Gas insulated lines (GIL)

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Challenges in Mega Cities

Data, Site Works & Laying Methods of GIL

Technical Advantages of GIL
- Capacitive Load
- EMV Radiation
- Transmission Losses
- Auto Reclosure Functionality
- Innovative Arc Location

References

Summary
Challenges: Transmission Grid in Densely Populated Areas ...in 1970 with 110kV
...in 2000 with several 110kV lines
...in Future with 400(500)kV
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Summary
Construction of a Welded GIL „OHL Underground“

- Connection of Al tubes and conductors by welding
- Supported by cast resin insulators
- Filled with gas mixture
- Protected by particle traps
## Technical Data

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rated Voltage</strong></td>
<td>245 kV... 550 kV</td>
</tr>
<tr>
<td><strong>Impulse withstand voltage</strong></td>
<td>... 1675 kV</td>
</tr>
<tr>
<td><strong>Rated current (typical)</strong></td>
<td>2000 ... 5000 A</td>
</tr>
<tr>
<td><strong>Rated short time current</strong></td>
<td>63 kA / 3s</td>
</tr>
<tr>
<td><strong>Rated Transmission Load</strong></td>
<td>up to 4700 MVA</td>
</tr>
<tr>
<td><strong>Capacitance</strong></td>
<td>55 nF/km</td>
</tr>
<tr>
<td><strong>Overload capability (typical)</strong></td>
<td>100 %</td>
</tr>
<tr>
<td><strong>Insulation gas mixture</strong></td>
<td>e.g. 80 % N$_2$ &amp; 20 % SF$_6$</td>
</tr>
</tbody>
</table>

Designed and tested according to IEC 61640
„HV gas-insulated transmission lines for rated voltages of 72.5 kV and above“
Fitting of GIL Conductor on Site
Automated Orbital Welding of GIL
GIL above Ground
GIL Laid in Tunnels or Directly Buried

- Small width of trench
- Min. interference with environment during installation
- Space saving concept
- Cost advantage
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Summary
Capacitive Load $C'$ of Transmission Systems

- OHL: 15nF/km
- GIL: 55nF/km
- XLPE-Cable: 210nF/km
- 2 XLPE-Cables in parallel: 420nF/km
GIL Comprise Low Electromagnetic Field: Calculated Enclosure Currents of GIL

GIL are installed with enclosures short-circuited and solidly grounded at both ends so that the return current over the enclosure is almost as high as the current of the conductor and therefore the resulting magnetic field outside of the GIL is very low.

(800 MVA, 400 kV)
Environment Friendly
Low Electromagnetic Fields
Comparison of Losses:
OHL vs. Cables & GIL (1 system)

<table>
<thead>
<tr>
<th>Type</th>
<th>Diameter</th>
<th>Material</th>
<th>Current</th>
<th>Power [W/m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead Line</td>
<td>4x240/40AlSt</td>
<td>XLPE Cable</td>
<td>1x2500mm²</td>
<td></td>
</tr>
<tr>
<td>Overhead Line</td>
<td>4x560/50AlSt</td>
<td>XLPE Cable</td>
<td>2XKLDE2Y</td>
<td></td>
</tr>
<tr>
<td>GIL</td>
<td>517/500-180/160</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Auto Reclosure on GIL

Scenario:
- fault detection by protection system
- line drop-off and arc extinguishing

Auto Reclosure:
- gas insulation is self-recovering
- successful auto re-closure: by-products are collected in the particle trap
- unsuccessful auto re-closure: no impact or fire outside the GIL

View inside the GIL
Test Conditions: 63 kA, 500ms

No external impact, no fire risk due to non inflammable materials
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Summary
**GIL Wehr, Germany**  
*(1975) Tube Length 4 kms*

