DYWIDAG-SYSTEMS INTERNATIONAL

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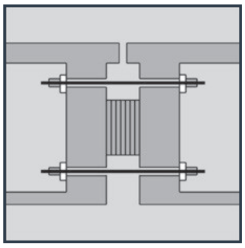
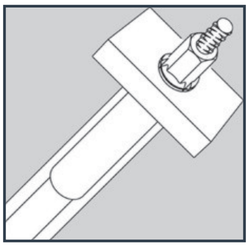
European Technical Approval
DYWIDAG Post-Tensioning

DYWIDAG
Post-Tensioning
System using Bars





Post-Tensioning Kit for Prestressing of Structures with Bars, internal bonded and unbonded and external

ETA-05/0123

Validity
20 October 2008 - 18 September 2015

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

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

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English translation, the original version is in German

Handelsbezeichnung *Trade name*	**DYWIDAG – Stabspannverfahren** *DYWIDAG – Post-tensioning bar tendon system*
Zulassungsinhaber *Holder of approval*	**DYWIDAG-Systems International GmbH Destouchesstraße 68 80796 München Deutschland**
Zulassungsgegenstand und Verwendungszweck *Generic type and use of construction product*	**Stabspannsystem für das Vorspannen von Tragwerken, intern mit und ohne Verbund sowie extern** *Post-tensioning kit for prestressing of structures with bars, internal bonded and unbonded and external*
Geltungsdauer vom *Validity from*	**19.09.2010**
bis zum *to*	**18.09.2015**
Herstellwerk *Manufacturing plant*	**DYWIDAG-Systems International GmbH Destouchesstraße 68 80796 München Deutschland**
Diese Europäische technische Zulassung umfasst *This European technical approval contains*	**64 Seiten, einschließlich 32 Anhängen** *64 Pages including 32 Annexes*
Diese Europäische technische Zulassung verlängert *This European technical approval extends*	**ETA-05/0123 mit Geltungsdauer vom 20.10.2008 bis 18.09.2010** *ETA-05/0123 with validity from 20.10.2008 to 18.09.2010*

I LEGAL BASES AND GENERAL CONDITIONS

1 This European technical approval is issued by Österreichisches Institut für Bautechnik in accordance with:

1. Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of Member States relating to construction products[1] – Construction Products Directive (CPD) –, amended by the Council Directive 93/68/EEC of 22 July 1993[2];

2. *dem Salzburger Bauproduktegesetz, LGBl. Nr. 11/1995, in der Fassung LGBl. Nr. 47/1995, LGBl. Nr. 63/1995, LGBl. Nr. 123/1995, LGBl. Nr. 46/2001, LGBl. Nr. 73/2001 und LGBl. Nr. 99/2001;*

   The Salzburg Construction Products Act, LGBl. № 11/1995, amended by LGBl. № 47/1995, LGBl. № 63/1995, LGBl. № 123/1995, LGBl. № 46/2001, LGBl. № 73/2001 and LGBl. № 99/2001;

3. Common Procedural Rules for Requesting, Preparing and the Granting of European technical approvals set out in the Annex of Commission Decision 94/23/EC[3];

4. Guideline for European technical approval of Post-Tensioning Kits for Prestressing of Structures, ETAG 013, Edition June 2002.

2 Österreichisches Institut für Bautechnik is authorised to check whether the provisions of this European technical approval are met. Checking may take place at the manufacturing plant. Nevertheless, the responsibility for the conformity of the products to the European technical approval and for their fitness for the intended use remains with the holder of the European technical approval.

3 This European technical approval is not to be transferred to manufacturers or agents of manufacturers other than those indicated on Page 1, or manufacturing plants other than those indicated on Page 1 of this European technical approval.

4 This European technical approval may be withdrawn by Österreichisches Institut für Bautechnik, in particular after information by the Commission on the basis of Article 5 (1) of the Council Directive 89/106/EEC.

5 Reproduction of this European technical approval including transmission by electronic means shall be in full. However, partial reproduction may be made with the written consent of Österreichisches Institut für Bautechnik. In this case partial reproduction has to be designated as such. Texts and drawings of advertising brochures shall not contradict or misuse the European technical approval.

6 The European technical approval is issued by the approval Body in its official language. This version corresponds to the version circulated within EOTA. Translations into other languages have to be designated as such.

[1] Official Journal of the European Communities № L 40, 11.02.1989, page 12
[2] Official Journal of the European Communities № L 220, 30.08.1993, page 1
[3] Official Journal of the European Communities № L 17, 20.01.1994, page 34

II SPECIFIC CONDITIONS OF THE EUROPEAN TECHNICAL APPROVAL

1 Definition of product and intended use

1.1 Definition of product

The European technical approval[4] (ETA) applies to a kit, the PT system

DYWIDAG – Post-tensioning bar tendon system,

comprising the following components:

- Tendon
  - Bonded bar tendon,
  - Unbonded bar tendon with free tendon duct,
  - Unbonded bar tendon without free tendon duct and
  - External bar tendon.
- Tensile element

Threadbars and plain bars made of prestressing steel, hot rolled, tempered from the rolling heat, stretched and annealed, with diameters and tensile strengths as given in Table 1.

Table 1: Tensile elements

Nominal bar diameter	mm	26.5	32	36	40	47
Threadbar (E)						
Designation	—	26 E	32 E	36 E	40 E	—
Nominal tensile strength R_m	N/mm²	1 030				
Threadbar (WR)						
Designation	—	26 WR	32 WR	36 WR	40 WR	47 WR
Nominal tensile strength R_m	N/mm²	1 050				
Plain bar (WS)						
Designation	—	—	32 WS	36 WS	—	—
Nominal tensile strength R_m	N/mm²	1 050				

NOTE 1 N/mm² = 1 MPa

[4] The European technical approval ETA-05/0123 was firstly issued in 2005 with validity from 19.09.2005, amended in 2008 with validity from 20.10.2008 and extended in 2010 with validity from 19.09.2010 to 18.09.2015.

- Anchorage and coupling
  - Stressing and fixed anchorage with anchor plate as solid plate, square, solid plate, rectangular or QR-plate and with domed anchor nut,
  - Fixed and movable coupling with coupler or transition coupler.
- Additional reinforcement in the anchorage zone
- Temporary and permanent corrosion protection systems for bar, coupling and anchorage

1.2 Intended use

The PT system is intended to be used for the prestressing of structures.

Use categories according to the type of tendon and material of structure:

- Internal bonded tendon for normal weight concrete, composite and masonry structures,
- Internal unbonded tendon for normal weight concrete, composite, steel, timber and masonry structures,
- External tendon for normal weight concrete, composite, steel, timber and masonry structures.

The provisions made in the European technical approval are based on an assumed intended working life of the PT system of 100 years with exception of three years for temporary corrosion protection. The indications given on the working life of the PT system cannot be interpreted as a guarantee given by the manufacturer or the approval Body, but are to be regarded only as a means for choosing appropriate components and materials in relation to the expected, economically reasonable working life of the construction works.

Bonded bar tendon – PT system

This section covers PT systems with bonded bar tendons. Additional specifications for PT systems of unbonded and external bar tendons are given in Clause 4.

2 Characteristics of product

2.1 Range and designation of anchorages and couplings

The components of anchorages and couplings are designated by the first two digits of the nominal bar diameter in mm, followed by "E" or "WR" for threadbar or "WS" for plain bar and a number allocated to the type of the component, e.g. anchor plate or coupler. An overview of the various types is given in Annex 1.

2.1.1 Anchorages

2.1.1.1 Stressing anchorages

The stressing anchorage consists of an anchor plate and normally a domed anchor nut with grout slots, see Annex 8. The anchor plate is fastened onto the formwork on site using a recess form, if required. The bar is fixed to the anchor plate by means of the domed anchor nut and the retaining nut.

The stressing anchorage can also be used as a fixed anchorage. In that case, a domed anchor nut without grout slots may be used.

At the anchorage the tendon layout shall provide a straight section over a length of at least 0.3 m ahead the end of the QR-plate or solid plate.

2.1.1.2 Fixed anchorages

The fixed anchorage consists of an anchor plate and a domed anchor nut with or without grout slots, see Annex 8. The domed anchor nut is tack welded perpendicularly onto the anchor plate at the factory. If the fixed anchorage is initially not completely embedded in concrete, a domed anchor nut with grout slots should be used.

At the anchorage the tendon layout shall provide a straight section over a length of at least 0.3 m ahead the end of the QR-plate or solid plate.

2.1.2 Couplings

2.1.2.1 Movable couplings D

The movable coupling D connects two bars by means of a coupler. The bars are stressed simultaneously, see Annexes 9 and 14.

2.1.2.2 Movable couplings G

The movable coupling G enables the direct connection of a bar to the stressing anchorage of an already stressed but still ungrouted tendon, see Annex 14. The bars can be stressed simultaneously.

2.1.2.3 Fixed couplings with grout cap

The fixed coupling with grout cap enables the direct connection of a bar to the stressing anchorage of an already stressed and grouted tendon, see Annexes 9 and 15.

2.2 Range and designation of tendons

Prestressing and overstressing forces are specified in the respective standards and regulations in force at the place of use. The maximum overstressing force applied to an tendon shall not exceed $0.95 \cdot F_{p0.1k}$ as given in Table 2. The maximum prestressing force at end of stressing shall not exceed $0.8 \cdot F_{pk}$ or $0.9 \cdot F_{p0.1k}$ as given in Table 2.

The designations of the tendons are given in Table 2 and the specifications and symbols of strength characteristics of the prestressing bars are given in the Annexes 30a and 30b.

Table 2: Maximum prestressing and overstressing forces

Designation	Nominal bar diameter	Nominal cross-sectional area	Maximum prestressing force[1)]	Maximum overstressing force[1), 2)]
Threadbar				
—	d_s	S_n	$0.9 \cdot F_{p0.1k}$	$0.95 \cdot F_{p0.1k}$
—	mm	mm^2	kN	kN
26 E	26.5	552	415	438
32 E	32	804	605	638
36 E	36	1 018	765	808
40 E	40	1 257	944	997

Designation	Nominal bar diameter	Nominal cross-sectional area	Maximum prestressing force[1)]	Maximum overstressing force[1), 2)]
—	d_s	S_n	$0.8 \cdot F_{pk}$	$0.95 \cdot F_{p0.1k}$
—	mm	mm²	kN	kN
26 WR	26.5	552	464	499
32 WR	32	804	676	722
36 WR	36	1 018	856	912
40 WR	40	1 257	1 056	1 131
47 WR	47	1 735	1 457	1 566
Plain bar				
—	d_s	S_n	$0.8 \cdot F_{pk}$	$0.95 \cdot F_{p0.1k}$
—	mm	mm²	kN	kN
32 WS	32	804	676	722
36 WS	36	1 018	856	912

1) The given values are maximum values according to Eurocode 2, i.e. $\min(k_1 \cdot f_{pk,}, k_2 \cdot f_{p0.1k})$ applies. The fulfilment of the stabilisation criteria and the requirements for crack widths in the load transfer tests were verified at $0.8 \cdot F_{pk}$.
$F_{pk} = S_n \cdot f_{pk}$
$F_{p0.1k} = S_n \cdot f_{p0.1k}$

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

Fatigue resistance has been tested with a stress variation of 80 N/mm² up to $2 \cdot 10^6$ load cycles.

2.3 Friction losses

For calculation of losses of prestressing forces due to friction, Coulomb's friction law applies. Calculation of friction loss is by the equation.

$$P_x = P_0 \cdot e^{-\mu \cdot (\theta + k \cdot x)}$$

Where

P_x........kN........ Prestressing force at a distance x from the stressing anchorage along the tendon

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

μ ....rad^{-1} ..... Friction coefficient, $\mu = 0.50$ rad^{-1} for threadbars and $\mu = 0.25$ rad^{-1} for plain bars

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

k ....rad/m ... Coefficient of unintentional angular deviation, $k = 8.7 \cdot 10^{-3}$ rad/m, corresponding to a wobble coefficient of $\beta = 0.5$ °/m

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

NOTE 1 rad = 1 m/m = 1

If longitudinal vibrations are applied to threadbars during stressing operations, the friction coefficient μ may be decreased to a reduced friction coefficient ${}_{red}\mu$. The longitudinal vibrations may be applied upon attainment of the allowable overstressing force. The reduced friction coefficient due to the application of longitudinal vibrations is to be calculated using the following equation.

$$ {}_{red}\mu = \mu \cdot \frac{\alpha + \beta \cdot l}{60} < \mu $$

Where

${}_{red}\mu$......... rad^{-1}...... Reduced friction coefficient

μ .... rad^{-1}...... Friction coefficient, $\mu = 0.50$ rad^{-1} for threadbars

α............ ° .... Sum of the angular displacements over the tendon length, irrespective of direction or sign

β .... °/m .... Wobble coefficient, $\beta = 0.5$ °/m

l .... m .... Tendon length

NOTE 1 rad = 1 m/m = 1

If longitudinal vibrations are applied to plain bars and the tendon length does not exceed 30 m, the reduced friction coefficient is ${}_{red}\mu = 0.15$ rad^{-1}.

Friction losses in anchorages are low and need not to be taken into consideration in design and execution.

2.4 Support of ducts

The ducts shall be secured in their positions. Spacing of duct support is up to 2.5 m.

2.5 Slip at anchorages and couplings

Slip at anchorages and couplings shall be taken into consideration in design and for determining tendon elongation. Table 3 specifies the slip values to be applied.

Table 3: Slip values

<table>
<tr><th rowspan="2">Nominal bar diameter</th><th rowspan="2">Anchor plate</th><th colspan="2">Slip at stressing anchorage</th><th>Slip at fixed anchorage</th><th>Slip at coupling</th></tr>
<tr><th>Slip to be considered for calculation of elongation</th><th>Slip at load transfer from the jack onto the anchorage</th><th colspan="2">Slip to be considered for calculation of elongation</th></tr>
<tr><td>mm</td><td>—</td><td>mm</td><td>mm</td><td>mm</td><td>mm</td></tr>
<tr><td colspan="6">Threadbar</td></tr>
<tr><td rowspan="2">26.5
32
36
40</td><td>Solid plate, square</td><td>1.5</td><td rowspan="2">1.7</td><td>3.2</td><td rowspan="2">2.0</td></tr>
<tr><td>Solid plate, rectangular, QR-plate</td><td>1.0</td><td>2.7</td></tr>
<tr><td>47</td><td>Solid plate, square</td><td>1.0</td><td>1.4</td><td>2.4</td><td>3.0</td></tr>
<tr><td colspan="6">Plain bar</td></tr>
<tr><td rowspan="2">32
36</td><td>Solid plate, square</td><td>1.5</td><td rowspan="2">0.7</td><td>2.2</td><td rowspan="2">1.0</td></tr>
<tr><td>Solid plate, rectangular</td><td>1.0</td><td>1.7</td></tr>
</table>

2.6 Centre and edge distances, concrete cover

The centre and edge distances of tendon anchorages given in the Annexes 10 to 13 shall be applied. They depend on the actual mean cylinder compressive strength of concrete at time of stressing, $f_{cm, 0, cyl}$.

The centre and edge distances of anchorages given in these Annexes may be reduced in one direction by up to 15 %, but shall not be lower than the outside dimensions of the additional reinforcement nor than the dimensions of the anchor plate. In case of a reduction of the distances in one direction, the centre and edge distances in the perpendicular direction shall be increased by the same percentage. The centric position of the additional reinforcement to the tendon axis shall be ensured by appropriate measures.

Verification of the transfer of the prestressing forces to the structural concrete is not required if the centre and edge distances of the tendons as well as grade and dimensions of additional reinforcement, see Annexes 12 and 13, are conformed to. The forces outside the area of the additional reinforcement shall be verified and, if necessary, covered by appropriate reinforcement. The reinforcement of the structure shall not be employed as additional reinforcement. Reinforcement exceeding the required reinforcement of the structure may be used as additional reinforcement if appropriate placing is possible.

If required for a specific project design, the reinforcement given in the Annexes 12 and 13 may be modified in accordance with the respective regulations in force at the place of use as well as with the relevant approval of the local authority and of the ETA holder to provide equivalent performance.

The concrete cover of the tendon may under no circumstances be less than 20 mm nor smaller than the concrete cover of the reinforcement installed in the same cross section. The concrete cover of the anchorage should be at least 20 mm. The respective standards and regulations on concrete cover in force at the place of use shall be considered.

2.7 Radii of curvature, working modulus

The minimum elastic radii of curvature min R_{el} not requiring cold bending as well as the minimum cold bent radii of curvature min R_{kv} are listed in Table 4. Thereby, the maximum prestressing forces given in Table 2 are applicable.

Table 4: Minimum elastic and cold bent radius of curvature

Designation	Minimum elastic radius of curvature	Minimum cold bent radius of curvature
—	min R_{el}	min R_{kv}
—	m	m
Threadbar		200 · d
26 E	65	5.3
32 E	75	6.4
36 E	85	7.2
40 E	100	8.0
26 WR	40	5.3
32 WR	40	6.4
36 WR	50	7.2
40 WR	60	8.0
47 WR	80	9.4
Plain bar		150 · d
32 WS	40	4.8
36 WS	50	5.4

The radius of curvature R may be less than the minimum elastic radius of curvature min R_{el}, see Table 4. In this case, the bars shall be cold bent. Cold bending may also be required for larger radii if the bar is not adapting itself to the intended curvatures, e.g. for very short tendons or horizontal layout. Cold bent radii of curvature R_{kv} less than the minimum cold bent radii of curvature min R_{kv}, see Table 4, may only be applied if their serviceability has been verified specifically.

If the bars are cold bent, the working modulus A for the determination of the tendon elongation shall be applied.

- A = 195 000 N/mm² where $500 \cdot d \leq R_{kv}$
- A = 185 000 N/mm² where $200 \cdot d \leq R_{kv} \leq 500 \cdot d$ (for threadbars)
- A = 185 000 N/mm² where $150 \cdot d \leq R_{kv} \leq 500 \cdot d$ (for plain bars)

For cold bending, only equipment which produces a uniform curvature and does not damage the bar, e.g. by friction marks etc., shall be used.

2.8 Strength of concrete

Concrete according to EN 206-1[5] shall be used.

The actual mean cylinder compressive strength of concrete at time of stressing, $f_{cm, 0, cyl}$, shall be at least as given in the Annexes 10 to 13.

2.9 Increased losses of prestressing forces at couplings

For verification of the limitation of crack widths and for verification of the stress range increased losses of prestressing forces at couplings due to creep and shrinkage of the concrete shall be taken into consideration. The determined losses of prestressing forces of tendons without the influence of couplings shall be multiplied by the factor 1.5 in the areas of fixed couplings. For movable couplings, increased losses of prestressing forces need not to be taken into consideration.

2.10 Couplings

With cold bent bars, couplings shall be installed in straight tendon sections ensuring a straight length of at least 0.3 m at both sides. The exact position of the straight tendon section shall be secured with special care by means of supports.

2.11 Bonded tendons in masonry structures – Load transfer to the structure

Load transfer of prestressing force to masonry structures shall be via concrete or steel members designed according to Clause 2.6 or Eurocode 3 respectively.

The concrete or steel members shall have dimensions as to permit a force of $1.1 \cdot F_{pk}$ being transferred into the masonry. The verification shall be done according to Eurocode 6 as well as to the respective standards and regulations in force at the place of use.

