DYWIDAG Prestressing Systems using Bars
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Construction products with a European Technical Approval (ETA) meet all essential demands given in the Construction Products Directive (CPD). The ETA holder is authorized to apply the CE-marking (Conformité Européenne) on his product. The CE-marking certifies the conformity with the technical specification and is the basis for the free movement of goods within the EU member states. DSI is proud to have European Technical Approvals for its PT-systems with bars, bonded strands and unbonded strands.
DYWIDAG Prestressing Systems are world renowned for reliability and performance, most suitable for all applications in post-tensioned and prestressed constructions. They embrace the whole spectrum from bridge construction, buildings, to civil applications, above and underground.

The first ever structure built with a prototype DYWIDAG Post-Tensioning System using bars was the arch-bridge Alsleben (Germany) in 1927. From that time on DYWIDAG has continuously improved its systems to keep up with the growing demand of modern construction technology. In addition to the traditional post-tensioning system using bars, that is mainly geared towards geotechnical applications, building rehabilitation and strengthening, DSI offers a complete product line in strand prestressing (bonded, unbonded and external) as well as stay-cables being able to fully serve the post-tensioning construction. DYWIDAG Prestressing Systems have always combined highest safety and reliability standards with most economical efficiency in their research and development. Dependable corrosion protection methods of the DYWIDAG Prestressing Systems contribute to the longevity of modern construction. High fatigue resistance is achieved with optimized material selection and cautious detailing of all the components especially in their system assembly.

The post-tensioning system for the prestressing of structures with bars (internal bonded, unbonded and external tendons) is regulated in European Technical Approval ETA-05/0123. This ETA can be downloaded at: https://www.dywidag-systems.com/emea/downloads/dsi-approvals/european-approvals.html

Advantages and Characteristics

- Easy system handling
- Robust design
- Flexible transport length due to couplers
- Also applicable for (very) short tendons due to little slip
- Used in new structures and for strengthening of existing structures
- Suitable as longitudinal or transversal tendons
- Usable as shear reinforcement
- Usable as straight or curved tendons
- Can be used as hangers for concrete or steel arch bridges
- Usable for the temporary or permanent connection of precast concrete elements
- Many combinations of any structural material are possible (such as steel with concrete)
- Preassembled unbonded or external tendons with permanent corrosion protection are available

Ground anchors of up to 47 mm are provided for geotechnical applications. Additionally, DSI USA provides DYWIDAG Prestressing Systems with 65 and 75 mm threadbars.

Internal bar tendons are mainly used in concrete, composite and masonry structures. Internal unbonded and external bar tendons are used for concrete, composite, steel, timber and masonry structures. Typical applications are transversal prestressing, strengthening of bridges, rehabilitations, connection elements for steel structures and machines and temporary applications.
Prestressing Bars and Technical Data

General
The prestressing bars are hot-rolled, tempered from the rolling heat, stretched and annealed, with a circular cross section.

The bars are of prestressing steel Y 1050 H according to prEN 10138-4.

The threadbars and plain bars are available in mill length up 18 m and may be cut to specified lengths before shipment to the jobsite.

Threadbars

Threadbars are available in diameters 17.5, 26.5, 32, 36, 40 and 47 mm.

The threadbars feature continuous hot-rolled ribs providing a right-handed thread along the entire length.

The threadbar can be cut anywhere and is threadable without further preparation.

The threadbars are specified by nominal diameter and WR, e.g. 26 WR

Plain bars

Plain bars are available in diameters 32 and 36 mm.

Both ends of a plain bar cut to the length specified in the project are provided with special cold-rolled threads.

The thread lengths are manufactured in the shop according to the specifications of the project.

The plain bars are specified by nominal diameter and WS, e.g. 32 WS.

