

Underground Solutions, Inc. Introductory Capabilities Presentation Pressure Pipe Technologies



Chad Andrews, EIT
March 7, 2019
ASCE



Introduction



Chad Andrews, EIT

- **UGSI Regional Sales Manager- South Region:** Alabama, Mississippi, Georgia & Florida Panhandle teaming with RSM's Dave Hunniford, P.E. and Robert Tatum, P.E.
- Based out of Tallahassee, FL
- B.S. and M.S. in Environmental Engineering with emphasis on Water Resources from the **University of Georgia.**

Pipeline Infrastructure

Infrastructure Solutions

Water & wastewater pipeline rehabilitation
Structural strengthening



Corrosion Protection

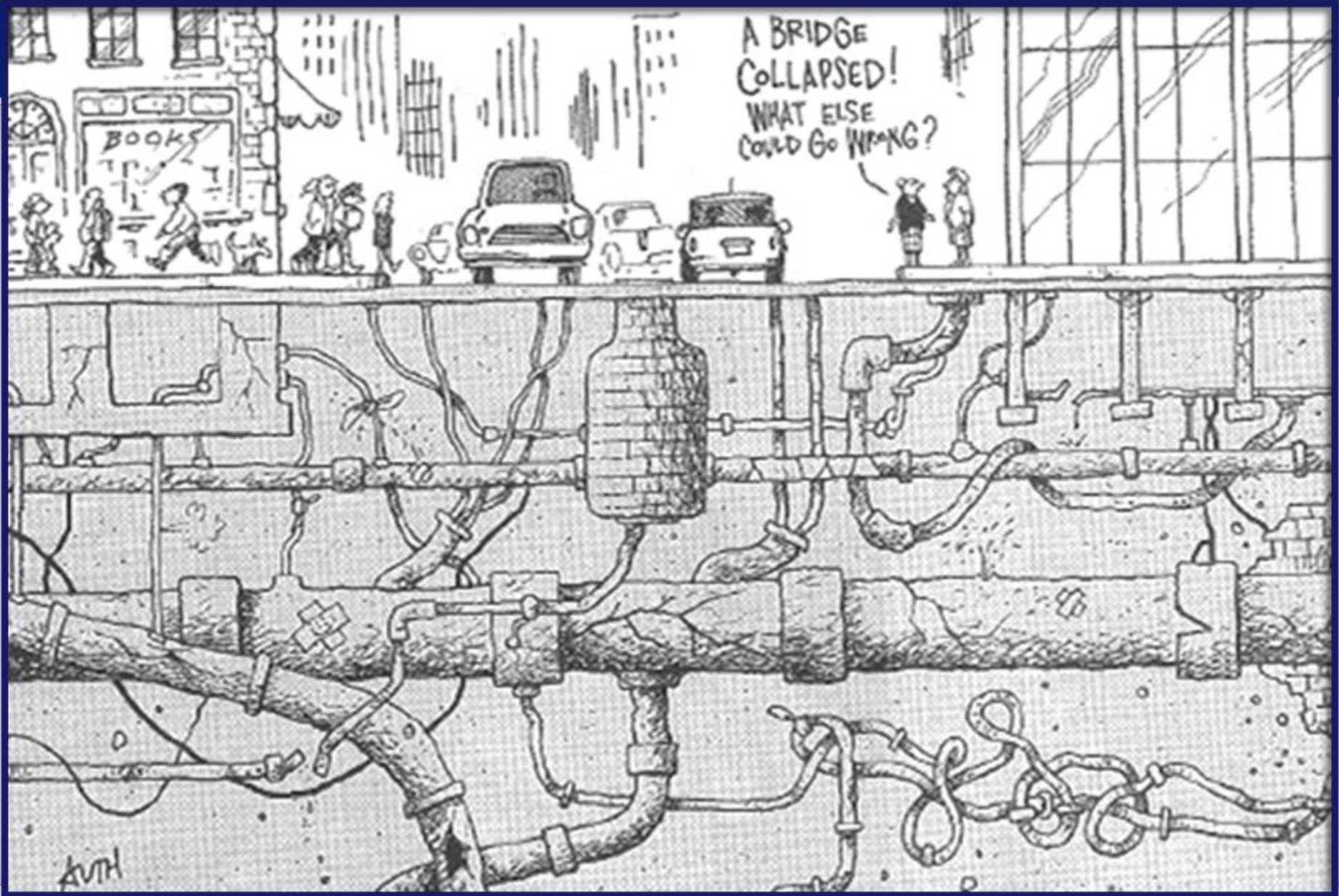
Pipeline corrosion prevention
Oil, gas and mining



Energy Services

Facility maintenance services





Trenchless Installation and Rehabilitation Methods Dramatically Reduce Project Costs

Hard Project Costs are Potentially Reduced by 20-40% through use of Trenchless Methods

- Traditional Direct-Bury, Open-Cut or Exhume & Bury pipe installation methods can be disruptive, impractical and limiting – especially in rehabilitation efforts
- Trenchless methods reduce:
 - Project costs
 - Business interruption costs
 - Political costs
 - Environmental costs



Aegion Pressure Pipe Rehab Toolbox



Cured-in-place pipe (CIPP)



Carbon/glass fiber (FRP)



Compressed fit
HDPE



Fusible PVC[®]



