DYNA Force® Elasto-Magnetic Force Monitoring System
We do not only talk about service – we offer it!

As a service provider DSI offers professional support by experts and the training of installation Personnel on site.

Our goal is to fulfill your expectations day by day.
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Introduction

There is an increasing demand for health monitoring systems for geotechnical applications as well as for bridges and buildings. For the mentioned structures, steel elements that are, either prestressed or subject to high compression forces are key elements for achieving the scheduled performance of the structure. On many occasions during the construction and service life of a structure, it is of decisive importance to know the stress level / the axial forces of the steel elements in use. Although there are many methods to measure the axial force, most of them are cumbersome, expensive, and the accuracy varies depending on the method used. DSI actively participated in the development, testing and utilization of the DYNAR Force® System for measuring the force in steel bars or strands.

The force measuring technique is based on the elasto-magnetic properties of ferromagnetic materials and is carried out using DYNAR Force® Sensors. The magnetic permeability of steel in a magnetic field changes as a function of the mechanic normal stress condition of the steel. By measuring the relative change in magnetic permeability, the normal stress in the steel tendon can be determined. The DYNAR Force® Monitoring System is based on the principle described above and can be used both for post-tensioned bars and for strands.

The hollow cylinder shaped monitoring sensors are available in different diameters to suit various bar and strand diameters.

A readout unit measures the magnetic permeability of the steel tendon through the sensor and shows the tendon force on the display. Each DYNAR Force® Sensor is fitted with an integrated temperature sensor in order to automatically compensate the influence of possible temperature alterations.

The DYNAR Force® System allows permanent monitoring of post-tensioning forces in steel tendons. Force readings as part of inspection procedures can be done within a few minutes without the need for lift-off equipment or other cost-intensive techniques.

Fields of Application

- Ground Anchors
- Tie-back and Tie-down Anchors
- Micropiles
- Soil Nails
- Stay Cable Bridges
- Post-Tensioning Tendons in Bridges and Buildings
- Air Traffic Control Towers
- Wind Energy Towers
- Repair and Strengthening of Post-Tensioned Structures

Key Features

For Owners:
- Lifetime monitoring of the post-tensioning performance in structures

For Contractors:
- Knowledge that their post-tensioning design is working as intended. The system permits posterior analysis and potential adjustment at any time in the future
- Monitoring of tendon forces at any time

For Engineers:
- Quality and support from the industry leading supplier
- Sensors can either be mounted in the factory or on site
- Typically, no extra work or interference with post-tensioning installation
- No large load cell at anchorages and no increased pocket depth
- Load check during stressing
- Increased construction site safety
- The electronic force readout is safe and reliable

Readout Unit with Two Types of Sensors
System Description

Manual System for Single Anchors

Key Features

- Each DYNA Force® Sensor is individually connected to the readout unit
- Force and temperature readings are realized sensor by sensor via the readout unit
- Readings are recorded manually

Multiple Reading System

Key Features

- All DYNA Force® Sensors are bundled and connected to the readout unit by multiplexers and main cables
- Multiple readings of all sensors can be done from a central location with a single click
- Local digital data storage
- Data can be imported to various programs for analysis

Fully Automatic Reading System

Key Features

- Automatic readings of all connected sensors
- Reading interval can be defined by the customer
- Automatic force-time-chart and temperature-time chart for data analysis possible
- Local data storage
- Download and control option from a remotely located laptop via GSM or LAN network connection
- Data can be imported to various programs for analysis
- Possibility to integrate DYNA Force® with other measurement instruments (for example wind speed, pore water pressure, slope measurements,...) in standard software

Testing and Calibration of DYNA Force® Sensor

Installation of DYNA Force® Sensor over Strand Anchor Bond Length
## System Components

### Overview

<table>
<thead>
<tr>
<th>Essential System Parts</th>
<th>Manual System for Single Anchors</th>
<th>Multiple Reading System</th>
<th>Fully Automatic Reading System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Readout Unit</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sensors</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Multiplexers</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Laptop/PC</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Controller / Remote Box</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Extension Cables (for connecting the sensors with the multiplexers)</td>
<td>X(^1)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Main Cables (for connecting the multiplexers with the readout unit)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>AC(230V) or DC (24[V]) Power Cord(^2)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>RS232 Cable</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>PowerEM Software (for local access)</td>
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<td></td>
<td>X</td>
</tr>
<tr>
<td>GreenEye Software (for remote access)</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>SimCard / Ethernet Network (provided by customer)</td>
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<td></td>
<td>X</td>
</tr>
<tr>
<td>Optional: Power Supply via 2x12[V] Batteries, Power Controller and Solar Panel</td>
<td>X(^3)</td>
<td>X(^3)</td>
<td>X(^3)</td>
</tr>
</tbody>
</table>

1) Depends on the accessibility of the sensor connectors on site  
2) Just in case the usual AC or DC power supply is not available  
3) Local power supply has to be provided by the customer

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![Readout Unit](image1)

![DYNA Force® Sensor](image2)

![Multiplexer](image3)

![6-Pin Sensor or Extension Cable Connectors](image4)

![12-Pin Main Cable Connectors](image5)

![Automated System](image6)

![Power Cord](image7)

![Enclosure (optional)](image8)
Technical Data

DYNA Force® Sensor

Key Features

- Sensor works touch-less and non-destructive
- Every DYNA Force® Sensor includes a temperature sensor to take into account the temperature influence during force readings
- Sensors and source material (strand/bar) are calibrated before shipping on site
- Sensors are robust and have no moving parts. All inside connections are sealed with epoxy coating
- Maximum cable distance between readout unit and DYNA Force® Sensor is 250m
- Installation of sensors is either done during the production of the anchors or directly on the job-site before stressing the steel tendon
- Operating temperature • -20[°C] up to +80[°C]