Technical data

<table>
<thead>
<tr>
<th>Designation</th>
<th>THREADBAR®</th>
<th>Plain bar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18 WR</td>
<td>26 WR</td>
</tr>
<tr>
<td>Nominal diameter $d_s$ [mm]</td>
<td>17.5</td>
<td>26.5</td>
</tr>
<tr>
<td>Cross section area $S_n$ [mm²]</td>
<td>241</td>
<td>552</td>
</tr>
<tr>
<td>Nominal mass per metre $M$ [kg/m]</td>
<td>1.96</td>
<td>4.48</td>
</tr>
<tr>
<td>Pitch $c$ [mm]</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Characteristic breaking load $F_m$ [kN]</td>
<td>255</td>
<td>580</td>
</tr>
<tr>
<td>Max. initial stressing force $P_{0,\text{max}} = S_n \times 0.8 \times f_{p,k}$ [kN]</td>
<td>204</td>
<td>464</td>
</tr>
<tr>
<td>Max. overstressing force $P_{0,\text{max}} = S_n \times 0.95 \times f_{p,0.1k}$ [kN]</td>
<td>219</td>
<td>499</td>
</tr>
</tbody>
</table>

1The nominal mass per metre includes 3.5% not load bearing portion of ribs.
2The given values are maximum values according to Eurocode 2, i.e. \( \min (k_1 \times F_{p,k}, k_2 \times F_{p,0.1k}) \) applies. The fulfillment of the stabilization criteria and the requirements for cracks width in the load transfer tests were verified at 0.8 \( F_{p,k} \).
3Overstressing 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.
<table>
<thead>
<tr>
<th>Available tendons</th>
<th>Anchor plate</th>
<th>18 WR</th>
<th>26 WR</th>
<th>32 WR</th>
<th>36 WR</th>
<th>40 WR</th>
<th>47 WR</th>
<th>32 WS</th>
<th>36 WS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonded bar tendon with QR-plate anchorage with additional reinforcement</td>
<td>2074</td>
<td>☑</td>
<td></td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td></td>
<td>☑</td>
</tr>
<tr>
<td>Bonded bar tendon with small solid rectangular plate anchorage with additional reinforcement</td>
<td>2076</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Bonded bar tendon with QR-plate anchorage without additional reinforcement</td>
<td>2074</td>
<td>☑</td>
<td></td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td></td>
<td>☑</td>
</tr>
<tr>
<td>Bonded bar tendon with small solid rectangular plate anchorage without additional reinforcement</td>
<td>2076</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Bonded bar tendon with small solid square plate anchorage without additional reinforcement</td>
<td>2011</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Bonded bar tendon with solid rectangular plate anchorage with additional reinforcement</td>
<td>2012</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Unbonded and external bar tendon with solid square plate anchorage without additional reinforcement</td>
<td>2011</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Unbonded and external bar tendon with solid rectangular plate anchorage with additional reinforcement</td>
<td>2012</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
</tbody>
</table>

*Hex nuts 2002 are not included in ETA-05/0123.*
Stressing anchorage, bonded
The bar is fixed with the domed anchor nut and the retaining nut to the anchorage plate and this latter will be fixed to the scaffolding. The retaining nut provides the connection to the duct. Grouting is performed through the grout cap, the domed anchor nut with the three grout slots and the retaining nut.

Fixed anchorage, bonded
The fixed anchorage is mostly completely embedded in the concrete. The domed anchor nut is tack welded perpendicularly onto the anchor plate. The duct sleeve B ends directly at the anchor plate the duct will be injected respectively vented there. A fixed anchorage can be designed as a stressing anchorage; the required bar-over length for the stressing can be dispensed.

Stressing anchorage, unbonded
Against water intrusion in the anchorage region a connection tube is welded to the anchor plate for bridging of a gap behind the anchor plate. Different corrosion protection systems are available.