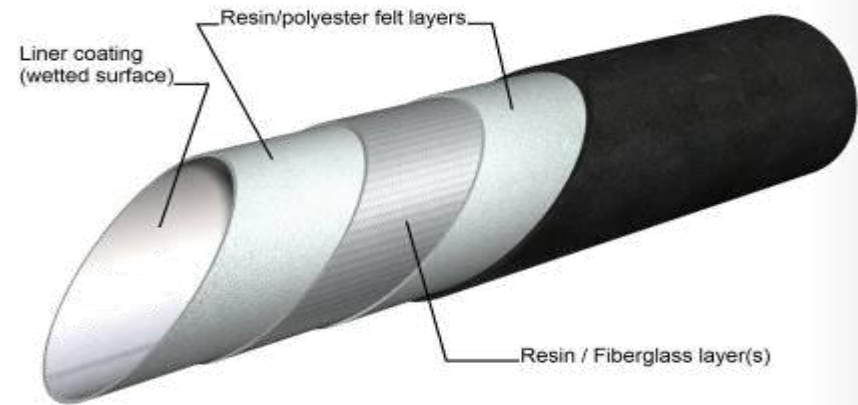
TerraBrute[®]



© Can Stock Photo

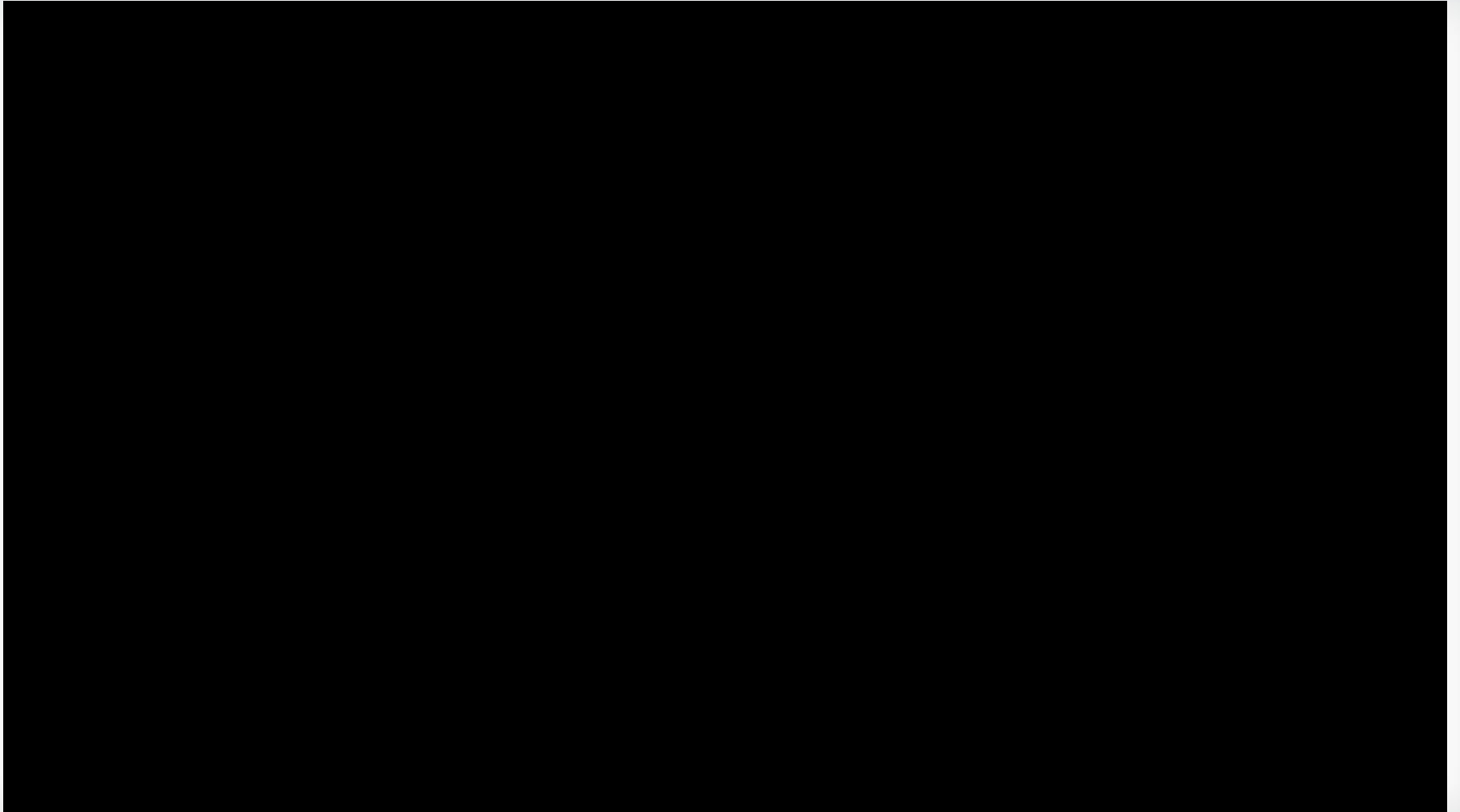
CIPP Fiber-reinforced composite structure

- Epoxy/fiberglass structure
 - Provides high tensile strength
 - Number of layers vary depending on diameter and internal pressure
- Epoxy/polyester felt structure
 - Provides for external load capacity
 - Layer thickness can be varied depending on loading conditions
- PP/TPU coating
 - Water contact surface
 - Coating also provides water barrier for installation processes



Diameter range	6" to 96"
Effluent temperature	Up to 130°F
Internal pressure capability	Up to 250 psi (safety factor of 4)
Bends	Up to 45°
Host pipe material	All materials
Mechanical properties	Exceeds ASTM F1216 and ASTM F1743