Bonded bar tendon – Components

This section covers components of bonded bar tendons. Additional specifications for components of unbonded and external bar tendons are given in Clause 4.

2.12 Bars

The characteristics of the bars are given in the Annexes 30a and 30b.

The bars are threadbars or plain bars with a circular cross section, made of prestressing steel Y1030H or Y1050H according to prEN 10138-4, hot rolled, tempered from the rolling heat, stretched and annealed.

[5] Standards and Guidelines referred to in the European technical approval are listed in the Annexes 32a and 32b.

2.12.1 Threadbars

Nominal diameters of threadbars are 26.5, 32, 36, 40 and 47 mm. The threadbars feature continuous hot rolled ribs providing a right-handed thread along the entire length.

2.12.2 Plain bars

Nominal diameters of plain bars are 32 and 36 mm. At both ends, the plain bars are provided with a special cold rolled thread.

2.13 Anchorages and couplings

The components of anchorages and couplings shall be in conformity with the specifications given in the Annexes and the technical documentation[6] of the European technical approval. Therein the components' dimensions, materials, material identification data with tolerances and the materials used in corrosion protection are specified.

2.13.1 Anchor plates

The anchor plates are the solid plates, square according to Annex 3, the solid plates, rectangular according to Annex 4 and the QR-plates according to Annex 5. All anchor plates provide a conical bore.

2.13.2 Anchor nuts

For stressing anchorages, the domed anchor nut with grout slots shall normally be used in order to permit both, injection and ventilation through the grout slots, see Annex 2. If the stressing anchorage is used as a fixed anchorage, the domed anchor nut without grout slots may be used.

For fixed anchorages, the domed anchor nut with or without grout slots may be used. At fixed anchorages, the nut is perpendicularly tack welded onto the anchor plate at the factory.

2.13.3 Couplers

Couplers according to Annex 6 are used. Transition couplers according to Annex 7 enable to couple threadbars and plain bars with the same nominal diameters.

2.14 Additional reinforcement

Steel grade, see Table 5, and dimensions, see Annexes 12 and 13, of the additional reinforcement shall be conformed to.

The centric position of the additional reinforcement to the tendon axis shall be ensured by appropriate measures.

2.15 Ducts

Steel strip ducts in accordance with EN 523 or plastic ducts in accordance with ETAG 013, Annex C.3 shall be applied.

In general, the bars are provided with ducts prior to installation. The steel strip ducts are coupled using duct sleeves C in accordance with EN 523. Around the coupling, a steel strip coupler tube in accordance with EN 523 is used.

2.16 Welding at anchorages

The domed anchor nut may be tack welded onto the anchor plate only at the factory.

After installation of the bars, no further welding operations shall be performed at the anchorages and immediate to the bars.

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[6] The technical documentation of the European technical approval is deposited at Österreichisches Institut für Bautechnik and, in so far as is relevant to the tasks of the approved body involved in the attestation of conformity procedure, is handed over to the approved body.

2.17 Material characteristics of the used components

Table 5: Material characteristics

Component	Standard / Specification
Solid plate, square	EN 10025
Solid plate, rectangular	EN 10025
QR-plate	EN 10083-2
Domed anchor nut, ∅ 26.5, 32, 36 mm	EN 10025
Domed anchor nut, ∅ 40, 47 mm	EN 10293
Domed anchor nut with grout slots, ∅ 26.5, 32, 36 mm	EN 10025
Domed anchor nut with grout slots, ∅ 40 mm	EN 10293
Couplers, ∅ 26.5, 32, 36 mm	EN 10083-2
Couplers, ∅ 40, 47 mm	Deposited at Österreichisches Institut für Bautechnik
Additional reinforcement	Ribbed reinforcing steel, $R_e \geq 500$ N/mm^2
Steel strip duct, Duct sleeve C, Coupler tube	EN 10139
Retaining nut	Deposited at Österreichisches Institut für Bautechnik
PE duct, Duct sleeve A, duct sleeve B, PE cap, hex nut with washer face, spacer	EN ISO 1872-1
Sealing ring	Natural rubber
Toroidal sealing ring	Neoprene
Grout cap	EN 10130

Bonded bar tendon – Assumptions

This section covers assumptions for bonded bar tendons. Additional assumptions for unbonded and external bar tendons are given in Clause 5.

3 Assumptions under which the fitness of the product for the intended use was favourably assessed

3.1 Manufacturing

The "DYWIDAG – Post-tensioning bar tendon system" is manufactured in accordance with the provisions of the European technical approval. Composition and manufacturing process are deposited at Österreichisches Institut für Bautechnik.

3.2 Design

3.2.1 General

Design and reinforcement of the anchorage zone shall permit correct placing and compacting of concrete.

Design of the structure shall permit correct installation, stressing and grouting of tendon. It should be noted that the diameters of the couplers are larger than the internal diameters of the ducts at the anchorages.

3.2.2 Movable couplings

The length of the coupler tube and its position relative to the coupling shall ensure unimpeded movement of the coupler in the coupler tube along a length of $1.2 \cdot \Delta L$, however at least of $\Delta L + 40$ mm, where ΔL in mm as the symbol for the expected movement, left and right, of the coupler.

3.2.3 Fixed couplings

Under all possible load combinations, the prestressing force at the coupling's side corresponding to the 2^{nd} construction stage shall at no time be higher than at the coupling's side corresponding to the 1^{st} construction stage, neither during construction nor in the final state.

3.2.4 Protection against dirt and water

If surface water or dirt can enter at the anchorage prior to grouting, a protective cap provided with a sealing ring shall be fastened onto the anchorage by means of a hex nut.

3.3 Installation

3.3.1 General

Assembly and installation of tendons shall only be by qualified PT specialist companies, which have the required resources and experience with the "DYWIDAG – Post-tensioning bar tendon system", see ETAG 013, Annex D.1. The respective standards and regulations in force at the place of use shall be considered. The company's PT site manager shall possess a certificate from the ETA holder, stating that she or he has been trained by the ETA holder and that she or he has the required qualifications and experiences with the "DYWIDAG – Post-tensioning bar tendon system".

3.3.2 Checking of tendons

During installation, careful handling of the tendons shall be ensured. Prior to placing of concrete, the person responsible shall perform a final check on the installed tendons.

3.3.3 Anchorages

3.3.3.1 Stressing anchorages

The individual components of the stressing anchorage are delivered to the construction site and assembled on the bar. If required by the design, a recess form shall be installed in the formwork.

On-site assembly comprises the following steps.

- Firstly, the retaining nut made of plastic is screwed onto the bar thread. The anchor plate, solid plate, square, solid plate, rectangular or QR-plate, is fixed onto the washer face of the retaining nut and clamped using the domed anchor nut, which shall be seated perpendicular to the anchor plate.
- The domed anchor nut is fastened tightly; thereby shearing off of the retaining nut's thread shall be avoided.

Stressing comprises the following steps.

- The pull rod coupler is threaded halfway onto the bar end.
- A hydraulic jack is positioned resting on the anchor plate, and the additional accessories for the jack are screwed onto the bar.
- The bar is stressed.
- During stressing, the domed anchor nut is continuously tightened. The revolutions of the nut are transmitted to a counter whereof the elongation can be determined. The force is monitored using manometer readings. The difference in length of the bar protrusion before and after stressing is determined as well.
- The measurement results are recorded in the stressing record.
- If longitudinal vibrations are to be applied, they are applied after attainment of the overstressing force, e.g. by strokes onto the front face of the bar.

3.3.3.2 Fixed anchorages

On-site assembly comprises the following steps.

- The duct sleeve B is threaded onto the bar and into the duct sleeve C and sealed using a chloride-free adhesive tape.
- The fixed anchorage, comprising an anchor plate and a domed anchor nut tack welded perpendicularly onto the anchor plate, is threaded onto the bar. The fixed anchorage shall be sufficiently secured in its position as to avoid unfastening.

3.3.4 Couplings

The couplings are shown in the Annexes 14 and 15.

On-site assembling comprises the following steps.

- Prior to installation, the threadbar respectively the thread of the plain bar shall be marked to enable control of the engagement length of the bar.
- If coupling is secured by gluing the bars ends into the coupler, the prestressing force may only be applied after the glue has sufficiently hardened.
- The coupler tube at the coupler shall be sealed using a chloride-free adhesive tape.

3.3.5 Sheathing

The sheathing consists of ducts with duct sleeves C.

On-site assembling shall consider:

- All joints of the connecting elements, e.g. retaining nuts, duct sleeves and ducts, shall be sealed using a chloride-free adhesive tape.
- In fixing the ducts, they shall not be damaged by compression.
- The vent and grout connections shall be installed tension proof.
- The sheathing of the couplings shall be secured in its position as to avoid unintentional displacement.
- If confusion is likely, the grout hoses shall be clearly marked, e.g. by using number plates.
- Prior to concrete placing, the sheathing shall be checked for damages.

3.3.6 Stressing and stressing records

3.3.6.1 Stressing

Upon attainment of the required mean cylinder compressive strength of the concrete, $f_{cm,\,0,\,cyl}$, in the anchorage zone, the maximum prestressing force may be applied, see Annexes 10 to 13. For partial prestressing with 30 % of the full prestressing force the actual mean value of the concrete compressive strength shall be at least $0.5 \cdot f_{cm\,0,\,cyl}$. Intermediate values may be interpolated linearly according to Eurocode 2. The respective standards and regulations in force at the place of use shall be considered.

Re-stressing of the tendons prior to final cutting of bar protrusions or grouting is permitted.

During stressing, the following instructions shall be observed:

- Until filling the tendon duct with cement grout, the prestressing force in the bar can be checked and corrected, if required, at any time.
- Straight tendons are stressed from one end. For curved tendons, stressing from both ends can be advisable in particular to avoid higher losses of prestressing forces due to friction.
- The thread of the retaining nut is deformed during stressing. The domed anchor nut features grout slots to permit penetration of grout into the cap during grouting.

3.3.6.2 Stressing records

All stressing operations shall be recorded for each tendon. In general, the required prestressing force is applied. The elongation is measured and compared with the calculated value.

3.3.6.3 Stressing equipment, space requirements and safety-at-work

For stressing, hydraulic jacks are used. Information about the stressing equipment has been submitted to Österreichisches Institut für Bautechnik.

To stress the tendons, clearance of approximately 1 m shall be considered directly behind the anchorages.

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

3.3.7 Grouting of tendons

3.3.7.1 Grout

Common grout according to EN 447 shall be used. For the grouting procedure, EN 446 applies.

3.3.7.2 Grouting

Grouting speed shall be between 5 and 15 m/min.

For tendon lengths exceeding 50 m, additional grouting inlets shall be installed.

For tendon paths with distinct high points, special post-grouting procedures shall be performed to avoid voids in the hardened grout. The design of the structure shall already have considered the required measures.

Following stressing, the grout is injected into the void between bar and duct. Thereby, bond between bar and concrete is established. To ensure correct filling of the voids, the following shall be considered in addition to EN 446.

- Only mixing and grouting equipment as permitted by the ETA holder shall be used.
- All vents and grouting inlets shall be sealed immediately after grouting to prevent escaping of grout from the duct. To ensure the duct is correctly filled up to the domed anchor nut at the stressing anchorage as well as at the fixed anchorage not embedded in concrete, grout shall penetrate through the grout slots of the domed anchor nut. Only then the vents may be closed, e.g. with plugs.
- Obstructed, ungrouted ducts shall be reported immediately to the responsible PT site manager.
- All grouting operations shall be recorded in detail in an injection data sheet. The respective standards and regulations in force at the place of use shall be conformed to.

3.3.8 Couplings

With the fixed coupling, a toroidal sealing ring (natural rubber, CR) shall be inserted between grout cap and coupler tube end piece and tightened using a flat hex nut. The bar at the toroidal sealing ring, the flat hex nut and the grout cap, see Annex 15, shall be provided with Denso-Jet or an equivalent corrosion protection compound that does not have an affect on the rubber.

Unbonded and external bar tendon – PT system

This section covers unbonded and external bar tendons. The specifications for bonded bar tendons are given in Clause 2 and in principle apply also to unbonded and external bar tendons.

4 Characteristics of product

4.1 Range and designation of anchorages and couplings

The components of anchorages and couplings are designated by the first two digits of the nominal bar diameter in mm, followed by "E" or "WR" for threadbar or "WS" for plain bar and a number allocated to the type of the component, e.g. anchor plate or coupler. An overview of the various types is given in Annex 1.

4.1.1 Anchorages – Stressing and fixed anchorages

The stressing and the fixed anchorage consists of an anchor plate and a domed anchor nut, see Annex 16.

4.1.2 Couplings – Movable couplings D

The movable coupling D connects two bars by means of a coupler. The bars are stressed simultaneously, see Annexes 17 and 20.

4.2 Range and designation of tendons

Prestressing and overstressing forces are specified in the respective standards and regulations in force at the place of use. Table 2 lists the maximum values and the designation of the tendons.

The specifications of the prestressing bars are given in the Annexes 30a and 30b.

4.3 Friction losses

Unbonded and external bar tendons are straight tendons only. Losses of prestressing force due to friction need generally not be taken into account.

4.4 Centre and edge distances, concrete cover

The centre and edge distances of tendon anchorages given in the Annexes 18 and 19 shall be applied. They depend on the actual mean cylinder compressive strength of concrete at time of stressing, $f_{cm,\,0,\,cyl}$.

4.5 Load transfer to the structure

4.5.1 External tendons in steel and composite structures

Transfer of prestressing force to steel structure shall be designed according to Eurocode 3 as well as to the respective standards and regulations in force at the place of use.

The design of the load transfer region shall permit a force of $1.1 \cdot F_{pk}$ being transferred into the steel or composite structure.

4.5.2 Unbonded tendons and external tendons in masonry structures

Transfer of prestressing force to masonry structures shall be via concrete or steel members designed according to Clause 4.4 or Eurocode 3 respectively.

The concrete or steel members shall have such dimensions as to permit a force of $1.1 \cdot F_{pk}$ being transferred into the masonry. The verification shall be done according to Eurocode 6 as well as to the respective standards and regulations in force at the place of use.

4.5.3 Unbonded tendons and external tendons in timber structures

Transfer of prestressing force to timber structures shall be via steel members designed according to Eurocode 3.

The steel members shall have such dimensions as to permit a force of $1.1 \cdot F_{pk}$ being transferred into the timber structure. The verification shall be done according to Eurocode 5 as well as to the respective standards and regulations in force at the place of use.

Unbonded and external bar tendon – Components

This section covers components of unbonded and external bar tendons. The specifications for components of bonded bar tendons are given in Clause 2 and in principle apply also to unbonded and external bar tendons.

4.6 Anchorages and couplings

4.6.1 Anchor plates

The anchor plates are solid plates, square according to Annex 3 and solid plates, rectangular according to Annex 4. All anchor plates provide a conical bore. Connection tubes are welded watertight onto the anchor plates at the factory, see Annex 16.

4.6.2 Anchor nuts

For stressing and fixed anchorages, the domed anchor nut with or without grout slots may be used, see Annex 2.

4.6.3 Couplers

Couplers according to Annex 6 shall, in general, be secured to ensure that no unscrewing occurs. This is attained using appropriate safety devices, e.g. lock nuts for plain bars and angular cuts on threadbars. If threadbars are made with an angular cut, coupler L type 3303, Annex 6, shall be used.

4.7 Additional reinforcement

Steel grade, see Table 5, and dimensions, see Annex 19, of the additional reinforcement shall be conformed to.

If required for a specific project design, the reinforcement given in Annex 19 may be modified in accordance with the respective regulations in force at the place of use as well as with the relevant approval of the local authority and of the ETA holder to provide equivalent performance.

The centric position of the additional reinforcement to the tendon axis shall be ensured by appropriate measures.

4.8 Sheathing

For sheathing of bars, smooth PE or steel tubes are used.

The dimensions given in the Annexes 21 to 25b are standard dimensions. The minimum nominal wall thickness of PE-tubes shall be 2 mm, of steel tubes 2 mm or, if used as a mechanical protection for heat-shrinking sleeves, 1 mm. Steel tubes shall conform to EN 10305-1. To compensate tolerances, the wall thicknesses of the tubes may be increased.

If steel tubes are used for permanent corrosion protection of tendons, which are filled with cement grout prior to installation, see Annex 22, only steel tubes with a length of maximum 12 m and without weld joints shall be used. Their internal surface shall be coated with RUST-BAN 393 or 397 at the factory.

4.9 Corrosion protection

4.9.1 General

Unbonded tendons with a free tendon duct and external tendons are provided either with a permanent or temporary corrosion protection. Unbonded tendons without free tendon duct are provided with a permanent corrosion protection only.

End anchorages and couplings shall be completely filled with the respective specified corrosion protection material. All joints and connections shall be carefully sealed using the prescribed material. The given insertion and overlapping lengths shall be observed, see Annexes 21 to 28.

The bar shall be dry, clean and free from rust prior to applying the coatings or shrinking on the heat-shrinking sleeve. The corrosion protection shall be applied under dry conditions.

The heat-shrinking sleeve shall be shrunk on using hot air or infrared radiation. The wall thickness following shrinking shall be at least 1 mm.

For unbonded tendons with free tendon duct, the tendon duct shall always be dry. This shall be attained using appropriate measures.

For tendons with permanent corrosion protection, corrosion protection of anchorages, steel tubes as well as all other exposed steel parts is attained as follows.

All exposed or outside surfaces of steel parts, e.g. connection tubes, anchorage components and caps, insufficiently covered with concrete shall be protected against corrosion using one of the protection systems specified below.

- Corrosion protection system without metallic coating

  EN ISO 12944-5/S5.12, /S5.13, /S5.15, /S5.16 and /S8.08

- Corrosion protection system with hot dip zinc coating

  EN ISO 12944-5/S9.10, /S9.11, /S9.12 and /S9.13

Surfaces shall be prepared in accordance with EN ISO 12944-4. To apply the corrosion protection, EN ISO 12944-7 shall be observed.

For tendons with temporary corrosion protection, the exposed steel parts other than prestressing steel need not to be protected if not required for aesthetic reasons.

For PE-tubes, corrosion protection measures are not required.

If heat-shrinking sleeves are used, a hot dip zinc coated steel tube shall be installed according to Annex 24. Inner and outer surfaces of the steel tube are hot dip zinc coated in accordance with EN ISO 1461.

If grout is used, see Annexes 22 and 23, the grout shall conform to EN 446. Grouting shall be in accordance with EN 447 and as given in the technical documentation of the European technical approval. The respective standards and regulations in force at the place of use shall be observed.

Table 6: Materials for corrosion protection systems depending on the temperature of construction works during working life

Temperature of structure around tendon	Corrosion protection tapes for the bar in accordance with relevant clauses of EN 12068	Corrosion protection compounds for anchorages and couplings
Up to + 45 °C	Densoflex-Binde from Denso, Leverkusen Kebu-Binde KF "spezial" from Kebulin-Gesellschaft, Kettler	Denso-Jet and Denso-Cord from Denso, Leverkusen Petro Plast from Neuber, Rheinbach
Above + 45 °C	Densocal-Binde from Denso, Leverkusen	Denso-Fill from Denso, Leverkusen Visconorust 2889 from Viscosity Oil Company, Chicago

4.9.2 Unbonded tendons with free tendon duct and external tendons

4.9.2.1 Temporary corrosion protection

The bar shall be provided with a corrosion protection coating, e.g. DYWIPOX® TE, in accordance with EN ISO 12944-5, with a thickness of at least 200 µm, and shall be installed within a smooth PE-tube in accordance with EN 12201-1, see Annex 21.