Fixed anchorage, unbonded
The fixed anchorage is mostly completely embedded in the concrete. The domed anchor nut is tack welded perpendicularly onto the anchor plate. The prestressing bar will be provided with the respective corrosion protection. The fixed anchorage can be carried out as an unbonded stressing anchorage, too.
Prestressing bar tendons can be used at new structures and for strengthening of existing structures, as longitudinal or transversal tendons, as shear reinforcement, straight or curved, as hangers at concrete or steel arch bridges, for temporary or permanent connections of precast concrete elements, fixations of concrete to concrete, new concrete to old concrete, steel to concrete, concrete to masonry or any combination of members made of any structural material.

Applications

Grand-Mère Generating Station, Canada

Church of Our Lady, Germany
Overview Bonded Bar Tendons

Bonded bar tendons are embedded in concrete. The corrosion protection of the prestressing steel and the bond with the structural concrete is provided by grout injected in the ducts.

A bonded tendon is intended to be used for concrete, composite and masonry structures.

Bonded bar tendon, design QR-plate, square and rectangular solid plates
Unbonded and external bar tendons are installed either inside or outside the cross section of the structure. For corrosion protection various systems are available, all of which do not bond with the structure. The tendons may be restressed at any time and depending on the tendon type, they can also be removed or exchanged.

Internal unbonded and external tendons are intended to be used for concrete, composite, steel, timber and masonry structures.

The corrosion protection of unbonded and external tendons depends on an environmental conditions and service time.

Bar tendons with free tendon duct, permanent corrosion protection executed during grouting before stressing, design square and rectangular solid plates

Bar tendons with free tendon duct, permanent corrosion protection executed by heatshrinking sleeve, design square and rectangular solid plate
## Overview of Corrosion Protection Systems

<table>
<thead>
<tr>
<th>Corrosion protection for</th>
<th>Temporary corrosion protection ≤ 3 years</th>
<th>Permanently corrosion protection</th>
<th>Permanently corrosion protection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Threadbar</strong></td>
<td><strong>Plain bar</strong></td>
<td><strong>coating</strong></td>
<td><strong>coating</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>grouting with cement grout before stressing (installation)</td>
<td>grouting with cement grout after stressing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>heatshrinking sleeve or corrosion protection tape</td>
<td>corrosion protection compound</td>
</tr>
<tr>
<td></td>
<td>coating acc. to EN ISO 12944-5 with protection tube (PE)</td>
<td>heatshrinking sleeve or corrosion protection tape with protection tube (PE or steel)</td>
<td>heatshrinking sleeve or corrosion protection tape with protection tube (PE or steel)</td>
</tr>
<tr>
<td><strong>Anchorage, range of connection tube</strong></td>
<td>corrosion protection compound or tape</td>
<td>sealing ring plus grout</td>
<td>sealing ring or heatshrinking sleeve plus corrosion protection compound</td>
</tr>
<tr>
<td></td>
<td></td>
<td>corrosion protection compound or tape</td>
<td>heatshrinking sleeve plus corrosion protection compound</td>
</tr>
<tr>
<td><strong>Anchorage, range of anchor nut</strong></td>
<td>corrosion protection compound or tape</td>
<td>corrosion protection compound or tape</td>
<td>corrosion protection compound</td>
</tr>
<tr>
<td></td>
<td>cap, PE or steel</td>
<td>cap, PE or steel</td>
<td>corrosion protection compound</td>
</tr>
<tr>
<td><strong>Coupler</strong></td>
<td>heatshrinking sleeve</td>
<td>tubes (PE or steel) with transition pieces, sealed with heatshrinking sleeve or tape, filled with corrosion protection compound or tape</td>
<td>tube with transition pieces, filled with corrosion protection compound</td>
</tr>
<tr>
<td></td>
<td>tubes (PE or steel)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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"Overview of Corrosion Protection Systems"
### Overview of Tensioning Jacks for Prestressing Tendons

<table>
<thead>
<tr>
<th>Bar designation</th>
<th>THREADBAR®</th>
<th>Plain bar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18 WR</td>
<td>26 WR</td>
</tr>
<tr>
<td>60 Mp</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>110 Mp</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>200 Mp</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ stressing force limited to 625 kN max.