InsituMain® CIPP installation



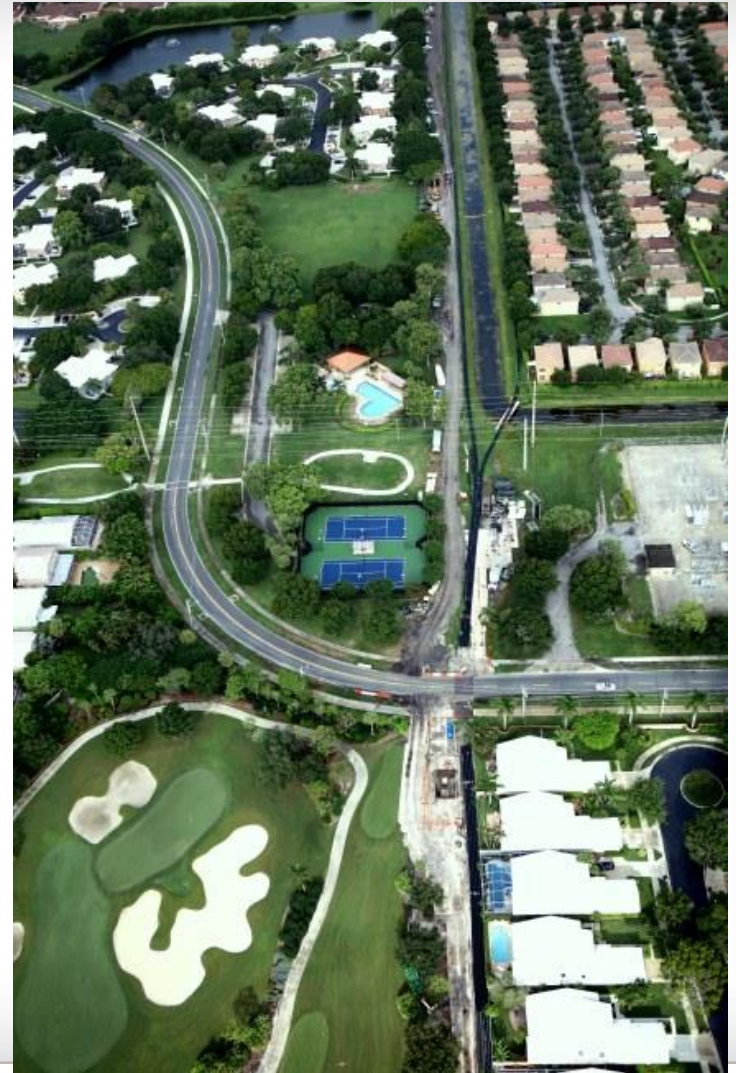
Town of Palm Beach E-3 Force Main Project

- 4,700 LF of 12-inch ductile iron force main
- Location: Intracoastal bike path corridor
 - High-end residential area
- Operating pressure: 30 psi
- Design: 7.5 mm sidewall thickness
- Impregnated with vinyl ester resin
- Solution: InsituMain® Class IV Fully-Structural CIPP
- Challenges included location and environmental concerns
- Project used specialized boiler and other equipment
- Anodes installed on rehabilitated pipeline for added corrosion protection



2017 Trenchless Project of the Year: Rehabilitation West Palm Beach 48" Force Main Project

- 5,800 LF of 48-inch PCCP
- Location: Near Canal and Country Club
 - High-end residential area
- Operating pressure: 30 psi
- Solution: InsituMain® Class IV Fully-Structural CIPP
- Completed six sections; averaged about 1000', longest shot 1145'
- Tube delivered to the site wetted
- Completed late summer, 2016



West Palm Beach 48" Force Main Project – Installation Site



TYFO- Carbon/Glass Fiber (FRP) Systems

- High-strength, lightweight, low profile characteristics provides a less intrusive value engineering solution; adds minimal weight/area and maintains hydraulics
- Installed without removal and replacement of many existing obstacles...trenchless
- Small project site footprint...low impact and rapid installation
- Proven long term durability and excellent resistance to corrosion
- Can be applied onto complex shapes (tees, elbows, etc.)



Independent/stand alone or an interactive/composite system

Diameter range	36" & Above (Internal)
Effluent temperature	Up to 150°F
Internal pressure capability	Up to 450 psi
Bends	Any
Host pipe material	All materials
Mechanical properties	Specifically designed as conditions require

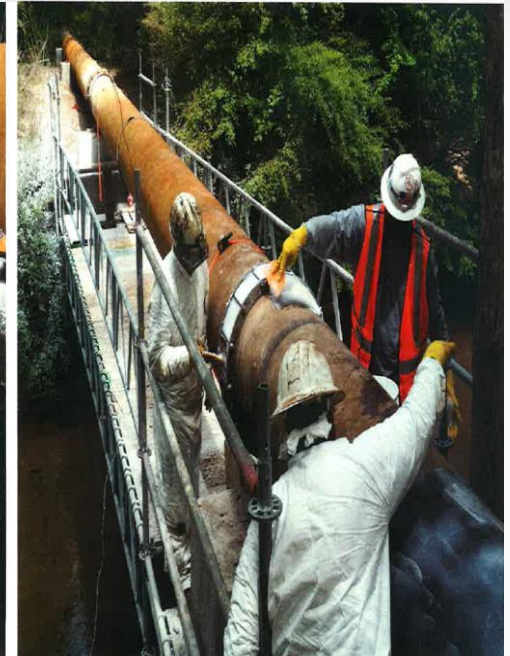
Capabilities of Internal or External Wrapping with FRP



- Restore pipeline to **original hydrostatic pressure capacity**
- Accommodate **increased internal pressure requirements**
- Re-establish **flexural loading capabilities**
- Restore original **external loading capacity** of pipeline
- Upgrade **external loading capability** due to higher live load/traffic requirements
- Provide **watertight rehabilitation** at joints/couplings or transition zones

Cobb County 24" Steel Pipe Aerial Crossing

- 40-year-old spiral-welded piping
- Deteriorated external coating and hole
- Difficult to access the pipe location with large equipment due to steep terrain



United Pipeline Systems-HDPE (Thermoplastic) Lining Systems (>16,000 Miles of Installed Pipe) Tite-liner

