable;
- Tendon transition from free length to anchorage: Transition pipe between anchor head or anchor plate and PE pipe, connected to anchor head or anchor plate, with sealing device between transition pipe and PE pipe, filled with soft corrosion protection filling material (EN 1537, Table C.2, Item 3);
- Stressing end anchorage: 7-wire prestressing steel strand coated with a layer of soft corrosion protection filling material, anchor head and anchor plate inside cap coated with a layer of soft corrosion protection filling material or, alternatively, the inside of the cap completely filled; anchor cap, anchor plate and steel transition pipe protected against corrosion in accordance with EN ISO 1461 or provided with coating type and thickness satisfying requirements of EN ISO 12944-2 for corrosivity Category C4, if the coating is renewable or, if not renewable, relevant components provided in corrosion resistant material providing at least equivalent protection when compared with EN ISO 12944-2 for corrosivity Category C4. Anchor caps not completely filled with soft corrosion protection filling material with drainage at lowest point of the cap. Protection of structural steel surfaces exposed to ground by cement grout is considered suitable such as, e.g., for the external surface of the transition pipe from the anchorage to the free length.

2.2.6 Enhanced corrosion protection (PLE2)

Enhanced corrosion protection components are assessed for the following aspects in accordance with EN 1537, Table C.2, and actual corrosion protection details of the kit shall be stated in the ETA:

- Tendon bond length: A single corrugated PE pipe, containing the 7-wire prestressing steel strands, and filled with internal grout. Limited crack width of internal grout under service loading results in 2 protective barriers. The end of the PE pipe is sealed with a cap (EN 1537, Table C.2, Item 1 c));
- Tendon free length: A single smooth or corrugated PE pipe, containing the individual PE or PP sheath and prestressing steel strand assemblies filled with soft corrosion protection filling material or the monostrands, and filled with internal grout (EN 1537, Table C.2, Item 2, first option combined with C);
- Tendon transition from bond length to free length: Sealing system between corrugated and smooth PE pipes, if applicable;
- Tendon transition from free length to anchorage – bare strands: Transition pipe between anchor head or anchor plate and PE pipe, connected to anchor head or anchor plate, with sealing device between transition pipe and PE pipe, filled with soft corrosion protection filling material (EN 1537, Table C.2, Item 3);
- Tendon transition from free length to anchorage – sheathed strands: Transition pipe between anchor head or anchor plate and individual PE or PP sheath, connected to anchor head or anchor plate, with sealing device between transition pipe and individual PE or PP sheath, filled with soft corrosion protection filling material (EN 1537, Table C.2, Item 3);
- Stressing end anchorage: 7-wire prestressing steel strand coated with a layer of soft corrosion protection filling material, anchor head and anchor plate inside cap coated with a layer of soft corrosion protection filling

material or, alternatively, the inside of the cap completely filled; anchor cap, anchor plate and steel transition pipe protected against corrosion in accordance with EN ISO 1461 or provided with coating type and thickness satisfying requirements of EN ISO 12944-2 for corrosivity Category C4, if the coating is renewable or, if not renewable, relevant components provided in corrosion resistant material providing at least equivalent protection when compared with EN ISO 12944-2 for corrosivity Category C4. Anchor caps, either completely filled with soft corrosion protection filling material or not completely filled with soft corrosion protection filling material and with drainage at lowest point of the cap.

2.2.7 Limited corrosion protection with extended working life (PLL+)

Limited corrosion protection with extended working life components are assessed for the following aspects in accordance with EN 1537, Table C.1, and actual corrosion protection details of the kit, including minimum external grout cover, shall be stated in the ETA:

- Tendon bond length: 7-wire prestressing steel strands protected with a minimum external grout cover (EN 1537, Table C.1, Item 1)
- Tendon free length: 7-wire prestressing steel strands, encapsulated inside individual PE or PP sheaths and all seven wires of the strands coated with soft corrosion protection filling material (EN 1537, Table C.1, Item 2b)).
- Tendon transition from free length to anchorage: PE or PP sheath ends next to anchor head and the connecting joint is sealed. Exposed prestressing steel surfaces coated with a layer of soft corrosion protection filling material. Sealing components are placed so that the entire transition from free length to anchorage is encapsulated.
- Stressing end anchorage: 7-wire prestressing steel strand coated with a layer of soft corrosion protection filling material, anchor head and anchor plate coated with a layer of soft corrosion protection filling material (EN 1537, Table C.1, Item 4a)) inside a cap coated with a layer of soft corrosion protection filling material or, alternatively, the inside of the cap completely filled; anchor cap, anchor plate, and steel reservation tube provided with corrosion protection.
- Dead-end anchorage where applicable: Compression pipe and anchorage unit assembly with a minimum of 20 mm external grout cover, anchorage unit sealed at the end, containing the 7-wire prestressing steel strands anchored inside the anchorage unit with (i) proprietary means and protected against corrosion with either cement grout or soft corrosion protection filling material or (ii) by bond and protected against corrosion by cement grout or (iii) a combination of the two alternatives.

2.2.8 Limited corrosion protection (PLL)

Limited corrosion protection components are assessed for the following aspects in accordance with EN 1537, Table C.1, and actual corrosion protection details of the kit, including minimum external grout cover, shall be stated in the ETA:

- Tendon bond length: 7-wire prestressing steel strands protected with a minimum external grout cover (EN 1537, Table C.1, Item 1);
- Tendon free length: Either (i) 7-wire prestressing steel strands encapsulated inside individual PE or PP sheaths and all seven wires of the strands coated with soft corrosion protection filling material (EN 1537, Table C.1, Item 2b)), or (ii) 7-wire prestressing steel strands inside a single smooth or corrugated PE pipe and all seven wires of the strands coated with soft corrosion protection filling material (EN 1537, Table C.1, Item 2d));
- Tendon transition from free length to anchorage: PE pipe and PE or PP sheath end immediately next to anchor head or anchor plate, exposed prestressing steel surfaces coated with a layer of soft corrosion protection filling material;
- Stressing end anchorage: 7-wire prestressing steel strand coated with a layer of soft corrosion protection filling material, anchor head and anchor plate coated with a layer of soft corrosion protection filling material (EN 1537, Table C.1, Item 4a));
- Optional stressing end anchorage: 7-wire prestressing steel strand coated with a layer of soft corrosion protection filling material, anchor head and anchor plate coated with a layer of soft corrosion protection filling material (EN 1537, Table C.1, Item 4a)) inside a cap coated with a layer of soft corrosion protection filling material or, alternatively, the inside of the cap completely filled; anchor cap, anchor plate and steel reservation tube are provided with corrosion protection.
- Dead-end anchorage where applicable: Compression pipe and anchorage unit assembly with a minimum of 20 mm external grout cover, anchorage unit sealed at the end, containing the 7-wire prestressing steel strands anchored inside the anchorage unit with (i) proprietary means and protected against corrosion with either cement grout or soft corrosion protection filling material or (ii) by bond and protected against corrosion by cement grout or (iii) a combination of the two alternatives.

2.2.9 Effect of removability of anchor on resistance

For kits with the option removability of anchor the effect of the detachment mechanism installed as intended to be used on site on the resistance to static load of the tendon shall be assessed by testing in accordance with EAD 160004-00-0301, Annex C.2.1, for external tendons. If the detachment mechanism is intended to be activated only at the time of removal of the anchor on site, it shall not be activated for the test.

One medium size anchor out of the series of kits shall be used as test specimen. The required performance of the tested kit shall be in accordance with EAD 160004-00-0301, Clause 2.2.1.

NOTE: Testing for assessment of removability may be combined with testing for resistance to static load, Clause 2.2.1. However, removability according to Clause 2.2.9 does not modify any testing requirement according to Clause 2.2.1 and Clause 2.2.2.

2.2.10 Effect of means for adjustment and monitoring of anchor force on resistance

For kits with the option adjustment and monitoring of anchor force, the additional components or means for adjustment or monitoring shall be assessed for resistance to static load. Assessment of the means for adjustment or monitoring of anchor force shall be based on the calibration range of the means, determined according to EN ISO 376, and equal to or exceeding F_{pk}.

The calibration range of the kits with the option adjustment and monitoring of anchor force shall be stated in the ETA.

2.2.11 Individual PE or PP sheath and prestressing steel strand assembly filled with soft corrosion protection filling material – Mass of soft filling material per metre (filling degree) (PLL+, PLC1, PLC2, PLE1, and PLE2)

Assessment of the filling degree of the smooth PE or PP sheath shall be based on testing of individual PE or PP sheath and prestressing steel strand assemblies with soft corrosion protection filling material in accordance with Annex B.2. Testing may be omitted if a monostrand, see Clause 2.2.14, is used as assembly.

Five individual PE or PP sheath and prestressing steel strand assemblies with soft corrosion protection filling material with a minimum free length of 15 m each and produced at five different production days shall be used for testing. The following aspects of the filling degree of the assemblies shall be stated in the ETA as follows:

- Extent of coating of strand: Coverage of each of the seven wires of the 7-wire prestressing steel strand over the entire assembly length with a layer of soft corrosion protection filling material. Coverage leaving no blank metallic surface of prestressing steel is suggested;
- Average filling degree: Average filling degree of each of the 5 assemblies. An average filling degree of 50% or more is suggested;
- Filling degree next to stressing end anchorage and other positions: Filling degree of each specimen cut next to the stressing end anchorage and other positions. A filling degree next to stressing end anchorage of 90% or more is suggested.

2.2.12 Individual PE or PP sheath and prestressing steel strand assembly filled with soft corrosion protection filling material – Maximum pull-out force for strand from sheath of manufactured assembly (PLL+, PLC1, PLC2, PLE1, and PLE2)

Assessment of the maximum pull-out force for strand from the sheath of the manufactured assembly shall be based on testing of individual PE or PP sheath and prestressing steel strand assemblies with soft corrosion protection filling material in accordance with Annex B.3.

Five samples of individual PE or PP sheath and prestressing steel strand assemblies (2 samples for Type A specimens, 3 samples for Type B specimens) with soft corrosion protection filling material with a minimum free length of 15 m each and produced at five different production days shall be used for testing.

The maximum pull-out force for strand from sheath without grout injection (Type A specimens) shall be $\leq$ 60 N/m. Testing may be omitted if a monostrand, see Clause 2.2.14, is used as assembly.

The maximum pull-out force for strand from sheath with grout injection (Type B specimens) shall be stated in the ETA. A pull-out force of 500 N/m or less is suggested.

NOTE: The required performance without grout injection originates from EAD 160004-00-0301, Clause 2.2.33.

2.2.13 Individual PE or PP sheath and prestressing steel strand assembly filled with soft corrosion protection filling material – Sealing of end of individual smooth PE or PP sheath (PLL+, PLC1, PLC2, PLE1, and PLE2)

Assessment of sealing of the end of individual smooth PE or PP sheath of manufactured assembly next to the bond length and next to the dead-end anchorage unit, where applicable, shall be based on testing of individual PE or PP sheath and prestressing steel strand assemblies with soft corrosion protection filling material in accordance with Annex B.4.

Five plus N (where N corresponds to the number of strands of the largest size anchor of the series) individual PE or PP sheath and prestressing steel strand assemblies with soft corrosion protection filling material with a minimum free length of 15 m each and produced at five different production days shall be used for testing.

Distance over which grout, if any, has penetrated the specimens shall be stated in the ETA. A distance of not more than 350 mm is suggested.

2.2.14 Individual PE sheath and prestressing steel strand assembly filled with soft corrosion protection filling material – Monostrand

Assessment of individual PE sheath and prestressing steel strand assembly filled with soft corrosion protection filling material, i.e., monostrand, according to EAD 160004-00-0301, Clauses 2.2.14 to 2.2.34.

2.2.15 Particular sealing and electrically insulating systems – Resistance of corrugated PE pipe under internal pressure (PLC1, PLC2, and PLE1)

Assessment of resistance of corrugated PE pipe under internal pressure shall be based on testing of corrugated PE pipe in accordance with Annex B.5.

Three specimens, each from 3 different production batches of each size of corrugated PE pipe of the kit, shall be used for testing.

The minimum electrical resistance during 24 hours under 3,5 bar internal pressure shall be stated in the ETA. A minimum of $\geq$ 200 MΩ is suggested. In addition, the pressure when first $<$ 200 MΩ applies and the pressure at failure of the specimen shall be stated in the ETA.

2.2.16 Particular sealing and electrically insulating systems – Resistance of transition from smooth PE pipe to corrugated PE pipe and of end cap on corrugated PE pipe (PLC1, PLC2, and PLE1)

Assessment of resistance of transition from smooth PE pipe to corrugated PE pipe and of end cap on corrugated PE pipe shall be based on testing in accordance with Annex B.6.

