Are preinsulated pipe systems according to the European standards over engineered for low temperature systems
The LOGSTOR Group & global presence

Global presence

LOGSTOR Group
- Headquarters in Denmark
- 1,300 employees
- Annual turnover > 230 MEUR
- Owner: Triton Fund III

Facts:
- 7 plants and 2 mobile production units
- 14 Sales Units
- Joint Venture in Dubai
- Distributors in more than 20 countries
- More than 4,000 km pre-insulated pipes every year
- More than 200,000 km LOGSTOR pipes supplied to date
- Since February 2017 Powerpipe/Sweden belongs to the LOGSTOR Group
Different type of District Heating Pipe networks

• Transmission pipe line from the production plant to a city or between cities
  • Steel pipe systems

• Distribution pipe lines in the streets in the city
  • Steel pipe systems (to the major extend)
  • Plastic pipe systems/flexible systems

• Service pipe lines between the distribution pipe line and the final customer (appartments, institutions, one-family houses)
  • Steel pipe systems
  • Flexible systems
European standards for preinsulated pipe systems

- The minimum requirements to the preinsulated components and system is defined in European standards
  - EN253 – pipes
  - EN448 – Fittings
  - EN488 – Steel valves
  - EN489 – Joints
  - EN15698 – Twin pipes (part 1 and 2)
  - EN13941 – Design and installation
  - EN14419 – Surveillance system
  - EN15632 – Flexible systems
    - Part 1 – general and test methods
    - Part 2 – Bonded plastic service pipes
    - Part 3 – non bonded system with plastic service pipes
    - Part 4 – Bonded system with metal media pipes
Scope for the standards related to steel pipes

- Directly buried hot water networks
- Steel service pipe
- Minimum service life of 30 years
- Continuous operation with hot water at various temperatures up to 120 °C
- Individual intervals with a peak temperature of 140 °C. The sum of these intervals must in average not exceed 300 hours a year
4 DH heading for low temperature systems

- Most projects are required to comply with the European standards no matter the actual system temperature

- 4 DH projects is heading against low temperature systems
  - A process that has started
  - It will take long time

- The risk is that preinsulated systems will be over engineered and too expensive for low temperature systems
4 DH heading for low temperature systems

- Higher temperature systems gives higher cost for the
  - media pipes
  - PUR insulation
  - casing
  - specific preinsulated components
  - static design
  - contractor work
- Miss the opportunity of choosing the optimum media pipe
Steel media pipe

• Fatigue stress
  • According to the standard the safety factor is between 5 – 10 depending on the project class
  • For main pipe lines number of full action cycles over life time (30 years) is defined to 250 cycles according to the standard
  • In project class A (small and medium size with low axial stress) the safety factor is 5
  • So preinsulated components are calculated for 1250 full action cycles
  • With low temperature systems can we base calculations on a lower safety factor?
  • This will result in lower cost on products and cheaper design

![Fatigue curve EN 13941 figure 32](image)

<table>
<thead>
<tr>
<th>N</th>
<th>Pr-class</th>
<th>( \gamma_{fat} )</th>
<th>( N_{des} )</th>
<th>( \Delta\sigma) all-weld</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>A</td>
<td>5</td>
<td>1250</td>
<td>841 MPa</td>
</tr>
<tr>
<td>250</td>
<td>B</td>
<td>6.67</td>
<td>1668</td>
<td>782 MPa</td>
</tr>
<tr>
<td>100</td>
<td>C</td>
<td>10</td>
<td>1000</td>
<td>889 MPa</td>
</tr>
</tbody>
</table>
Steel media pipe

- **Steel pipe quality**
  - Changing from P235TR1/TR2 to P235GH
  - Mechanical properties of P235TR1 is stated at room temperature
  - Mechanical properties of P235GH is stated at a higher set of temperature
  - Is this needed for low temperature systems?
  - P235GH is 7% more expensive than P235TR1
  - We have 30+ years good experience with steel 37 (P235TR1)

<table>
<thead>
<tr>
<th>Requirements</th>
<th>TR1</th>
<th>TR2</th>
<th>P235GH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notch bar impact test</td>
<td>None</td>
<td>At 0°C or -10°C</td>
<td>At 0°C or -10°C</td>
</tr>
<tr>
<td>Manufacturing method</td>
<td>Cold, no heat treatment</td>
<td>Annealed, normalized</td>
<td>Annealed, normalized</td>
</tr>
<tr>
<td>Weld seam excess</td>
<td>Inside 1.5 mm</td>
<td>Inside 0.5 mm + 0.05xT</td>
<td>Inside 0.5 mm + 0.05xT</td>
</tr>
<tr>
<td>Yield strength at elevated temperature</td>
<td>Not available</td>
<td>Not available</td>
<td>Available</td>
</tr>
<tr>
<td>Test certificate</td>
<td>2.2 – optional 3.1-3.2</td>
<td>3.1 – optional 3.2</td>
<td>3.1 – optional 3.2</td>
</tr>
<tr>
<td>Chemical analysis</td>
<td>Limited</td>
<td>Extended</td>
<td>Full</td>
</tr>
<tr>
<td>PED</td>
<td>Not allowed</td>
<td>Allowed</td>
<td>Allowed</td>
</tr>
</tbody>
</table>
HDPE casing

- Quality of the casing material has developed over the last decades.
- Thickness of the casing is defined by requirement to withstand the following loads:
  - Production
  - Stock
  - Transport
  - Installation
  - Operation where pipe is moving in the ground.
- With low temperature systems the axial movements in the ground will be lower (Fewer full load temperature cycles). Resulting in lower load on the casing during lifetime.
- In theory the wall thickness of the casing can be 2.5 – 3 mm independently from the size of pipe.
- Today wall thickness according to requirement in the standard is 3 – 10 mm. The higher diameter the higher wall thickness.
- Potential saving is possible on low temperature systems.