4.9.2.2 Permanent corrosion protection

Two corrosion protection systems may be applied.

4.9.2.2.1 Corrosion protection with grout

The bar is sheathed with a PE- or steel tube and centred using spacers at a distance of maximum 1 m. The gap between the bar and PE-tube is filled with grout in accordance with EN 446. The thickness of the grout shall be at least 5 mm. Grouting can be performed prior to tendon installation or after stressing.

If grouting is prior to installation, duct sleeves B shall be installed at both ends of the sheathing, and over a length of approximately 100 mm a corrosion protection coating, e.g. DYWIPOX® TE, shall be applied on the bar, see Annex 22. The length of a grouted section with PE-tubes shall not exceed 50 m. For tendons with a length of more than 50 m, additional grouting inlets shall be installed.

Grouting after stressing shall be applied for plain bars only, using a domed anchor nut with grout slots.

- Grouting prior to tendon installation, see Annex 22.

  Steel tubes shall be without weld joints and their lengths shall not exceed 12 m. After application of the external corrosion protection coating, the steel tubes shall be flushed using RUST-BAN 393 or 397, which shall have dried prior to inserting the bar.

  For grouting, the tendon shall be supported in a slightly inclined position, vibration-free and protected from sunlight until the cement grout has sufficiently set and hardened. The grout is injected through the lower duct sleeve.

- Grouting after stressing, see Annex 23.

  With plain bars, the grout is injected, as in case of bonded tendons, through the grout slots of the domed anchor nut using a grout cap. Post-grouting is usually required, particularly if the inclination of the tendon is greater than 30 °.

4.9.2.2.2 Corrosion protection using heat-shrinking sleeves

Prior to installation, a SATM or CPSM heat-shrinking sleeve with inner coating, see Annex 31, is shrunk onto the bar. For mechanical protection, a smooth steel tube in accordance with EN 10305-1, hot dip zinc coated on the inner and outer surface, or a smooth PE-tube in accordance with EN 12201-1 is slipped over the bar with applied heat-shrinking sleeve, see Annex 24.

4.9.3 Unbonded tendons without free tendon duct

Directly behind and within the fixed anchorage embedded in concrete, the bar is protected by the concrete. Corrosion protection of the bar is attained by means of a heat-shrinking sleeve. A PE-tube is slipped over the entire length of the heat-shrinking sleeve in order to protect it.

The heat-shrinking sleeve is installed as described in Clause 4.9.1. At the fixed anchorage, the tube ends approximately 100 mm ahead the end of the heat-shrinking sleeve and shall be sealed against the heat-shrinking sleeve using a chloride-free adhesive tape or a heat-shrinking sleeve, see Annexes 25a and 25b. At the stressing anchorage, the PE-tube shall be sealed against the connecting tube in the same way.

4.9.4 Anchorages

All anchor plates including the connection tubes, if not sufficiently covered with concrete, shall be appropriately coated on their exposed surfaces, see Clause 4.9.1. For temporary corrosion protection, this may only be required for aesthetic reasons.

The void between the connection tube and the bar is filled with corrosion protection compound or a corrosion protection tape. For tendons with free tendon duct and plain bars, this is not required if the grout is injected after stressing, see Clause 4.9.2.2.1.

The domed anchor nuts are protected against corrosion using caps filled with corrosion protection compound, corrosion protection tapes or grout, see Annex 28. If no or only low mechanical stress is to be expected, a PE cap with hex nut is fastened onto the bar and sealed with two sealing rings. For high mechanical stress, e.g. in case of accessible anchorages, a corrosion protected thick walled steel cap, t ≥ 4 mm, with a sealing ring is fastened onto the anchor plate with screws.

For filling the gap between the bar and connection tube, two methods can be used.

- The connection tube is filled with a corrosion protection compound prior to slipping on the anchorage.
- The bar is covered wrinkle-free with a corrosion protection tape until the outside diameter corresponds approximately to the internal diameter of the connection tube. The outside of the PE-tube in the overlapping area shall be additionally covered with corrosion protection compound.

To ensure correct filling, in case of accessible fixed anchorages the corrosion protection compound shall penetrate through the domed anchor nut during threading on of the anchorage and in case of stressing anchorages after stressing. Otherwise additional corrosion protection compound shall be injected.

4.9.5 Couplings

4.9.5.1 Unbonded tendons with free tendon duct and external tendons

4.9.5.1.1 Temporary corrosion protection

The smooth tubes slipped over the bar are pushed against the coupling, see Annex 26. A heat-shrinking sleeve is shrunk onto the coupler overlapping the tubes over at least 100 mm.

4.9.5.1.2 Permanent corrosion protection

The coupling is sheathed with a coupler tube made of steel, with a wall thickness, t, of at least 2 mm, or PE, with a wall thickness, t, of at least 2 mm, with transition pieces made of steel, with a wall thickness, t, of at least 0.8 mm, or PE, with a wall thickness, t, of at least 2 mm, at both ends. The joints between the tube and the transition pieces shall be sealed with a heat-shrinking sleeve; see Annex 26.

The void is filled with grout in accordance with EN 446 or a corrosion protection compound or tape. The corrosion protection tape is wrapped wrinkle-free around the bar until the outside diameter of the bar corresponds approximately to the internal diameter of the coupler tube, which is slipped on tightly. If grouting is to be applied, grouting inlets and vents shall be installed.

4.9.5.2 Unbonded tendons without free tendon duct

The coupling is sheathed with a duct in accordance with EN 523 with transition pieces at both ends, see Annex 27. The joints of the sheathing shall be sealed using chloride-free adhesive tape or a heat-shrinking sleeve.

The void is filled with corrosion protection compound. If necessary, vents shall be installed.

Unbonded and external bar tendon – Assumptions

This section covers assumptions of unbonded and external bar tendons. The assumptions for bonded bar tendons are given in Clause 3 and in principle apply also to unbonded and external bar tendons.

5 Assumptions under which the fitness of the product for the intended use was favourably assessed

5.1 Manufacturing

The "DYWIDAG – Post-tensioning bar tendon system" is manufactured in accordance with the provisions of the European technical approval. Composition and manufacturing process are deposited at Österreichisches Institut für Bautechnik.

Unbonded tendons may be manufactured at the factory as prefabricated tendons or on site. Prefabricated tendons shall leave the factory only provided with the appropriate corrosion protection and sealed at both ends. For permanent corrosion protection, the cement grout may also be injected on site. In this case any manufacturing on site shall be performed according to the installation guideline of the ETA holder and shall be supervised by the ETA holder.

5.2 Design

5.2.1 General

Design and reinforcement of the anchorage zone shall permit correct placing and compacting of concrete.

Unbonded tendons shall only be with straight tendon paths.

Design of the structure shall permit correct installation, stressing and grouting of tendon. It should be noted that the diameters of the couplers including corrosion protection are larger than the internal diameters of the ducts at the anchorages.

5.2.2 Protection against dirt and water

If surface water or dirt can enter at the anchorage prior to grouting, a protective cap provided with a sealing ring shall be fastened onto the anchorage by means of a hex nut, see Annex 28.

5.2.3 Safety against shooting out of the bar

Prevention of shooting out of the bar in case of a bar failure shall be ensured. The safety devices shown in Annex 29 shall be designed based on the expected impact force/energy.

5.3 Installation

5.3.1 General

Assembly and installation of tendons shall only be by qualified PT specialist companies, which have the required resources and experience with the "DYWIDAG – Post-tensioning bar tendon system", see ETAG 013, Annex D.1. Standards and regulations in force at the place of use shall be considered. The company's PT site manager shall possess a certificate from the ETA holder, stating that she or he has been trained by the ETA holder and that she or he has the required qualifications and experiences with the "DYWIDAG – Post-tensioning bar tendon system".

5.3.2 Checking of tendons and repair of the corrosion protection

Tendons with free tendon duct are usually installed after placing of concrete. Check and, if necessary, repair shall be ensured by the person responsible.

5.3.3 Anchorages

For tendons with free tendon duct, the bar is usually provided with one anchorage prior to installation. The other anchorage is installed on the structure.

For tendons without free tendon duct, both anchorages are usually installed on the bar prior to installation.

5.3.3.1 Stressing anchorages

On-site assembly comprises the following steps.

- During installation, the corrosion protection compound is applied in the anchor plate and connection tube.
- The applied corrosion protection shall not be damaged. For unbonded tendons with free tendon duct, the tendons shall be lifted for insertion into the structure in order to prevent the tube from rubbing on the concrete edge at the beginning of the tendon. If required, an auxiliary insertion device shall be used. Corrosion protected steel tubes shall be inserted protected by a PE-tube, which is subsequently pulled out.
- The bearing surface of the anchor plate shall be positioned perpendicular to the tendon. If required, a compensating layer shall be applied.
- In general, Clause 4.9 shall be observed for corrosion protection.
- The pull rod coupler is threaded halfway onto the bar end.
- A hydraulic prestressing jack is positioned resting on the anchor plate, and the additional accessories for the jack are screwed onto the bar.
- The bar is stressed.
- During stressing, the domed anchor nut is continuously tightened. The revolutions of the nut are transmitted to a counter whereof the elongation can be determined. The force is monitored using manometer readings. The difference in length of the bar protrusion before and after stressing is determined as well.
- The measurement results are recorded in the stressing record.
- Re-stressing of the tendons to increase or decrease the prestressing force is permitted.
- For grouted tendons with free tendon duct and steel tubes, the prestressing force shall firstly be increased to the maximum stressing force according to Table 2 and subsequently completely relaxed. Then the final prestressing force can be applied.

5.3.3.2 Fixed anchorages

For tendons without free tendon duct, anchor plates without connection tubes are used at the fixed anchorages.

5.3.4 Couplings

During on-site assembly, it shall be ensured that for tendons without free tendon duct the coupler and for tendons with free tendon duct the sheathing of the coupling enables the required movement.

5.3.5 Stressing and stressing records

5.3.5.1 Stressing

Upon attainment of the required mean cylinder compressive strength of concrete, $f_{cm, 0, cyl}$, in the anchorage zone, the maximum prestressing force may be applied, see Annexes 18 and 19. For partial prestressing with 30 % of the full prestressing force the actual mean value of the concrete compressive strength shall be at least 0.5 · $f_{cm\,0,\,cyl}$. Intermediate values may be interpolated linearly according to Eurocode 2. The respective standards and regulations in force at the place of use shall be considered.

Re-stressing of the bars prior to final cutting of bar protrusions or grouting is permitted.

5.3.5.2 Stressing records

All stressing operations shall be recorded for each tendon. In general, the required prestressing force is applied. The elongation is measured and compared with the calculated value.

5.3.5.3 Stressing equipment, space requirements and safety-at-work

For stressing, hydraulic jacks are used. Information about the stressing equipment has been submitted to Österreichisches Institut für Bautechnik.

To stress the tendons, clearance of approximately 1 m shall be considered directly behind the anchorages.

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

Bonded, unbonded and external bar tendon

6 Characteristics of product, methods of verification and identification

6.1 Dangerous substances

The release of dangerous substances is determined according to ETAG 013, Clause 5.3.1. The PT system conforms to the provisions of Guidance Paper H[7] relating to dangerous substances.

A manufacturer's declaration in this respect was made by the manufacturer.

In addition to the specific clauses relating to dangerous substances contained in the European technical approval, there may be other requirements applicable to the product falling within its scope (e.g. transposed European legislation and national laws, regulations and administrative provisions). In order to meet the provisions of the Construction Products Directive, these requirements need also to be conformed to, when and where they apply.

6.2 Methods of verification

The assessment of the fitness of the "DYWIDAG – Post-tensioning bar tendon system" for the intended use in relation to the requirements for mechanical resistance and stability in the sense of Essential Requirement 1 of the Council Directive 89/106/EEC has been made according to the Guideline for European technical approvals of "Post-Tensioning Kits for Prestressing of Structures", ETAG 013, Edition June 2002, based on the provisions for all systems.

6.3 Identification

The European technical approval for the "DYWIDAG – Post-tensioning bar tendon system" is issued on the basis of agreed data, deposited with Österreichisches Institut für Bautechnik, which identifies the "DYWIDAG – Post-tensioning bar tendon system" that has been assessed and judged. Changes to the production process of the "DYWIDAG – Post-tensioning bar tendon system", which could result in this deposited data being incorrect, should be notified to Österreichisches Institut für Bautechnik before the changes are introduced. Österreichisches Institut für Bautechnik will decide whether or not such changes affect the European technical approval and consequently the validity of the CE marking on the basis of

[7] Guidance Paper H: A harmonised approach relating to dangerous substances under the Construction Products Directive, Rev. September 2002.

the European technical approval and, if so, whether further assessment or alterations to the European technical approval are considered necessary.

7 Evaluation of conformity and CE marking

7.1 Attestation of conformity system

The system of attestation of conformity assigned by the European Commission to this product in accordance with Council Directive 89/106/EEC of 21 December 1988, Annex III (2) (i), referred to as system 1+, provides for:

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

(a) Tasks for the manufacturer

(1) Factory production control;

(2) Further testing of samples taken at the factory by the manufacturer in accordance with the prescribed test plan[8];

(b) Tasks for the approved body

(3) Initial type-testing of the product;

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

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

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

7.2 Responsibilities

7.2.1 Tasks for the manufacturer – Factory production control

At the manufacturing plant, the manufacturer shall implement and continuously maintain a factory production control system. All the elements, requirements and provisions adopted by the manufacturer shall be documented systematically in the form of written operating and process instructions. The factory production control system shall ensure that the product is in conformity with the European technical approval.

Within the framework of factory production control, the manufacturer shall carry out tests and controls in accordance with the prescribed test plan, which is fixed with the European technical approval. Details of the extent, nature and frequency of testing and controls to be performed within the factory production control shall correspond to this prescribed test plan, which forms part of the technical documentation of the European technical approval.

The results of factory production control shall be recorded and evaluated. The records shall include at least the following information:

- Designation of the products and of the basic materials,
- Type of control or testing,
- Date of manufacture of the products and date of testing of the products or basic materials or components,
- Result of control and testing and, if appropriate, comparison with requirements,
- Name and signature of person responsible for factory production control.

[8] The prescribed test plan has been deposited at Österreichisches Institut für Bautechnik and is handed over only to the approved body involved in the conformity attestation procedure. The prescribed test plan is also referred to as control plan.

On request, the records shall be presented to Österreichisches Institut für Bautechnik.

If test results are unsatisfactory, the manufacturer shall immediately take measures to eliminate the defects. Construction products which are not in conformity to the requirements shall be removed. After elimination of the defect the respective test shall be repeated immediately, if technically required for verification.

The basic elements of the prescribed test plan conform to ETAG 013, Annex E.1 and are specified in the quality management plan of the "DYWIDAG – Post-tensioning bar tendon system".

Table 7: Contents of the prescribed test plan

Component	Item	Test / Check	Traceability	Minimum frequency [1]	Documentation
Domed anchor nut, Coupler	Material	Check	full [2]	100 %	"3.1" [3]
	Detailed dimensions [4]	Test		5 % [5] ≥ 5 specimen	yes
	Strength [6]	Test		0.5 % ≥ 5 specimen per batch	yes
	Visual inspection [7]	Check		100 %	no
Solid plate, square, Solid plate, rectangular, QR-plate	Material	Check	full [2]	100 %	"3.1" [3]
	Detailed dimensions [4]	Test		3 % [8] ≥ 2 specimen	yes
	Visual inspection [7], [9]	Check		100 %	no
Rolled-on special thread of plain bar	Material	Check	full [2]	100 %	"3.1" [3]
	Visual inspection [7], [10]	Check		100 %	no
Threadbar, Plain bar [11]	Material	Check	"CE"	100 %	"CE"
	Diameter	Test		each bundle	no
	Visual inspection [7]	Check		each bundle	no

Component	Item	Test / Check	Trace-ability	Minimum frequency [1]	Documen-tation
Duct	Material	Check	"CE"	100 %	"CE"
	Visual inspection	Check		100 %	no
Components of the corrosion protection system (tube, cap, etc.)	Visual inspection [7]	Check	full [2]	100%	no

[1] All samples shall be randomly selected and clearly identified.
[2] full: Full traceability of each component to its raw material.
[3] "3.1": Inspection certificate "3.1" according to EN 10204.
[4] Detailed dimensions: Measurement of all external dimensions and angles according to the specification given in the prescribed test plan.
[5] In case of a continuous manufacture without retooling of at least 1000 parts, the frequency may be reduced to 1 % with at least 1 specimen per shift. The stability of the process of the continuous manufacture shall be verified.
[6] Strength: Determination of strength by means of hardness tests or similar.
[7] Visual inspection: E.g. main dimensions of threads, gauge testing, correct marking or labelling, surfaces, ribs, kinks, smoothness, corrosion protection, corrosion, notches, coating, as given in the prescribed test plan.
[8] In case of a continuous manufacture without retooling of at least 1000 parts, the frequency may be reduced to 1 % with at least 1 specimen per day. The stability of the process of the continuous manufacture shall be verified.
[9] Visual inspection: All conical bores for accommodation of the domed anchor nuts in regard to angle, diameter and surface grade.
[10] Visual inspection: Dimensions of the rolled-on thread of the plain bar.
[11] As long as the basis for CE marking for prestressing steel is not available, an approval or certificate according to the respective standards and regulations in force at the place of use shall accompany each delivery.

7.2.2 Tasks for the approved body

7.2.2.1 Initial type-testing of the product

For initial type-testing, the results of the tests performed as part of the assessment for the European technical approval may be used unless there are changes in the manufacturing process or plant. In such cases, the necessary initial type-testing shall be agreed between Österreichisches Institut für Bautechnik and the approved body involved.

7.2.2.2 Initial inspection of factory and of factory production control

The approved body shall ascertain that, in accordance with the prescribed test plan, the manufacturing plant, in particular personnel and equipment, and the factory production control are suitable to ensure a continuous and orderly manufacturing of the PT system according to the specifications mentioned in Section II as well as in the Annexes of the European technical approval.

7.2.2.3 Continuous surveillance

The kit manufacturer shall be audited at least once a year by the approved body. Each component manufacturer of the components listed in Table 8 shall be audited at least once in five years. It shall be verified that the system of factory production control and the specified manufacturing process are maintained taking account of the prescribed test plan.

The results of product certification and continuous surveillance shall be made available on demand by the approved body to Österreichisches Institut für Bautechnik. In cases where the provisions of the European technical approval and of the prescribed test plan are no longer fulfilled, the certificate of conformity shall be withdrawn and Österreichisches Institut für Bautechnik informed immediately.

7.2.2.4 Audit testing of samples taken at the factory

During surveillance inspections, the approved body shall take samples at the manufacturing plant of components of the kit or individual components, for which the European technical approval has been granted for independent testing. For the most important components, Table 8 given below summarises the minimum procedures, which shall be performed by the approved body.