Five specimens for series A to E for each a small, intermediate and the largest PE pipe diameter out of the series of available anchor sizes of the kit shall be used for testing.

The minimum electrical resistance during 24 hours under 3,5 bar internal pressure and during 2 hours under 1,5 bar external pressure shall be stated in the ETA. A minimum of $\geq$ 200 MΩ is suggested. In addition, the pressure when first $<$ 200 MΩ applies and either the maximum pressure or the pressure at failure, as applicable, of the specimens shall be stated in the ETA.

2.2.17 Particular sealing – Tightness of transition from smooth PE pipe to corrugated PE pipe and of end cap on corrugated PE pipe (PLE2)

Assessment of tightness of transition from smooth PE pipe to corrugated PE pipe and of end cap on corrugated PE pipe shall be based on testing in accordance with Annex B.7.

Three specimens for series B, C, D, and E for each small, intermediate, and largest PE pipe diameter out of the series of sizes shall be tested.

- Leakage and damages after 2 hours holding time at the highest-pressure step, in general of 1,5 bar for external pressure and 3,5 bar for internal pressure, or the conclusion that no leakage and no damage occurred, and
- Pressure at failure or in case of no failure the pressure of the highest-pressure step, in general 1,5 bar and 3,5 bar,

are stated in the ETA.

2.2.18 Particular sealing and electrically insulating systems – Resistance of sealing of free length PE pipe to anchorage under external pressure (PLC1, PLC2, and PLE1)

Assessment of resistance of sealing of free length PE pipe to anchorage under external pressure shall be based on testing in accordance with Annex B.8.

One sample each of a small and of the largest PE pipe diameters out of the series of available anchor sizes of the kit shall be used for testing.

The minimum electrical resistance during 24 hours under 1,5 bar external pressure shall be stated in the ETA. A minimum of $\geq$ 200 MΩ is suggested. In addition, the pressure when first $<$ 200 MΩ applies and the pressure at failure of the specimens shall be stated in the ETA.

2.2.19 Particular sealing – Tightness of sealing of free length PE pipe to anchorage under external pressure (PLE2)

Assessment of resistance of sealing of free length PE pipe to anchorage under external pressure shall be based on testing in accordance with Annex B.9.

One sample each of small and largest PE pipe diameters out of the series of available anchor sizes shall be tested.

- Leakage and damages after 2 hours holding time at the highest-pressure step, in general of 1,5 bar, or the conclusion that no leakage and no damage occurred, and
- Pressure at failure or in case of no failure the pressure of the highest-pressure step, in general 1,5 bar,

are stated in the ETA.

2.2.20 Individual PE or PP sheath and prestressing steel strand assembly filled with soft corrosion protection filling material – Tightness of transition free length to anchorage (PLL+ and PLE2)

Assessment of tightness of sealing of free length of individual PE or PP sheath to anchorage under external pressure shall be based on testing in accordance with Annex B.10.

One sample each of small and largest PE pipe diameter out of the series of anchor sizes shall be tested.

- Leakage and damages after 2 hours holding time at the highest-pressure step, in general of 1,5 bar, or the conclusion that no leakage and no damage occurred, and
- Pressure at failure or in case of no failure the pressure of the highest-pressure step, in general 1,5 bar,

are stated in the ETA.

2.2.21 Crack width of grout within corrugated PE pipe in bond length (PLC2 and PLE2)

Assessment of crack width of grout within corrugated PE pipe in bond length shall be based on testing in accordance with Annex B.11.

One sample each of small and largest PE pipe diameter out of the series of sizes shall be tested.

- Shape of corrugated PE pipe in representations like outline drawings,
- Dimensions of the corrugated PE pipe,
- Description of damage to corrugated plastic PE pipe or the conclusion that no damage is present, and
- Maximum of crack width

are stated in the ETA.

2.2.22 Particular sealing and electrically insulating systems – Electrical resistance of insulating plate between anchor head and anchor plate (PLC1 and PLC2)

Assessment of the insulating plate in tendon anchorage for mechanical strength to transfer tendon force and for electrical resistance may be based on information from material data sheets of the insulating plate.

In addition, the anchor system testing in accordance with 2.2.4 and Annex B.1 shall be used to assess the electrical resistance of the stressed anchor / tendon from the structure and ground.

2.2.23 Particular sealing and electrically insulating systems – Filling of space outside of transition pipe from anchorage to free length for corrosion protection by cement grout (PLC1 and PLE1)

The mean of corrosion protection of the external surface of a steel transition pipe, if applicable, from the anchorage to the free length shall be assessed. If the corrosion protection is intended to be provided by cement grout, the

feasibility of filling of the space outside of the transition pipe shall be assessed either based on documented experience or equivalently based on testing. Reference method is assessment based on testing.

For assessment based on testing, three samples of an intermediate anchorage size out of the series of available anchor sizes of the kit shall be used for testing. The assembly of the anchor components, see Figure 2.2.23.1, and the filling procedures shall be as intended to be used on site. After hardening of the cement grout but not earlier than 7 days after filling, the assembly is dissected. The presence of voids shall be assessed by visual inspection on the dissected assembly.

The feasibility of completely filling of the space outside of the transition pipe from the anchorage to the free length and of covering the metallic surfaces shall be stated in the ETA.

NOTE: Small air voids of few millimetres depth, discovered by visual inspection after dissection, are considered to represent no harm to the corrosion protection.

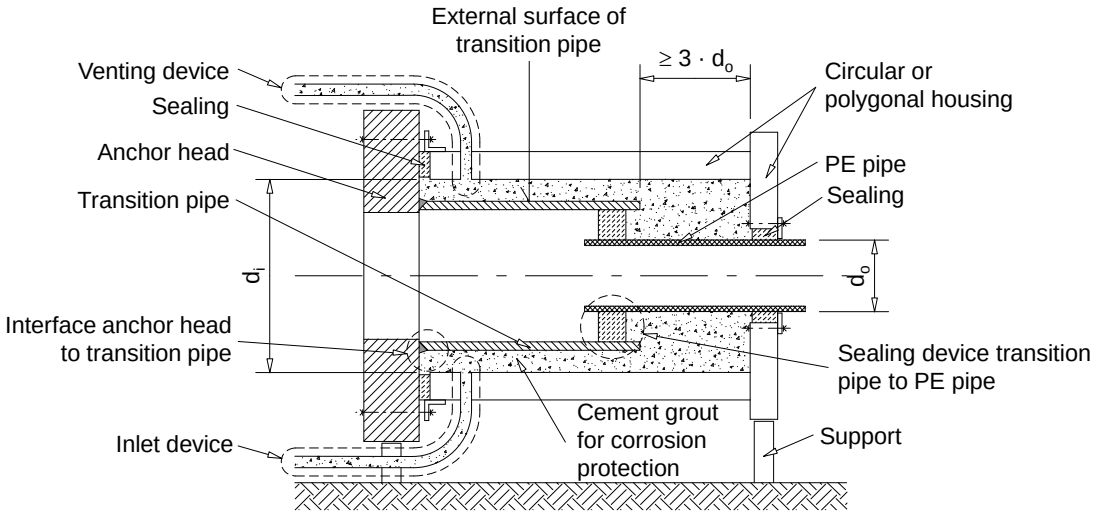


Figure 2.2.23.1 Filling test

Key

d_i ..... Minimum inner diameter of aperture of anchorage zone

d_o ..... Outer diameter of PE pipe

Transition pipe, PE pipe, Anchor plate
Components of the rock and soil anchor

Sealing device transition pipe to PE pipe, Inlet device, Venting device
Devices of the rock and soil anchor as installed on site

Interface anchor plate to transition pipe
Interface of the rock and soil anchor as installed on site

External surface of transition pipe
Surface to be inspected after dissection of the assembly. Further surface of anchor plate and sealing device transition pipe to PE pipe are inspected.

Circular or polygonal housing
Housing made of wood based material, plastic, or steel

Sealing ..... Sealing as provided for in testing

Support ..... Support for horizontal alignment in testing

3 Assessment and verification of constancy of performance

3.1 System of assessment and verification of constancy of performance to be applied

For the products covered by this EAD the applicable European legal act is Commission Decision 98/456/EC.

The system is 1+.

3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 3.2.1.

Table 3.2.1 Control plan for the manufacturer; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Factory production control (FPC) including testing of samples taken at the factory in accordance with a prescribed test plan					
1	Anchor plate and other force transfer units (compression pipe, anchorage unit), material	Checking of relevant certificate [1)]	Control plan	100 %	continuous
	Anchor plate and other force transfer units (compression pipe, anchorage unit), detailed dimensions	Testing	Control plan	3 % ≥ 2 samples	continuous
	Anchor plate and other force transfer units (compression pipe, anchorage unit), visual inspection [3)]	Testing	Control plan	100 %	continuous
	Anchor plate and other force transfer units (compression pipe, anchorage unit), traceability	bulk			
2	Anchor head material	Checking of relevant certificate [2)]	Control plan	100 %	continuous
	Anchor head, detailed dimensions	Testing	Control plan	5 % ≥ 2 samples	continuous
	Anchor head, visual inspection [3)]	Checking	Control plan	100 %	continuous
	Anchor head, traceability	full			
3	Wedge, material	Checking of relevant certificate [2)]	Control plan	100 %	continuous
	Wedge, treatment, hardness	Testing	Control plan	0,5 % ≥ 2 samples	continuous
	Wedge, detailed dimensions	Testing	Control plan	5 % ≥ 2 samples	continuous
	Wedge, visual inspection [3)]	Checking	Control plan	100 %	continuous
	Wedge, traceability	full			
4	Tensile element, material	Checking of relevant certificate or (CE) [4)]	Control plan	100 %	continuous

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
	Tensile element, diameter	Testing	Control plan	1 sample	each coil or every 7 tons [5]
	Tensile element, visual inspection [3] (including signs of corrosion)	Checking	Control plan	1 sample	each coil or every 7 tons [5]
	Tensile element, traceability	full			
5	Corrugated and smooth PE pipe, individual smooth PE or PP sheath, material	Checking of relevant certificate or (CE) [4]	Control plan	100 %	continuous
	Corrugated and smooth PE pipe, individual smooth PE or PP sheath, dimensions	Testing	Control plan	1 sample	each supply batch
6	Helix for local anchorage zone reinforcement other than reinforcing steel, material	Checking of relevant certificate (CE) [4]	Control plan	100 %	continuous
	Helix for local anchorage zone reinforcement other than reinforcing steel, visual inspection [3]	Checking	Control plan	100 %	continuous
7	Constituents of internal grout as per EN 447	Checking of relevant certificate [4]	Control plan	all	100 %
	Internal grout traceability	full			
8	Soft corrosion protection filling materials, material	Checking of relevant certificate [4]	Control plan	all	100 %
9	Cement grout for dead-end anchorage unit, material	Checking of relevant certificate [4]	Control plan	all	100 %
	Cement grout for dead-end anchorage unit, traceability	full			
10	Sealing devices, material	Checking of relevant certificate [4]	Control plan	all	100 %
	Sealing devices, dimensions	Testing	Control plan	3 % $\geq$ 2 samples	continuous
11	insulating plate, material	Checking of relevant certificate [4]	Control plan	all	100 %
	Insulating plate, dimensions	Testing	Control plan	3 % $\geq$ 2 samples	continuous
12	Mass of soft corrosion protection filling material per metre (filling degree)	Annex B.2	Control plan	2 samples of 3 specimens each	2/year
13	Monostrand used as assembly for free length, if applicable	FPC according to EAD 160004-00-0301 applies			
14	Electrical resistance of end cap and of transition from smooth PE pipe to corrugated PE pipe	Annex B.1 [6]	Control plan	1 sample	10/year

Key

1) The certificate is at least a test report 2.2 according to EN 10204.

2) The certificate is an inspection report 3.1 according to EN 10204.

3) Successful visual inspection does not need to be documented.

4) CE marking and declaration of performance or, if basis for CE marking is not available, certificate of supplier

5) Maximum of a coil or 7 tons has to be taken into account.

6) Anchors from ongoing production shall be tested in the area of end cap and of transition from free length to bond length only for electrical resistance, see Annex B.1.

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body in the procedure of assessment and verification of constancy of performance for the kit for rock and soil anchors are laid down in Table 3.3.1.

