HDPE For Drinking Water Pipes
The European Experience From The Beginning Until Today

Ulrich Schulte
Chairman of the PE100+ Association

Denver, CO, Sept. 28, 2012
Outline

• PE100+ Association
• How Do PE100 materials compare to PE4170 materials
• Regulatory approach to pressure pipe design in accordance with ISO standards
• Actual failure statistics
• Composition of the European drinking water grid (selected countries)
• Conclusion
PE100 vs PE4710

• Same Material Listed:
  — For example, PPI TR-4 listing for Borealis BorSafe HE3490-LS
• Culmination of extensive advancements by the PE resin manufacturers

<table>
<thead>
<tr>
<th>Classification</th>
<th>BorSafe HD3490-LS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE100</td>
<td>PE4710</td>
</tr>
<tr>
<td>Temperature</td>
<td>68°F</td>
</tr>
<tr>
<td>HDB</td>
<td>--</td>
</tr>
<tr>
<td>MRS</td>
<td>1450 psi (10 Mpa)</td>
</tr>
</tbody>
</table>
PE100 vs PE4710

- Differences:
  - Calculating Long Term Pressure Strength
  - Maximum Operating Pressure Equations Different

\[ MOP_{AWWA} = \frac{2 \times HDB \times DF}{(SDR-1)} \]

\[ MOP_{ISO} = \frac{20 \times MRS}{C \times [SDR-1]} \]
PE100 vs PE4710

• Pressure Rating of Pipe
  — Systems and Equations Different

<table>
<thead>
<tr>
<th></th>
<th>PE 3408</th>
<th>PE 4710</th>
<th>PE 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDB, psi</td>
<td>1600</td>
<td>1600</td>
<td></td>
</tr>
<tr>
<td>MRS, psi</td>
<td></td>
<td></td>
<td>1450</td>
</tr>
<tr>
<td>Design factor</td>
<td>0.5</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>Design coefficient</td>
<td></td>
<td></td>
<td>1.25</td>
</tr>
<tr>
<td>Pressure (DR 11), psi</td>
<td>160</td>
<td>200</td>
<td>232</td>
</tr>
</tbody>
</table>

— PE4710 Pressure Rating Still 16% lower than PE100
Requirements of PE pipe resins for water supply according to ISO 4427

Table 3 — Material designation and corresponding maximum design stress values

<table>
<thead>
<tr>
<th>Designation</th>
<th>Minimum required strength (MRS) MPa</th>
<th>σₚ MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE 100</td>
<td>10,0</td>
<td>8,0</td>
</tr>
<tr>
<td>PE 80</td>
<td>8,0</td>
<td>6,3</td>
</tr>
<tr>
<td>PE 63</td>
<td>6,3</td>
<td>5,0</td>
</tr>
<tr>
<td>PE 40</td>
<td>4,0</td>
<td>3,2</td>
</tr>
</tbody>
</table>

Design stress, σₚ, is derived from the MRS by application of the overall service (design) coefficient, C = 1.25.

NOTE A higher value for C can be used; for example, if C = 1.6, this gives a design stress of 5.0 MPa for PE 80 materials. A higher value for C can also be obtained by choosing a higher PN class.
Regulatory approach to the design of pressure pipes for water supply

- Specific codes of Industry Associations based on ISO and EN standards:
  - German DVGW Technical Code GW335-A2, Plastic piping systems in gas and water supply; requirements and testing – pipes made from PE80 and PE100
  - French NF114
  - UKWIR standards
  - Other European countries
DVGW code W400-1
Approved pipe dimensions for drinking water

<table>
<thead>
<tr>
<th></th>
<th>PE80</th>
<th>PE100</th>
<th>PE-Xa</th>
<th>PVC-U</th>
<th>Ductile Iron</th>
<th>Steel</th>
<th>GRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accepted diameters DN [inch]</td>
<td>≤25</td>
<td>≤25</td>
<td>≤10</td>
<td>≤16</td>
<td>3-79</td>
<td>3-79</td>
<td>6-95</td>
</tr>
<tr>
<td>Admissible DR and pressure [psig]</td>
<td>DR7.4 up to 290</td>
<td>DR11 up to 232</td>
<td>SDR7.4 up to 290</td>
<td>DR13.6 up to 232</td>
<td>Pressure less</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DR11 up to 182</td>
<td>DR17 up to 147</td>
<td>DR11 up to 182</td>
<td>DR21 up to 147</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DR34.4 up to 87</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Design coefficient for pipes made from PE80 and PE100 is 1.25!
Drinking water mains in **France** are standardized by NF144