Table 8: Audit testing

Component	Item	Test / Check [1]	Sampling – Number of components per visit
Domed anchor nut, coupler	Material according to specification	Test / Check	2
	Detailed dimensions	Test	1
	Visual inspection [2]	Check	5
Solid plate, square, Solid plate, rectangular, QR-plate	Material according to specification	Test / Check	2
	Detailed dimensions	Test	
	Visual inspection [2]	Check	
Rolled-on special thread of plain bar	Material according to specification	Test / Check	2
	Visual inspection [2]	Check	
Single tensile element test	According to ETAG 013, Annex E.3	Test	1 series

[1] All samples shall be randomly selected and clearly identified.

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

7.3 CE marking

The delivery note, associated with the components of the PT system, shall contain the CE marking. The symbol "CE" shall be followed by the identification number of the certification body and shall be accompanied by the additional information:

- Name or identifying mark and address of manufacturer and manufacturing plant;
- The last two digits of the year in which the CE marking was affixed;
- Number of the European technical approval;
- Number of the certificate of conformity;
- Identification of the product (trade name).

8 Recommendations for the manufacturer

8.1 Recommendations on packaging, transport and storage

The ETA holder shall keep available instructions concerning:

- Temporary protection of bars and components in order to prevent corrosion during transportation from the production site to the job site.
- Transportation, storage and handling of the bars and of other components as to avoid any mechanical, chemical or electrochemical changes.
- Protection of bars and other components from moisture.
- Shielding of bars when welding operations are performed.

8.2 Recommendations on installation

The installation guidelines of the ETA holder shall be followed, see ETAG 013, Annex D.3. The respective standards and regulations in force at the place of use should be observed.

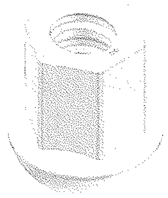
8.3 Accompanying information

It is the responsibility of the ETA holder to ensure that all necessary information (design and installation) is submitted to those responsible for design and execution of the works constructed with the "DYWIDAG – Post-tensioning bar tendon system".

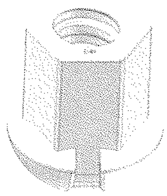
On behalf of Österreichisches Institut für Bautechnik

Rainer Mikulits

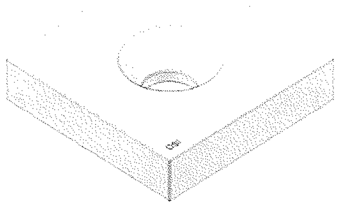
Managing Director



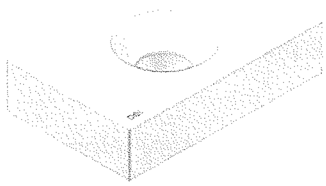
Domed anchor nut
2001



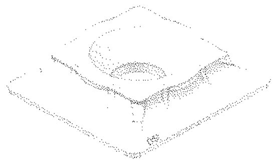
Domed anchor nut with grout slots
2099



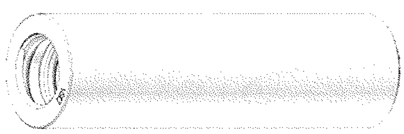
Solid plate, square
2011



Solid plate, rectangular
2012

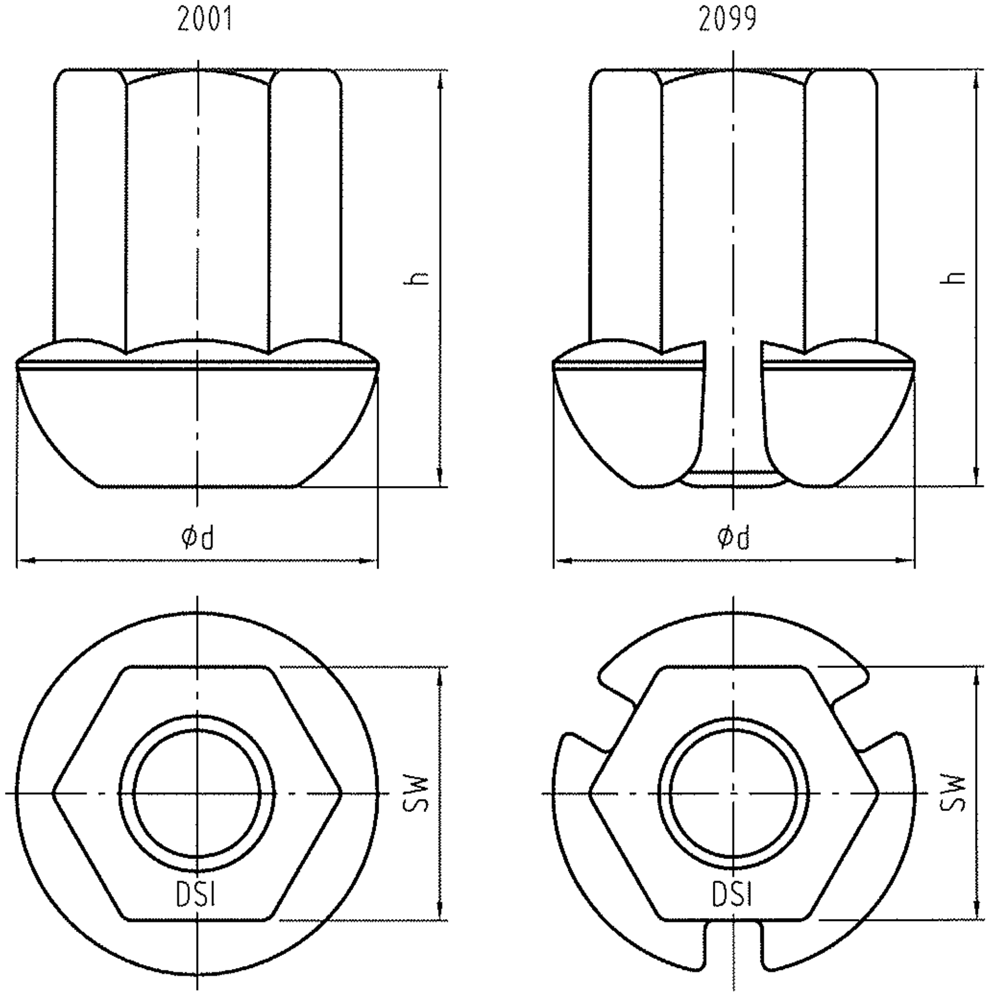


QR-plate
2074



Coupler, Coupler L
3003, 3303
Transition coupler
3004

Member of EOTA



Prestressing bar	Nominal bar diameter	SW	Ø d	h
	mm	mm	mm	mm
Threadbar	Ø 26.5	50	72	75
	Ø 32	60	80	90
	Ø 36	65	90	100
	Ø 40	70	100	115
	Ø 47*	80	110	135
Plain bar	Ø 32	55	72	46
	Ø 36	65	90	60

* 47 WR 2099 is not available.

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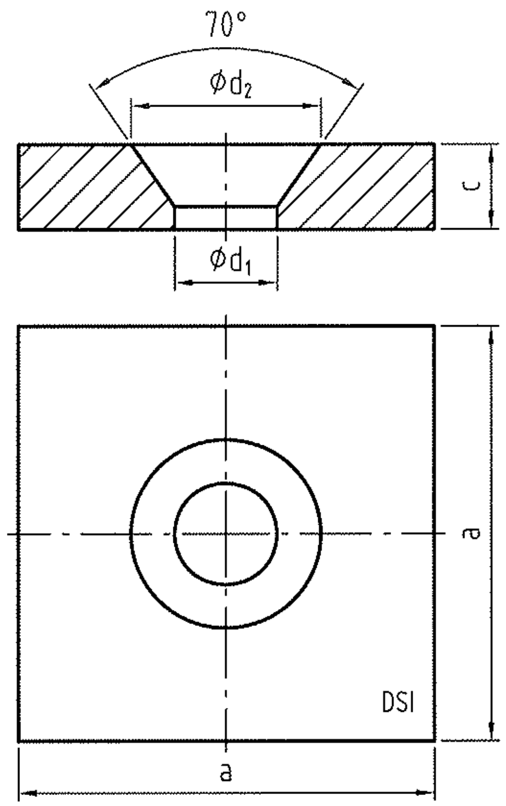
DYWIDAG-PT bar tendon, bonded, unbonded and external tendon

Domed anchor nut 2001
Domed anchor nut with grout slots 2099

Annex 2



Prestressing bar	Nominal bar diameter	a	c	∅ d_1	∅ d_2
	mm	mm	mm	mm	mm
Threadbar	∅ 26.5	150	35	39	72
	∅ 32	180	40	45	82
	∅ 36	200	45	49	92
	∅ 40	220	45	54	100
	∅ 47	260	50	64	110

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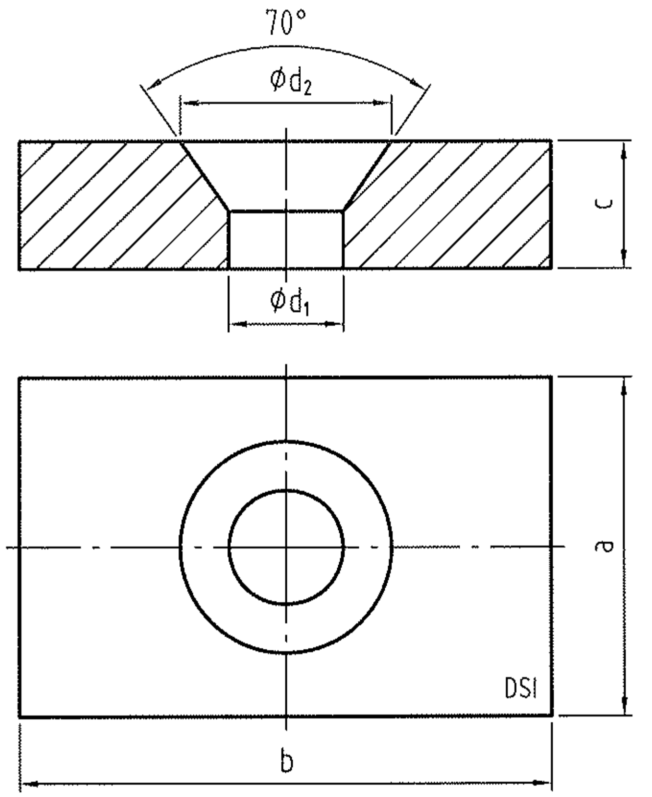
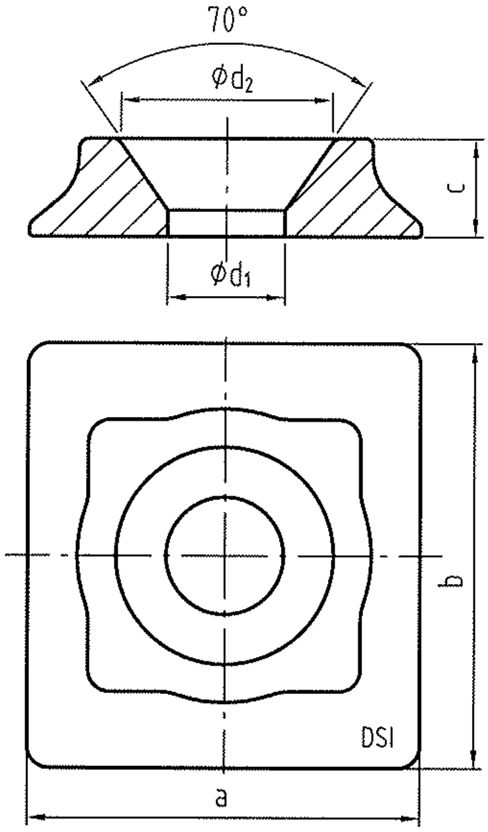
DYWIDAG-PT bar tendon, bonded, unbonded and external tendon

Solid plate, square 2011

Annex 3



Prestressing bar	Nominal bar diameter	a	b	c	∅ d_1	∅ d_2
	mm	mm	mm	mm	mm	mm
Threadbar	∅ 26.5	130	150	35	39	72
	∅ 32	140	180	40	45	82
	∅ 36	150	220	50	49	92
	∅ 40	160	250	60	54	100
Plain bar	∅ 32	140	180	40	45	72
	∅ 36	150	220	50	49	92



Prestressing bar	Nominal bar diameter	a	b	c	∅ d_1	∅ d_2
	mm	mm	mm	mm	mm	mm
Threadbar	∅ 26.5	120	130	30	39	72
	∅ 32	140	165	35	45	82
	∅ 36	160	180	40	49	92
	∅ 40	180	195	45	54	100

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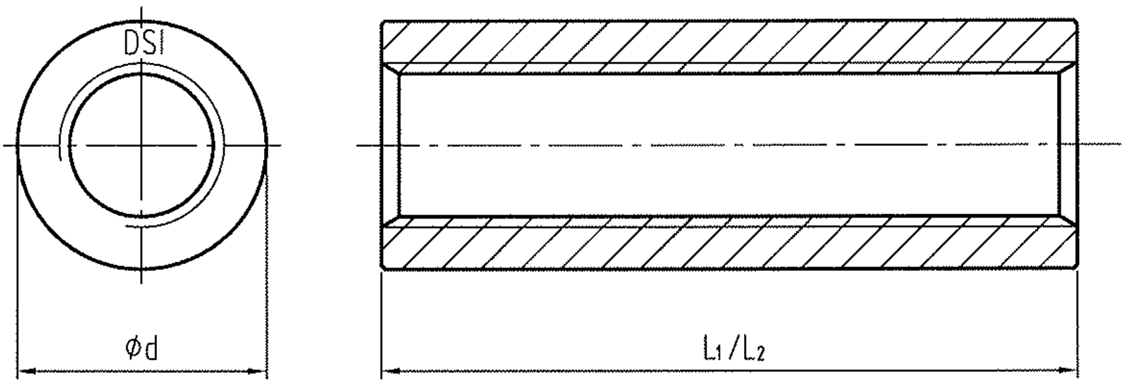
DYWIDAG-PT bonded bar tendon

QR-plate 2074

Annex 5

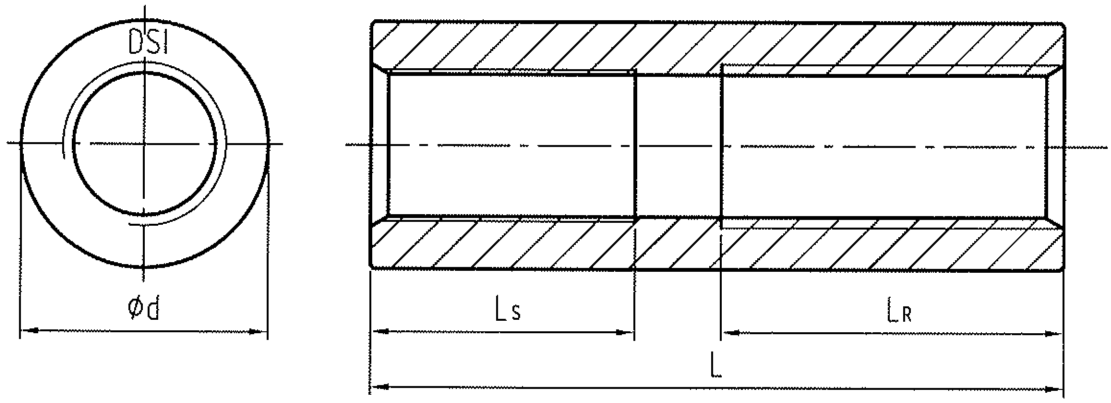


L_1: length of coupler 3003
L_2: length of coupler L 3303 (coupler L for unbonded tendon with angular cut threadbars)

Prestressing bar	Nominal bar diameter	∅ d	L_1	L_2
	mm	mm	mm	mm
Threadbar	∅ 26.5	50	170	195
	∅ 32	60	200	230
	∅ 36	68	210	245
	∅ 40	70	245	285
	∅ 47	83	270	—
Plain bar	∅ 32	60	110	—
	∅ 36	68	160	—

DYWIDAG-Systems International GmbH www.dywidag-systems.com	DYWIDAG-PT bar tendon, bonded, unbonded and external tendon Coupler 3003 Coupler L 3303	Annex 6

Member of EOTA



L_R: length of thread for threadbar
L_S: length of thread for plain bar

Prestressing bar	Nominal bar diameter	∅ d	L	L_R	L_S
	mm	mm	mm	mm	mm
Threadbar Plain bar	∅ 32	60	200	100	55
	∅ 36	68	210	105	80

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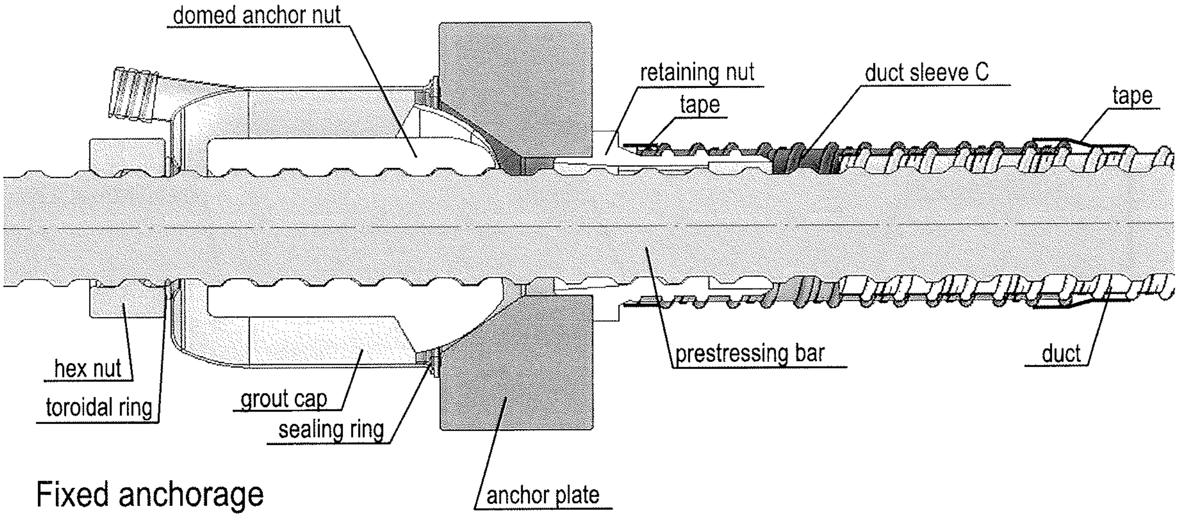
DYWIDAG-PT bar tendon, bonded, unbonded and external tendon