Table 3.3.1 Control plan for the notified body; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples [1)]	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control					
1	FPC documentation system: Procedures and technical forms	Documents	Control plan	all	Not applicable
2	Records of the FPC documentation system	Records	Control plan	1 for type	Not applicable
3	Factory organisation: Qualifications, tasks, and responsibilities of the technical and management staff	Documents and records	Control plan	all	Not applicable
4	Product flow	Documents	Control plan	all	Not applicable
5	Order management: Offer, order, and accompanying documentation	Documents	Control plan	1	Not applicable
6	Preparation of the register of manufacturers and the Declaration of Performance	Documents	Control plan	all	Not applicable
7	Criteria, methods, and records of materials internal controls and checks of the acceptance controls	Documents and records	Control plan	1 for type	Not applicable
8	Production management: Frequency, number, and location of samples of finished products or components, periodic tests, identification system for products and their components, material certificates	Documents and records	Control plan	1 for type	Not applicable
9	Records of tests performed by the manufacturer	Records	Control plan	all	Not applicable
10	Inspection of production plants and warehouses	Visual	Control plan	all	Not applicable
11	Manufacturer testing laboratory: Check of critical equipment for the purpose of experimental measurements and / or controls, assurance metrological traceability of measurement and control equipment	Visual, documents and records	Control plan	all	Not applicable

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples [1)]	Minimum frequency of control
12	Treatment of non-conforming products, criteria for declassification and segregation	Visual	Control plan	1	Not applicable
13	Traceability of products, from raw materials to the job site and vice versa	Visual and records	Control plan	1	Not applicable
Continuous surveillance, assessment, and evaluation of factory production control					
14	FPC documentation system: Procedures and technical forms	Documents	Control plan	modifications only	1/year
15	Records of FPC documentation system	Records	Control plan	1 for type	1/year
16	Factory organisation: Qualifications, tasks, and responsibilities of technical and management staff	Documents and records	Control plan	modifications only	1/year
17	Production flow	Documents	Control plan	modifications only	1/year
18	Register of manufacturers	Records	Control plan	all	1/year
19	Records of audits of component manufacturers	Records	Control plan	all	1/year
20	Declaration of Performance	Records	Control plan	1	1/year
21	Order management: Offer, order, and accompanying documentation	Records	Control plan	1	1/year
22	Criteria, methods, and records of materials internal controls and checks of the acceptance controls	Records	Control plan	1	1/year
23	Production management: Frequency, number, and location of samples of finished products or components, periodic tests, identification system for products and their components, material certificates	Records	Control plan	1 for type	1/year
24	Records of tests performed by the manufacturer	Records	Control plan	1	1/year
25	Inspection of production plants and warehouses	Visual	Control plan	all	1/year
26	Manufacturer testing laboratory: Check of critical equipment for the purpose of experimental measurements and / or controls, assurance metrological traceability of measurement and control equipment	Visual and records	Control plan	all	1/year
27	Treatment of non-conforming products, criteria for declassification and segregation	Visual and records	Control plan	1	1/year
28	Traceability of products from raw materials to job site and vice versa	Visual and records	Control plan	1	1/year

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples [1)]	Minimum frequency of control
Audit-testing of samples taken by the notified product certification body at the manufacturing plant or at the manufacturer's storage facilities					
29	Anchor plate and other force transfer units (compression pipe, anchorage unit), material	Checking and testing (hardness)	Control plan	1	1/year
	Anchor plate and other force transfer units (compression pipe, anchorage unit), detailed dimensions	Testing	Control plan	1	1/year
	Anchor plate and other force transfer units (compression pipe, anchorage unit), visual inspection	Checking	Control plan	1	1/year
30	Anchor head, material	Checking and testing (hardness and chemical)	Control plan	1	1/year
	Anchor head, detailed dimensions	Testing	Control plan	1	1/year
	Anchor head, visual inspection	Checking	Control plan	1	1/year
31	Wedge, material	Checking and testing (mechanical and chemical)	Control plan	2	1/year
	Wedge, treatment, hardness	Checking and testing (hardness profile)	Control plan	2	1/year
	Wedge, detailed dimensions	Testing	Control plan	1	1/year
	Wedge, main dimensions, surface hardness	Testing	Control plan	5	1/year
	Wedge, visual inspection	Checking	Control plan	5	1/year
32	Single tensile element test (see EAD 160004-00-0301)	Annex C.7	Annex C.7	9	1/year
33	Corrugated and smooth PE pipe, individual smooth PE or PP sheath, material	Checking	Control plan	1	1/year
	Corrugated and smooth PE pipe, individual smooth PE or PP sheath, dimensions	Testing	Control plan	1	1/year

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples [1)]	Minimum frequency of control
34	Mass of soft corrosion protection filling material per metre (filling degree)	Annex B.2	Control plan	2 samples of 3 specimens each	1/year [2)]
35	Monostrand used as assembly for free length, if applicable	Audit-testing according to EAD 160004-00-0301 applies			

Key

1) If the kit comprises different types of anchor heads, e.g., with different materials, different shape, different wedges, different pipes, etc., then the number of samples are understood as per type.

2) May be combined with FPC

4 Reference documents

EAD 160004-00-0301:02-2016	Post-tensioning kits for prestressing of structures
EAD 160027-00-0301:02-2016	Special filling products for post-tensioning kits
EN 445:2007	Grout for prestressing tendons – Test methods
EN 446:2007	Grout for prestressing tendons – Grouting procedures
EN 447:2007	Grout for prestressing tendons – Basic requirements
EN 1537:2013	Execution of special geotechnical works – Ground anchors
EN 1992-1-1:2004 + AC:2008 + AC:2010 + A1:2014	Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings
EN 10204:2004	Metallic products – Types of inspection documents
EN ISO 376:2011	Metallic materials – Calibration of force-proving instruments used for the verification of uniaxial testing machines
EN ISO 1461:2009	Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods
EN ISO 12944-2:2017	Paints and varnishes – Corrosion protection of steel structures by protective paint systems
EN ISO 22477-5:2018	Geotechnical investigation and testing – Testing of geotechnical structures – Part 5: Testing of grouted anchors
EN ISO/IEC 17025:2017	General requirements for the competence of testing and calibration laboratories

A Annex A - Essential characteristics relevant for the different intended uses

The following Table A.1 summarises the essential characteristics which can be considered as relevant to the different intended uses of the kit for rock and soil anchors.

Table A.1 Essential characteristics for the intended uses

Essential characteristics, Clause	PLC1 Anchor	PLC2 Anchor	PLE1 Anchor	PLE2 Anchor	PLL+ Anchor with individual PE or PP sheath assembly in free length	PLL Anchor with individual PE or PP sheath assembly in free length	PLL Anchor with general PE pipe in free length
	Temporary and/or permanent use. For use in non-aggressive and in aggressive ground and/or exposure to critical stray currents.	Temporary and/or permanent use. For use in non-aggressive and in aggressive ground and/or exposure to critical stray currents.	Temporary and/or permanent use. For use in non-aggressive and in aggressive ground but without exposure to critical stray currents.	Temporary and/or permanent use. For use in non-aggressive and in aggressive ground but without exposure to critical stray currents	Temporary use with extended working life. For use in non-aggressive ground and without exposure to critical stray currents.	Temporary use. For use in non-aggressive ground and without exposure to critical stray currents.	Temporary use. For use in non-aggressive ground and without exposure to critical stray currents.
2.2.1	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2.2.2	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2.2.3	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2.2.4	Yes	Yes	---	---	---	---	---
2.2.5	---	---	Yes	---	---	---	---
2.2.6	---	---	---	Yes	---	---	---
2.2.7	---	---	---	---	Yes	---	---
2.2.8	---	---	---	---	---	Yes	Yes
2.2.9	---	---	---	---	Yes	Yes	Yes
2.2.10	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2.2.11	Yes	Yes	Yes	Yes	Yes	---	---
2.2.12	Yes	Yes	Yes	Yes	Yes	---	---
2.2.13	Yes	Yes	Yes	Yes	Yes	---	---
2.2.14	Yes [1)]	Yes [1)]	Yes [1)]	Yes [1)]	Yes [1)]	Yes [1)]	Yes [1)]
2.2.15	Yes	Yes	Yes	---	---	---	---
2.2.16	Yes	Yes	Yes	---	---	---	---

2.2.17	---	---	---	Yes	---	---	---
2.2.18	Yes	Yes	Yes	---	---	---	---
2.2.19	---	---	---	Yes	---	---	---
2.2.20	---	---	---	Yes	Yes	---	---
2.2.21	---	Yes	---	Yes	---	---	---
2.2.22	Yes	Yes	---	---	---	---	---
2.2.23	Yes	---	Yes	---	---	---	---

[1)] Only for rock and soil anchor with monostrands.

B Annex B - Testing of anchor systems (kit for rock and soil anchors)

B.1 System performance test (PLC1 and PLC2 and anchors for which friction in free length is assessed based on testing)

B.1.1 Test specimen

The anchor kit shall be assembled in accordance with the instructions of the manufacturer from randomly selected components providing a minimum free length of 15 m and a bond length suitable for testing in the intended ground conditions. The fully assembled anchor kit of PLC1 and PLC2 only shall be subjected to an electrical resistance test in the factory in accordance with B.1.2.1. The anchor shall then be transported to site, stored on site, and installed in suitable ground at the testing site in accordance with the instructions of the manufacturer.

B.1.2 Test procedure

B.1.2.1 Electrical resistance (factory test, PLC1 and PLC2)

This test is generally recommended for all kits but may be omitted for kits with sufficient experience. The electrical resistance of the end cap and of the transition from free length (smooth PE pipe) to bond length (corrugated PE pipe) of the fully assembled anchor PLC1 and PLC2 only shall be measured in the factory in accordance with Figure B.1.3.1 with an LCR meter at a direct current of 500 V and a measuring range $\geq$ 10 kΩ. Drinking water shall be used to fill the inside of the anchor and the tank.

B.1.2.2 Apparent tendon free length

The installed anchor shall be stressed to the proof load and subsequently unloaded for the determination of the apparent tendon free length in accordance with EN 1537 and EN ISO 22477-5, Annex D.

B.1.2.3 Electrical resistance (site test, PLC1 and PLC2)

After completion of the procedures according to B.1.2.1 and B.1.2.2, if applicable, PLC1 and PLC2 anchor specimens only shall be stressed to a suggested proof load of at least $P_p = 0{,}70\ F_{pk}$ (where F_{pk} is the characteristic ultimate resisting force of the tensile elements of the tendon) and locked-off at $P_0 \geq 0{,}5\ F_{pk}$, be injected in accordance with the manufacturer's instructions and any eventual finishing works specified in the manufacturer's instructions shall be performed. The electrical resistance of the fully stressed and injected anchor shall be measured between the tendon (anchor head or strand) and the ground in accordance with Figure B.1.3.2 with an LCR meter at DC voltage of 500 V and a measuring range $\geq$ 10 kΩ. During the measurement, the anchor shall be connected to the positive pole, the ground to the negative pole. In general, metallic components stuck into the ground may be used for the connection to the ground.

The measurement of electrical resistance shall be performed after each of the following steps:

- primary injection;
- each post-injection, if applicable;
- locking-off the anchor subsequently to application of proof load but prior to injection of anchor head;
- finishing work on / filling of the anchor head.

B.1.3 Measurements and observations

- Document all materials and dimensions of components used for testing;
- Document specified free length and bond length of anchor used for testing and tendon length in stressing jack;
- Measure and record the electrical resistance of the end cap and the transition from free length to bond length of the anchor PLC1 and PLC2 only in the factory test;
- Measure and record tendon load and tendon elongation at all load steps and calculate the apparent tendon free length in accordance with EN 1537 and EN ISO 22477-5;
- Measure and record the electrical resistance for each of the steps specified under B.1.2.3;
- Document the testing with photos;
- Record any particular observations during the test;
- Record measurements and observations in accordance with Annex C.