### Geometrical Characteristics of Accessories

<table>
<thead>
<tr>
<th>Bar designation</th>
<th>THREADBAR®</th>
<th>Plain bar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18 WR</td>
<td>26 WR</td>
</tr>
<tr>
<td>Domed Anchor Nut 2099</td>
<td>length [mm]</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>width across flat [mm]</td>
<td>36</td>
</tr>
<tr>
<td>Hex Nut 2002</td>
<td>length [mm]</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>width across flat [mm]</td>
<td>41</td>
</tr>
<tr>
<td>Coupler (Standard) 3003</td>
<td>length [mm]</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>outside diameter [mm]</td>
<td>36</td>
</tr>
<tr>
<td>Square Solid Plate 2011</td>
<td>width [mm]</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>length [mm]</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>thickness [mm]</td>
<td>25</td>
</tr>
<tr>
<td>Rectangular Solid Plate (Unbonded and Bonded) 2012</td>
<td>width [mm]</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>length [mm]</td>
<td>130</td>
</tr>
<tr>
<td></td>
<td>thickness [mm]</td>
<td>30</td>
</tr>
<tr>
<td>Rectangular Solid Plate (Bonded) 2076</td>
<td>width [mm]</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>length [mm]</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>thickness [mm]</td>
<td>25</td>
</tr>
<tr>
<td>QR-Plate 2074</td>
<td>width [mm]</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>length [mm]</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>thickness [mm]</td>
<td>-</td>
</tr>
<tr>
<td>Corrugated Duct 4061</td>
<td>internal diameter [mm]</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>outside diameter [mm]</td>
<td>30</td>
</tr>
<tr>
<td>Minimum Bar Protrusion at stressing anchorage</td>
<td>[mm]</td>
<td>60</td>
</tr>
</tbody>
</table>

⁴ Hex nuts 2002 are not included in ETA-05/0123.
DYWIDAG-Systems International offers a full line of special installation accessories to facilitate field assembly and installation. Installation shall be carried out by properly trained and experienced personnel. Tendons can be delivered to the jobsite prefabricated when desired (e.g. unbonded bar tendon), too.

In the area of anchorage adequate space shall be accomplished through a pocket former assembled at the formwork before concreting in order to put on the jack and for the grout cap.
Stressing and Grouting

The small, light and conveniently operated DYWIDAG-Systems International jacks facilitate the stressing operation. Heavy lifting aids are generally not necessary.

The jack is pushed over a pull rod coupler that is threaded onto the bar protrusion behind the domed anchor nut. The jack is then fixed with a pulling nut.

The tension load is hydraulically transferred. The domed anchor nut is tightened by an internal wrench. The bar 47 WR has a specially equipped stressing jack.

Stressing notes

Straight tendons are generally stressed from one end only. In order to reduce friction losses (especially in draped tendons) it is recommended to stress from both sides.

The prestressing load can be adjusted up and down at any given time until the tendon is fully grouted by simply reinstalling the jack. This allows partially stressing. Several controls during and after the stressing operation check the effective stressing load:

- bar protrusion at the anchorage before and after stressing to evaluate the effective elongation
- counter control for elongation during stressing operation
- gauge control for hydraulic pressure

To comply with exceptional high demands on accuracy for example on very short tendons special accessories can be applied to minimize the influence of alignment tolerances.

Grouting

The durability of bonded post-tensioned construction depends to a great degree on the success of the grouting operation. The hardened cement grout provides bond between concrete and tensile elements as well as primary long term corrosion protection (alkaline medium) for the prestressing steel.

DYWIDAG-Systems International has developed a grouting operation that is based on highly plasticized grout with thixotropic properties, and utilizes durable grouting equipment. Advanced methods such as pressure grouting, post-grouting and vacuum grouting are all results of many years of development.