Transition coupler 3004

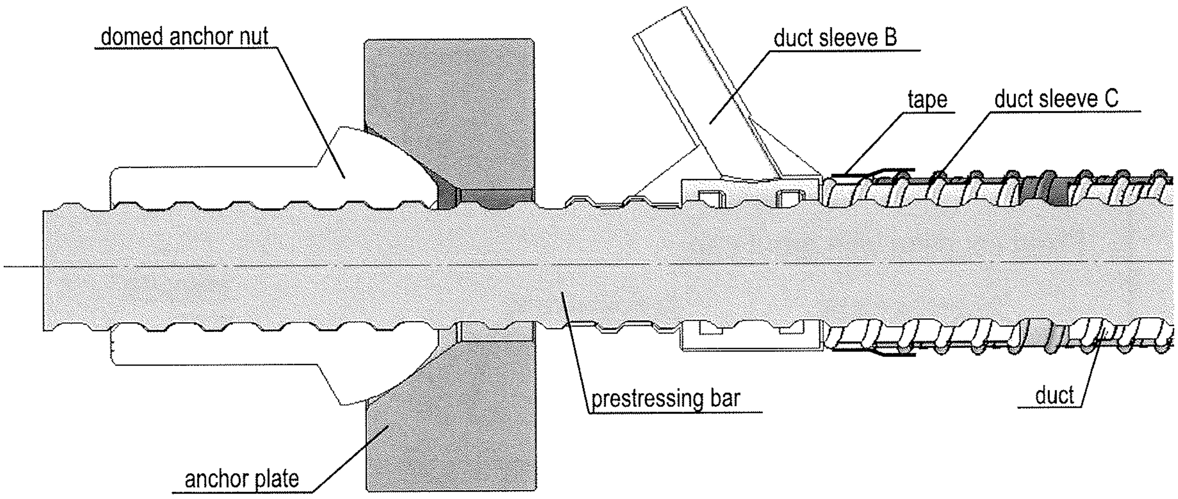
Annex 7

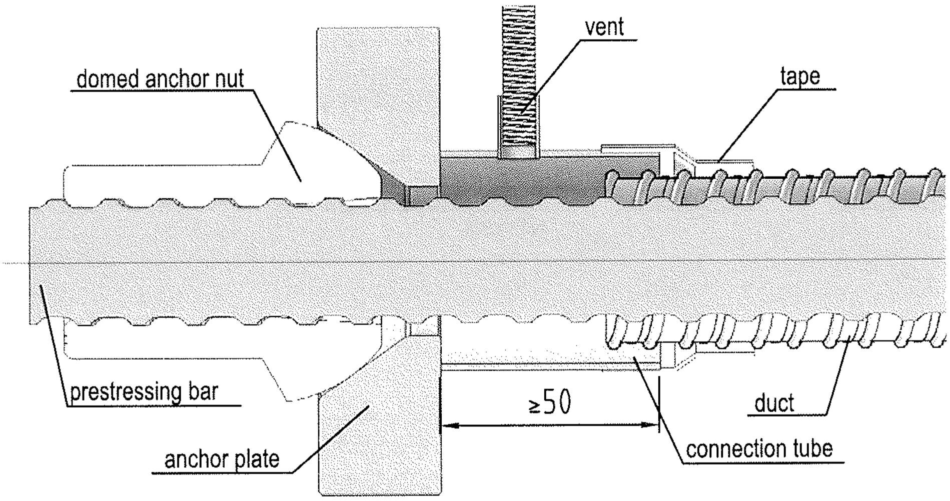
ETA, bar, Annex 7

Stressing anchorage



Fixed anchorage



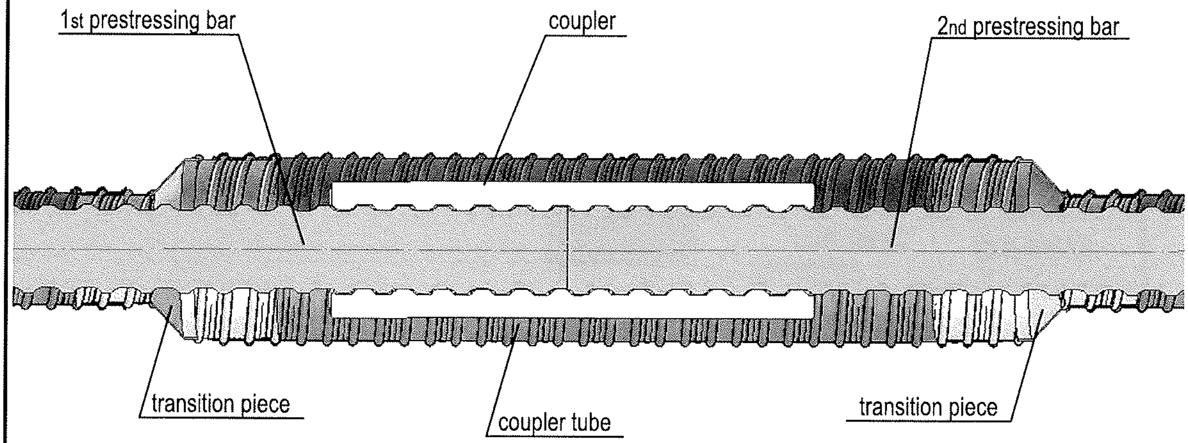


All dimensions in mm

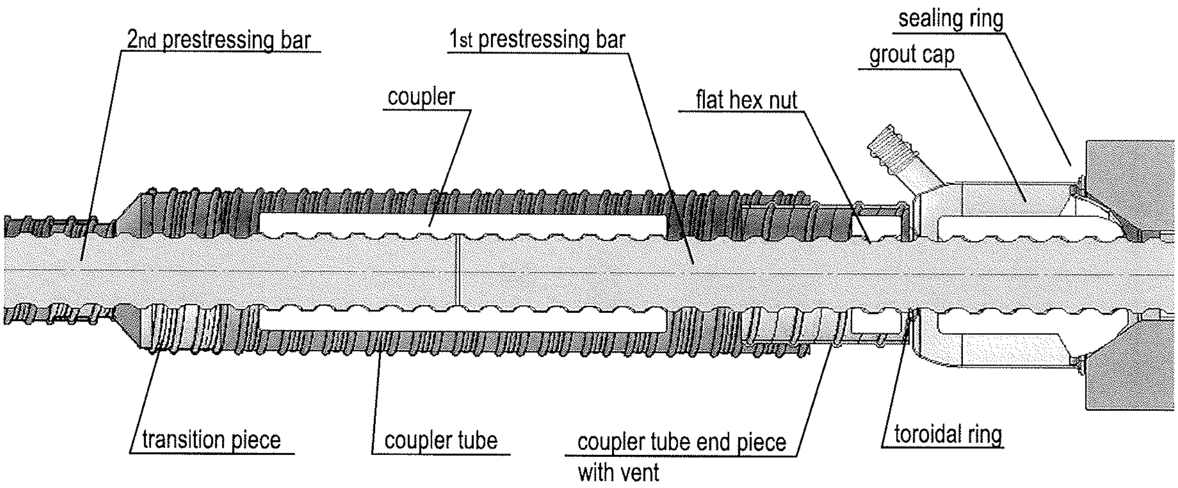
DSI DYWIDAG-Systems International GmbH www.dywidag-systems.com	DYWIDAG-PT bonded bar tendon **Stressing and fixed anchorage**	Annex 8

Member of EOTA

Movable coupling D



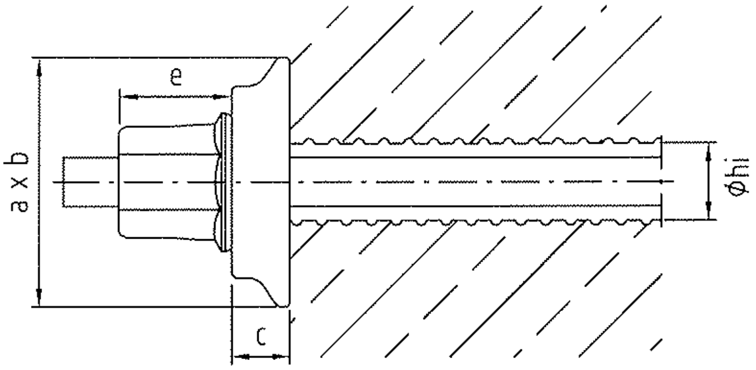
Fixed coupling with grout cap



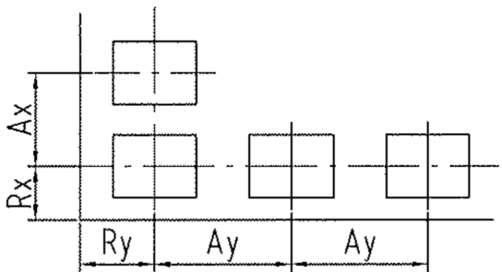
DYWIDAG-Systems International GmbH www.dywidag-systems.com	DYWIDAG-PT bonded bar tendon Movable and fixed coupling	Annex 9

ETA, bar, Annex 9

Member of EOTA



Nominal bar diameter		26.5	32	36	40
Dimensions	a	120	140	160	180
	b	130	165	180	195
	c	30	35	40	45
	~e	60	70	76	90
	$\varnothing h_i$	38	44	51	55
Min. actual concrete strength $f_{cm,0,cyl}$ at stressing in N/mm²		30	30	30	30
Centre distance Ax		230	260	280	320
Centre distance Ay		250	300	340	360
Edge distance R		0.5 · centre distance + concrete cover - 10 mm			



All dimensions in mm

DSI
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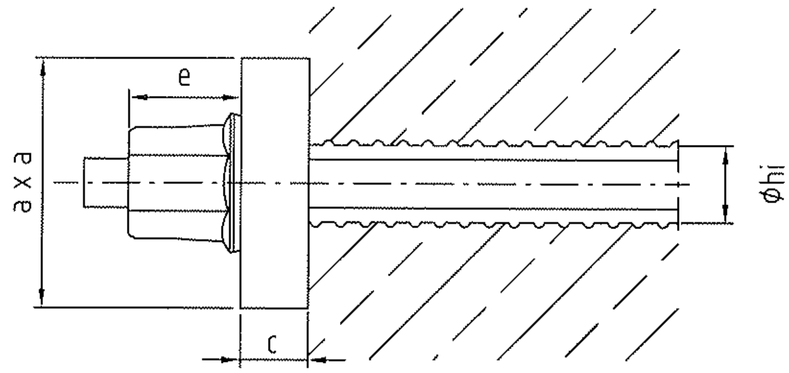
DYWIDAG-PT bonded bar tendon

Stressing and fixed anchorage
QR-plate without additional reinforcement
Center and edge distances

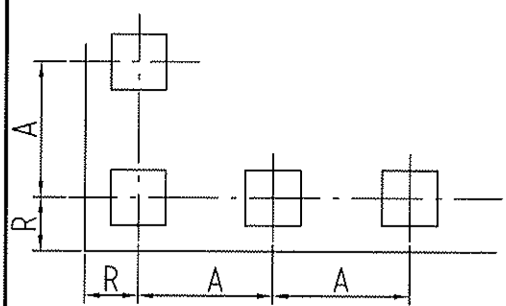
Annex 10

ETA, bar, Annex 10

Member of EOTA



Nominal bar diameter		26.5	32	36	40
Dimensions	a	150	180	200	220
	c	35	40	45	45
	~e	60	70	76	90
	Øh$_i$	38	44	51	55
Min. actual concrete strength $f_{cm,0,cyl}$ at stressing in N/mm²		20	20	20	20
Centre distance A		280	340	380	420
Edge distance R		0.5 · centre distance + concrete cover - 10 mm			



All dimensions in mm

DSI
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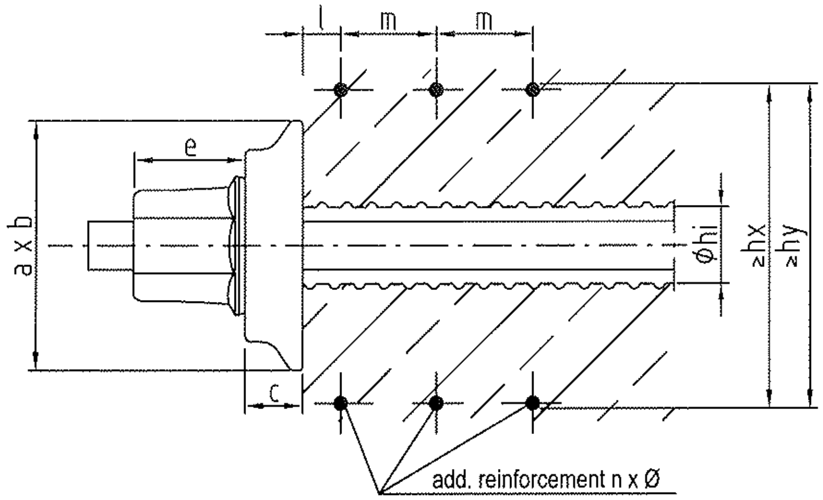
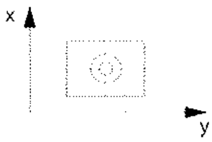
DYWIDAG-PT bonded bar tendon

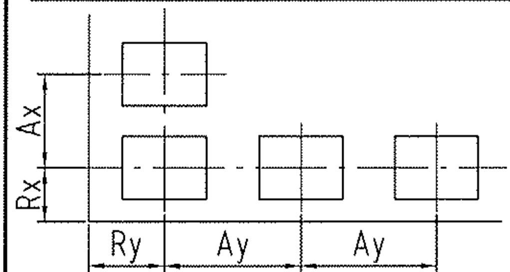
Stressing and fixed anchorage
Solid plate, square without add. reinforcement
Center and edge distances

Annex 11

ETA, bar, Annex 11



Nominal bar diameter		26.5			32			36			40		
Dimensions 	a	120			140			160			180		
	b	130			165			180			195		
	c	30			35			40			45		
	~e	60			70			76			90		
	Øh$_i$	38			44			51			55		
Min. actual concrete strength $f_{cm,0,cyl}$ at stressing in N/mm²		20	30	40	20	30	40	20	30	40	20	30	40
Centre distance Ax		190	160	140	230	200	170	260	220	190	280	250	220
Centre distance Ay		210	180	150	250	220	190	280	250	220	320	280	240
Edge distance R		0.5 · centre distance + concrete cover - 10 mm											
Additional reinforcement	n	4	4	3	5	4	3	4	4	3	4	4	3
	Ø	10	10	10	10	10	10	10	10	10	10	10	10
	m	50	50	60	50	60	60	60	60	60	60	60	60
	l	40	40	40	40	40	40	40	40	40	40	40	40
	hx	170	140	120	210	180	150	240	200	170	260	230	200
	hy	190	160	130	230	200	170	260	230	200	300	260	220



Additional reinforcement: stirrup or orthogonal reinforcement.
Orthogonal reinforcement has to be anchored properly.

All dimensions in mm

DSI
DYWIDAG-Systems International GmbH
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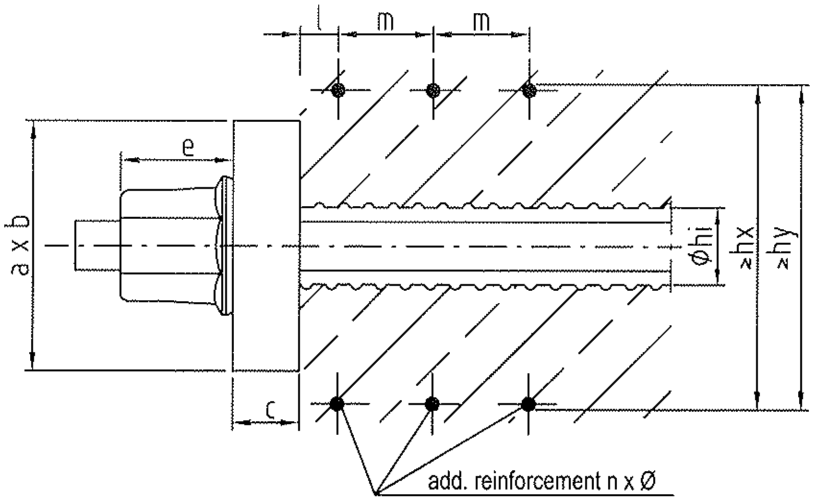
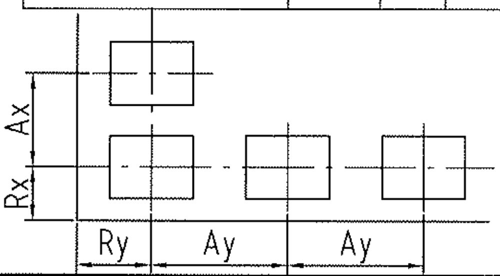
DYWIDAG-PT bonded bar tendon

Stressing and fixed anchorage
QR-plate with additional reinforcement
Center and edge distances

Annex 12



Nominal bar diameter		26.5			32			36			40		
Dimensions	a	130			140			150			160		
	b	150			180			220			250		
	c	35			40			50			60		
	~e	60			32 WR 32 E		32 WS	36 WR 36 E		36 WS	90		
					70		30	76		36			
	Øh$_i$	38			44			51			55		
Min. actual concrete strength $f_{cm,0,cyl}$ at stressing in N/mm²		20	30	40	20	30	40	20	30	40	20	30	40
Centre distance Ax		180	160	150	210	190	180	230	210	180	260	220	200
Centre distance Ay		240	190	160	300	230	190	340	260	240	380	320	270
Edge distance R		0.5 · centre distance + concrete cover - 10 mm											
Additional reinforcement	n	4	3	3	5	4	4	5	4	4	6	5	5
	Ø	12	12	12	12	12	12	12	12	12	12	12	12
	m	60	60	60	60	60	60	60	60	60	60	60	60
	l	20	20	20	20	20	20	20	20	20	20	20	20
	hx	160	140	130	190	170	160	210	190	160	240	200	180
	hy	220	170	140	280	210	170	320	240	220	360	300	250



Additional reinforcement: stirrup or orthogonal reinforcement.
Orthogonal reinforcement has to be anchored properly.