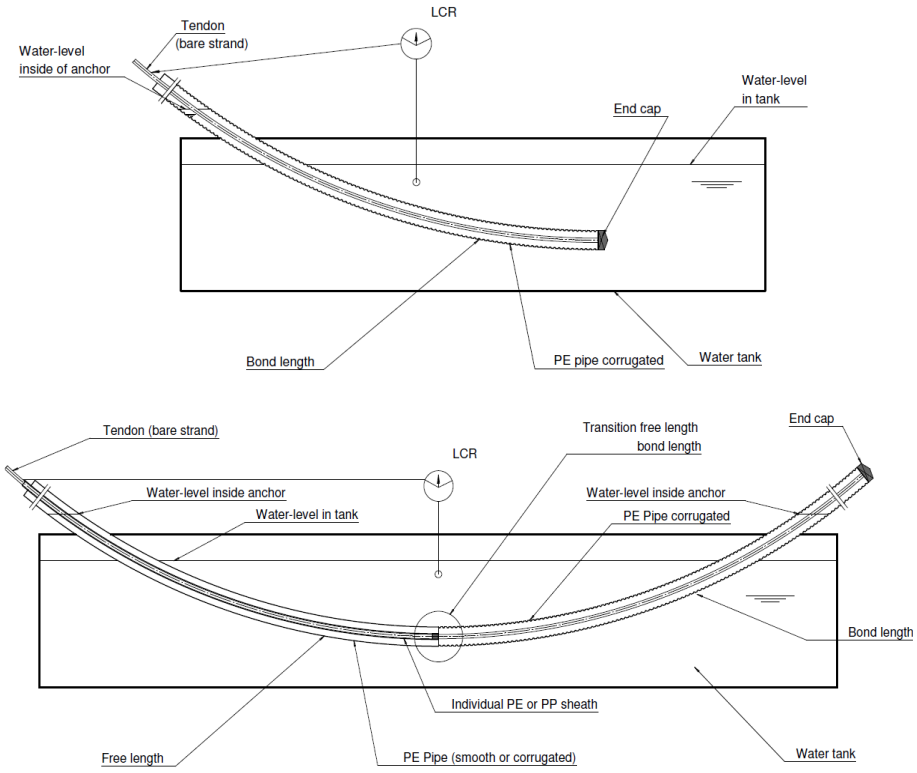


Figure B.1.3.1 Electrical resistance measurement on PLC1 and PLC2 anchor (factory test)

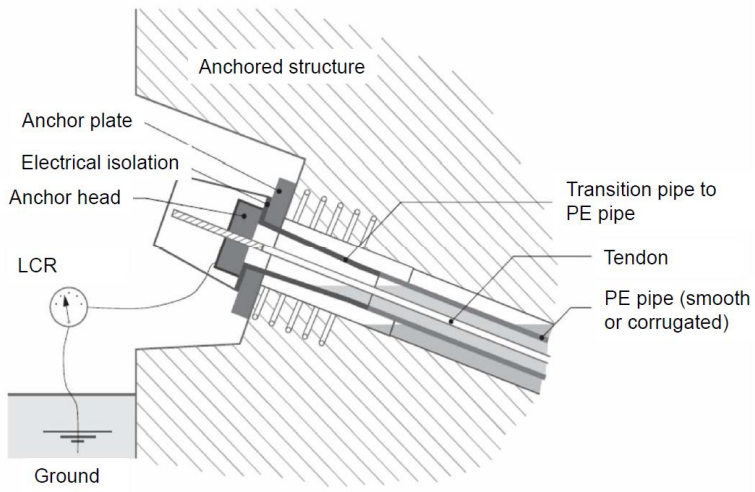


Figure B.1.3.2 Electrical resistance measurement on PLC1 and PLC2 anchor (site test)

NOTE: LCR measurement equipment: L = inductance; C = capacitance; R = resistance

B.2 Individual PE or PP sheath and prestressing steel strand assembly filled with soft corrosion protection filling material - Mass of soft filling material per metre (filling degree) (PLL+, PLC1, PLC2, PLE1, and PLE2)

B.2.1 Test specimen

Randomly collect 5 samples of PE or PP sheath and prestressing steel strand assemblies with soft corrosion protection filling material, each with at least 15 m long free length, and each produced on a different day. Cut 3 specimens of 1,0 m minimum length from each of the 5 assemblies at three positions, i.e., one at the end next to the intended position of the stressing end anchorage, one in the middle of the free length, and one next to the transition to the bond length. This results in a total of 15 specimens. Mark each specimen for traceability of the sample and position on the sample.

B.2.2 Test procedure

The following procedure shall be applied:

- Measure and record the length L (accuracy +/- 1 mm) and weight w_a (accuracy +/- 1 g) of each specimen;
- Measure and record the external diameter and the wall thickness of the sheath at both ends of each specimen in two orthogonal diameters. Calculate the actual sheath internal diameter d_i as the average value of all four measurements on each specimen;
- Cut PE or PP sheath of each specimen longitudinally, assess visually the surface of the strand and record any areas which are not covered with a layer of soft corrosion protection filling material of each specimen;
- Carefully remove all soft corrosion protection filling material from each of the 7 wires of prestressing steel strands and from the PE or PP sheaths of each specimen, measure and record the weight of wires w_w and sheath w_{sh} of each specimen.

B.2.3 Measurements and observations

- Document all materials and dimensions of components used for testing;
- Inspect the surface of the strand of each specimen and record any surface areas which are not covered with a layer of soft filling material (location and extent);
- Document the observations with photos.
- Calculate and record the filling degree of each of the 15 specimens based on geometrical and physical (density) properties of sheath, strand, and filling material:
- Weight of filling material: $w_f = w_a - w_w - w_{sh}$;
- Volume of filling material: $V_f = w_f / \rho_f$ where ρ_f is the density of the filling material;
- Volume inside sheath: $V_{sh} = (d_i^2 \pi/4)\ L$
- Filling degree of specimen: FD = V_f / ($V_{sh} – A_p\ L$) where A_p is the nominal cross section of strand
- Calculate the filling degree of each of the five samples for each of the three positions, i.e., at the end next to the intended position of the stressing end anchorage, in the middle of the free length, and next to the intended position of the bond length;
- Calculate the average filling degree for each of the five samples, i.e., average value of filling degree of the three positions;
- Record any particular observations during the test;
- Record measurements and observations in accordance with Annex C.

B.3 Individual PE or PP sheath and prestressing steel strand assembly filled with soft corrosion protection filling material - Maximum pull-out force for strand from sheath of manufactured assembly (PLL+, PLC1, PLC2, PLE1, and PLE2)

B.3.1 Test specimen

Randomly collect 2 samples of PE or PP sheath and prestressing steel strand assemblies with soft corrosion protection filling material each with at least 15 m long free length, and each produced on a different day. Cut 2 specimens of at least 1,0 m length from each of the 2 samples to suit the test set-up, one in the middle of the free length, and one in the zone where under Annex B.2 the highest filling degree was measured. This results in a total of 4 specimens of Type A. Mark each specimen for traceability of the sample and position on the sample.

Repeat the above procedure specified for Type A with another 3 samples of PE or PP sheath and prestressing steel strand assemblies with soft corrosion protection filling material each with at least 15 m long free length, and each produced on a different day. Cut 2 specimens of at least 1,0 m length from each of the 3 samples to suit the test set-up, one in the middle of the free length, and one in the zone where under Annex B.2 the highest filling degree was measured. This results in a total of 6 specimens of Type B. Mark each specimen for traceability of the sample and position on the sample.

Cut the sheath on each specimen to a length of 1 m and record the length (accuracy +/- 1 mm) of the sheath of each specimen of Type A and Type B.

Install and fix the 6 specimens of Type B in straight alignment inside a steel pipe, seal the ends of the pipe, inject the pipe with internal grout with a flow time (cone method) according to EN 445 of not more than 13 seconds, and apply by air a pressure of at least 3,5 bar onto the grout until it has set but for not less than 24 hours. After setting of the grout but earliest after 3 days remove the ends of the steel pipe. Figure B.3.3.1 illustrates a suggested set-up for preparation of specimens Type B.

B.3.2 Test procedure

The following procedure shall be applied:

- Condition all specimens of Type A and Type B at an ambient temperature of not more than 18 °C;
- Install the specimens Type A into a suitable test frame which permits holding the sheath (e.g., by clamping the sheath without restraining the strand) while pulling the strand on the opposite end. For test specimens Type B the steel pipe may serve as test frame and the grout may be assumed to hold back the sheath;
- When the temperature of the specimens has stabilised at not more than 18 °C, slowly apply a pulling load to the strand of each specimen of Type A and Type B until the strand slides relative to the sheath and reaches a displacement of at least 100 mm relative to the sheath.

B.3.3 Measurements and observations

- Document all materials and dimensions of components used for testing;
- Document the following grout properties in accordance with EN 445: fluidity (cone method), bleeding (wick-induced method) and fluid density;
- Inspect each specimen Type B whether any grout has penetrated the sheath. Record and document any such observations with photos;
- Measure and record the pull-out load of the strand as a function of the displacement for each specimen;
- For each specimen of Type A and Type B, calculate and record the maximum pull-out force per length (measured load / sample length) during the test as well as the average pull-out load per length at the start of strand sliding and when 100 mm strand displacement is reached;
- Document the specimens after testing with photos;
- Record any particular observations during the test;
- Record measurements and observations in accordance with Annex C.

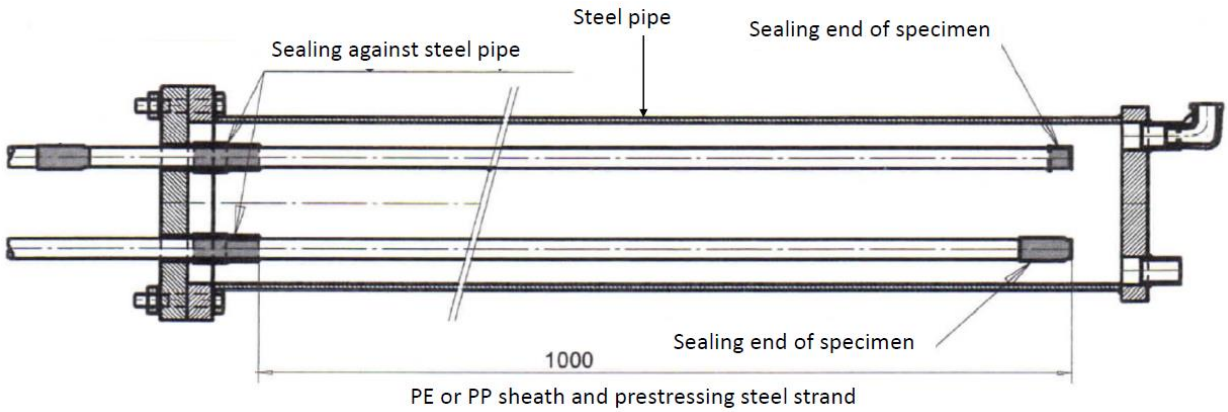


Figure B.3.3.1 Set-up for preparation and testing of specimens Type B

B.4 Individual PE or PP sheath and prestressing steel strand assembly filled with soft corrosion protection filling material - Sealing of end of individual smooth PE or PP sheath (PLL+, PLC1, PLC2, PLE1, and PLE2)

B.4.1 Test specimen

Randomly collect 5 samples of PE or PP sheath and prestressing steel strand assemblies with soft corrosion protection filling material each with at least 15 m long free length, and each produced on a different day. Cut 1 specimen of 1,5 m minimum length from each of the 5 samples, next to the bond length, with the transition from sheathed to bare strand approximately in the middle of the specimen. Seal the sheath of each specimen against the bare strand at the transition from free length to bond length in accordance with the manufacturer's instructions. This results in a total of 5 specimens Type A. Mark each specimen for traceability of the sample and position on the sample.

Fabricate N number of samples (where N corresponds to the number of strands of the largest size anchor of the series) of PE or PP sheath and prestressing steel strand assemblies with soft corrosion protection filling material, each with at least 30 m long free length and 10 m bond length. Seal the sheath of each sample against the bare strand at the transition from free length to bond length in accordance with the manufacturer's instructions. Assemble the largest size anchor of the series with these N samples in accordance with the manufacturer's instructions and install the anchor on a coil with the smallest radius of curvature intended to be used for transportation and storage on site. A minimum of 3 days later, uncoil the anchor and cut 1 specimen of 1,5 m minimum length, next to the bond length, with the transition from sheathed to bare strand approximately in the middle of the specimen, from each assembly. This results in a total of N specimens of Type B. Mark each specimen for traceability of the sample and position on the sample.

B.4.2 Test procedure

The following procedure shall be applied:

- Place all specimens of Type A and Type B into a steel pipe as, e.g., shown in Figure B.4.3.1, seal the ends of the pipe;
- Inject the pipe with internal grout with a flow time (cone method) according to EN 445 of not more than 13 seconds and apply by air a pressure of at least 3,5 bar onto the grout, maintain the pressure for 2 hours;
- Release the pressure, remove the specimens, remove any grout on the external surface of the specimens;
- Longitudinally cut and carefully open the sheath of each specimen, measure and record the distance over which the grout has penetrated into the sheath, if any.

B.4.3 Measurements and observations

- Document all materials and dimensions of components used for testing;
- Document the following grout properties in accordance with EN 445: fluidity (cone method), bleeding (wick-induced method) and fluid density;
- Inspect each specimen whether any grout has penetrated into the sheath. Document any such observations with photos;
- Measure and record the distance over which the grout has penetrated into the sheath for each specimen;
- Document the specimens after testing with photos;
- Record any particular observations during the test;
- Record measurements and observations in accordance with Annex C.

