E-Power Pipe®: A new trenchless method for underground cable installation

Dr. Gerhard Lang

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High Voltage Power Grid in Germany.

- Intention to replace nuclear power plants with renewable energy until 2025.
- Electrical power grid extension to connect the windfarms in the North Sea with the industry in the south. (underground cable priority for DC)
  - North – South connections (New DC lines) as underground cables
    - 1,500 to 2,250km (900 – 1,600 mi.)
  - Overhead lines use AC technology under special conditions (e.g. distance protected areas), underground lines favor DC.
  - Protests against overhead lines lead to trenchless technology.
- Commissioning of North-South connections in 2025 (formerly 2022)
## Underground Cable Installation

### Installation methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Open Trench</strong></td>
<td>Shallow installation mostly soft ground Rural area</td>
</tr>
<tr>
<td><strong>Semi-Trenchless</strong></td>
<td>Shallow installation Soft &amp; mixed ground Rural/less populated area</td>
</tr>
<tr>
<td><strong>Trenchless</strong></td>
<td>Deep installation All ground conditions Urban area/ river crossings</td>
</tr>
</tbody>
</table>
Conventional Open Cut installation method.
Example Project Raesfeld.

- Soil excavation
- Soil layers stored separately
- Casing pipe installation
- Refilling of soil in separate layers
- Cable pull-in
- Cable pull-in lubrication
- Surface preparation/renaturation
- One year later
Underground Cable Installation.
Existing trenchless and semi-trenchless methods.
Restrictions for cable installation.
by Transition System Operator (TSO).

- Limited job site, construction roads, preparation area
- No heavy equipment between launch and reception point
- Steerable installation of casing pipes for AC & DC lines
- Length: 3,300ft – 4,000ft
- Depth: 5ft m to 13ft, constant
- Diameter casing: ca. DN10” – 16” (250-400mm)
- Casing material: plastic, non-conductive, e.g. PEHD
- Distance between lines: 3ft constant
- Available on market: 2017
## Comparison Trenchless and Semi-Trenchless Cable Installation Methods.
### Options & Limits.

<table>
<thead>
<tr>
<th></th>
<th>Pipe Express® Semi-trenchless</th>
<th>HDD trenchless</th>
<th>Direct Pipe® trenchless</th>
<th>Pipe Jacking trenchless</th>
<th>Segment Lining trenchless</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diameter [mm]</strong></td>
<td>ID 900-1500</td>
<td>ID 250-1500</td>
<td>ID 711-1500</td>
<td>ID 250-4000</td>
<td>ID 2300-4000</td>
</tr>
<tr>
<td><strong>Pipe material</strong></td>
<td>Steel Concrete Plastic (HDPE)</td>
<td>Steel Plastic (HDPE) Cast iron</td>
<td>Steel (Plastic)</td>
<td>Steel Concrete GRP/Hobas Clay pipe</td>
<td>Concrete segments Combisegments (incl. Inliner) Rib &amp; Lagging</td>
</tr>
<tr>
<td><strong>Max. drive length</strong> <em>dep. On Ø</em></td>
<td>40° – 60°: 1000m</td>
<td>Ø bis 20°: 4km Ø bis 60°: 1,7km</td>
<td>Ø bis 38°: 300m Ø bis 60°: 1,4km</td>
<td>Ø 250mm: 100 m Ø3000mm: 1.5 km</td>
<td>Ø 2000mm: 2 km Ø 3000mm: 8 km</td>
</tr>
<tr>
<td><strong>Geology</strong></td>
<td>all Rock up to 100MPa</td>
<td>stable</td>
<td>all Rock up to 150MPa</td>
<td>all</td>
<td>all</td>
</tr>
<tr>
<td><strong>Shaft building</strong></td>
<td>Pit</td>
<td>Pit</td>
<td>Pit with bottom plate and sealing</td>
<td>Shaft with bottom plate and sealing</td>
<td>Shaft with bottom plate and sealing</td>
</tr>
<tr>
<td><strong>Access</strong></td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>yes &gt; Ø 3000 mm</td>
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Comparison Trenchless and Semi-Trenchless Cable Installation Methods.
Options & Limits.

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<th>Shallow</th>
<th>Accuracy</th>
<th>Length &gt; 1,000 m</th>
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<td>Pipe Jacking</td>
<td>250-4,000</td>
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<td>HDD</td>
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<td>Direct Pipe®</td>
<td>700-1,500</td>
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<tr>
<td>Casings Tunnels</td>
<td>Ø 1,500 mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Casings Tunnel</td>
<td>Ø 3,000 mm</td>
<td></td>
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Separate Installation
~500mm / 20°
## Trenchless underground cable construction.

