High Temperature Polyethylene (PE-RT)
Thermal Distribution Application
Overview
Design
Installation
PE-RT Pipe Sizes & Pressure Rating

Solid Wall Conventional Extrusion
OD Controlled Process
- Iron Pipe Size (IPS): 2” - 54”
Standard Dimension Ratios (SDR’s)
- DR 7.3 to DR 32.5
- Pressure Rated up to 180°F

<table>
<thead>
<tr>
<th>SDR</th>
<th>PR @ 73°F</th>
<th>PR @ 180°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>333</td>
<td>167</td>
</tr>
<tr>
<td>9</td>
<td>250</td>
<td>125</td>
</tr>
<tr>
<td>11</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>13.5</td>
<td>160</td>
<td>80</td>
</tr>
<tr>
<td>17</td>
<td>125</td>
<td>63</td>
</tr>
<tr>
<td>21</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>26</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>32.5</td>
<td>63</td>
<td>32</td>
</tr>
</tbody>
</table>
What is Polyethylene?

• **Thermoplastic**
  – Plastic that can be repeatedly softened by heating and hardened by cooling
  – Process is reversible and repeatable
  – Retains all physical properties

• **Semi-Crystalline Polymer**
  – Molecules pack in Tight Formations
  – Up to 90% Crystalline region
  – Side branching effects Density
  – Tensile Strength, Stiffness, Abrasion, Hardness, Chemical Resistance
Benefits of PE-RT HDPE Pipe

- Higher Operating Temperature
- >20 times Stress Crack Resistant
- Use of Native Backfill for Installation
- Higher Chlorine Resistance
- Lightweight and Flexible
- Outstanding Chemical / Corrosion Resistance
- Abrasion Resistance
- Excellent Flow Characteristics
- Full Range of Pipe Sizes, Molded Fittings and Pressure Capabilities
Resin Evolution

Hydrostatic Design Stress (Water), psi

Polyethylene Material Designation

PE 3408 DR 11 = 160 psi

vs.

PE 4710 DR 11 = 200 psi
### Long-Term Hydrostatic Strength

1. **ASTM D2837** – Testing Standard to obtain Hydrostatic Design Basis (HDB)
2. Data Analysis must yield Straight Line through at least 100,000 hours → 50 yrs
3. Long Term Hydrostatic Strength (LTHS) is determined at 100,000 hours
4. \( \text{HDS} = \text{HDB} \times \text{DF} \) → 1000 psi = 1600 psi \times 0.63

**Graph Details:**
- **HDB**
- **HDS**
- **Linear Regression**
- **DF**
- **Manufacturing Variation**
- **Handling/Shipping/Storage**
- **Temperature up to 80°F**
- **Installation/Soil Conditions**
- **Surges/Water Hammer**

**Graph:**
- **Hoop Stress @ 20°C (psi)**
- **Time (Hours)**
- **11.4 yrs**
- **115 yrs**

**Data Points:**
- 100, 1000, 10000, 115 years
- Stress values at 1000 psi, 1600 psi, 3500 psi, etc.
1. Total Pressure = Working Pressure (Steady) + Surge Allowance (Anticipated)
2. Reoccurring Surge Allowance = 150% x Pressure Rating
3. Occasional Surge Allowance = 200% x Pressure Rating

+10 Million Cycles
13 Surges/hr
300 Surge/day
100 Yrs
Resistance to Slow Crack Growth

PENT, hours

Reduces need for bedding and embedment
Embrittlement Range

1. Water Can Freeze in HDPE pipe without Damage
2. Glass Transition Temperature for PE is -130°F

- HDPE
  - Brittle
  - Ductile
  - -130°F to 0°F to 73°F

- Amorphous Polymer
  - Brittle
  - Ductile
  - 0°F to 73°F to 221°F

Increased Toughness
Larger Deformation
High Impact
High RCP Resistance
DriscoPlex® 1000 PE-RT Series
High Temperature PE Pipe

• IPS Size
  • 2” – 36”
• PE 4710
• Standards
  – ASTM D3350
  – ASTM F714/D3035
• Industrial
  – Mining
  – Power plants
  – Landfill
  – Pulp and Paper Mill
• Municipal
  – Water/Wastewater
  – Dual Containment
Overview

Design

Installation
Thermal Expansion

1. PE has Higher Coefficient of Thermal Expansion (\( \alpha \)) than other Piping Materials
2. PE Has Lower Modulus of Elasticity than other Piping Materials
3. PE Thermal Expansion \( \approx 1 \text{ in}/10^\circ F/100 \text{ ft} \)