All dimensions in mm

DSI
DYWIDAG-Systems International GmbH
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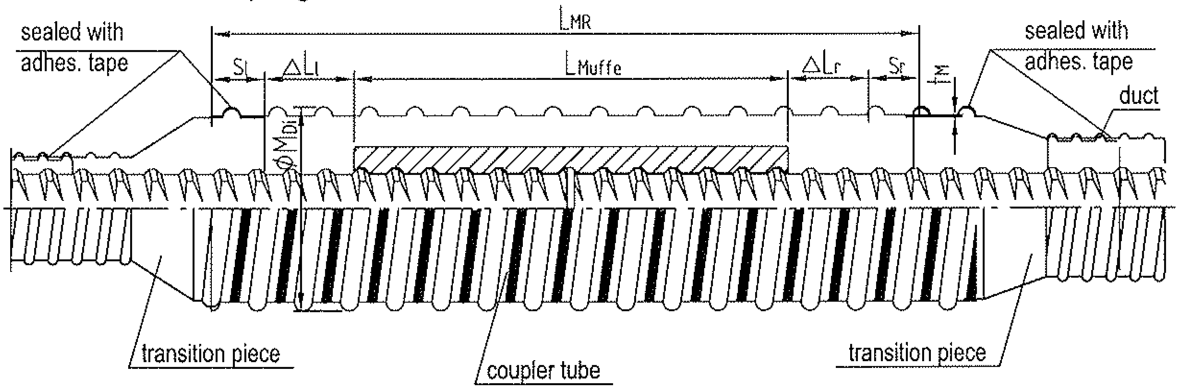
DYWIDAG-PT bonded bar tendon

Stressing and fixed anchorage
Solid plate, rectangular with add. reinforcement
Center and edge distances

Annex 13

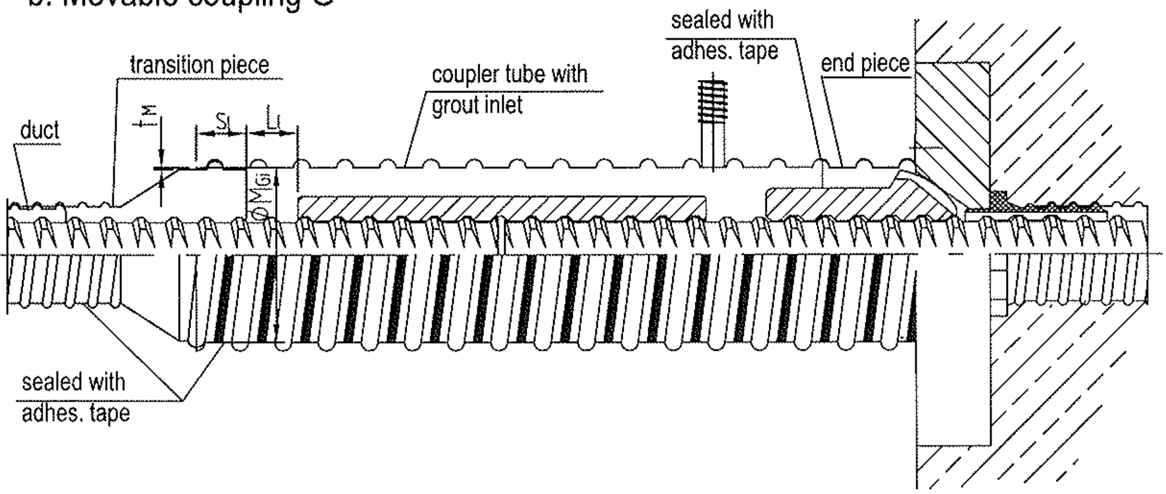
a. Movable coupling D



$L_{Mr} = L_{Muffe} + \Delta L_l + \Delta L_r + s_l + s_r$

L_{Mr} length of coupler tube
L_{Muffe} length of coupler/transition coupler
ΔL_l, ΔL_r movement of coupler on left and right resp.
s_l, s_r safety clearance ($0.2 \cdot \Delta L \geq 40$ mm)

b. Movable coupling G



Bar designation		26 WR 26 E	32 WR 32 E	36 WR 36 E	40 WR 40 E	32 WS	36 WS
Coupler tube							
for coupling D	Ø M_{Di}	65	75	85	85	75	85
Thickness of the metal sheet	t_M	0.35	0.35	0.35	0.35	0.35	0.35
for coupling G	Ø M_{Gi}	90	105	110	120	105	110
Thickness of the metal sheet	t_M	0.4	0.4	0.4	0.4	0.4	0.4

All dimensions in mm

DSI
DYWIDAG-Systems International GmbH
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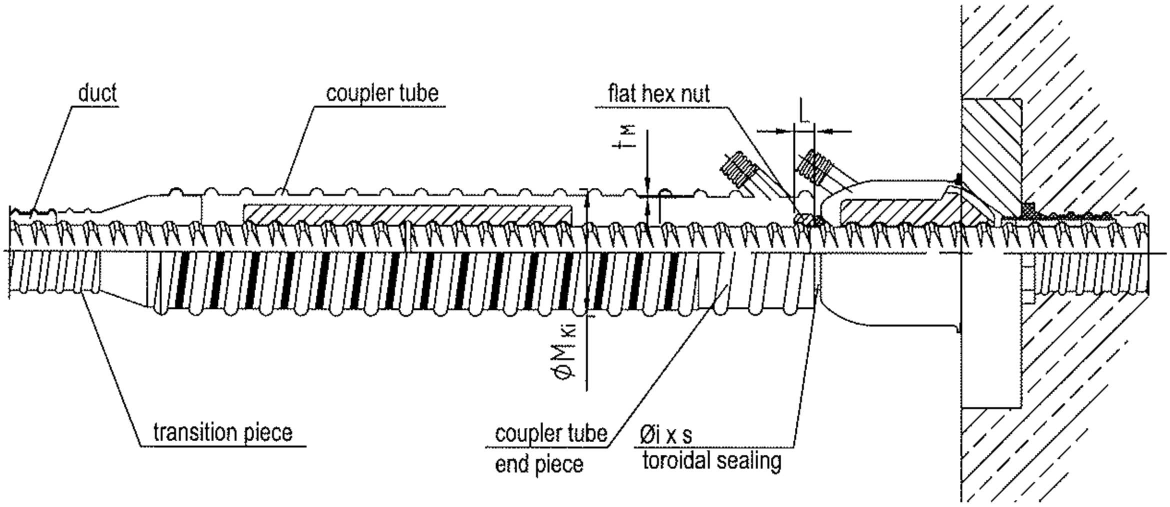
DYWIDAG-PT bonded bar tendon
Movable coupling

Annex 14

Fixed coupling with grout cap

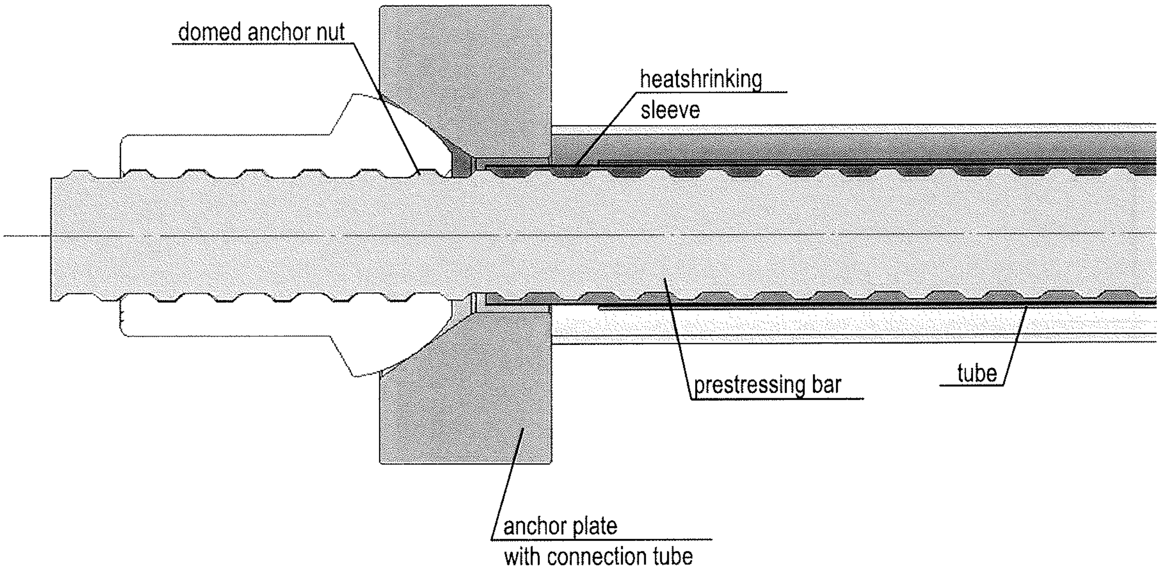


Bar designation		26 WR 26 E	32 WR 32 E	36 WR 36 E	40 WR 40 E	32 WS	36 WS
Coupler tube	Ø M_{Ki}	65	75	85	85	75	85
Coupler tube, thickness of metal sheet	t_M	0.35	0.35	0.35	0.35	0.35	0.35
Flat hex nut	SW	41	46	50	55	46	50
	L	15	15	20	25	15	15
Toroidal ring	Øi	22	26	30	36	26	30
	s	8	8	8	8	8	8

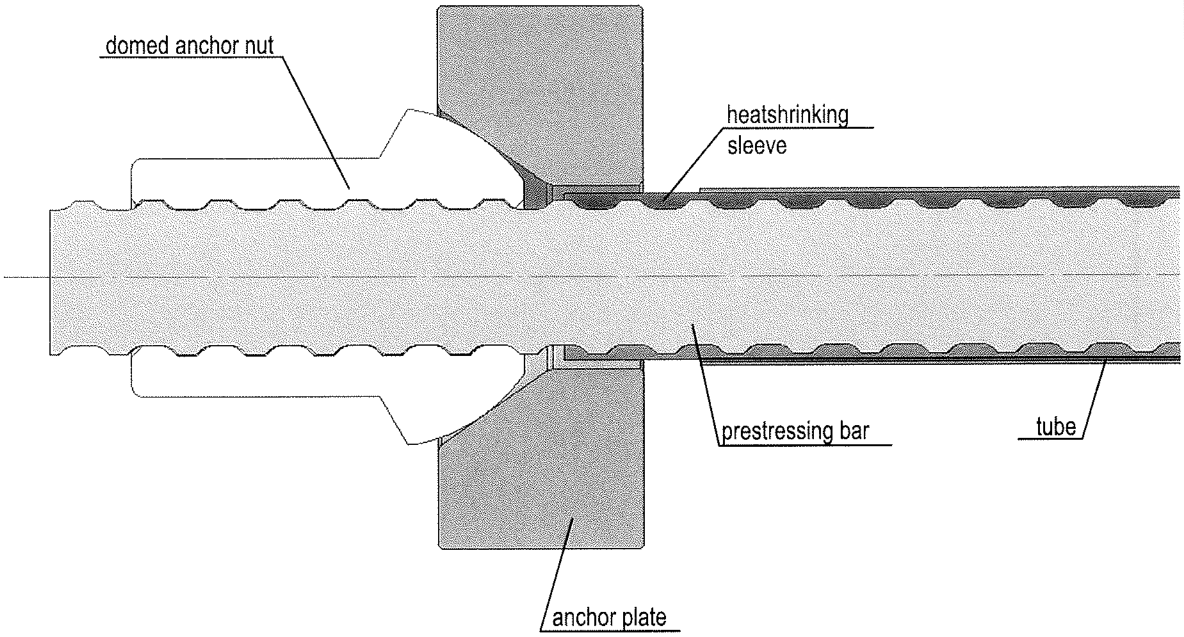
All dimensions in mm

DSI DYWIDAG-Systems International GmbH www.dywidag-systems.com	DYWIDAG-PT bonded bar tendon Fixed coupling	Annex 15

Stressing anchorage



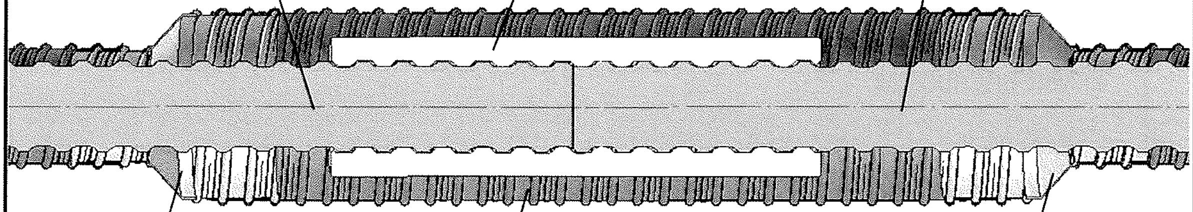
Fixed anchorage



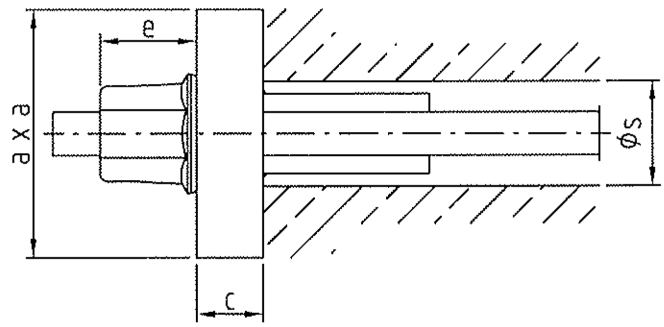
DSI DYWIDAG-Systems International GmbH www.dywidag-systems.com	DYWIDAG-PT unbonded and external bar tendon **Stressing and fixed anchorage**	Annex 16

ETA, bar, Annex 16

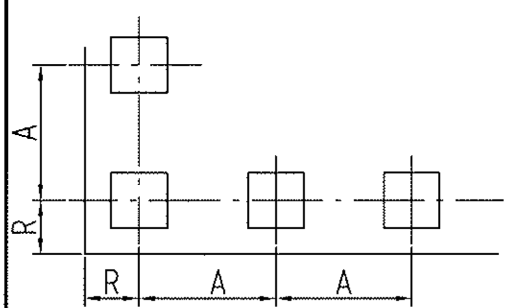
Movable coupling D



Member of EOTA



Nominal bar diameter		26.5	32	36	40	47
Dimensions	a	150	180	200	220	260
	c	35	40	45	45	50
	~e	60	70	76	90	108
	max. ∅s	63.5	70	76.1	76.1	101.6
Min. actual concrete strength $f_{cm,0,cyl}$ at stressing in N/mm²		20	20	20	20	20
Centre distance A		280	340	380	420	500
Edge distance R		0.5 · centre distance + concrete cover - 10 mm				



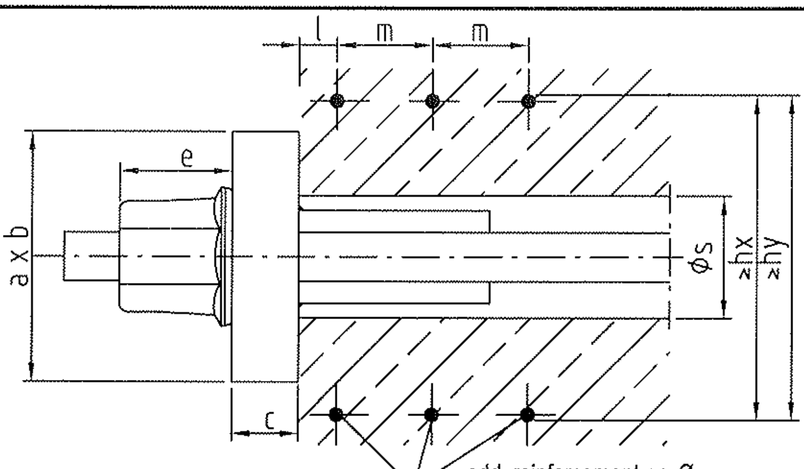
All dimensions in mm

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

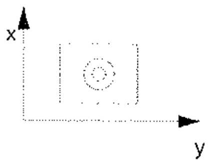
DYWIDAG-PT unbonded and external bar tendon

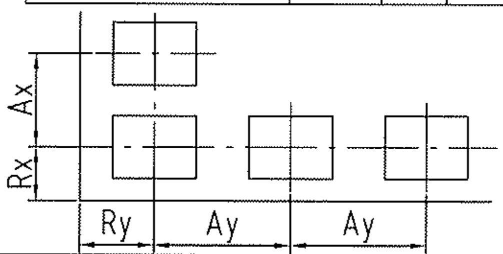
Stressing and fixed anchorage
Solid plate, square without add. reinforcement
Center and edge distance

Annex 18



Nominal bar diameter		26.5			32			36			40		
Dimensions	a	130			140			150			160		
	b	150			180			220			250		
	c	35			40			50			60		
	~e	60			32 WR / 32 E: 70		32 WS: 30	36 WR / 36 E: 76		36 WS: 36	90		
	max. Øs	63			70			76			90		
Min. actual concrete strength $f_{cm,0,cyl}$ at stressing in N/mm²		20	30	40	20	30	40	20	30	40	20	30	40
Centre distance Ax		180	160	150	210	190	180	230	210	180	260	220	200
Centre distance Ay		240	190	160	300	230	190	340	260	240	380	320	270
Edge distance R		0.5 · centre distance + concrete cover - 10 mm											
Additional reinforcement	n	4	3	3	5	4	4	5	4	4	6	5	5
	Ø	12	12	12	12	12	12	12	12	12	12	12	12
	m	60	60	60	60	60	60	60	60	60	60	60	60
	l	20	20	20	20	20	20	20	20	20	20	20	20
	hx	160	140	130	190	170	160	210	190	160	240	200	180
	hy	220	170	140	280	210	170	320	240	220	360	300	250





Additional reinforcement: stirrup or orthogonal reinforcement.
Orthogonal reinforcement has to be anchored properly.

All dimensions in mm

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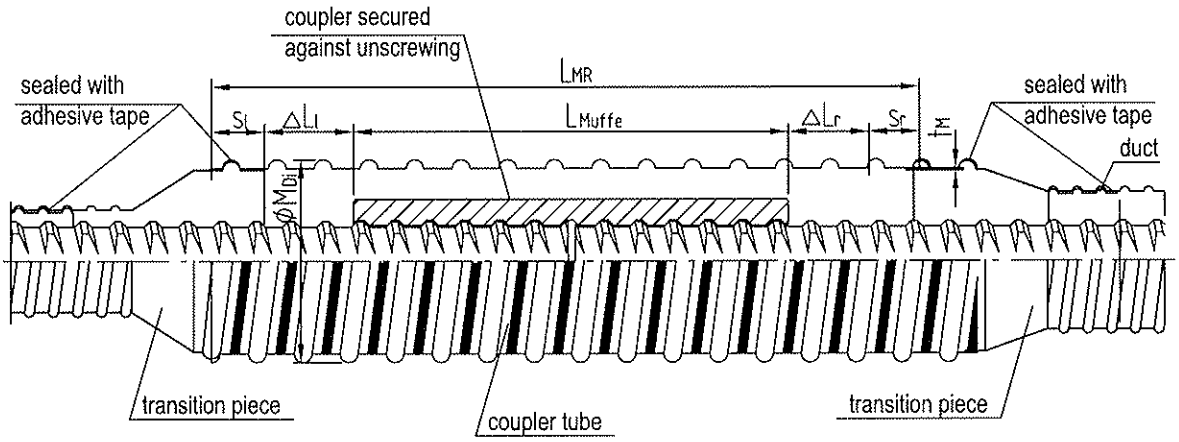
DYWIDAG-PT unbonded and external bar tendon

Stressing and fixed anchorage
Solid plate, rectangular with add. reinforcement
Center and edge distance

Annex 19

ETA, bar, Annex 19

Movable coupling D



$L_{Mr} = L_{Muffe} + \Delta L_l + \Delta L_r + s_l + s_r$

L_{Mr}	length of coupler tube
L_{Muffe}	length of coupler/transition coupler
ΔL_l, ΔL_r	movement of coupler on left and right resp.
s_l, s_r	safety clearance ($0.2 \cdot \Delta L \geq 40$ mm)

Bar designation		26 WR 26 E	32 WR 32 E	36 WR 36 E	40 WR 40 E	47 WR	32 WS	36 WS
Coupler tube	Ø M_{Di}	65	75	85	85	100	75	85
Thickness of metal sheet	t_M	0.35	0.35	0.35	0.35	0.4	0.35	0.35