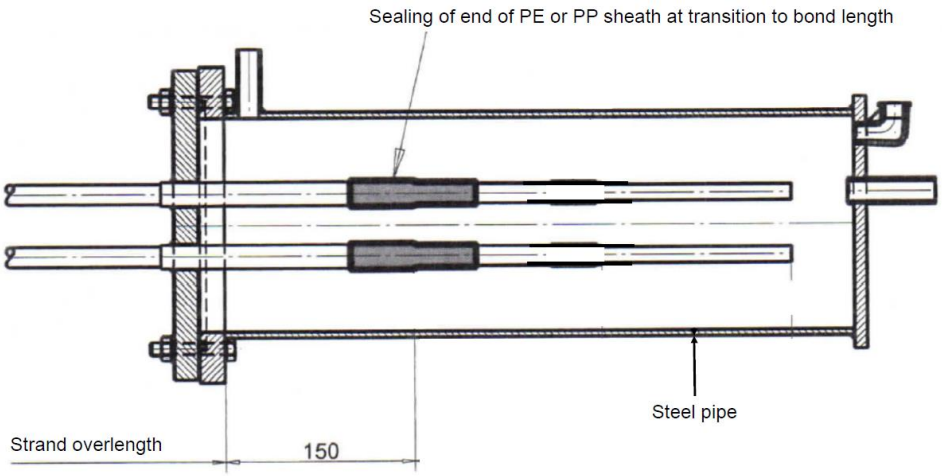


Figure B.4.3.1 Test set-up for leak tightness test of transition of sheath from free to bond length

B.5 Particular sealing and electrically insulating systems (for option comprehensive corrosion protection only) - Resistance of corrugated PE pipe under internal pressure (PLC1, PLC2, and PLE1)

B.5.1 Test specimen

For each type and each diameter of corrugated PE pipe intended to be used for the kit, randomly collect 3 specimens each from 3 different production batches, each specimen having 1,5 m minimum length, i.e., a total of 9 specimens per pipe diameter. Seal the ends of the test specimens with suitable means such as indicated in Figure B.5.3.1.

B.5.2 Test procedure

The following procedure shall be applied:

- Condition the specimens and perform testing at an ambient temperature of not more than 18 °C;
- Fill the inside of the specimens with drinking water, immerse the specimens into a steel pipe filled with drinking water (except the end where the electrical contact to the interior of the pipe is made) and apply an internal pressure of 3,5 bar (accuracy +/- 0,1 bar). Hold the pressure for 24 hours;
- Measure and record the electrical resistance between the inside and the water on the outside of the PE pipe with an LCR-meter at 500 Volt direct current and a measuring range $\geq$ 10 kΩ at least after 1, 3, 5, 15, 60 minutes and at the end of the 24 hours;
- Subsequently, increase the pressure by 1 bar over a period of 1 minute, measure and record the electrical resistance after holding the pressure for 5 minutes;
- Repeat the pressure increments of 1 bar and measurements of electrical resistance as specified above until the specimen fails, record pressure and electrical resistance at each step and at failure. The test may be terminated once the pressure step of 5.5 bar has been completed.

Thereby, failure is any event that affects the specimen to an extent that it no longer functions properly. Examples are bursting or collapsing of components, sudden and essential drop of electrical resistance or water pressure, sudden leakage, etc.

B.5.3 Measurements and observations

- Document all materials and dimensions of components used for testing;
- Measure and record external pipe diameter, internal pipe diameter and wall thickness of each specimen at both ends of each specimen in two orthogonal diameters prior to testing;
- Measure the internal pressure in the specimen during the entire period of the test and record the pressure at each pressure step;
- Measure and record the electrical resistance at each pressure step;
- Measure and record the pressure at failure of the specimen;
- Document the specimens after testing with photos;
- Record any particular observations during the test;
- Record measurements and observations in accordance with Annex C.

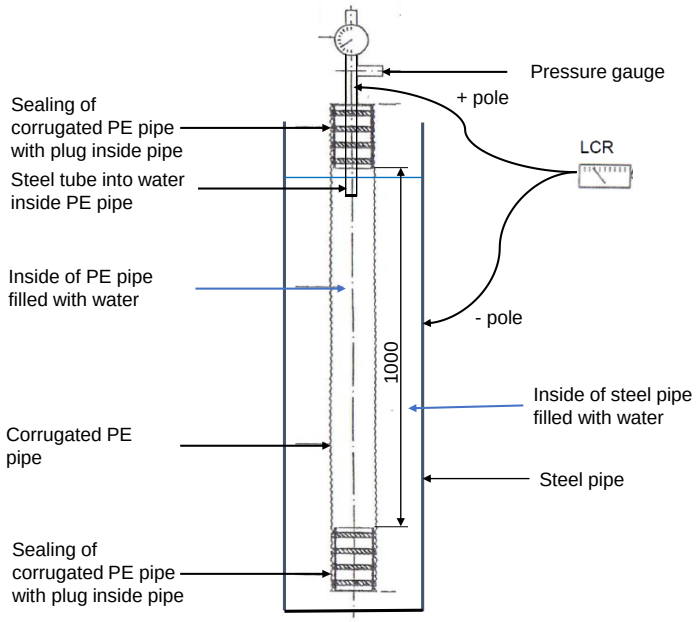


Figure B.5.3.1 Test specimen for internal pressure test with end caps

B.6 Particular sealing and electrically insulating systems (for option comprehensive corrosion protection only) - Resistance of transition from smooth PE pipe to corrugated PE pipe and of end cap on corrugated PE pipe (PLC1, PLC2, and PLE1)

B.6.1 Test specimen

For each of the test series A to E specified below, assemble one test specimen each with a small, intermediate and the largest pipe diameter specified for the kit. Each test specimen shall consist of a corrugated PE pipe with the corresponding end cap and a smooth PE pipe with the transition between the pipes sealed with means as intended to be used in the kit, see Figure B.6.3.1 and Figure B.6.3.2. This results in a total of 15 test specimens.

The following pre-conditioning shall be applied to the specimens:

- For test series A in internal pressure test: No pre-conditioning, test on the completed specimen;
- For test series B in internal pressure test: Each specimen is bent on a template twice forth and back to the minimum radius of curvature as intended to be used with the coil for transportation and storage on site;
- For test series C in external pressure test: Same as for test series B;
- For test series D in internal pressure test: Each specimen is bent to the minimum radius of curvature of test series B, maintained in the bent position and exposed to the environment for at least 14 days with a peak daily temperature of at least 25 °C (days with less than 25 °C peak temperature shall not be considered), with exposure to diffuse sunlight, and finally bent back to straight in warm condition. Alternatively, the specimen in bent position may be exposed for 14 days in a chamber to controlled daily ambient temperature cycles of at least 30 °C for 8 hours, and a maximum of 15 °C for 8 hours, with gradual transitions in between, and finally bent back to straight in warm condition. Reference is conditioning in chamber;
- For test series E in internal pressure test: Each specimen is bent to the minimum radius of curvature of test series B, maintained in the bent position at an ambient temperature of not more than -10 °C for at least 24 hours, and finally bent back to straight at a temperature of not higher than the minimum temperature permitted by the kit manufacturer for bending back at cold condition.

B.6.2 Test procedure

The following procedure shall be applied:

- Condition the specimens and perform all testing at an ambient temperature of not more than 18 °C.

Perform internal pressure tests with specimens pre-conditioned in series A, B, D and E as follows (suggested test set-up is illustrated in Figure B.6.3.1):

- Fill the inside of the specimens with drinking water, seal the end of the smooth pipe with suitable means and immerse the specimen in a steel pipe filled with drinking water such as indicated in Figure B.6.3.1. Apply an internal pressure of 3,5 bar (accuracy +/- 0,1 bar). Hold the internal pressure for 24 hours;
- Measure and record the electrical resistance between the inside and outside of the PE pipe with an LCR-meter at 500 Volt direct current and a measuring range $\geq$ 10 kΩ at least after 1, 3, 5, 15, 60 minutes and at the end of the 24 hours;
- Subsequently, increase the pressure by 1 bar over a period of 1 minute, measure and record the electrical resistance after holding the pressure for 5 minutes;
- Repeat the pressure increments of 1 bar and measurements of electrical resistance as specified above until the specimen fails, record pressure and electrical resistance at each step and at failure. The test may be terminated once the pressure step of 5.5 bar has been completed.

Thereby, failure is any event that affects the specimen to an extent that it no longer functions properly. Examples are bursting or collapsing of components, sudden and essential drop of electrical resistance or water pressure, sudden leakage, etc.

Perform external pressure tests with specimens pre-conditioned in series C as follows (suggested test set-up illustrated in Figure B.6.3.2):

- Fill the space outside of the specimens with drinking water and seal the ends with suitable means such as indicated in Figure B.6.3.2. Fill the inside of the specimens with drinking water but do not seal the end of the smooth pipe such that there is always ambient air pressure on the inside of the specimen, see Figure B.6.3.2. Apply an external pressure of 1,0 bar (accuracy +/- 0,1 bar). Hold the external pressure for 2 hours;

- Measure and record the electrical resistance between the inside and outside of the PE pipe with an LCR-meter at 500 Volt direct current and a measuring range ≥ 10 kΩ every 15 minutes.
- Subsequently, increase the pressure to 1,5 bar, hold the pressure for 2 hours, measure and record the electrical resistance every 15 minutes;
- Subsequently, increase the pressure by increments of 0,5 bar, measure and record the electrical resistance after holding the pressure after each increment of 0,5 bar for 5 minutes;
- Repeat the pressure increments until the specimen fails or the specimen has maintained a maximum pressure of 3,5 bar, record the pressure at each step and at failure or the maximum pressure.

Thereby, failure is any event that affects the specimen to an extent that it no longer functions properly. Examples are bursting or collapsing of components, sudden and essential drop of electrical resistance or water pressure, sudden leakage, etc.

B.6.3 Measurements and observations

- Document all materials and dimensions of components used for testing;
- Measure and record external pipe diameter, internal pipe diameter and wall thickness of each specimen at both ends of each specimen in two orthogonal diameters prior to testing;
- Document the pre-conditioning of the specimens of series A to E (radius of curvature, ambient temperature and peak daily temperatures of pipe surface over the test period, exposure conditions and time of exposure);
- Measure the internal or external pressure in the specimen during the entire period of the test and record the pressure at each pressure step;
- Measure and record the electrical resistance at each pressure step;
- Measure and record the pressure at failure of the specimen or maximum pressure;
- Document the specimens after testing with photos;
- Record any particular observations during the test;
- Record measurements and observations in accordance with Annex C.

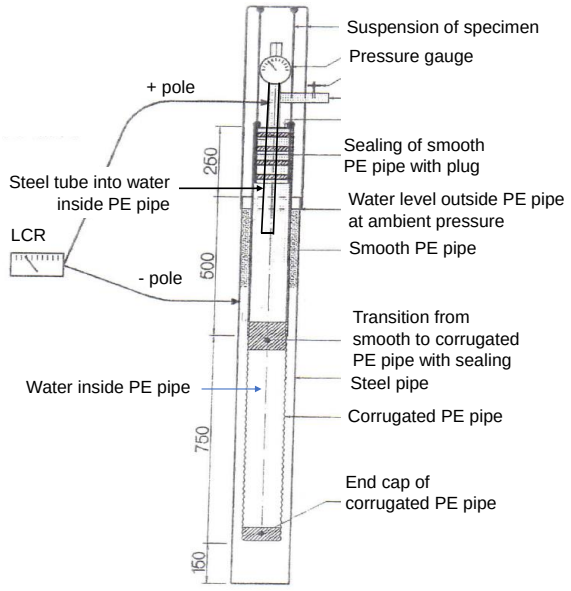


Figure B.6.3.1 Set-up for internal pressure test

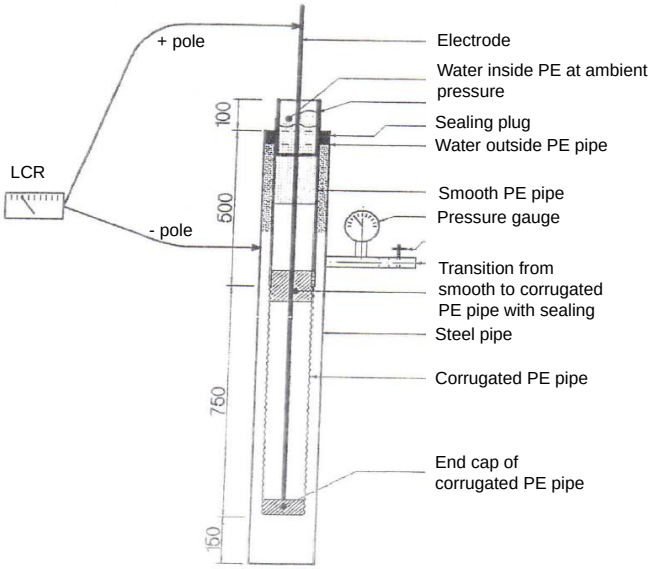


Figure B.6.3.2 Set-up for external pressure test

B.7 Particular sealing – Tightness of transition from smooth PE pipe to corrugated PE pipe and of end cap on corrugated PE pipe (PLE2)

B.7.1 Test specimen

For each of the test series B, C, D, and E prepare specimens according to Clause B.6.1. Following preparation of the specimens, condition the specimens for at least 24 hours prior to testing at an ambient temperature of (23 ± 2) °C.