### Options & Limits – E-PP meets all requirements.

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<td></td>
<td></td>
</tr>
<tr>
<td><strong>POWER PIPE</strong></td>
<td>250-700</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
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### SEPARATE INSTALLATION

- ~500mm / 20"

### CASING TUNNELS

- Ø 1,500 mm

### CASING TUNNEL

- Ø 3,000 mm
Trenchless underground cable construction.
Machine technology AVNS.
Trenchless underground cable installation.
Machine technology AVNS.
NEW Jet Pump Technology.

Working principle.

Nozzle:
- $v = 100 \text{ m/s (328 ft/s)}$
- $p = 50 \text{ bar (725 psi)}$

Diffuser:
- $v = 3.5 \text{ m/s (11.5 ft/s)}$
- $p = 20 \text{ bar (290 psi)}$
NEW Jet Pump Technology.
First used in conjunctions with the FF Holeopener in HDD.
Trenchless underground cable installation.

Principle.

**Step 1**
Plot Bore to target point with preliminary casing pipes

**Step 2**
Disassembly of pipe jacking machine

**Step 3**
Mounting of pullhead and product pipe and pullback

Up to 1.200m (4,00ft)
Special installation pipes.
Installation pipes & joint design.

Length 9 m (30ft)
Demo Movie.
Trenchless underground cable installation.
Jobsite setup.

- Current planning: shaft length: ~ 20m | Pilot pipe length: 9m | reduced coupling → high performance
- Adjustable dimensions for pilot pipes, jacking frames and shaft
Trenchless underground cable construction.
Expected installation performance.

<table>
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<tr>
<th>Installation step</th>
<th>1.000m casing installation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot Bore 3,300ft (1.000m)</td>
<td>10 days</td>
</tr>
<tr>
<td>Rotation of jacking frame 180° and preparation of pull-in</td>
<td>1 day</td>
</tr>
<tr>
<td>Pull-in of casing pipes 3,300ft (1.000m)</td>
<td>3 days</td>
</tr>
<tr>
<td>Rotation of jacking frame 180° and preparation of pilot Bore</td>
<td>1 day</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>**15 days</td>
</tr>
</tbody>
</table>

* When using a second jacking frame: pull-in and next pilot bore simultaneously possible = 3 days saving
Trenchless underground cable installation.
Development roadmap.

July 2016
Machine manufacturing
Herrenknecht Plant, Schwanau

November/December 2016
Equipment in Test
Later Measurements
Temperature & Magnetic field, IFHT
Herrenknecht Plant, Schwanau

November/December 2016 Product Launch, Schwanau

February/March 2017
Pilot project
Amprion; 3 x 300m
Borken (DE)

Q2 2017
Market entry

15.12.2016 Product Launch, Schwanau

6 Test drills.

Test criteria's:
- Different soil composition, distance, depth
- Construction process
- Cable pull-in + Load monitoring
- Measurement of thermal conductivity over 6 months
- ...

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[Diagram of test setup with labels and measurements]
Test plant.
Pilot project February/March 2017. Amprion – Project Borken

- 3 x 1,00ft (300 m)
- Mostly silt, sand, marl
- Constant depth of 3ft
- Spacing of approx. 30"
- Drilling in February/March 2017
Pilot project Borken February/March 2017.
Amprion – Project Borken.
Pilot project Borken February/March 2017.
Pilot Bore.
Pilot project Borken February/March 2017.
Pull-in of HDPE pipe.
Pilot project Borken February/March 2017.
Overview.

<table>
<thead>
<tr>
<th></th>
<th>Drive 1</th>
<th>Drive 2</th>
<th>Drive 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pilot Bore</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration</td>
<td>36.5h</td>
<td>39h</td>
<td>/</td>
</tr>
<tr>
<td>Performance average</td>
<td>600mm/min</td>
<td>800mm/min</td>
<td>800mm/min</td>
</tr>
<tr>
<td>Performance max.</td>
<td>1.200mm/min</td>
<td>&gt; 1.200mm/min</td>
<td>&gt; 1.200mm/min</td>
</tr>
<tr>
<td>Best daily advance</td>
<td>99m</td>
<td>107m</td>
<td>126m</td>
</tr>
<tr>
<td>Pipe handling cycle</td>
<td>40min → 20min</td>
<td>20-25min</td>
<td>20-25min</td>
</tr>
<tr>
<td><strong>Pull-in of casing pipe</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance max.</td>
<td>1.200mm/min</td>
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</tr>
<tr>
<td>Best daily advance</td>
<td>107m</td>
<td>134m</td>
<td>266m</td>
</tr>
<tr>
<td><strong>Max. tolerance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical</td>
<td>horizontal</td>
<td>400mm</td>
<td>500mm</td>
</tr>
<tr>
<td>* Installation depth changed</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Pilot project Borken February/March 2017.
Overview.
Jobsite Images.

- Project: 6 x 270m (890ft) drives
- Installation depth: 2.5-4.5m (8-15ft), curve radius: r=500m (1,640ft)
Together we build our future.