All dimensions in mm

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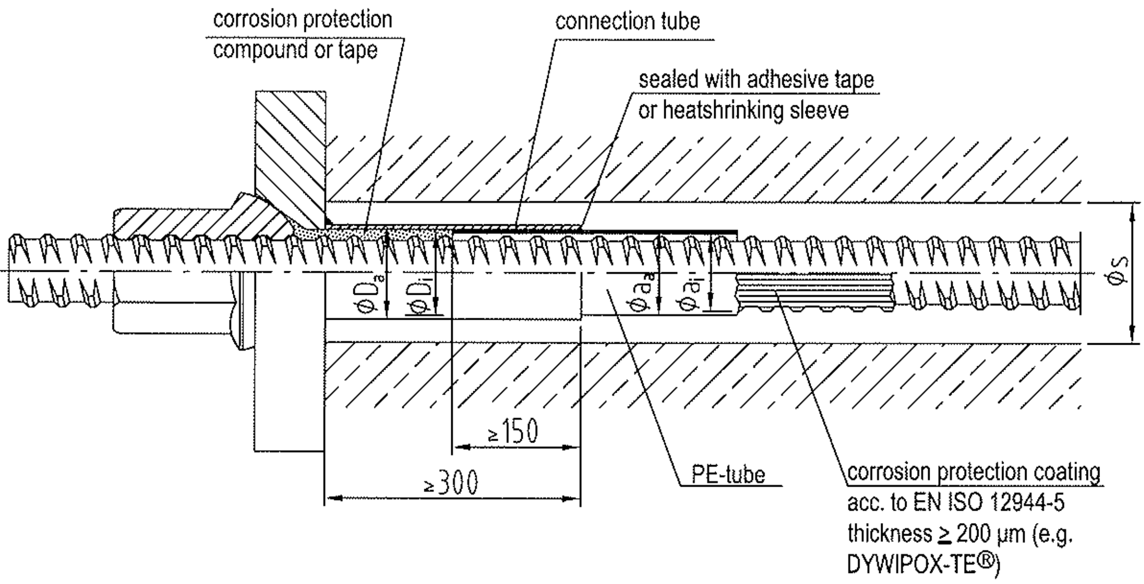
Movable coupling

Annex 20



Bar designation		26 WR 26 E	32 WR 32 E	36 WR 36 E	40 WR 40 E	47 WR	32 WS	36 WS
Connection tube	max. $Ø\ D_a$	48.3	60.3	60.3	73	76.1	48.3	60.3
	min. $Ø\ D_i$	42	53	53	66	66	42	53
PE-tube	max. $Ø\ a_a$	40	50	50	63	63	40	50
	min. $Ø\ a_i$	34	39	44	48	56	35	39
Tendon duct diameter at the anchorage, max.	Ø s	63	70	76	90	101.5	70	76

All dimensions in mm

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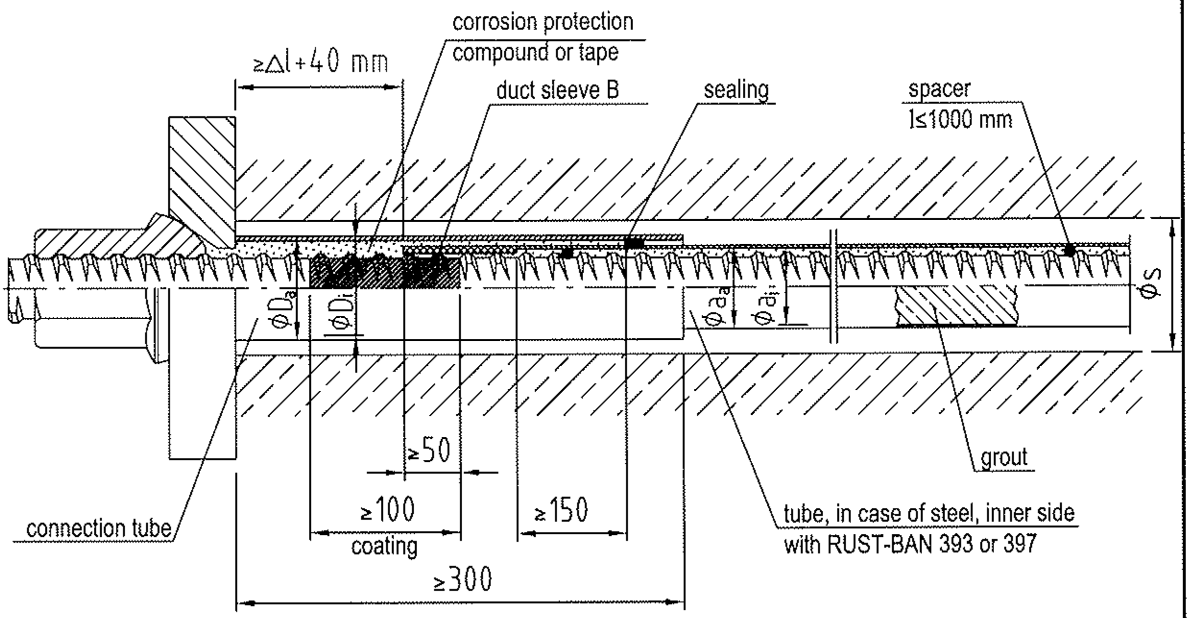
DYWIDAG-PT unbonded and external bar tendon

Tendon with free tendon duct
Temporary corrosion protection

Annex 21

ETA, bar, Annex 21



Bar designation		26 WR 26 E	32 WR 32 E	36 WR 36 E	40 WR 40 E	47 WR	32 WS	36 WS
Connection tube	max. Ø D_a	57	60.3	70	73	76.1	60.3	63.5
	min. Ø D_i	50	55	63	66	68	54	57
Steel tube	max. Ø a_a	44.5	51	57	60.3	63.5	48.3	51
	min. Ø a_i	34	39	44	48	56	35	39
PE-tube	max. Ø a_a	40	50	50	63	63	50	50
	min. Ø a_i	34	39	44	48	56	35	39
Tendon duct diameter at the anchorage, max.	Ø s	63	70	76	90	101.5	70	76

All dimensions in mm

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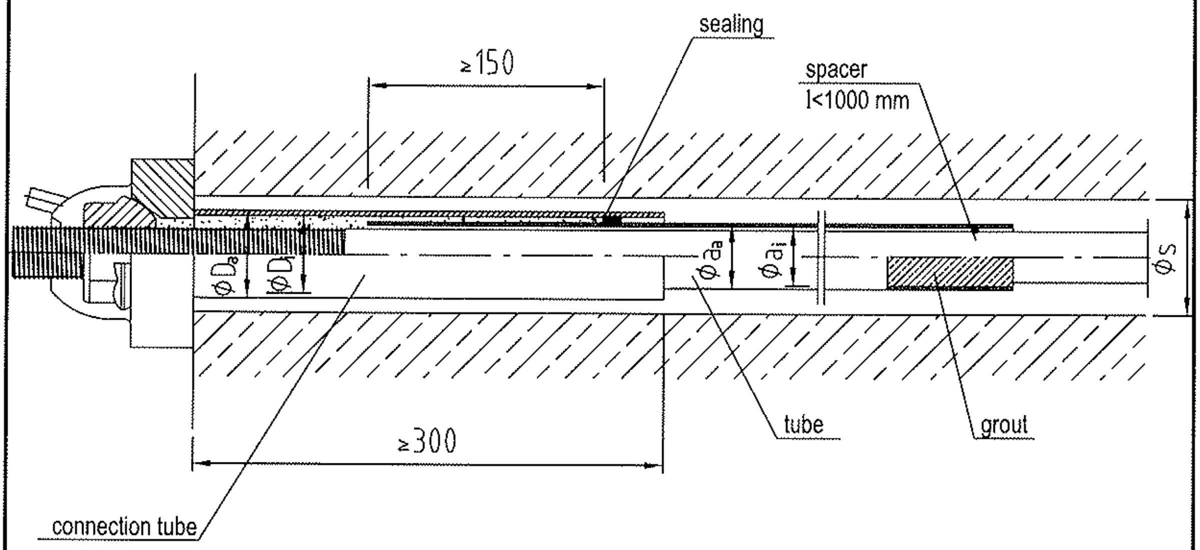
DYWIDAG-PT unbonded and external bar tendon

Tendon with free tendon duct
Permanent corrosion protection
Grouting before stressing

Annex 22

Member of EOTA



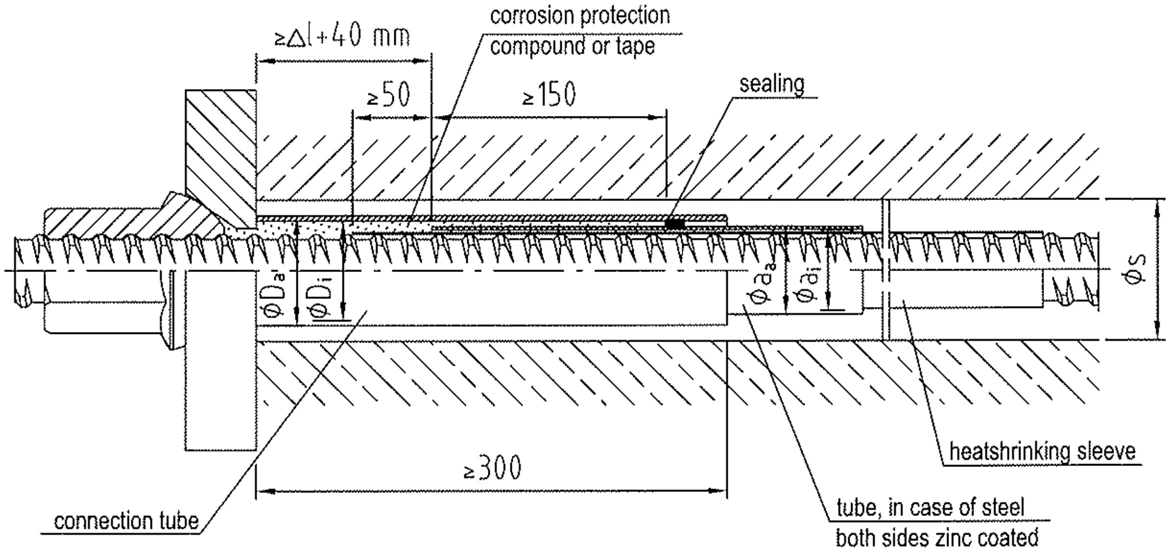
Bar designation		32 WS	36 WS
Connection tube	max. Ø D_a	60.3	63.5
	min. Ø D_i	54	56.5
Steel tube	max. Ø a_a	48.3	51
	min. Ø a_i	39	44
PE-tube	max. Ø a_a	50	50
	min. Ø a_i	39	43
Tendon duct diameter at the anchorage, max.	Ø s	70	76

All dimensions in mm

DSI DYWIDAG-Systems International GmbH www.dywidag-systems.com	DYWIDAG-PT unbonded and external bar tendon Tendon with free tendon duct Permanent corrosion protection Grouting after stressing	Annex 23

ETA, bar, Annex 23

Member of EOTA



Bar designation		26 WR 26 E	32 WR 32 E	36 WR 36 E	40 WR 40 E	47 WR	32 WS	36 WS
Heatshrinking sleeve SATM/CPSM	Type	37/12	45/24	50/18	50/18	70/26	45/24	45/24
Connection tube	max. Ø D_a	57	60.3	70	73	76.1	60.3	63.5
	min. Ø D_i	50	55	63	67	68.5	55	57
Steel tube	max. Ø a_a	44.5	51	57	60.3	63.5	48.3	51
	min. Ø a_i	36	43	48	52	58	39	43
PE-tube	max. Ø a_a	40	50	50	63	63	50	50
	min. Ø a_i	35	43	46	52	56	39	43
Tendon duct diameter at the anchorage, max.	Ø s	63	70	76	90	101.5	70	76

All dimensions in mm

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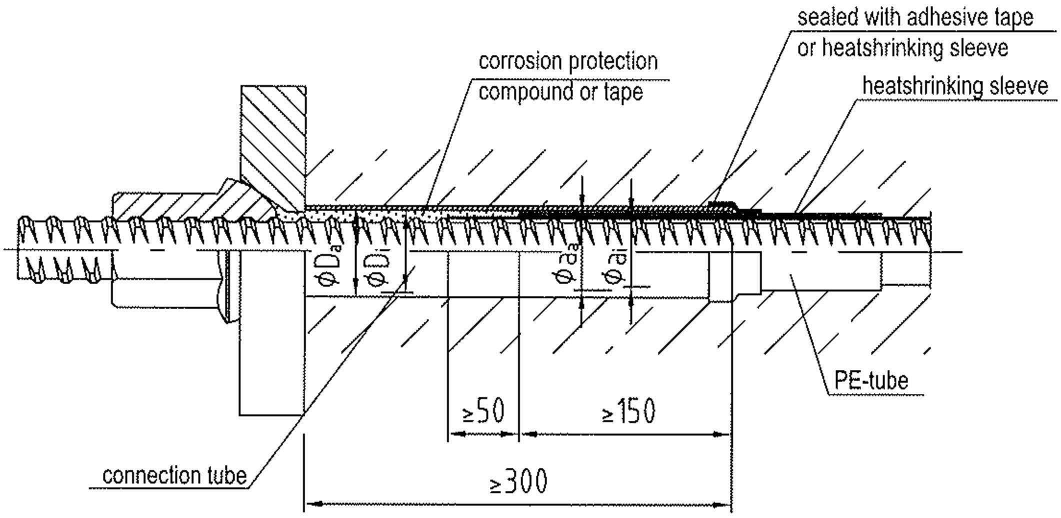
DYWIDAG-PT unbonded and external bar tendon

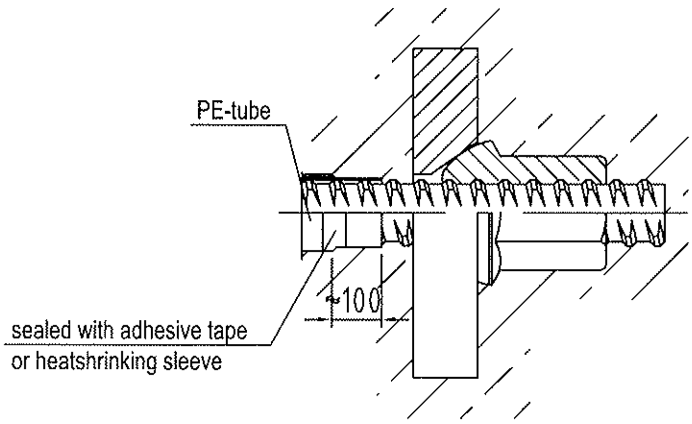
Tendon with free tendon duct
Permanent corrosion protection
with heatshrinking sleeve

Annex 24

ETA, bar, Annex 24

Member of EOTA





Bar designation		26 WR 26 E	32 WR 32 E	36 WR 36 E	40 WR 40 E	47 WR
Heatshrinking sleeve SATM/CPSM	Type	37/12	45/24	50/18	50/18	70/26
Connection tube	max. Ø D_a	48.3	60.3	60.3	73	76.1
	min. Ø D_i	42	52	52	65	65
PE-tube	max. Ø a_a	40	50	50	63	63
	min. Ø a_i	35	43	46	52	56

All dimensions in mm

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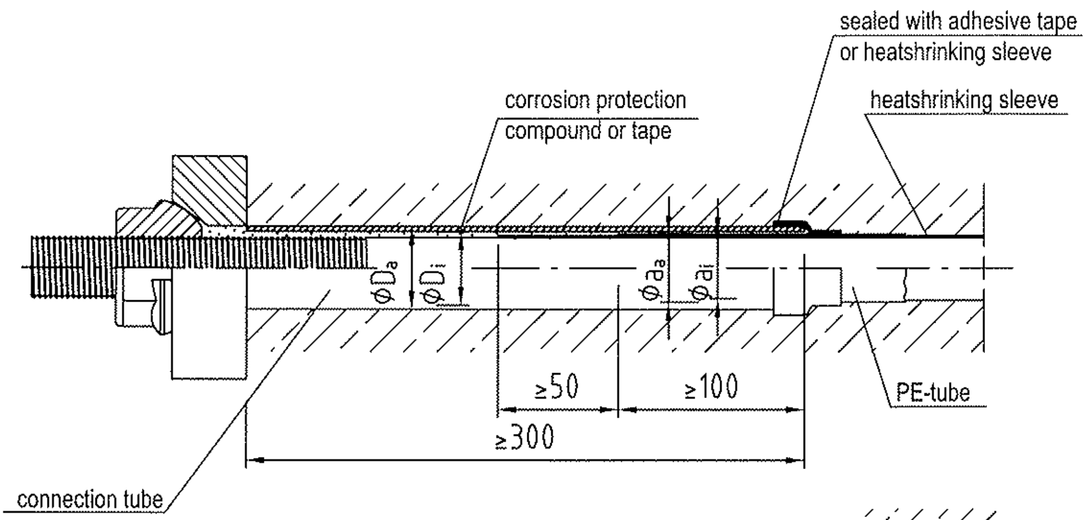
DYWIDAG-PT unbonded bar tendon

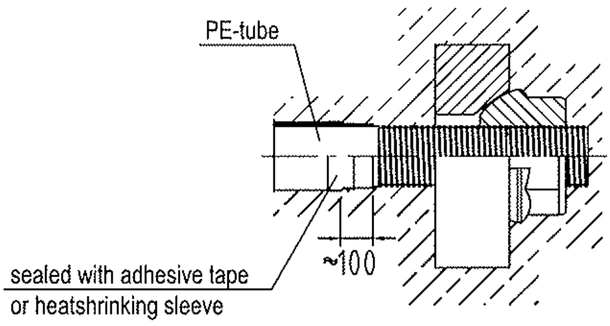
Tendon without free tendon duct
Permanent corrosion protection for threadbars with heatshrinking sleeve

Annex 25a

ETA, bar, Annex 25a

Member of EOTA



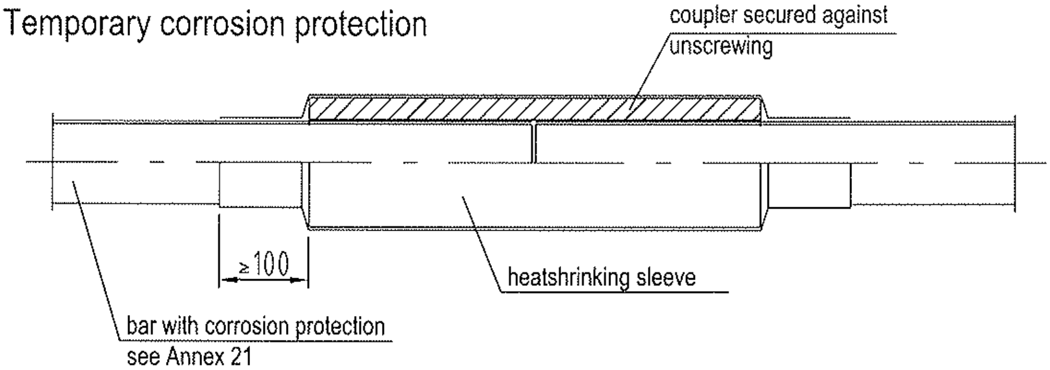


Bar designation		32 WS	36 WS
Heatshrinking sleeve SATM/CPSM	Type	45/24	45/24
Connection tube	max. Ø D_a	60.3	60.3
	min. Ø D_i	52	52
PE-tube	max. Ø a_a	50	50
	min. Ø a_i	39	43

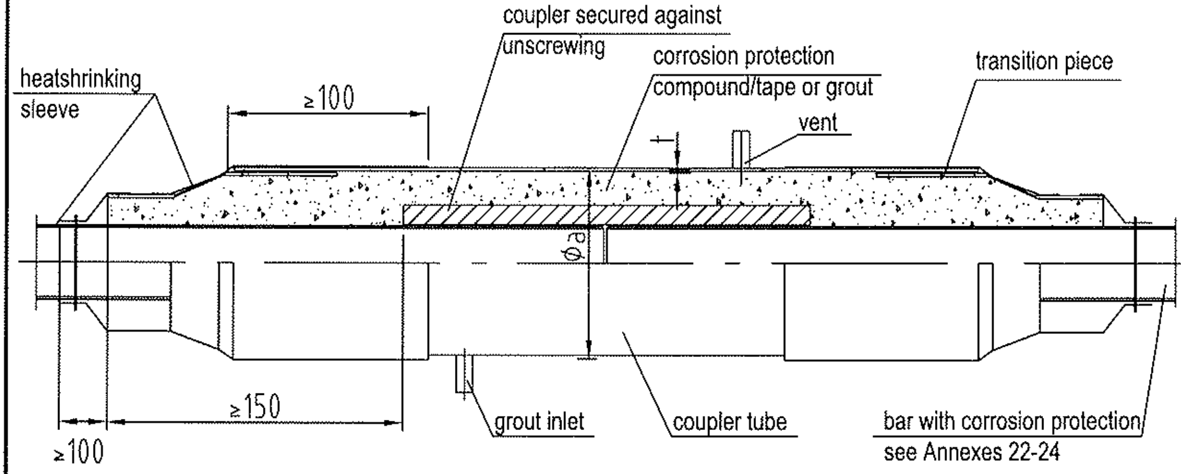
All dimensions in mm

DSI DYWIDAG-Systems International GmbH www.dywidag-systems.com	DYWIDAG-PT unbonded bar tendon **Tendon without free tendon duct Permanent corrosion protection for plain bars with heatshrinking sleeve**	Annex 25b

a. Temporary corrosion protection



b. Permanent corrosion protection



Apply grout inlets and vents only when necessary. Steel tubes' outer side corrosion protected.