### PE 100 PIPES (cont.)

<table>
<thead>
<tr>
<th>Nominal outer diameter Dn (1) (mm)</th>
<th>S.D.R. (2)</th>
<th>Nominal pressure (bar)</th>
<th>Nominal thickness t (3) (mm)</th>
<th>Tolerances in relation to nominal values (mm)</th>
<th>Absolute maximum out-of-round values (4) on straight pipe</th>
<th>Mass per meter (kg/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7.4</td>
<td>25</td>
<td>24.6</td>
<td></td>
<td></td>
<td>12.100</td>
</tr>
<tr>
<td>180</td>
<td>9</td>
<td>20</td>
<td>20.1</td>
<td></td>
<td></td>
<td>10.200</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>16</td>
<td>16.4</td>
<td></td>
<td></td>
<td>8.550</td>
</tr>
<tr>
<td></td>
<td>13.6</td>
<td>12.5</td>
<td>13.3</td>
<td></td>
<td></td>
<td>7.100</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>10</td>
<td>10.7</td>
<td></td>
<td></td>
<td>5.800</td>
</tr>
</tbody>
</table>

- **Design coefficient is 1.25!**
UK – Choice of materials

• „In common with the vast majority of UK water companies, Thames‘ standard material for new lay distribution mains and services is polyethylene (PE).

• Specifically, PE100 SDR 17 pipes for mains (147 psig rated)

• …and PE80 SDR 11 (182 psig rated) pipes for services.“

• Hence a design coefficient of 1.25 is applied here as well

Regulatory approach to the design of pressure pipes for water supply

- **ISO Standards**
  - **ISO 4427**: Plastic piping systems; Polyethylene pipes and fittings for water supply

- **European System Standards deriving from ISO with national preambles**
  - **EN 12201**: Plastic piping systems for water supply - Polyethylene
Total failure statistics of Gelsenwasser mains

- 19 failures in 2009 on a total PE100 network of 800 km result in an average failure rate of 2.4 failures /100 km and year
- A low failure rate of 9.4 for the total pipe grid is still significantly higher than the rate of 2.4 just for the PE part.
Failure statistics of UK water mains for reference

>7 inch Piping: Drinking water supply in Europe

*Intermaterial competition – Long term demand 1999 - 2008*

Germany: PE 100 is gaining ground vs. steel, PVC and PE80

Source: AMI and LYB Market Intelligence
> 7 inch Piping: Drinking water supply in Europe

Intermaterial competition – Long term demand 1999 - 2008

% Share of Kilometers by Material, DN ≥ 7 inch (180 mm)

UK: PE100 pipes are well established, above Ø300 dominates ductile iron

Source: AMI and LYB Market Intelligence
Drinking water supply in Europe in a nut shell!

TEPPFA: Today about 90% (in length) of all newly installed pipes are made from certified HDPE grades.
The vision of the 1950s has today become a reality

- Following the discovery of the low-pressure process, the production of HDPE began at a pace that would be inconceivable today.
- From the very beginning, pipes manufactured from HDPE were able to meet high service life expectations.
- Today's HDPE pipe extrusion compounds of the 4th generation are high-performance materials distinguished by their strength, stability and durability.
- The development of HDPE as a pipe extrusion compound has not yet reached its peak – the next generation is only just around the corner.

Pipes made from HDPE have proven highest reliability over the recent half century. This covers the total diameter range from less than 1“ up to 65 inches.
HDPE For Drinking Water Pipes
*The European Experience From The Beginning Until Today*

Thank you

Ulrich Schulte
Chairman of the PE100+ Association
Denver, CO, Sep. 28, 2012