Multiple Design Challenges Require Multiple Installation Techniques for High Pressure Water Line

Western Berks Water Authority
Bern Township Transmission Main
Project Description as designed and constructed
7,440 l.f. 16” water line – total project

- 900-l.f. 16” DR 14 Fusible C905®
  - HDD crossing under trout stocked cold water fishery stream, wetlands, and historic canal

- 5,490-l.f. 16” DR 14 Fusible C905®
  - open cut

- 1,050-l.f. 16” Class 54 DIP
  - open cut
Design Challenges

- 7,400 foot long high pressure pipeline to convey water wholesale to adjacent township authority, a new bulk water customer for WBWA
- 175 - 190 psi working pressure
- 65% of WBWA pipeline close to cathodically protected petroleum product pipelines
- Several petroleum pipeline crossings and highway embankment crossing
- Crossing of 150-foot wide trout stream, wetlands, and historic canal
- Fixed project budget dictated by agreed to bulk water rate to new customer, Bern Township Municipal Authority (BTMA)
- Easements negotiated with U.S. Army Corps of Engineers, County, and a private land owner
Horizontal Directional Drill (HDD) Selected as Stream Crossing Method

- 900 foot crossing of stream, wetlands, historic canal chosen
- Environmental and historic preservation permitting concerns
- Save time needed for permitting of open cut crossing
- Cost comparable to other methods

Tulpehocken Creek
Horizontal Directional Drill Profile

Source: SSM Group Inc
Pipe Size and Material Selection – Goals

- Current and future water flow quantity delivery goals
- Pressure requirement for County Prison on a hill (BTMA’s largest customer)
- Ability to deliver needed fire flow to far reaches of new BTMA service area (approx. 14,500 feet, through existing BTMA distribution system)
- Corrosion-resistant (due to nearby cathodically protected pipelines)
- Cost Goal
  - Pipe 175 psi working pressure and compliance with Recurring Surge and Occasional Surge goals in AWWA standards
  - Once Horizontal Directional Drilling was chosen for crossing, then consideration of HDD requirements, such as wall thickness allowance for rock scoring of pipe wall, minimization of borehole diameter
- Restrained joints were desired due to high water pressure
- Pipeline Longevity and resistance to degradation of “C Factor”
- Traceable with pipefinder
Pipe Size and Material Selection Standards

Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In. Through 48 In. (350 mm Through 1,200 mm)

ANSI Standard

Polyethylene (PE) Pressure Pipe and Fittings, 4 In. (100 mm) Through 63 In. (1,600 mm), for Water Distribution and Transmission

ANSI Standard
PVC Selected for Hydraulic Capacity and HDD Considerations Then Checked for AWWA C905 Surge Compliance

- DR18 found to comply for surge with working pressure of 175 psi

- However DR14 selected due to:
  - Extra wall thickness allowance for O.D. scoring by rock during pipe pull through HDD bore hole
  
  - Extra wall thickness for extra safety factor when contractor pulls 900 foot long sections around job site with sling and heavy construction equipment

  - Extra safety factor for high pressure and surge

  - Extra wall thickness to better ensure reliable “bite” by MJ fittings
### PVC versus HDPE Pipe

**PVC Requires Less OD (Pipe Volume) and Weight for a Given ID (Flow) Than HDPE**

**Example: Fixed I.D., Fixed Pressure Class**

#### 16” Nominal

<table>
<thead>
<tr>
<th></th>
<th>16” PVC DR 14</th>
<th>16” PE DR 7.3</th>
<th>PVC % Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>OD (inches)</td>
<td>17.40</td>
<td>17.40</td>
<td>0%</td>
</tr>
<tr>
<td>Wall Thickness (inches)</td>
<td>1.24</td>
<td>2.38</td>
<td>92%</td>
</tr>
<tr>
<td>ID (inches)</td>
<td>14.77</td>
<td>12.35</td>
<td>16%</td>
</tr>
<tr>
<td>Pressure rating (PSI)</td>
<td>305</td>
<td>255</td>
<td>16%</td>
</tr>
<tr>
<td>Weight (lbs. / ft.)</td>
<td>41.50</td>
<td>48.90</td>
<td>18%</td>
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</tbody>
</table>

#### 14.5” Inside

<table>
<thead>
<tr>
<th></th>
<th>16” PVC DR 14</th>
<th>20” PE DR 7.3</th>
<th>PVC % Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>OD (inches)</td>
<td>17.40</td>
<td>21.60</td>
<td>24%</td>
</tr>
<tr>
<td>Wall Thickness (inches)</td>
<td>1.24</td>
<td>2.96</td>
<td>139%</td>
</tr>
<tr>
<td>ID (inches)</td>
<td>14.77</td>
<td>15.33</td>
<td>-3.8%</td>
</tr>
<tr>
<td>Pressure rating (PSI)</td>
<td>305</td>
<td>255</td>
<td>16%</td>
</tr>
<tr>
<td>Weight (lbs. / ft.)</td>
<td>41.50</td>
<td>75.3</td>
<td>81%</td>
</tr>
</tbody>
</table>

Source: UGSI
Assumptions:
A flow coefficient (C) of 150 was used for 16" DR 14 DIPS Fusible C-900®/B&S PVC.
A flow coefficient (C) of 150 was used for 16" DR 7.3 DIPS HDPE.
A flow coefficient (C) of 150 was used for 20" DR 7.3 DIPS HDPE.