DYNA Force® Sensor Data

<table>
<thead>
<tr>
<th>Type</th>
<th>Steel Element Diameter [mm]</th>
<th>Inner / Outer Diameter of Sensor [mm]</th>
<th>Sensor Length [mm]</th>
<th>Part Number</th>
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</thead>
<tbody>
<tr>
<td>Strand Tendon</td>
<td>15.3 - 15.7</td>
<td>20 / 36</td>
<td>132</td>
<td>DFS010101</td>
</tr>
<tr>
<td>Bar Tendon</td>
<td>16 - 36</td>
<td>43 / 80</td>
<td>180</td>
<td>DFS020101</td>
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<tr>
<td>Bar Tendon</td>
<td>40 - 47</td>
<td>53 / 99</td>
<td>200</td>
<td>DFS030101</td>
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<tr>
<td>Bar Tendon</td>
<td>50 - 63.5</td>
<td>73 / 145</td>
<td>310</td>
<td>DFS040101</td>
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<td>Bar Tendon</td>
<td>75</td>
<td>85 / 155</td>
<td>330</td>
<td>DFS050101</td>
</tr>
</tbody>
</table>

Readout Unit

- Measurement range
  - 0 – 95% yield stress level of the steel tendon
- Power supply
  - AC: 90-246[V], 60/50[Hz], 300[W]
  - DC: 24[V], Peak 17A, Standby 200[mA]
- Operating temperature
  - 0° up to 50 °C
- Interface
  - RS232C

Multiplexer

- Standard multiplexers
  - 8 or 16 Channels
- Serial connection of a number of multiplexers via main cable possible
- Additional standard enclosure in case of outside storage: painted steel or stainless steel available

Cables

- Main cable
  - 12 contacts
  - Connector body
- Nickel plated
- PVC jacket
- Extension cable
  - 6 contacts
  - Connector body
  - Plastic
  - PVC jacket

System Accuracy

- Tests have confirmed the high measuring accuracy of the DYNA Force® Sensors
- The Diagram on the right shows the anchor force of a 59-0.6” strand anchor during different load levels
- DYNA Force® Sensors correspond very closely to the jack readings during the loading stages
- Throughout the testing, the DYNA Force® Sensors were consistently more accurate than the load cells

![Diagram showing anchor force comparison between Hydraulic Jack, DYNA Force®, and Load Cell during loading steps 1 to 7.](image-url)
DYNA Force® Sensors installed on DYWIDAG Anchors

**DYWIDAG Bar Anchors**

- DYNA Force® Connector
- Wedge Plate
- DYNA Force® Sensor
- DYWIDAG Prestressing Steel / GEWI® Threadbar
- Cap
- Nut
- Unbonded Anchor Length
- Bonded Length
- Currogated Sheathing
- Grout Body
- Spacer

**DYWIDAG Strand Anchors**

- DYNA Force® Connector
- Bearing Plate
- DYNA Force® Sensor
- DYWIDAG Prestressing Steel / GEWI® Threadbar
- Cap
- Wedge Plate
- Unbonded Anchor Length
- Bonded Length
Installation Process

Anchor with DYNA Force® Sensor

Stressing

Anchor with Sensor Cable

Installed and Connected Anchor

Multiplexer

GreenEye

PowerEM
Maximum Flexibility: DSI develops Restressable Anchor Heads for Choranche Dam, France

**Owner** EdF, France +++ **General Contractor** Eiffage, France +++ **Subcontractor** Résirep, France +++ **Consulting Engineers** EdF, France

**DSI Unit** DSI France SAS, France
**DSI Scope** Development, production, supply, engineering services, technical support, supervision
**DYWIDAG Products** 8 Type 13-0.62" DYWIDAG Strand Anchors, 8 Type 22-0.62" DYWIDAG Strand Anchors, 4 DYNA Force® Sensors, 1 Readout Unit

**DYNA Force® System Premiere on Frankfurt’s Opera Square, Germany**

**Contractor** Joint venture Spezialtiefbau Opernplatz, consisting of PST Spezialtiefbau Sued GmbH and DEMLER Spezialtiefbau GmbH & Co. KG, both Germany +++ **Engineers** IGG - Ingenieurgemeinschaft Grundbau GmbH, Germany (planning of excavation)

**DSI Unit** DYWIDAG-Systems International GmbH, BU Geotechnics, Germany
**DSI Scope** Production, supply, installation, test installation
**DYWIDAG Products** 1,700 temporary Type 4-0.6" DYWIDAG Strand Anchors, 30 DYNA Force® Sensors, Readout Unit
References

Dam, Trebinje, Bosnia and Herzegovina

Client: GEOSONDA ZENICA BH  
General Contractor: GEOSONDA ZENICA BH  
Subcontractor: HISTEH D.O.O.
Consulting Engineers: IBE Consulting Engineers Ljubljana Slovenia

DSI Unit: DYWIDAG-Systems International GmbH, Austria
DSI Scope: Production, supply, supervision
DYWIDAG Products: Type 12-0.62” DYWIDAG Electrically Testable Permanent Strand Anchors – El-Iso System Length up to 61.5m

Sheet Pile Wall, Ile Seguin, Paris, France

Owner: VNF, France  
General Contractor: EIFFAGE TP, France  
Subcontractor: SPIE FONDATIONS, France

DSI Unit: DSI France SAS, France
DSI Scope: Production, supply, technical assistance
DYWIDAG Products: 23 DYWIDAG Strand Anchors with 2 strands, 23 DYNA Force® Sensors
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