Bar designation		26 WR 26 E	32 WR 32 E	36 WR 36 E	40 WR 40 E	47 WR	32 WS	36 WS
Temporary corrosion protection								
Heatshrinking sleeve SATM/CPSM	Type	70/28	80/55	90/36	90/36	115/30	80/55	90/36
Min. tendon duct dia.	Ø s	65	75	82	90	100	75	82
Permanent corrosion protection								
Heatshrinking sleeve SATM/CPSM	Type	90/36	90/36	115/30	115/30	115/30	115/30	115/30
Coupler tube, steel	Ø a	70	80	90	90	100	80	90
	min. t	2	2	2	2	2	2	2
Min. tendon duct dia.	Ø s	80	90	100	100	110	90	100
Coupler tube, PE-HD	Ø a	75	75	90	90	100	75	90
	min. t	2	2	2.2	2.2	2.2	2	2.2
Min. tendon duct dia.	Ø s	85	85	100	100	110	85	100

Ø s, not shown

All dimensions in mm

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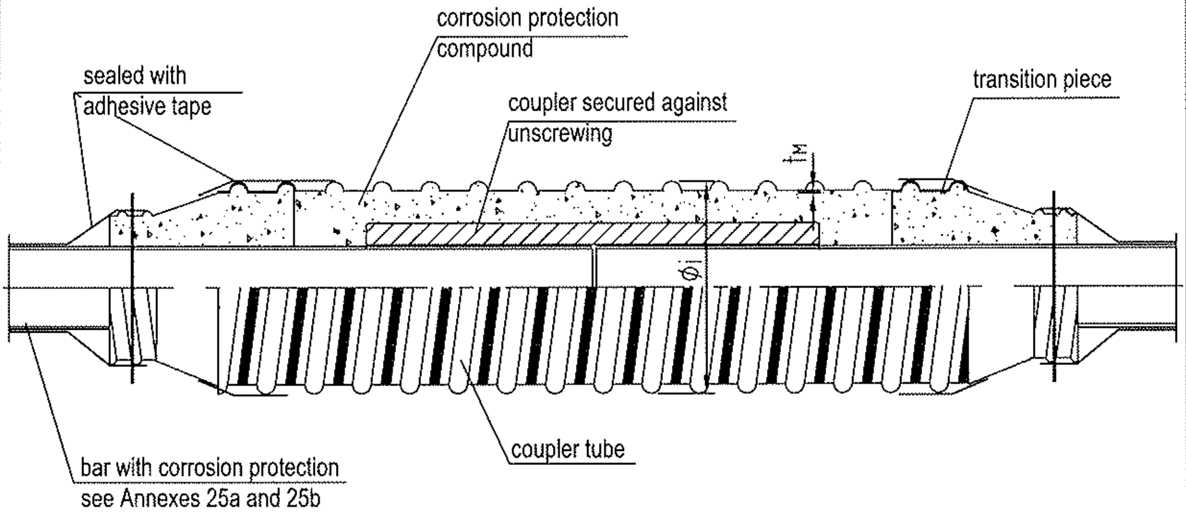
DYWIDAG-PT unbonded and external bar tendon

Tendon with free tendon duct
Corrosion protection
Coupling

Annex 26

ETA, bar, Annex 26

Member of EOTA



Bar designation		26 WR 26 E	32 WR 32 E	36 WR 36 E	40 WR 40 E	47 WR	32 WS	36 WS
Permanent corrosion protection								
Coupler tube, nom. diameter	Ø i	65	75	85	85	100	75	85
Coupler tube, sheet thickness	t_M	0.35	0.35	0.35	0.35	0.4	0.35	0.35

All dimensions in mm

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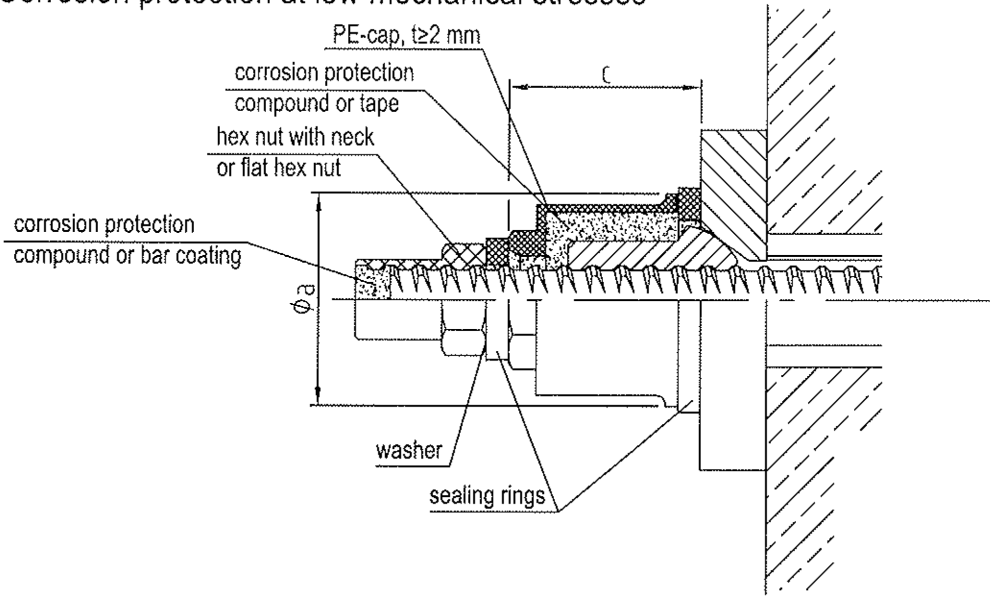
DYWIDAG-PT unbonded bar tendon

Tendon without free tendon duct
Corrosion protection
Coupling

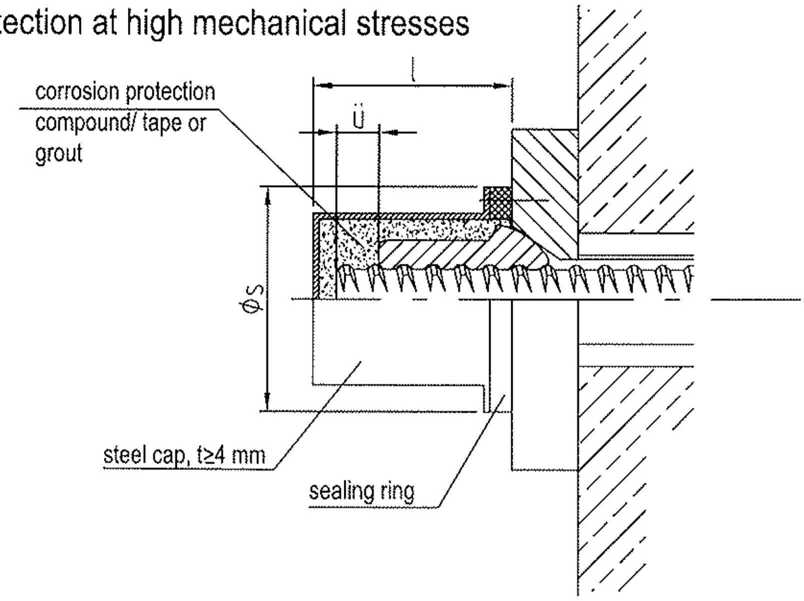
Annex 27

ETA, bar, Annex 27

a. Corrosion protection at low mechanical stresses



b. Corrosion protection at high mechanical stresses

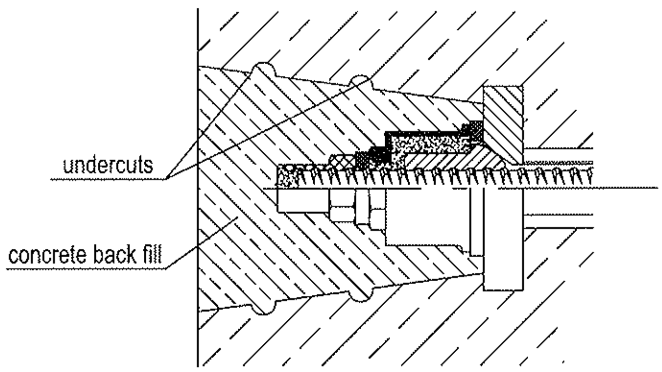


Bar designation		26 WR 26 E	32 WR 32 E	36 WR 36 E	40 WR 40 E	47 WR	32 WS	36 WS
In case of low mechanical stresses PE-cap	Ø a	95	105	125	115	135	95	115
	c	110	110	120	115	135	58	83
In case of high mechanical stresses Steel cap	min. Ø s	129	139	148	159	171	129	148
	min. l	105	105	115	110	130	55	80

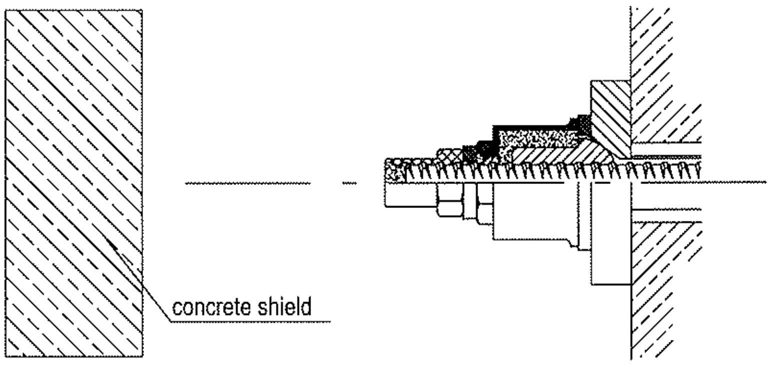
Min. l for a bar projection length of ü = 5 mm

All dimensions in mm

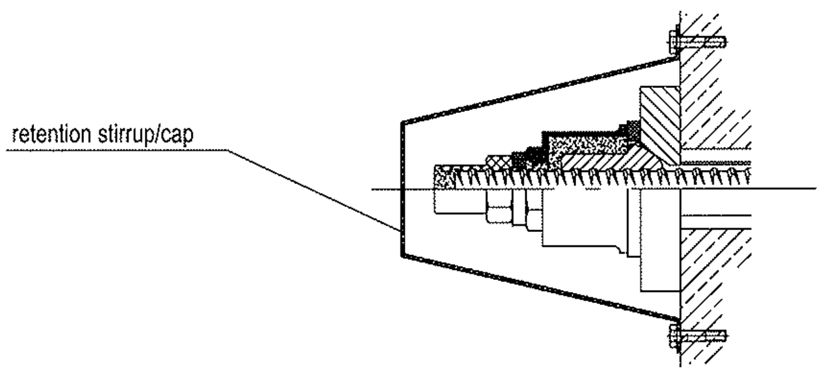
a. Anchorage with concrete cover



b. Free anchorage with concrete shield

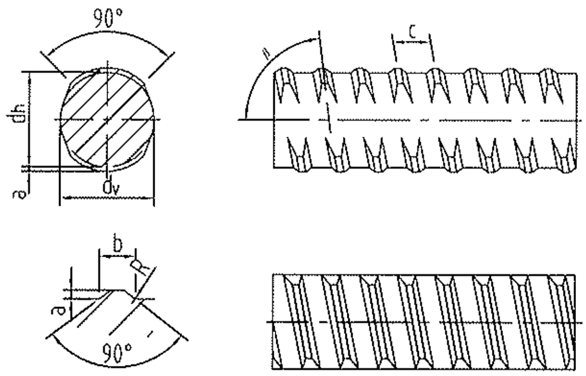


c. Free anchorage with retention stirrup/cap



Safety against shooting out of bar
Examples

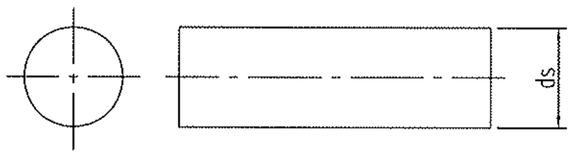
Threadbar, WR and E, surface configuration and dimensions



Nominal diameter	Nominal mass per metre[1)]	Nom. cross sectional area	Core diameter		Depth	Width	Pitch	Gradient	Radius
d_s	M	S_n	d_h	d_v	min a	b	c	β	R
mm	kg/m	mm²	mm	mm	mm	mm	mm	deg	mm
26.5	4.48	552	26.4	25.9	1.7	6.2	13	81.5	2.6
32	6.53	804	31.9	31.4	1.9	7.6	16	81.5	3.2
36	8.27	1 018	35.9	35.4	2.1	8.7	18	81.5	3.6
40	10.205	1 257	39.7	38.9	2.1	9.6	20	81.5	4.0
47	14.10	1 735	46.6	45.8	2.4	10.5	21	82.5	4.0

[1)] The nominal mass per metre includes 3.5% not load bearing portion of ribs.
Tolerances: +3% / -2% of nominal mass

Plain bar, WS, dimensions



Nominal diameter	Nominal mass per metre	Nom. cross sectional area
d_s	M	S_n
mm	kg/m	mm²
32	6.313	804
36	7.99	1 018

Mechanical characteristics:

Nominal diameter		Elastic limit	0.1% - proof stress	Tensile strength	Characteristic 0.1% - proof force	Characteristic Maximum force	
d_s		$R_{p0.01}$, $f_{p0.01}$	$R_{p0.1}$, $f_{p0.1}$	R_m, f_m	$F_{p0.1}$	F_m	α[1]
mm		N/mm²	N/mm²	N/mm²	kN	kN	%
WR	26.5	850	950	1 050	525	580	5
	32				760	845	
	36				960	1 070	
	40				1 190	1 320	
	47				1 650	1 820	
E	26.5	735	835	1 030	461	568	5
	32				672	828	
	36				850	1 048	
	40				1 049	1 294	

Additional characteristics:

Total elongation at maximum force[2] (calculated as $A_g + \frac{R_{m,a}}{E} \cdot 100$)	A_{gt}	%	5	5[1]
Force range F_r (at upper load $F_{up} = 0.70 \cdot F_{m,a}$ and $N = 2 \cdot 10^6$ load cycles)	Plain bar		200 N/mm² · S_n	
	Threadbar		180 N/mm² · S_n	
Isothermal stress relaxation	Losses from an initial force of $0.70 \cdot F_{m,a}$ after 1 000 h ≤ 3%			

[1] Quantile for a statistical probability of $W = 1 - \alpha = 0.95$ (one sided)

[2] $E \approx 205{,}000$ N/mm²

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DYWIDAG-PT bar tendon, bonded, unbonded and external tendon

Prestressing bars
Threadbars and plain bars
Specifications

Annex 30b

Specification heatshrinking sleeve SATM:

Properties	Test method / Standard	Typical value
Tensile strength	ISO 527	20 N/mm²
Elongation	ISO 527	580 %
Hardness, Shore D	ASTM D-2240	55
Shrink force	ASTM D-638	40 psi (~0.28 N/mm²)
Impact strength	EN 12068	> 8 Nm
Indentation resistance	EN 12068	> 0.6 mm
Peel to steel	7 N / 25 mm	
Internal coating	Self-priming mastic sealant (butyl-caoutchouc-basis) containing active corrosion inhibitor, free of Sulphid, Chloride and Sulphate	
Amount of coating	min. 700 g/m², mean value 1 100 g/m², Nominal thickness 0.95 mm	
Shrinking temperature	min. 125 °C, optimal 250 - 300 °C (using hot-air or infrared radiator)	
Recommended surface preparation	clean, dry, free of fat	

General properties:

- The heatshrinking sleeves resist mechanical stresses: flexural, abrasion, indentation and impact, also corrosive gases and liquids.
- The specially developed internal coating guarantees a strong, durable adhesion, hence an efficient protection. Small leaks will be closed self-acting by the sealing material.

References

Guideline for European technical approval

ETAG 013 (06.2002)	Guideline for European technical approval of Post-Tensioning Kits for Prestressing of Structures

Eurocodes

Eurocode 2	Eurocode 2: Design of concrete structures
Eurocode 3	Eurocode 3: Design of steel structures
Eurocode 5	Eurocode 5: Design of timber structures
Eurocode 6	Eurocode 6: Design of masonry structures

Standards

EN 206-1+A1+A2 (06.2005)	Concrete - Part 1: Specification, performance, production and conformity
EN 446 (03.1996)	Grout for prestressing tendons - Grouting procedures
EN 447 (03.1996)	Grout for prestressing tendons - Specification for common grout
EN 523 (08.2003)	Steel strip sheaths for prestressing tendons - Terminology, requirements, quality control
EN 10025-Series (11.2004)	Hot rolled products of structural steels - Series
EN 10083-2 (02.1991)	Quenched and tempered steels - Part 2: technical delivery conditions for unalloyed quality steels (Historical standard)
EN 10130 (12.2006)	Cold-rolled low carbon steel flat products for cold forming - technical delivery conditions
EN 10139 (11.1997)	Cold rolled uncoated mild steel narrow strip for cold forming - technical delivery conditions
EN 10204 (10.2004)	Metallic products - Types of inspection documents
EN 10293 (04.2005)	Steel castings for general engineering uses
EN 10305-1 (11.2002)	Steel tubes for precision applications - technical delivery conditions - Part 1: Seamless cold drawn tubes

EN 12068 (08.1998)	Cathodic protection - External organic coatings for the corrosion protection of buried or immersed steel pipelines used in conjunction with cathodic protection - Tapes and shrinkable materials
EN 12201-1 (03.2003)	Plastics piping systems for water supply - Polyethylene (PE) - Part 1: General
EN ISO 1461 (02.1999)	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
EN ISO 1872-1 (05.1999)	Plastics - Polyethylene (PE) moulding and extrusion materials - Part 1: Designation system and basis for specifications
EN ISO 12944-4 (05.1998)	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 4: Types and surface preparation
EN ISO 12944-5 (05.1998)	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 5: Protective paint systems
EN ISO 12944-7 (05.1998)	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 7: Execution and supervision of paint work
prEN 10138-4 (08.2009)	Prestressing steels - Part 4: Bars

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