Source: UGSI
Underground Solutions Fusible PVC™ Selected

- Fusible PVC™ selected (over B & S PVC) to provide guaranteed 100% restrained joints
- Fusible PVC™ selected for 900 foot HDD installation to allow trouble free pipe pull through bore hole and smaller bore hole than fused HDPE
- Ductile Iron Pipe Sizes (DIPS) allow compatibility between PVC and Fusible PVC™ and ductile iron pipe fittings and valves
Fusible C-900®, Fusible C-905®, And FPVC® Pipe Deliver Results With A Smaller Outer Diameter (OD) Than Other Pipe Systems – Thereby Reducing Costs

Pipe Material Costs Are Typically 10-40% Of Total Project Costs

UGSI Fusible PVC™ Products Are Competitive On Material Cost And Reduce Installation Costs

Smaller OD Means . . .

<table>
<thead>
<tr>
<th>HDD</th>
<th>Less back reaming, less drilling mud, less spoil disposal and less weight to pull</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDD Smaller Than HDPE or Restrained PVC Systems</td>
<td></td>
</tr>
</tbody>
</table>

Source: UGSI
Traditional Restrained PVC Joints Limit Applications

Conventional Gasketed & Restrained PVC to PVC Connections - 12” Example

Fusible C-900®, Fusible C-905®, FPVC® Low Profile Restrained Joint

Barrel = 13.2”
Bell = 16.75”
Restraining Hardware = 19.45”

TerraBrute™
Barrel = 13.2”
Bell = 16.75”

Certa-Lok™
Barrel = 13.2”
Bell = 15.83”

Barrel and Fused Joint Have Consistent O.D. = 13.2”

Source: UGSI
Fusible PVC™ pipe uses industry standard couplings and fittings for reconnection to existing systems

Connecting to Fittings

Mechanical Joint Fittings:

Flanged Joint Fittings:

Connecting to Pipe

Same Piping Size:

Different Piping Size:

Pictures from various manufacturers of fittings: JCM, Smith Blair, EBAA Iron, Romac Industries.
Thousands of Hours and Thousands of Individual Sample Tests by Independent Sources further Verify Mechanical Properties of UGSI Fusible PVCTM

- **Tensile Strength**
  - >1000 fused samples verify fused joint strength ~ 7000 psi ultimate tensile strength or typically 95-105% of the un-fused pipe strength (within the variability found in commercial PVC pipe)

- **1000 Hour Sustained Pressure Test**
  - per ASTM D1598 at 500psi (DR18) for 10x the ASTM threshold of 1000 hours – UGSI test duration was 10,000 hours – fused and un-fused pipe

- **1,000,000 Cycle Pressure Test**
  - (94-188psi for DR18) demonstrating cyclic surge on a fused joint system per ASTM F1674 – simulating a severe duty cycle (3.5 million completed)

- **5000 Hour Scratch/Pressure Test**
  - Gouge depths of 5-10% on samples under 500psi (DR18) pressure were successfully tested (pipe and fused joint)
Internal and External Bead Removal is Optional – friction losses are negligible ('C'-factor of 150) and are significantly less than mechanically joined pipe (i.e. for 8” DR18 with 1000gpm in a length of 1000LF, flow loss is 0.173 gpm and a head loss of 0.013 ft) and pipe tensile strength is not impaired (extra material in bead)
Pipe Fusion Machine
Pipe Fusion Machine with Weather Protective Tent
Western Berks Water Authority

Open-Trench & HDD
Other Project Aspects

- Moving Fused Pipe
- Back Reamer
- Pipe Stockpile before Fusing
Vacuum Excavation Location of Petroleum Pipelines
Project Construction Staging Area # 2
Pulling Pipe Through HDD Bore Hole
Cost Goal Was Achieved

Engineers Construction Cost Opinion: $1,635,000
15% Contingency: $245,250
Total: $1,880,250

As-Bid: $1,896,985
Net Change Order Add-Deducts: -$226,217
As-Built, after Change Orders: $1,670,768

Source: SSM Group Inc
Acknowledgements

- William Murray
  - Former Chair and Currently Vice Chair, WBWA

- Leonard (Chip) Bilger II
  - Executive Director, WBWA

- Matthew Walborn
  - Director of Operations, WBWA

- Leonard Bilger III
  - Chief Operator and Inspector, WBWA

- Joao & Bradley Construction Co., Inc.
  - General Contractor

- James Carr, CCM, CCCA
  - Construction Manager, SSM Group Inc.

- Darryl Jenkins, PE
  - Division Vice President, SSM Group Inc.
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