- **Tight-fit or Close-fit** (not slipline)
 - Custom engineered & manufactured
 - Maximizes flow over standard IPS
 - Installed by compression or deformation
 - Allows flexibility for challenging installations
 - Usually <1" of "gap" is all that is needed
 - 2" to 54" diameter
- **Non-structural liners**
 - Liner relies on host pipe
 - Thin-wall; < DR32.5
 - Eliminates leaky joints and/or internal corrosion
- **Structural liners**
 - For use where host pipe is NOT structurally sound
 - > DR32.5, up to DR 17
 - Sections of host can be removed
 - Solves internal and external corrosion



HDPE Lining Installation methods

Radial Compression



- Diameter is temporarily reduced by radial compression
- Timing is important as the liner will begin to grow back once tension is released
- Can be used for structural or non-structural
- Entire liner section is installed in a single and continuous “pull”

Elastic Deformation



- Achieves significant cross sectional reduction
- Wall thickness limitations—maximum w.t. of 1” is limitation
- Not suitable for structural loading
- “Fuse and fold” method facilitates small worksite footprint
- Only moderate collapse resistance
- Re-rounded after installation

Tite-liner Installation Animation



IDEAL PROJECT CHARACTERISTICS

- Pressure Sewer or Raw Water Mains
- Diameter Range of 8in – 54in
- Installation sections \geq 300 LF
- Typical Operation Pressure \leq 126 psi (DR 17)
- Host pipe has a consistent ID
- Ductile Iron, Cast Iron, PCCP, ACP, RCCP, Steel
- Available access points, and room to string liner

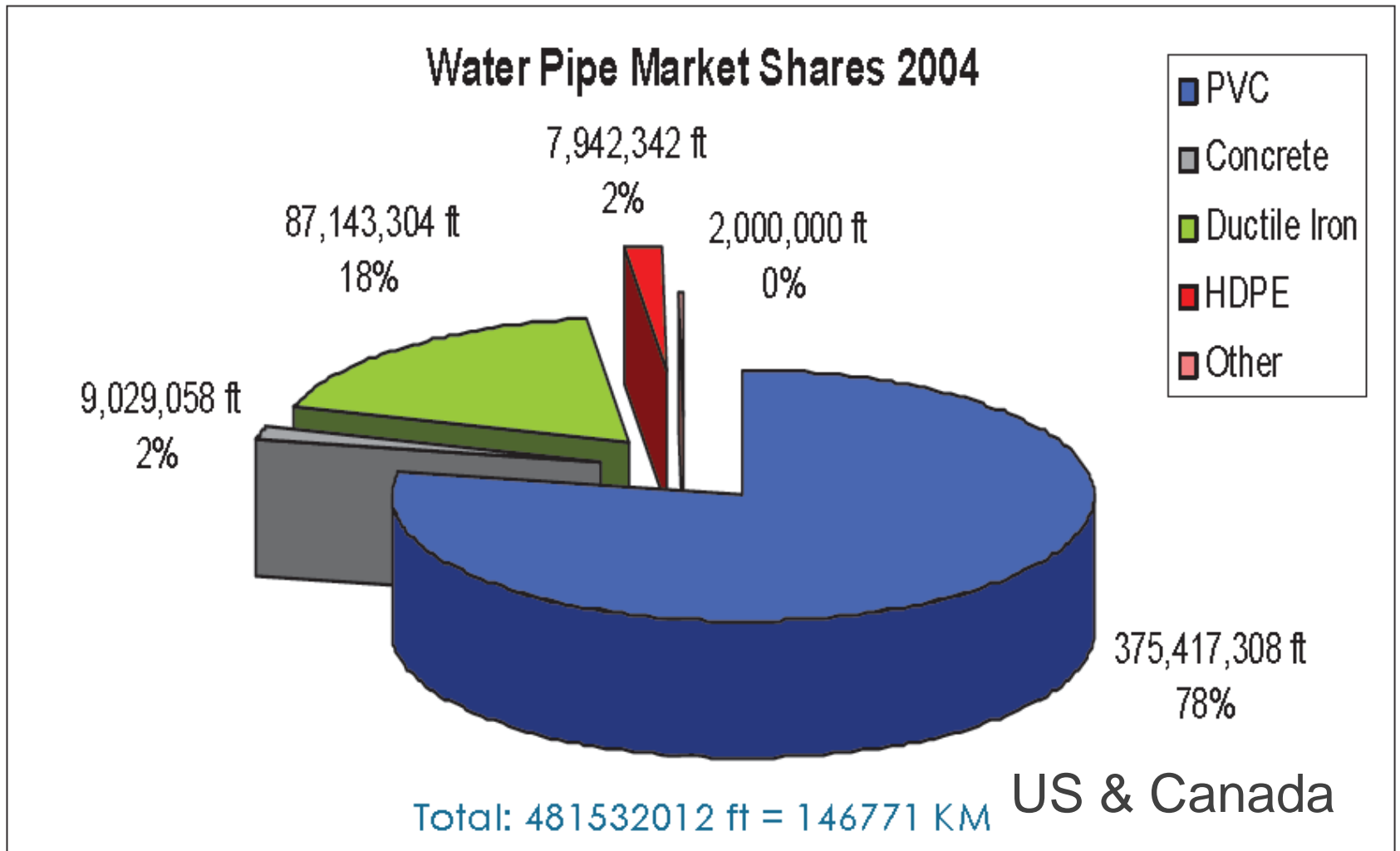


Tite Liner[®] system in Valley Forge allows for new pipeline in environmentally sensitive area