B.7.2 Test procedure

The following procedure shall be applied:

Perform internal pressure tests with specimens pre-conditioned in series B and E as follows, test set-up according to Figure B.7.3.1 for specimen with transition smooth to corrugated PE pipe or Figure B.7.3.3 for specimen with corrugated PE pipe only. Series D is only tested for specimen with transition smooth to corrugated PE according to Figure B.7.3.1:

- Perform tests at an ambient temperature of (23 ± 2) °C.
- Seal the end of the specimen with suitable means and connect water supply with manometer as indicated in Figure B.7.3.1 or Figure B.7.3.3. For tests with corrugated PE pipes, the specimen can be restrained in longitudinal direction.
- Completely fill the specimen with drinking water.
- Apply an internal pressure of 0,1 bar. Wait for 5 minutes while checking the test set-up for correct configuration.
- After 5 minutes holding time, the pressure is increased by 0,4 bar, followed by again 5 minutes holding time. During holding time of pressure steps, the specimen is inspected for leakage. Leakage during holding time, if any, is recorded.
- Steps with an increase of 0,5 bar and a holding time of 5 minutes are continued up to failure of the specimen. Increase of pressure may be terminated once a pressure step of 3,5 bar is attained.
- At a pressure of 3,5 bar, if attained, wait for 2 hours.
- Inspect the specimen for leakage. Leakage during holding time, if any, is recorded.
- Release pressure, disassemble the specimen, and inspect for damage and leakage of water.

Thereby, failure is any event that affects the specimen to an extent that it no longer functions properly. Examples are bursting or collapsing of components, sudden and essential drop of electrical resistance or water pressure, sudden leakage, etc.

Perform external pressure tests with specimens pre-conditioned in series C as follows, test set-up according to Figure B.7.3.2 for specimen with transition smooth to corrugated PE pipe or Figure B.7.3.4 for specimen with corrugated PE pipe only:

- Seal the end of the specimen with suitable means and connect water supply with manometer as indicated in Figure B.7.3.2 or Figure B.7.3.4. The specimen can be provided with tensile elements as for the rock and soil anchor.
- Completely fill the void outside of the smooth and corrugated PE pipes with drinking water.
- Apply an external pressure of 0,1 bar. Wait for 5 minutes while checking the test set-up for correct configuration.
- After 5 minutes holding time, the pressure is increased by 0,4 bar, followed by again 5 minutes holding time. During holding time of pressure steps, the specimen is inspected for leakage. Leakage during holding time, if any, is recorded.
- Steps with an increase of 0,5 bar and a holding time of 5 minutes are continued up to failure of the specimen. Increase of pressure may be terminated, once a pressure step of 1,5 bar is attained.
- At a pressure of 1,5 bar, if attained, wait for 2 hours.
- Inspect the specimen for leakage. Leakage during holding time, if any, is recorded.
- Release pressure, disassemble the specimen, and inspect for damage and leakage of water.

Thereby, failure is any event that affects the specimen to an extent that it no longer functions properly. Examples are bursting or collapsing of components, sudden and essential drop of electrical resistance or water pressure, sudden leakage, etc.

B.7.3 Measurements and observations

- Document all materials and dimensions of components used for testing.
- Measure and record external pipe diameter, internal pipe diameter, and wall thickness of each specimen at both ends of each specimen in two orthogonal diameters prior to testing.
- Document the pre-conditioning of the specimens of series B, C, D, and E (radius of curvature, ambient temperature, and peak daily temperatures of pipe surface over the test period, exposure conditions and time of exposure).
- Measure the internal or external pressure in the specimens throughout the test and record the pressure at each pressure step.
- Record any leakage and damage throughout the test.
- Measure and record the pressure at failure of the specimens or maximum pressure throughout the test.
- Document the specimens after testing with photos.
- Record any particular observations during the test.
- Record measurements and observations in accordance with Annex C.

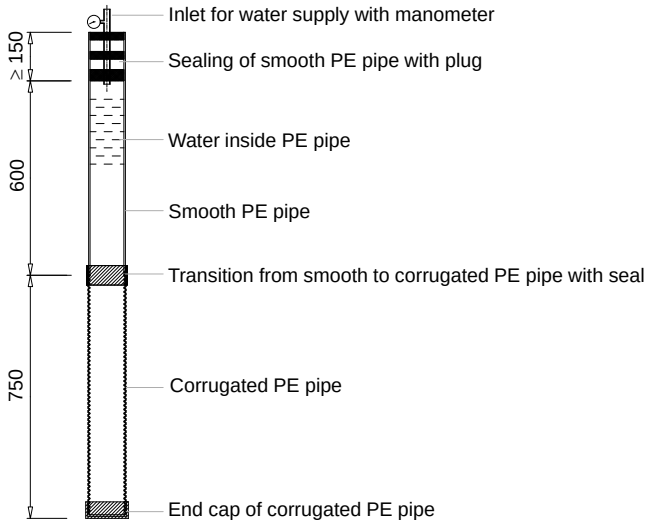
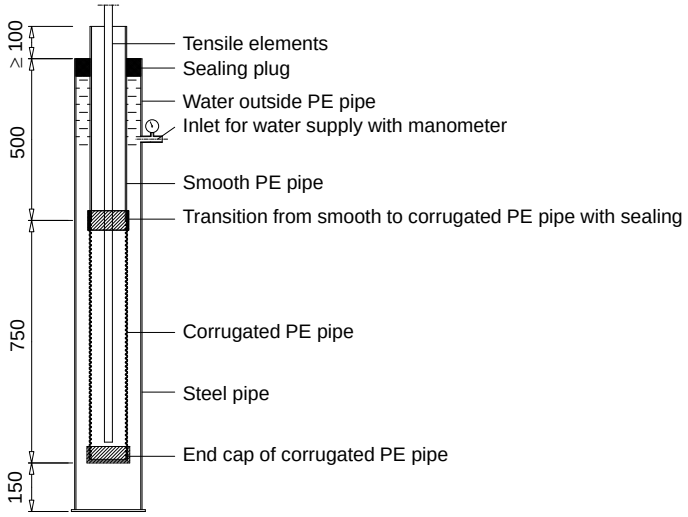


Figure B.7.3.1 Set-up for internal pressure test



Dimensions in mm

Figure B.7.3.2 Set-up for external pressure test

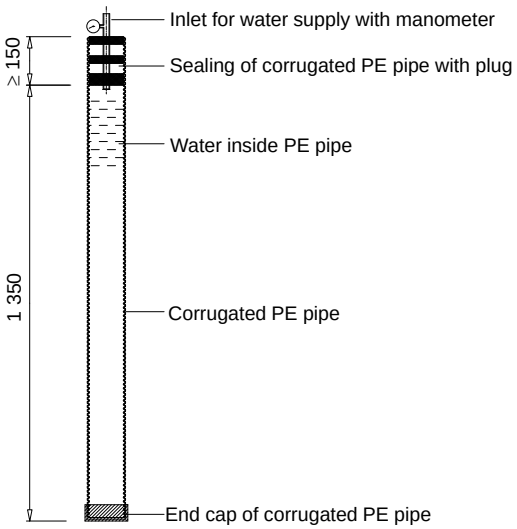
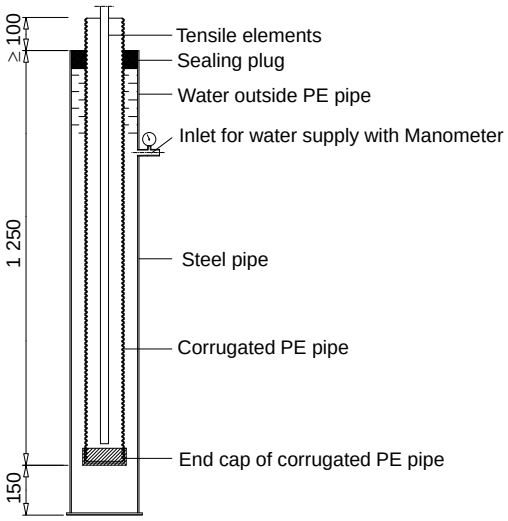


Figure B.7.3.3 Set-up for internal pressure test



Dimensions in mm

Figure B.7.3.4 Set-up for external pressure test

B.8 Particular sealing and electrically insulating systems - Resistance of sealing of free length PE pipe to anchorage under external pressure (PLC1, PLC2, and PLE1)

B.8.1 Test specimen

Assemble one specimen each of a small size and the largest size of the anchorage of the series of anchor kits from randomly collected components, consisting of anchor head, anchor plate, insulating plate, transition pipe to free length PE pipe, a section of the free length PE pipe of about 1,0 m length and the sealing device between transition pipe and free length PE pipe as intended to be used in the kit. If several types of sealing devices are intended to be used, one specimen each of a small size and the largest size of the anchorages of the series of anchor kits shall be tested for each type of sealing device.

B.8.2 Test procedure

The following procedure shall be applied:

- Condition the specimens and perform all testing at an ambient temperature of not more than 18 °C;
- Install the specimen in a test set-up allowing to apply an imposed longitudinal relative displacement of 30 mm between transition pipe and free length PE pipe and applying an external pressure. A suggested test set-up is illustrated in Figure B.8.3.1 before applying the longitudinal displacement at the left end;
- Apply a longitudinal relative displacement of 30 mm between the transition pipe and the free length PE pipe;
- Fill the space inside the transition pipe of the specimen with soft corrosion protection filling material as intended to be used with the kit and in accordance with instructions of the manufacturer;
- Fill the space outside of the specimen with drinking water, apply and hold an external pressure of 1,0 bar (accuracy +/- 0,1 bar) on the specimen for 1 hour, measure and record the electrical resistance between the inside and the outside of the specimen with an LCR-meter at 500 Volt direct current and measuring range $\geq$ 10 kΩ every 15 minutes. Figure B.8.3.2 illustrates the specimen during electrical measurement between the inside of the specimen and the outside water or outside surface of steel pipe;
- Subsequently, increase the external pressure to 1,5 bar, hold the pressure for 24 hours, measure and record the electrical resistance at least after 1, 3, 5, 15, 60 minutes and at the end of the 24 hours;
- Subsequently increase the external pressure by increments of 0,5 bar, measure and record the electrical resistance after holding the pressure after each increment of 0,5 bar for 5 minutes, repeat these pressure increments until the specimen fails, record the external pressure at each step and at failure. The test may be terminated once the pressure step of 3.5 bar has been completed.

Thereby, failure is any event that affects the specimen to an extent that it no longer functions properly. Examples are bursting or collapsing of components, sudden and essential drop of electrical resistance or water pressure, sudden leakage, etc.

B.8.3 Measurements and observations

- Document all materials and dimensions of components used for testing;
- Document properties of soft corrosion protection filling material in accordance with EAD 160027-00-0301;
- Measure the external pressure on the specimen during the entire period of the test and record the pressure at each pressure step;
- Measure and record the electrical resistance at each pressure step;
- Measure and record the pressure at failure of the specimen;
- Record the location and the mechanism of failure of the specimen;
- Document the specimens after testing with photos;
- Record any particular observations during the test;
- Record measurements and observations in accordance with Annex C.