Grouting is always done from a low-point of the tendon. This can be one of the anchorages with a grout cap with grout inlet or along the tendon utilizing an intermediate grout saddle. All grouting components are threaded for easy, fast and proper connection.
### Equipment for Stressing and Grouting

#### Tensioning jacks

![Image of Tensioning jack 110 Mp/60 Mp and Tensioning jack HOZ 200 Mp]

**Dimensions (for Block-Out design)**

<table>
<thead>
<tr>
<th>Tensioning jacks</th>
<th>L</th>
<th>Ø E stroke</th>
<th>piston area Ak</th>
<th>capacity max. piston pressure</th>
<th>weight</th>
<th>A</th>
<th>B</th>
<th>Ø C</th>
<th>Ø D</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 Mp Series 04</td>
<td>401</td>
<td>190 50</td>
<td>132.5</td>
<td>625</td>
<td>500</td>
<td>36</td>
<td>225</td>
<td>176</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>60 Mp Series 05</td>
<td>456</td>
<td>190 100</td>
<td>132.5</td>
<td>625</td>
<td>500</td>
<td>44</td>
<td>225</td>
<td>231</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>110 Mp Series 01</td>
<td>494</td>
<td>267 50</td>
<td>235.6</td>
<td>1,100</td>
<td>500</td>
<td>46</td>
<td>275</td>
<td>219</td>
<td>375</td>
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</tr>
<tr>
<td>110 Mp Series 03</td>
<td>594</td>
<td>267 150</td>
<td>235.6</td>
<td>1,100</td>
<td>500</td>
<td>54</td>
<td>275</td>
<td>319</td>
<td>375</td>
<td></td>
</tr>
<tr>
<td>200 Mp</td>
<td>865</td>
<td>315 150</td>
<td>361.3</td>
<td>2,000</td>
<td>600</td>
<td>172</td>
<td>350</td>
<td>515</td>
<td>375</td>
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</table>

<table>
<thead>
<tr>
<th>Ø C Ø D for type of bar</th>
<th>[mm]</th>
<th>[mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>3)</td>
<td>105</td>
<td>106</td>
</tr>
<tr>
<td></td>
<td>135</td>
<td>114</td>
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<tr>
<td>4)</td>
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<td>125</td>
<td>110</td>
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<tr>
<td></td>
<td>125</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>134</td>
<td>134</td>
</tr>
</tbody>
</table>

#### Hydraulic pumps

<table>
<thead>
<tr>
<th>Hydraulic pumps</th>
<th>Tensioning jacks</th>
<th>60 Mp</th>
<th>110 Mp</th>
<th>200 Mp</th>
</tr>
</thead>
<tbody>
<tr>
<td>77-193 A</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td></td>
</tr>
<tr>
<td>R 3.0 V</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td></td>
</tr>
<tr>
<td>R 6.4</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pump type</th>
<th>max. operating pressure</th>
<th>oil flow rate</th>
<th>usable oil capacity</th>
<th>weight with oil</th>
<th>dimensions L x W x H</th>
</tr>
</thead>
<tbody>
<tr>
<td>77-193 A</td>
<td>600</td>
<td>3.0</td>
<td>10</td>
<td>63</td>
<td>420x380x480</td>
</tr>
<tr>
<td>R 3.0 V</td>
<td>600</td>
<td>3.0</td>
<td>13</td>
<td>98</td>
<td>600x390x750</td>
</tr>
<tr>
<td>R 6.4</td>
<td>600</td>
<td>6.4</td>
<td>70</td>
<td>310</td>
<td>1,400x700x1,100</td>
</tr>
</tbody>
</table>

1) Hydraulic pumps will be supplied without oil.

#### Grouting equipment (mixing and pumping)

<table>
<thead>
<tr>
<th>Grouting equipment</th>
<th>max. injection pressure</th>
<th>capacity</th>
<th>weight</th>
<th>dimensions L x W x H</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP2000-5</td>
<td>15</td>
<td>420</td>
<td>300</td>
<td>2,000x950x1,600</td>
</tr>
</tbody>
</table>
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Malaysia
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