- 30-inch force main traveling directly through Valley Forge National Historic Park along the Schuylkill River
- Over 40 years old
 - 3 separate failures precipitated need for repair/replacement PCCP host pipe
- 18,000 linear feet
- Aegion's Tite Liner[®] system was chosen to rehabilitate the pipeline
- Worked closely with CH2M Hill and general contractor, PACT, to complete the project
- Completed in 6 months
- Pressure tested at 60 psi
- Increased Flow from 22mgd to 28mgd

On a Linear Basis, PVC Pipe Accounts for 78% of All New Water Pipe Installations in the US & Canada

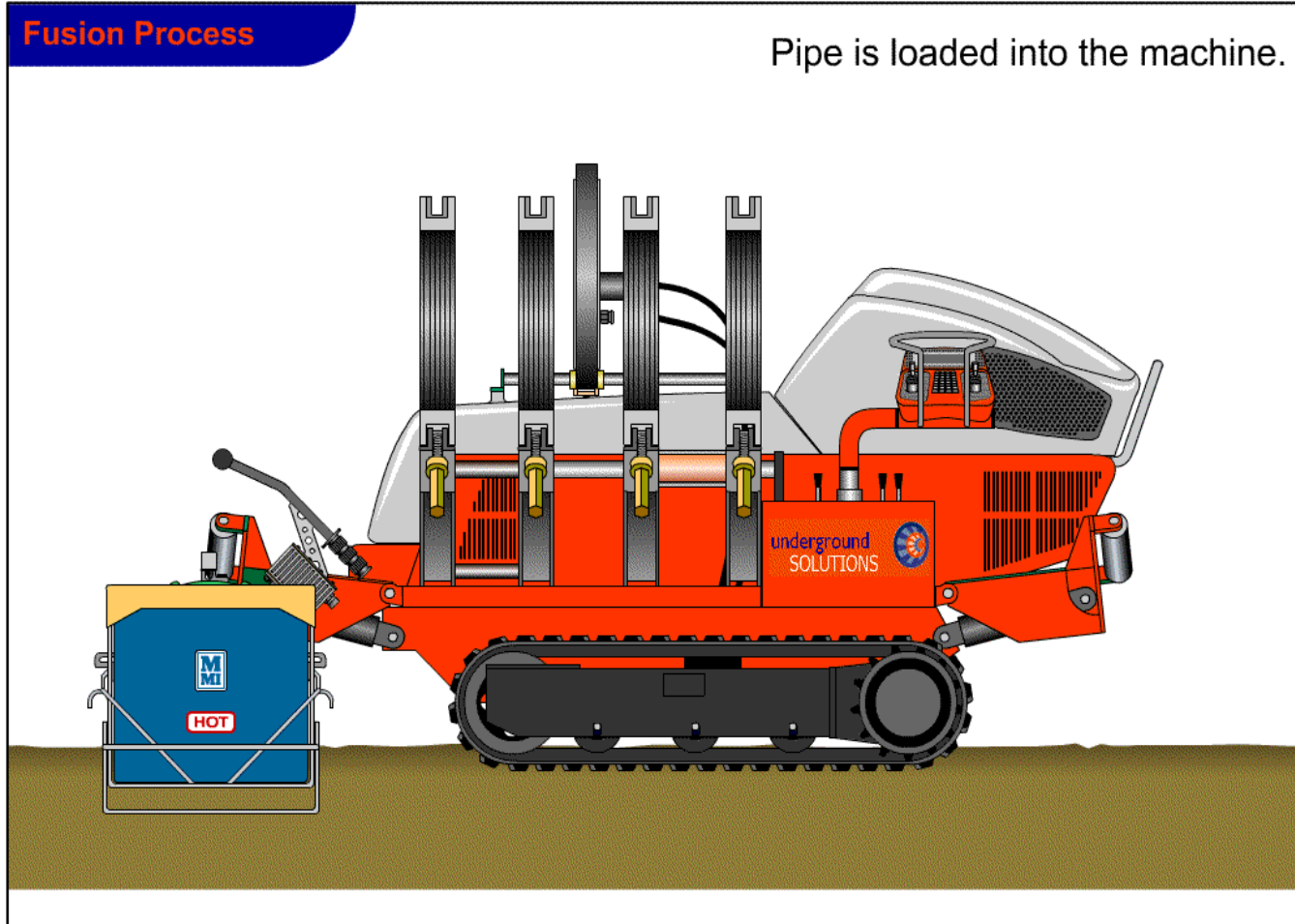


Underground Solutions: Bringing Innovation to the Underground Infrastructure Market

- Fastest growing underground infrastructure product-line in North America
 - Leak free, restrained joint pipe systems
 - Trenchless installation modes that reduce contractor costs
 - Rehabilitation capabilities for difficult high pressure water pipe applications
 - “Trenchless Project of the Year 2010, 2013, & 2016 – Trenchless Technology magazine
- Over 13,000 successful projects installed to date with ~ 2,840 miles (15 Million Feet) in service worldwide
 - In 50 states, Canada, Latin America, New Zealand, Australia
 - Over 40 Military Bases
 - Over 14,000 separate installations (HDD, Slipline, Pipe Burst, Open-Cut)
 - Over 12,000 HDD’s (horizontal directional drills) completed
- Pipe meets relevant industry pipe standards
 - AWWA C900, C905, C605, NSF-61, NSF-14, PPI-TR2, ASTM Cell Classification 12454
 - Utilizes standard PVC and ductile iron fittings
 - Available in all water industry configurations



The Underground Solutions® PVC Fusion Process: Utilizes Industry Standard Fusion Equipment



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 1,000 gpm in a length of 1000 LF, 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)

