Cryogenic transfer line systems
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- The company Nexans
- Overview of cryogenic transfer systems
- Nexans CRYOFLEX Transfer Lines
- Applications
Global presence

• Industrial presence in more than 40 countries
• Worldwide commercial activities
• 23,700 local experts

• > 6 Billion Euro sales per year

Nexans is one of the biggest Cable Companies worldwide
History of CRYOFLEX Transfer Lines

- 1st Superconducting Cable 1970
  - Niobium SC
  - 3 flows of cold liquid and gas
  - 3 vacuum enclosures

- 1980 1st vacuum insulated transfer line delivered to CERN (4-tube design for LHe/GHe)

- 1980 – 2011 design, production and delivery of numerous transfer line systems for industrial applications and research institutes all over the world

⇒ More than 40 years Experience in design and production of Cryogenic transfer lines
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Transfer possibilities for cryogenic liquids

**Dewars:**
- low consumption quantities and frequencies
- low investment costs
- High filling losses (up to 40%)
- Manual handling -> labour costs, risks of accidents

**Filling hoses:**
- High flexible
- Mostly non-insulated because of high flow rates and short operation time

**Transfer lines:**
- Permanent installations
- higher flow rates and/or operation times
- different systems available
- investment costs depend on TL system
<table>
<thead>
<tr>
<th>Transfer lines for cryogenic liquids</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-insulated pipes</strong></td>
</tr>
<tr>
<td>Used for short distances and high flow rates</td>
</tr>
<tr>
<td>Very high losses</td>
</tr>
<tr>
<td>Condensation and icing</td>
</tr>
<tr>
<td>Very low investment costs</td>
</tr>
<tr>
<td><strong>Foam insulated pipes</strong></td>
</tr>
<tr>
<td>Used for short distances and high flow rates</td>
</tr>
<tr>
<td>Increased heat inleak (~20 times higher than VIP)</td>
</tr>
<tr>
<td>Maintenance demand through frost damage</td>
</tr>
<tr>
<td>High operating costs through heat inleak and maintenance</td>
</tr>
<tr>
<td>Low investment costs</td>
</tr>
<tr>
<td><strong>Vacuum insulated pipes (VIP):</strong></td>
</tr>
<tr>
<td>very low losses even on long distances</td>
</tr>
<tr>
<td>Maintenance free (depending on system)</td>
</tr>
<tr>
<td>low lifecycle costs</td>
</tr>
<tr>
<td>High investment costs</td>
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</tbody>
</table>
Cryogenic Transfer Systems

**Vacuum insulated transfer lines**

<table>
<thead>
<tr>
<th><strong>Dynamically pumped</strong></th>
<th><strong>Assembled, pumped and sealed on-site</strong></th>
<th><strong>Pre-fabricated with static vacuum:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Low lead times</td>
<td>Low lead time</td>
<td>Constant and reliable manufacturing conditions</td>
</tr>
<tr>
<td>Constant vacuum quality over time</td>
<td>Low material costs</td>
<td>highest quality standard possible (cleanliness, leak detection, pumping time)</td>
</tr>
<tr>
<td>Constant energy consumption</td>
<td>Longer installation time on site</td>
<td>-&gt; highest vacuum quality and lowest heat leak</td>
</tr>
<tr>
<td>Maintenance for pumps</td>
<td>Conditions on site: difficult leak detection, cleanliness, short pumping time</td>
<td>high lead times for custom components</td>
</tr>
</tbody>
</table>

- -> lower vacuum quality and higher heat leak than static vacuum pipes
- -> faster vacuum level degradation over time

high material costs (depending on system)
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Flexible, coaxial Transfer Line for liquefied gases

1. Corrugated inner pipe
2. Spacer
3. Super insulation
4. Vacuum space
5. Corrugated outer pipe
6. Jacket

4-Tube coaxial Transfer Line:
- flexible
- vacuum insulated
- extremely low heat inleak
- 2 flow channels
Various corrugated tubes with different diameters and shapes have been examined.

- optimum design for maximum flow, flexibility and stability
- certified max. operating pressure: 20bar
Unique manufacturing Process:
- longitudinal welding and corrugation of stainless steel in one step
- Automated winding of several layers of superinsulation and spacer

Automated Tube production
- no length limitation
- constant quality standard
- cost leading
Non-insulated Screwing Connection

Pumping Port

Spinning Rotor vacuum gauge

Special Getter Materials inside

Rupture Disc

Static, long lasting vacuum at $1 \times 10^{-5}$ mbar or better
Johnston Bayonet Couplings

- Male part
- Female part
- Clamp Chain

T-Pieces

Realization of complex distribution systems
Installation of CRYOFLEX Transfer Lines:

- Fast, Easy, Cost effective
- Fixed with standard cable clamps
- Easy Transport
CRYOFLEX – Customer Value

- **Flexible cryogenic transfer lines with almost unlimited length**
  - bayonet connections or on-site welding can be avoided

- **Fast, easy & cost effective installation**
  - even in the most difficult to access environment

- **No exact on-site measurement necessary**
  - greatly reduced lead time

- **CRYOFLEX is reusable**
  - pipe routing changes can easily be realized
  - dismounted lines can be used for new projects

- **Stable, long lasting vacuum**
  - far more than 10 years operation without any maintenance

- **Low wall thickness**
  - fast cool down, low weight
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Vacuum insulated Transfer Lines

**Special Applications**
- Superconductivity
- Space technology
- Particle acceleration
- Electron beams
- Fusion technology

**Industrial Applications (LN2)**
- cleaning and milling
- food freezing
- deburring of rubber parts
- pressurization of plastic bottles
- freezing and storing of organic materials like blood, sperm and bacteria
- Semiconductor production
HTS Cable Systems

- **Cable Core**
  - Transport the current
  - Withstand the voltage

- **Cryostat**
  - Insulate thermally / keeping the cable cold
  - Transport of liquid nitrogen

- **Termination**
  - Connect the system to the grid
  - Manage the transition between cold temperature and room temperature
  - Provide connection to the cooling system

- **Joints**
  - Connection of two cables
  - Intermediate access to cooling medium
Ampacity Project

- Project objectives
  - Development and field test of a 10 kV, 40 MVA (2.3 kA) HTS cable in combination with a superconducting fault current limiter (FCL)

- Project partners
  - RWE: Specification and field test
  - Nexans: HTS cable and FCL
  - KIT: HTS tests and characterization

- Installation in downtown of Essen, connection of two substations

- Approx. 1 km cable system length with one joint

- Installation in Q4 / 2013, afterwards at least two year field test in grid
Thank you for your attention!