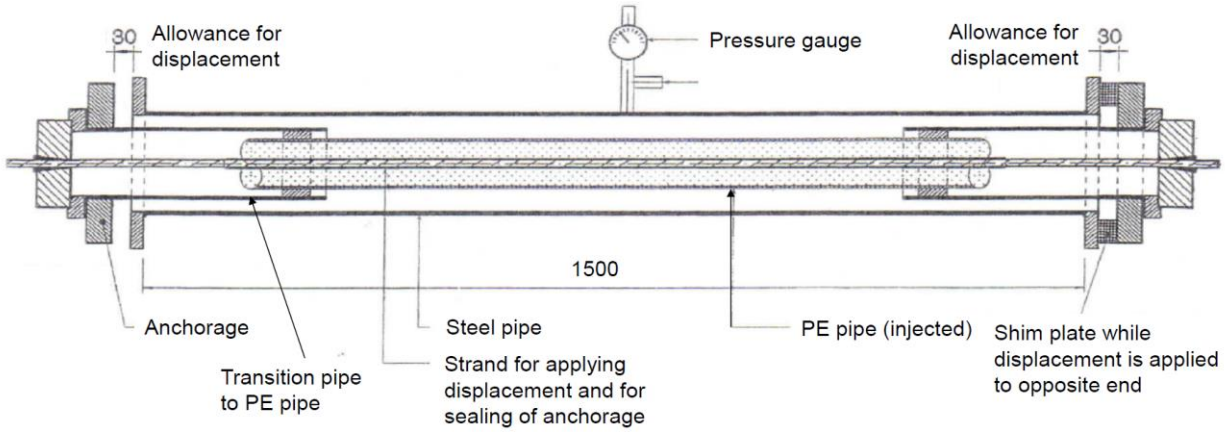


Figure B.8.3.1 Suggested test set-up for external pressure test on transition from free length to anchorage

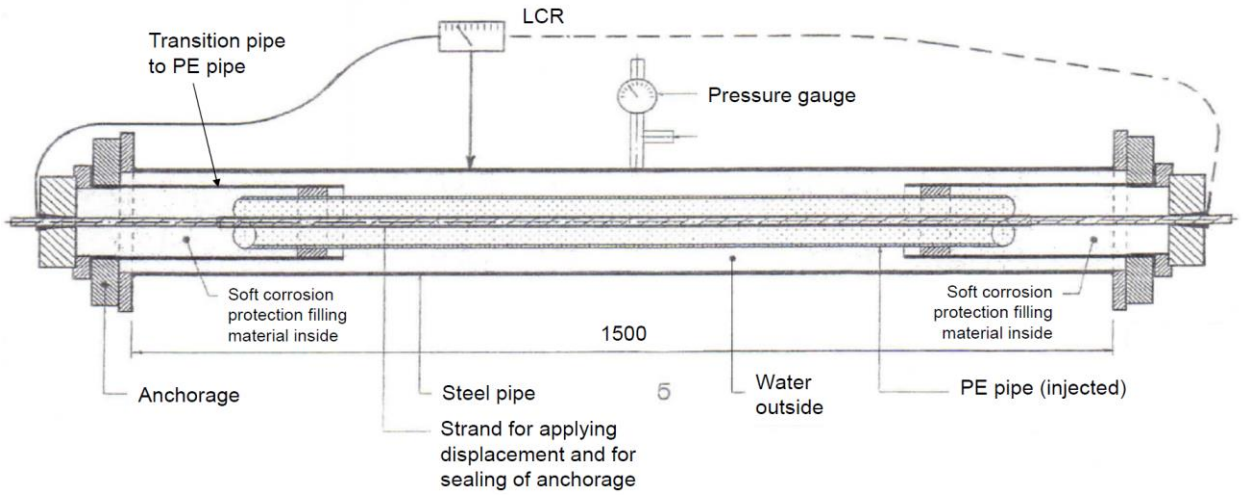


Figure B.8.3.2 Set-up for measurement of electrical resistance between inside of specimen and outside water or steel pipe (electrical measurement to be performed at each step from left end followed by measurement from right end)

B.9 Particular sealing – Tightness of sealing of free length PE pipe to anchorage under external pressure (PLE2)

B.9.1 Test specimen

Assemble one specimen each of a small size and the largest size of the anchorage of the series of anchor kits from randomly collected components, consisting of anchor head, anchor plate, transition pipe to free length PE pipe, a section of the free length PE pipe of about 1,0 m length, and the sealing device between transition pipe and free length PE pipe as intended to be used in the kit. If several types of sealing devices are intended to be used, one specimen each of a small size and the largest size of the anchorages of the series of anchor kits shall be tested for each type of sealing device. Condition the specimens for at least 24 hours prior to testing at an ambient temperature of (23 ± 2) °C.

B.9.2 Test procedure

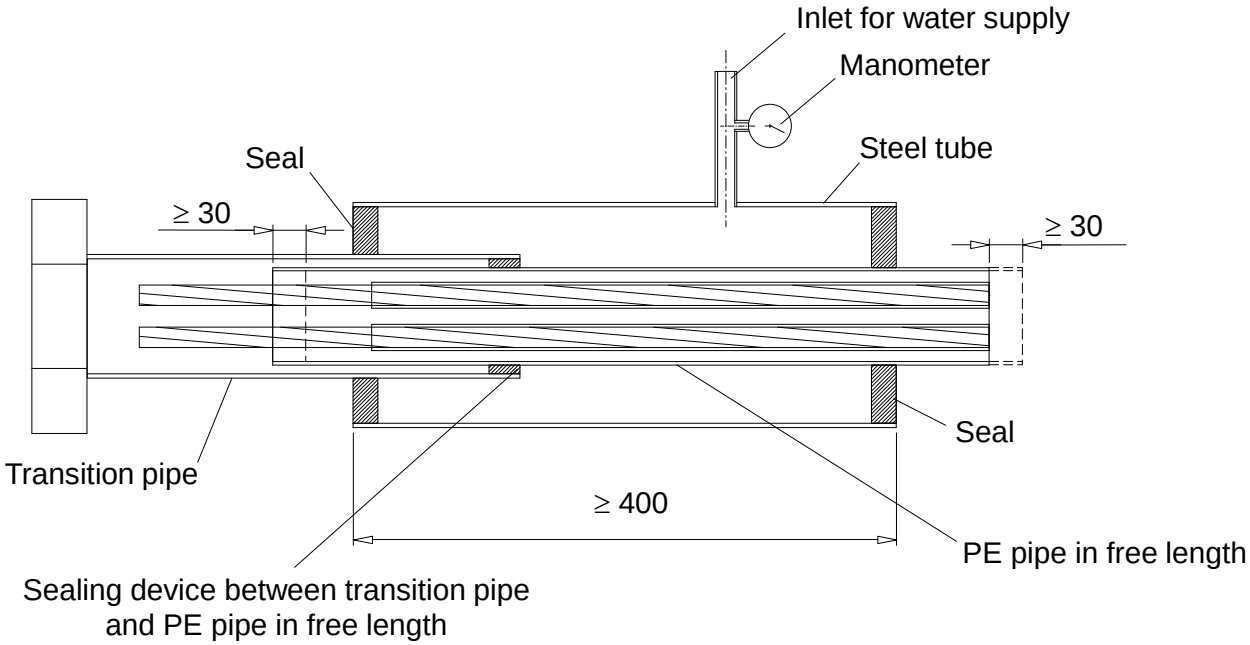
The following procedure shall be applied:

- Perform all testing at an ambient temperature of (23 ± 2) °C.
- Install the specimen in a test set-up allowing to apply an imposed longitudinal relative displacement of 30 mm between transition pipe and free length PE pipe and applying an external pressure. A test set-up is shown in Figure B.9.3.1 after applying the longitudinal displacement.
- Apply a longitudinal relative displacement of 30 mm between the transition pipe and the free length PE pipe.
- Completely fill the void outside of transition pipe and free length PE pipe with drinking water.
- Apply an external pressure of 0,1 bar. Wait for 5 minutes while checking the test set-up for correct configuration.
- After 5 minutes holding time, the pressure is increased by 0,4 bar, followed by again 5 minutes holding time. During holding time of pressure steps, the specimen is inspected for leakage. Leakage during holding time, if any, is recorded.
- Steps with an increase of 0,5 bar and a holding time of 5 minutes are continued up to failure of the specimen. Increase of pressure may be terminated, once a pressure step of 1,5 bar is attained.
- At a pressure of 1,5 bar, if attained, wait for 2 hours.
- Inspect the specimen for leakage. Leakage during holding time, if any, is recorded.
- Release pressure, disassemble the specimen, and inspect for damage and leakage of water.

Thereby, failure is any event that affects the specimen to an extent that it no longer functions properly. Examples are bursting or collapsing of components, sudden and essential drop of electrical resistance or water pressure, sudden leakage, etc.

B.9.3 Measurements and observations

- Document all materials and dimensions of components used for testing.
- Measure the external pressure in the specimens throughout the test and record the pressure at each pressure step.
- Record any leakage and damage throughout the test.
- Measure and record the pressure at failure of the specimens or maximum pressure throughout the test.
- Document the specimens after testing with photos.
- Record any particular observations during the test.
- Record measurements and observations in accordance with Annex C.



Dimensions in mm

Figure B.9.3.1 Testing tightness of transition anchorage to free length

B.10 Individual PE or PP sheath and prestressing steel strand assembly filled with soft corrosion protection filling material – Tightness of transition free length to anchorage (PLL+ and PLE2)

B.10.1 Test specimens

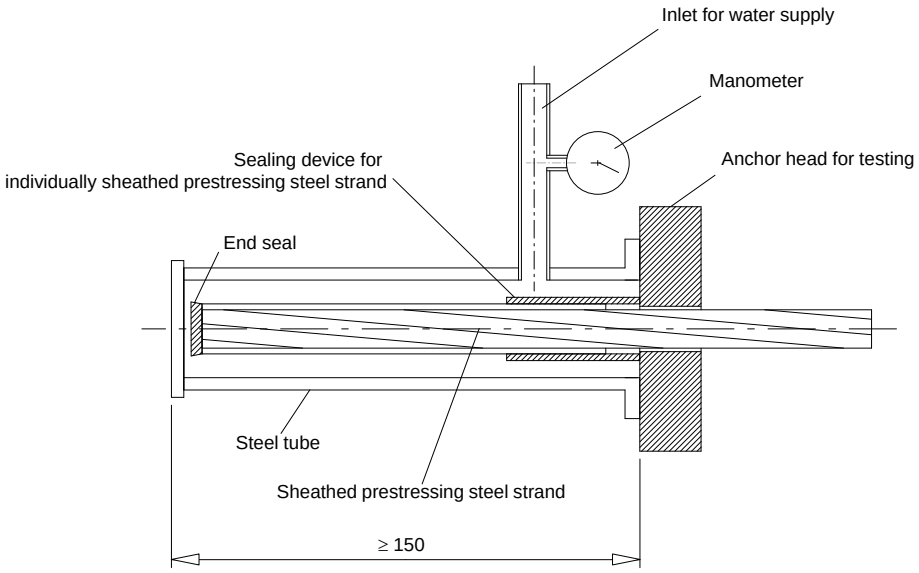
For each test A and B as specified below, one specimen is assembled.

Specimen A

The specimen, see Figure B.10.1.1, comprises

- Length of sheathed prestressing steel strand;
- Device including sealing that establishes the transition free length of sheathed prestressing steel strand to anchorage;
- Anchor head or steel disc with bore of the same geometry as the anchor head;
- Encasement with inlet, attached to the steel disc, to create a tight void containing the pressurised water;
- Inlet for pressurised water with manometer.

Condition the specimens for at least 24 hours prior to testing at an ambient temperature of (23 ± 2) °C.



Dimensions in mm

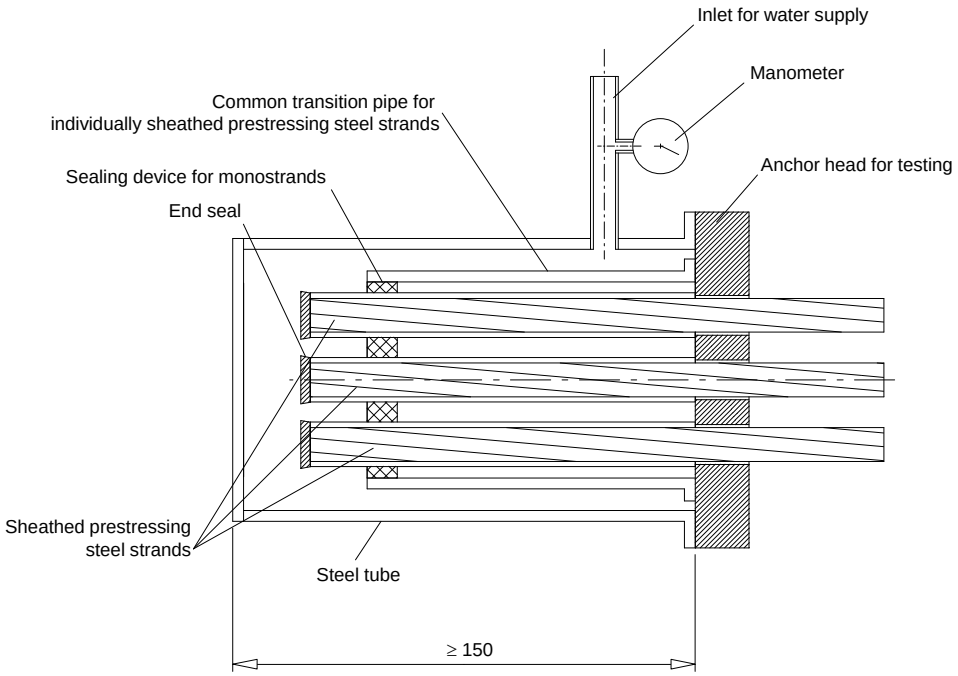
Figure B.10.1.1 PE or PP sheath and prestressing steel strand assembly, filled with soft corrosion protection filling material – Testing tightness of transition free length to anchorage with one single sheathed prestressing steel strand – Specimen A

Specimen B

The specimen, see Figure B.10.1.2, comprises

- Lengths of sheathed prestressing steel strand;
- Device including sealing that establishes the transition free length of sheathed prestressing steel strand to anchorage;
- Anchor head or steel disc with bores of the same geometry as the anchor head;
- Encasement with inlet, attached to the steel disc, to create a tight void containing the pressurised water;
- Inlet for pressurised water with manometer.