Fusible C-900®, Fusible C-905® and FPVC ®: Fusion Process is Tightly Controlled

- **Qualified fusion technicians** are trained and retrained every year by Underground Solutions
 - Initial 3 day course
- **Fusion equipment** must meet minimum company standards to be approved for PVC fusion
- **Data loggers** record critical fusion data for each joint
 - Provide real time feedback on joint integrity
 - Provide record of entire project for proof of system integrity
- Fusion conditions logged by technician and “as-built **fusion joint record** can be provided for the owner



Fusible PVC® Pipe Products Cover Water, Wastewater, Reclaimed Water and Raw Water: Fusible C-900®, Fusible C-905® and FPVC®

Pipe Type	Sizes (Nominal OD)	DIPS or IPS or Schedule	Dimension Ratios (DR)	Uses	Color
Fusible C-900®	4" – 36"	DIPS	DR 14, 17, 18, 21, 25, 26, 32.5, 41	Potable Water AWWA C900	Blue
FPVC®	4" – 36"	DIPS, IPS, or Schedule	DR 14, 17, 18, 21, 25, 26, 32.5, 41 and Sch.80	Non-Potable Water or Potable Water Applications not in C900/C905 Dimensions	Blue, Purple, Green, White, Grey

* Not all diameters are extruded to all listed DR's.

PVC Property Advantages Over HDPE Provide Better Performance and Economic Savings

Property	Specification	PVC	HDPE 3408/3608 ¹	HDPE 4710 ²
Tensile Strength psi	ASTM D638	7,000	3,000	3,500
Specific Gravity	ASTM D1505	1.40	0.94	0.95
ASTM D3350 Cell Class	ASTM D3350	NA ³	345464	445574
Hydrostatic Design Basis At 73° F, psi	ASTM D2837	4,000	1,600	1,600
Modulus of Elasticity psi (Short Term)	ASTM D638	400,000	29,000 ⁴	29,000 ⁴
Hardness (Rockwell R)	ASTM D785	117	52	NA
Coefficient of Linear Expansion In./In. deg F	ASTM D696	0.3×10^{-4} .36"/ 100'/ 10°F	1.2×10^{-4} 1.44"/ 100'/ 10°F	1.2×10^{-4} 1.44"/ 100'/ 10°F
Water Disinfectant Induced Oxidation ⁵		Highly Resistant	Low Resistance	Low Resistance
Hydrocarbon Permeation ⁶		Highly Resistant	Highly Permeable	Highly Permeable

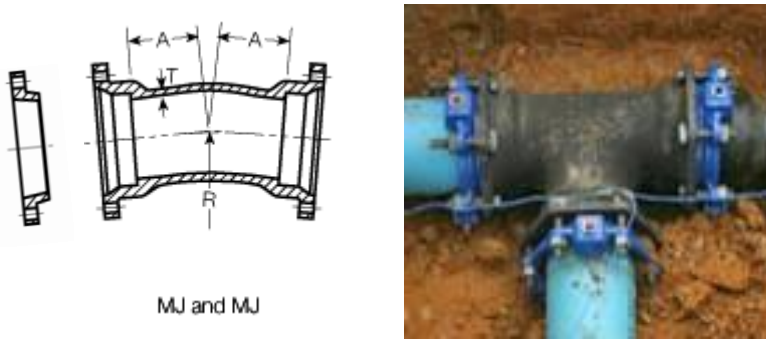
1. HDPE 3408/3608 also referred to as PE80
2. HDPE 4710 also referred to as PE100
3. PVC Pipe Cell Class per ASTM D1784 (12454)
4. PPI – PE Handbook – Long Term Modulus of Elasticity is 28,200 psi
5. Carollo Engineers 2008, Choi 2008, Chung 2008, Fumire 2008, Rozental 2008, Castegnetti 2007, Audouin 2007, Dear 2006,
6. Lundback 2005, Hassinen 2004
7. Water Research Foundation (formerly AWWA Research Foundation 2008)

Connections with Fusible PVC® Pipe can be Easily Accomplished with Industry Standard Couplings and Fittings

Connecting to Fittings

Connecting to Pipe

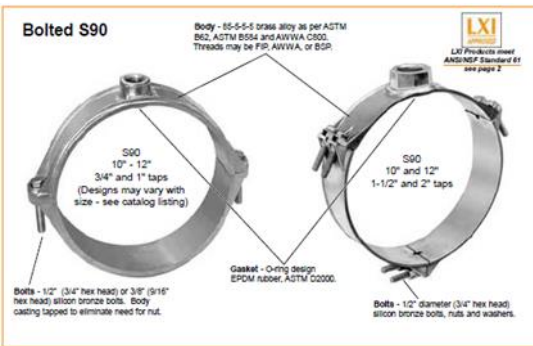
Mechanical Joint Fittings:



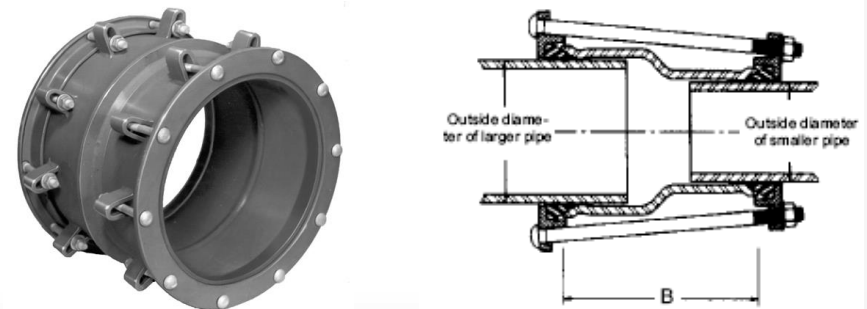
Same Piping Size:



Tapping:

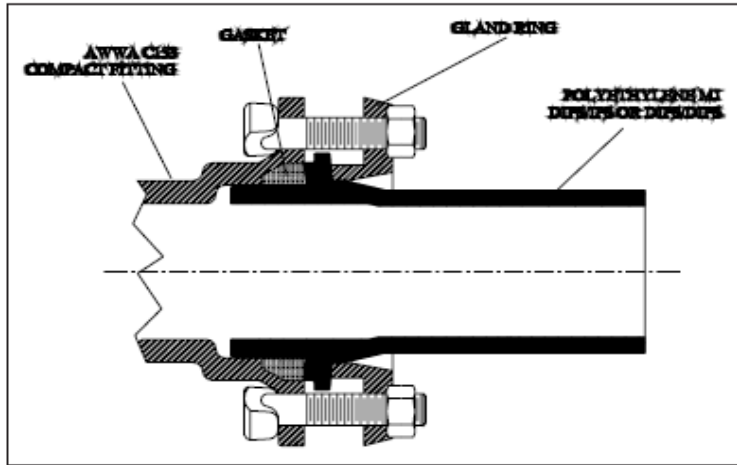


Different Piping Size:


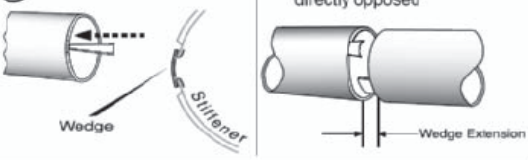
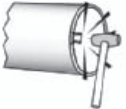


Pictures from various manufacturers of fittings: JCM, Smith Blair, EBAA Iron, Romac Industries.

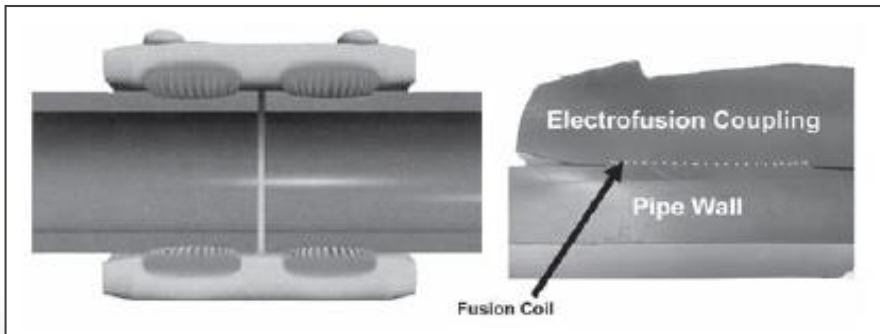
Non-Standard Stiffener Inserts, Couplings or Fusion Equipment are Required with HDPE Systems



Easy Installation...

- 1 Both pipe ends being joined require stiffeners. Insert stiffener into each pipe so that stiffener lip touches pipe end.

- 2 Insert wedge into stiffener. Make sure wedges are not directly opposed.

- 3 Fix wedge firmly in stiffener by striking with a rubber hammer.


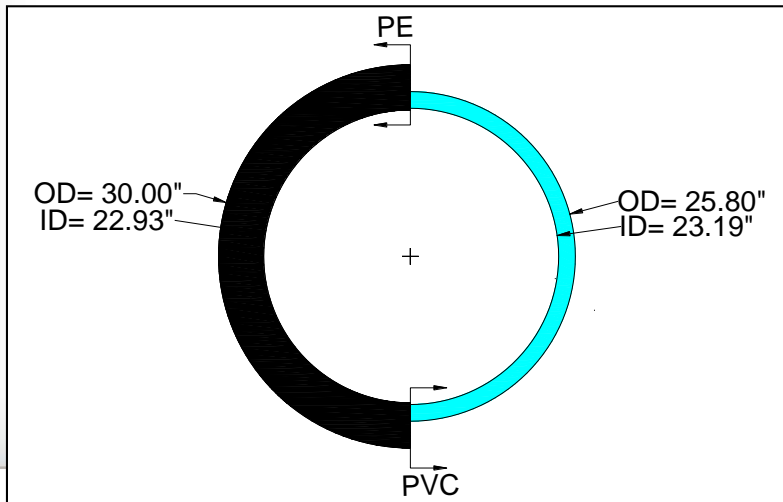
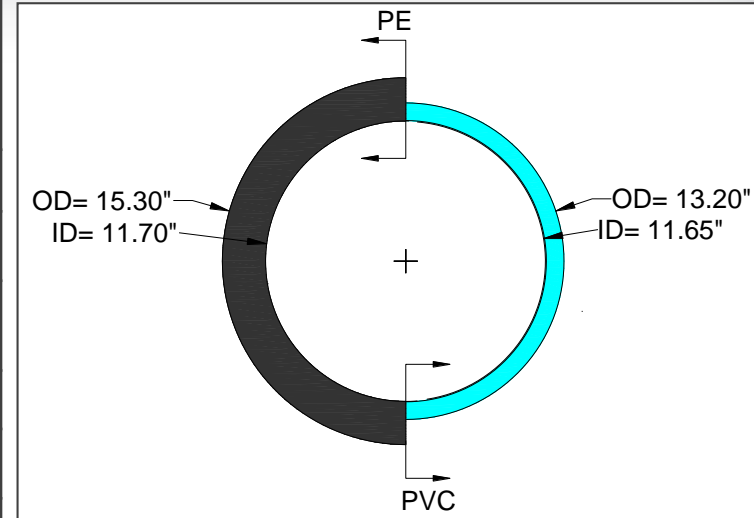
! A stiffener MUST be used in each PE pipe end. Exact SDR of PE used is required when ordering.