Potential saving is possible on low temperature systems.
HDPE casing

- In todays standards it is only allowed to use rework on the HDPE casing from our own production
- This is to secure that all requirements in the standard are full filled
- Think about if we could make a preinsulated pipe with casing made of different kind of rework
- Compromising some of the requirements in the standards but still good enough for low temperature pipe systems (life time minimum 30 years)
PUR (insulation material)

- In the standard there is a requirement of maximum 0.029 W/mK in lambda value
- The standard has minimum requirements to the mechanical properties
  - Density of the foam
  - Compressive strength
  - Axial shear strength
  - Long term creep resistance
- With low temperature systems it will be possible to have lower requirements to the mechanical properties
- When lowering the requirements to the mechanical properties it is possible to improve the heat loss properties
- This will lead to lower heat loss cost over lifetime

Heat conductivity

\[ \lambda_{\text{PUR}} = \lambda_{\text{solid}} + \lambda_{\text{radiation}} + \lambda_{\text{GAS}} \]

\[ \lambda_{\text{GAS}} \text{ is app. } 2/3 \text{ of } \lambda_{\text{PUR}} \]

**Mechanical properties**

<table>
<thead>
<tr>
<th>PUR foam:</th>
<th>Certificate / average value ( \lambda ) – pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional prod.</td>
<td>0.0257 / 0.027 W/mK</td>
</tr>
<tr>
<td>Axial Conti prod.</td>
<td>0.0223 / 0.023 W/mK</td>
</tr>
<tr>
<td>Spiro Conti prod.</td>
<td>0.0241 / 0.025 W/mK</td>
</tr>
</tbody>
</table>
PUR (insulation material)

- Mechanical properties
  - Creep value (compressive strength is based on max 15% deformation over 30 years with a constant load of 0.25 MPa
  - Safety factor 1.5
- Bends are in reality not laying with a constant load
- Can we use lower safety factor when systems are build with lower temperture?
- With lower safety factor we can avoid or minimize the use of foam pads and make cheaper design
The preinsulated pipe (sandwich construction)

Arrhenius curves for thermal life at continuous operating temperature.

<table>
<thead>
<tr>
<th>Actual temperature in profile</th>
<th>Expected thermal life at constant temperature</th>
<th>Operating period in a year for actual profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimim lifetime acc. EN 253</td>
<td>LOGSTOR pipe with S = 2 on lifetime</td>
<td></td>
</tr>
<tr>
<td>65 °C</td>
<td>10.193 Years</td>
<td>190,0 days</td>
</tr>
<tr>
<td>55 °C</td>
<td>28.324 Years</td>
<td>90,0 days</td>
</tr>
<tr>
<td>75 °C</td>
<td>3.668 Years</td>
<td>64,0 days</td>
</tr>
<tr>
<td>80 °C</td>
<td>2.201 Years</td>
<td>20,0 days</td>
</tr>
<tr>
<td>85 °C</td>
<td>1.320 Years</td>
<td>1,0 days</td>
</tr>
</tbody>
</table>

Expected thermal lifetime with variations in temperature and operating period as in actual profile

Sum of days pr year: 365 days
Max temperature in profile: 85 °C

Expected thermal lifetime based on above temperature profile:
- Minimim lifetime acc. EN 253: > 100 years
- LOGSTOR pipe with S = 2 on lifetime: > 100 years
The preinsulated pipe (sandwich construction)

- Life time on pipe systems shall be minimum 30 years on a system with continuous temperature 120 °C and peak temperatures 140 °C

- That are the design criteria for the preinsulated components

- Life time on district heating networks at other temperatures can be calculated based on the so-called Arrhenius equation

- With set of temperatures between 55 – 85 °C calculated life time will far more than 1000 years

- Nice – but do we need that?

- Or can we reduce on some requirements and save cost

Sheer test at 140 C minimum 0,08 Mpa
Friction force on casing gives less than 0,027 Mpa (steel)
We need the sheer strength but do we need more than 1000 years
The preinsulated pipe (sandwich construction) - design

- Examples on first time movements
  - 65°C  DN 100/225  $\Delta L = 19$ mm
  - 75°C  DN 100/225  $\Delta L = 27$ mm
  - 110°C DN 100/225  $\Delta L = 66$ mm

- Design with the right set of temperatures instead of using the normal design temperatures

- Saving on the cost of handling the expansion of pipes in the ground
Shallow pipe burial

- Disadvantages by using more shallow pipe burial
  - Larger movements
  - Increased risk for vertical instability and buckling of the pipe line through the overfill

- With the low temperature systems the risk of vertical instability and buckling of the pipe line through the overfill is minimized
  - Due to lower stress in the steel pipes
  - Cost saving on contractor cost by using more shallow burial
Does the standards prevent development?

- PEXb as an example
- PEXb where cross linking will happen when taken into operation with hot water
  - Full filled all requirement to tests described in the standards (temperature, pressure, life time etc etc)
  - Full filled all requirements from the standard except for 1 – it would not be cross linked when delivered but when taken into operation
- Would even be better compared to other PEX types on certain parameters
- Would be cheaper material
- PEXb that would cross link when taken was not voted into the standard

- Going in the direction of low temperature systems
- There will be a need of developing new materials that are optimal for low temperature systems
- How do we prevent that existing standards are blocking for needed new development?
The need for an additional standard?

Is there a need to extend the standards to cover low temperature district heating systems as well?
Questions ?