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>600 MVA Transformer</td>
<td>Rated Voltage: 420 kV</td>
</tr>
<tr>
<td>2</td>
<td>Encapsulated Surge Arrestors</td>
<td>Rated Impulse</td>
</tr>
<tr>
<td>3</td>
<td>Transfer Switching units</td>
<td>Withstand Voltage: 1640 kV</td>
</tr>
<tr>
<td>4</td>
<td>GIL Connection</td>
<td>Rated Current: 2000 A</td>
</tr>
<tr>
<td>5</td>
<td>Open Air Surge Arrestor</td>
<td>Rated Short-Time Current: 53 kA</td>
</tr>
<tr>
<td>6</td>
<td>Overheadline</td>
<td></td>
</tr>
</tbody>
</table>

**Diagram:**
- **Distance:**
  - Overheadline: 3.5 m
  - Between units: 2.8 m

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Stephan Poehler / E T TS 2 G&C
Palexpo Fair Building  
Airport Geneva, Switzerland (2002)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Voltage</td>
<td>300 kV</td>
</tr>
<tr>
<td>Rated Current</td>
<td>2000 A</td>
</tr>
<tr>
<td>Rated Impulse Withstand Voltage</td>
<td>1050 kV</td>
</tr>
<tr>
<td>Rated Short-Time Current</td>
<td>50 kA, 1s</td>
</tr>
<tr>
<td>Length app.</td>
<td>2500 m</td>
</tr>
</tbody>
</table>
Customer: China Three Gorges Corporation  
Country: China  
Commissioning: 2013

**Requirements**

Connection of a 500-kV-OHL to an underground GIS with through a 480m deep shaft (~2x240m).

Very high safety requirements with regard to fire protection, as the tunnel is used also as ventilation shaft.

Maximum reliability needed for the connection.

**Products**

Gas Insulated Transmission Line (GIL) for 500kV; seven systems with 7 x 4500 A rated current.

**Customer benefit**

Underground power transmission on highest reliability level.
**Xiluodu GIL, Sichuan, China (II)**

<table>
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<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Voltage</td>
<td>550 kV</td>
</tr>
<tr>
<td>Rated Impulse-withstand Voltage</td>
<td>1675 kV</td>
</tr>
<tr>
<td>Single phase length</td>
<td>app. 12750 m</td>
</tr>
<tr>
<td>Rated Current</td>
<td>4500 A</td>
</tr>
<tr>
<td>Rated Short-Time-withstand Current</td>
<td>63 kA, 3 s</td>
</tr>
<tr>
<td>Single phase length</td>
<td>480m vertical shaft in each circuit</td>
</tr>
</tbody>
</table>
OHL gantry

Customer: Amprion
Location: Airport Frankfurt
Contract award: July 2008
Operation: April 2011
Insulation Gas: 80%N\textsubscript{2}, 20%SF\textsubscript{6}
Transmission Power: 2x1800MVA
Installation: 1st GIL Directly Buried

400 kV GIS

1km

Kelsterbach Airport Frankfurt, Germany (I) (2011)
Kelsterbach (II)
Site View before Refilling of the Trench
Neuwied, Munich, Germany (2014)

Customer: Stadtwerke Munich
Location: Neuwied
Contract award: Feb. 2013
Commercial Operation: Dec. 2013
Insulation Gas: 80%N$_2$, 20%SF$_6$
Transmission Power: 2x2000MVA
Installation: Tunnel

Länge System 1: 420m
Länge System 2: 450m
Länge Gesamt: 870m
Länge Rohr Gesamt: 2610m
Bausteine: 220 St.

1. Tunnel
2. Mast Nord
3. Mast Süd
4. Vorfertigung / Schweifen
Selected References – Gas Insulated Transmission Lines, Status November 2013*

*) overall tube length 92,959 m
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Summary
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- Sealed for lifetime
- Continuously welded
- High ampacity
- Low losses
- Long lifetime through particle trap
- No reactive compensation (<100km)
- No ageing of insulating gas
- Automatic reclosure functionality
- Low external electromagnetic fields
- High safety (no fire hazard)
Thank you!