Condition the specimens for at least 24 hours prior to testing at an ambient temperature of (23 ± 2) °C.



Dimensions in mm

Figure B.10.1.2 PE or PP sheath and prestressing steel strand assembly, filled with soft corrosion protection filling material – Testing tightness of transition free length to anchorage with multiple sheathed prestressing steel strand – Specimen B

B.10.2 Test procedure

Specimen A and B

- Perform all testing at an ambient temperature of (23 ± 2) °C.
- Install the specimen in a test set-up according to Figure B.10.1.1 and Figure B.10.1.2.
- Completely fill the void outside of the sealing device with drinking water.
- Apply an external pressure of 0,1 bar. Wait for 5 minutes while checking the test set-up for correct configuration.
- After 5 minutes holding time, the pressure is increased by 0,4 bar, followed by again 5 minutes holding time. During holding time of pressure steps, the specimen is inspected for leakage. Leakage during holding time, if any, is recorded.
- Steps with an increase of 0,5 bar and a holding time of 5 minutes are continued up to failure of the specimen. Increase of pressure may be terminated, once a pressure step of 1,5 bar is attained.
- At a pressure of 1,5 bar, if attained, wait for 2 hours.
- Inspect the specimen for leakage. Leakage during holding time, if any, is recorded.
- Release pressure, disassemble the specimen, and inspect for damage and leakage of water.

Thereby, failure is any event that affects the specimen to an extent that it no longer functions properly. Examples are bursting or collapsing of components, sudden and essential drop of electrical resistance or water pressure, sudden leakage, etc.

B.10.3 Measurements and observations

- Record all materials and dimensions of components used for testing, take photos.
- Measure the external pressure in the specimens throughout the test and record the pressure at each pressure step.
- Record any leakage and damage throughout the test.
- Measure and record the pressure at failure of the specimens or maximum pressure throughout the test.
- Document the specimens after testing with photos.

- Record any particular observations during the test.
- Record measurements and observations in accordance with Annex C.

B.11 Crack width of grout within corrugated PE pipe in bond length (PLC2 and PLE2)

B.11.1 Test specimen

The specimen corresponds to EN 1537, Annex A, Test B. The following parameters apply in relation to EN 1537, see Figure B.11.1.1 and Figure B.11.1.3.

- The encapsulated tendon is assembled according to the specifications of the manufacturer, including all of the important components and geometrical features of the anchor in bond length.
- The encapsulated tendon is confined in a square prism of grout, i.e., external grout, within a steel box with dimensions according to Table B.11.1.1.
- Within the square prism, the encapsulated tendon is centred with spacers.
- The corrugated PE pipe is grouted with cement grout, i.e., internal grout, following EN 446 and the grouting method as specified by the manufacturer.
- Between prestressing steel strands and corrugated PE pipe, a cover of at least 5 mm is observed. Organisers are arranged to hold in place the prestressing steel strands and ensure the cover of grout.
- The specimen is grouted, external and internal grout, according to the manufacturer's specification.
- Prisms according to EN 445 are moulded of the internal grout for strength monitoring.
- With cords placed prior to grouting and pulled afterward, continuous and unblocked cavities for injection of resin for crack identification are created within the internal grout, in the longitudinal direction along the full length of the bond length of the specimen, as shown in Figure B.11.1.3. For the small size at least one cavity and for the largest size at least 2 cavities, diameter $\geq$ 3 mm, are created at positions close to the outer layer of prestressing steel strands. Distance cavity to prestressing steel strand is (0,1–0,5) · nominal diameter of prestressing steel stand. Inlets of injection at stressing side and outlets of injection at end of bond side are attached to the cavities. Each cavity is provided with individual inlet and outlet.

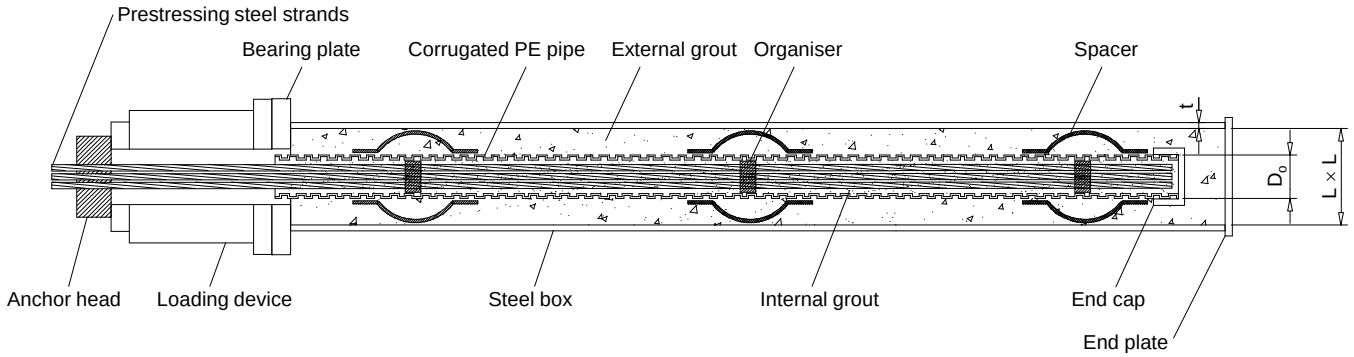


Figure B.11.1.1 Specimen for EN 1537, Annex A, Test B – Schematic example

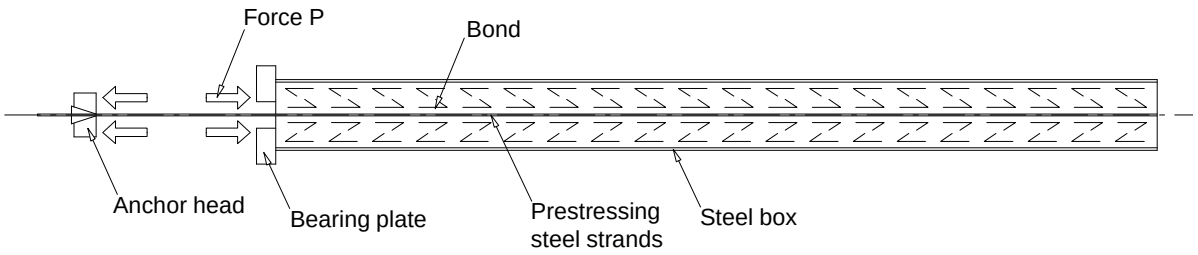


Figure B.11.1.2 Force distribution within specimen of Figure B.11.1.1 – Schematic

Table B.11.1.1 Dimensions of specimen for EN 1537, Annex A, Test B

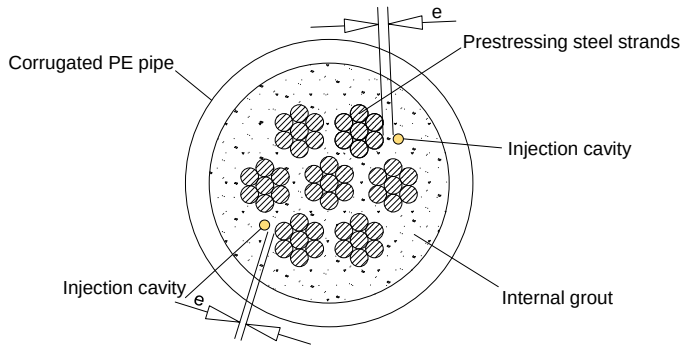
Width of steel box	Wall thickness of steel box
$L \geq \min. \begin{cases} 0{,}80 \cdot D_o \cdot \sqrt{1 + 0{,}057 \cdot D_o^{1,1}} \\ 350 \text{ mm} \end{cases}$	$D_o < 120$ mm $\quad t = \begin{cases} 0{,}1 \cdot D_o \\ \text{to} \\ 0{,}15 \cdot D_o \end{cases}$
	$D_o \geq 120$ mm $\quad t = \begin{cases} 0{,}1 \cdot D_o \\ \text{to} \\ 0{,}2 \cdot D_o \end{cases}$

Where

D_o ..... mm ..... Outer diameter of corrugated PE pipe

L ..... mm ..... Inner dimensions of steel box

t ..... mm ..... Wall thickness of steel box



e = (0,1–0,5) · nominal diameter of prestressing steel stand

Figure B.11.1.3 Specimen for EN 1537, Annex A, Test B – Exemplary position of injection cavity

B.11.2 Test procedure

The test is performed according to EN 1537, Annex A, Test B. The following parameters apply in relation to EN 1537.

- Testing is commenced at an age of the grout of 2 days or until the specified strength of internal grout has been attained.
- At the unloaded end of the specimen, slip of core wire is measured. For the small size core wire of one prestressing steel strand and for the largest size core wires of two prestressing steel strands are measured.
- The specimen is loaded in 6 equal and consecutive steps until the proof force P_p. Loading speed is not less than 1 MPa/s.
- Force distribution within the specimen is shown in Figure B.11.1.2.
- At each load step, the force is kept constant for at least 1 minute.
- At proof load P_p the force is kept constant for 5 minutes.
- The force is reduced to minimum $0{,}65 \cdot F_{pk}$ and maintained constant.
- A dyed resin of low viscosity is injected into the inlets of the cavities.
- The pressure for injecting the resin should be at or above 1 bar. After the resin escapes from the outlets at the end of the specimen, the outlets are sealed. The pressure is maintained for at least 10 minutes and the inlets are closed as well.

- After the resin has set and hardened, the specimen is unloaded.
- Steel box and external grout are removed.
- The corrugated PE pipe is inspected for damage.
- The corrugated PE pipe is removed, and the internal grout body examined for cracks. Only cracks filled with resin are considered.
- Crack widths are measured, and the maximum crack width determined. Check the resin has penetrated cracks $\leq$ 0,05 mm wide.

Where

P ..... N .....Force loading the specimen

P_p ..... N .....Proof load, i.e., minimum $\begin{cases} 0{,}80 \cdot F_{pk} \\ 0{,}95 \cdot F_{p0,1} \end{cases}$

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

$F_{p0,1}$ ..... N .....Characteristic 0,1 %-proof force of tendon

A_p ..... mm^2 .....Cross-sectional area of prestressing steel of tendon

NOTE 1 For F_{pk} and $F_{p0,1}$ cf. EN 1992-1-1
$F_{pk} = f_{pk} \cdot A_p$
$F_{p0.1} = f_{p0,1k} \cdot A_p$

NOTE 2 Prestressing steel as defined by the manufacturer.

B.11.3 Measurements and observations

- Record all materials and dimensions of components used for testing, take photos.
- Shape of the corrugated PE pipe is determined by visual inspection by reference to workshop drawings. The relevant dimensions, diameter, thickness, corrugation of the corrugated PE pipe are determined.
- Record slip of core wires at each load step
- Record location and kind of damage of the corrugated PE pipe, if any.
- Take photos of specimen after testing and at the various dismantling stages.
- Record position and widths of cracks, including maximum crack width.
- Record any particular observations during the test.
- Record measurements and observations in accordance with Annex C.

C Annex C - Contents of test records

The testing of the kit for rock and soil anchors shall be documented with test reports that should be prepared in accordance with the general principles of EN ISO/IEC 17025 and include at least the following specific information:

- Name and address of the test laboratory;
- Test report number or unique identification;
- Name and address of the client who has contracted the laboratory;
- A signed statement by the laboratory or body that has carried out or witnessed the tests that these tests have been carried out in accordance with this EAD;
- Identification of all components of the kit for rock and soil anchors;
- Certificates of all relevant materials to confirm compliance with relevant specifications. Actual characteristics of components (mechanical, chemical, metallurgical, geometrical, etc. as relevant) at time of testing in accordance with EAD 160004-00-0301, Annex C, and source of manufacture. These include in particular tensile elements, anchorage components and corrosion protection components (internal grout, cement grout, soft corrosion protection filling materials, smooth and corrugated PE pipes, smooth PE or PP sheath, etc.) and may include some ancillary components used in testing;
- Certificates of equipment and test machine calibration;
- Description and drawing of test specimen with actual dimensions;
- Description and drawing of test set-up and measuring equipment including calibration certificate;
- Description of detailed test procedure;
- Actual ambient temperature, where relevant;
- Record of all measurements and observations;
- Photographs of test specimen prior, during, and after testing;
- Any other information specified in the test procedures of Annex B;
- Statement of any unexpected or unusual behaviour / observation of components during testing;
- Date and place of testing;
- Name and signature of person responsible for testing.