<table>
<thead>
<tr>
<th>Piping Material</th>
<th>Coeff. Thermal Exp/Cont, (( \alpha )) in/in-( ^\circ )F</th>
<th>Elastic Modulus (E) psi</th>
<th>Stress ( \sigma = \alpha E \Delta T ) psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Steel</td>
<td>6.1 x 10^{-6}</td>
<td>29 x 10^6</td>
<td>177( \Delta T )</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>9.1 x 10^{-6}</td>
<td>28 x 10^6</td>
<td>255( \Delta T )</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>80 x 10^{-6}</td>
<td>0.065 x 10^6</td>
<td>5.2( \Delta T )</td>
</tr>
</tbody>
</table>

Force to Required to Prevent Thermal Expansion?

\[
F = \sigma A \\
\sigma = E \alpha \Delta T \\
F = E \alpha \Delta TA
\]

HDPE Pipe

2” DR11 HDPE pipe; Length = 200 ft; \( \Delta T = 40^\circ F \)

Carbon Steel Pipe

2” Sch. 40 steel pipe; Length = 200 ft; \( \Delta T = 40^\circ F \)
Bend Radius

1. Function of Pipe Size, DR and Bend Ratio
2. Lower DR = Tighter Bend Capability
3. Short Term vs. Long Term Bend Radius

<table>
<thead>
<tr>
<th>Pipe DR</th>
<th>Minimum Long Term Bend Ratio, $\alpha$</th>
<th>Minimum Short Term Bend Ratio, $\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\leq 9$</td>
<td>20 times pipe OD</td>
<td>10 times pipe OD</td>
</tr>
<tr>
<td>11 - 13.5</td>
<td>25 times pipe OD</td>
<td>13 times pipe OD</td>
</tr>
<tr>
<td>17 - 21</td>
<td>27 times pipe OD</td>
<td>17 times pipe OD</td>
</tr>
<tr>
<td>26</td>
<td>34 times pipe OD</td>
<td>-</td>
</tr>
<tr>
<td>32.5</td>
<td>42 times pipe OD</td>
<td>-</td>
</tr>
<tr>
<td>41</td>
<td>52 times pipe OD</td>
<td>-</td>
</tr>
<tr>
<td>Fitting or flange present in bend</td>
<td>100 times pipe OD</td>
<td>-</td>
</tr>
</tbody>
</table>

Bend Radius?

$$R = \alpha \times OD$$

Lay Length Required?

$$S = \Theta \frac{\pi}{180^\circ} R$$

Example:

$$R = 25 \times 13.2" = 28 \text{ ft}$$

$$S = 90^\circ \times \frac{\pi}{180^\circ} \times 28' = 44 \text{ ft}$$
Overview
Design
Installation
Heat Fusion Joining Options

- Butt Fusion
- Electrofusion
- Saddle Fusion
Fitting Options

Molded

Fabricated

Specialty
Mechanical Joining Options

- Flange Adapter
- Mechanical Joint Adapter
- Restraint Device
- Transition Fitting

Source: Poly-Cam
Branching/Tapping Option

In-line Tapping

Saddle Tapping Tee

Mechanical Tapping Saddle

Electrofusion Branch Saddle
Repair Options

Puncture Repair

Rupture Repair
Why Use?

### Short-Term

<table>
<thead>
<tr>
<th>Property</th>
<th>HDPE</th>
<th>Steel</th>
<th>Iron</th>
<th>PVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td>3500 psi</td>
<td>Higher</td>
<td>Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>1150 psi</td>
<td>Higher</td>
<td>Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>Modulus of Elasticity</td>
<td>130,000 psi</td>
<td>Higher</td>
<td>Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>Poisson's Ratio</td>
<td>0.45</td>
<td>Higher</td>
<td>Higher</td>
<td>Higher</td>
</tr>
</tbody>
</table>

### Long-Term

<table>
<thead>
<tr>
<th>Property</th>
<th>HDPE</th>
<th>Steel</th>
<th>Iron</th>
<th>PVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrosion Resistant?</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Leak Free Joints?</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Seismic Resistant?</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Abrasion Resistant?</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Toughness?</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

### Direct Cost
- Design
- Construction
- Equipment
- Installation

### Operational Cost
- Maintenance
- Repair
- Rehabilitation
- Replacement

### Indirect Cost
- Water Loss
- Pumping Cost
- Hydraulic Efficiency
- Corrosion Cost
- Failure Penalties

Lowest life cycle cost of all water piping solutions
QUESTIONS?

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