When Designing for Flow, Fusible PVC® Pipe Requires less OD (Pipe Volume) and Weight for a Given ID (Flow) than HDPE

Example: Fixed I.D., Fixed Pressure Class

12" ID	12" PVC DR 18 SF = 2.0	14" PE DR 9 SF = 2.0	PVC % Advantage
OD (inches)	13.20	15.30	16%
Volume per Foot (ft³)	0.95	1.28	34%
Wall Thickness (inches)	0.73	1.80	90%
ID (inches)	11.65	11.70	-0.5%
Pressure Rating (PSI)	235	200	15%
Weight (lbs./ft.)	19.05	31.64	70%

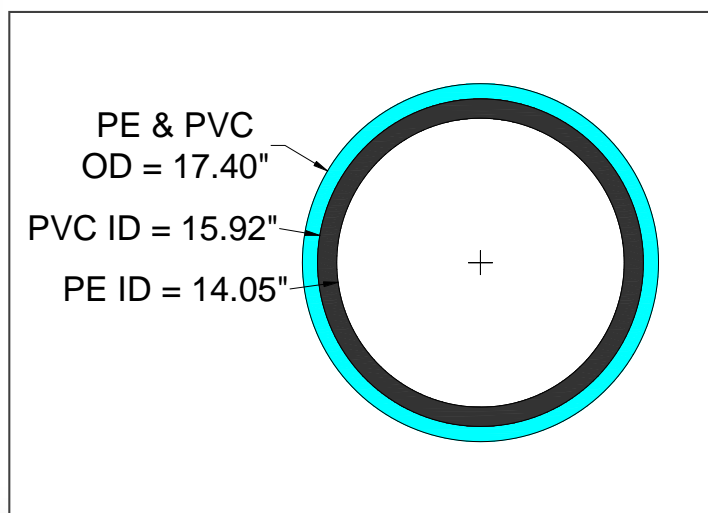
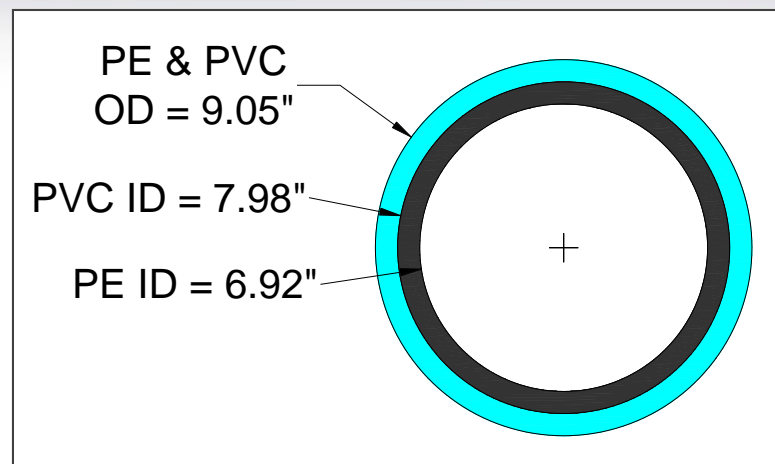


24" ID	24" PVC DR 21 SF = 2.0	30" PE DR 9 SF = 2.0	PVC % Advantage
OD (inches)	25.80	30.00	16%
Volume per Foot (ft³)	3.63	4.91	35%
Wall Thickness (inches)	1.23	3.33	171%
ID (inches)	23.19	22.93	1%
Pressure Rating (PSI)	200	200	0%
Weight (lbs./ft.)	61.49	121.62	98%

Fusible PVC® Pipe Delivers 20-30% More Cross-Sectional Flow Area than HDPE for a Given OD

Example: Fixed O.D., Fixed Pressure Class

8" Pipe	8" PVC DR 18 SF = 2.0	8" PE DR 9 SF = 2.0	% PVC Advantage
OD (inches)	9.05	9.05	-
Wall Thickness (inches)	0.51	1.01	98%
ID (inches)	7.98	6.92	13%
Flow Area (inches ²)	50.01	37.61	25%
Pressure Rating (PSI)	235	200	15%
Weight (lbs. / ft.)	8.75	11.07	27%



16" Pipe	16" PVC DR 25 SF = 2.0	16" PE DR 11 SF = 2.0	% PVC Advantage
OD (inches)	17.4	17.4	-
Wall Thickness (inches)	0.69	1.68	141%
ID (inches)	15.92	14.05	12%
Flow Area (inches ²)	199.06	155.04	22%
Pressure Rating (PSI)	165	160	3%
Weight (lbs. / ft.)	23.70	34.29	45%

Underground Solutions Fusible PVC® Pipe is Well Suited to Trenchless and Open-Cut Installation Techniques

Horizontal Directional Drilling

- 50% of UGSI Fusible PVC® pipe installed by directional drilling techniques

- Pulls of over 7,000 ft accomplished (AWWA C905 – 16")
- Pulls of over 7,000 ft accomplished (AWWA C905 – 24")
- Over 10,000 separate pull-ins
- Pipe diameters of 4" - 36" installed

Sliplining

- 20% of UGSI Fusible PVC® pipe installed in sliplining applications

- Pull of over 7,000 ft accomplished with 14" pipe
- Pull of over 2,800 ft accomplished with 24" pipe
- Pull of over 2,000 ft accomplished with 30" pipe
- Pull of over 1,000 ft accomplished with 36" pipe
- Pipe diameters of 4"- 36" installed

Pipe Bursting

- 15% of UGSI Fusible PVC® pipe installed in pipe bursting applications

- Pulls of over 2,000 ft accomplished with 8" and 10" pipe
- Greater than 1 Million Feet Installed
- Pipe Diameters 4"-24"

Open-Trench/ Direct Bury

- 15% of UGSI Fusible PVC® pipe installed in direct-bury applications

Georgia Installation Base Summary

- 230+ Projects
- HDD, J&B, Slipline, OC, Pipe Burst
- 4300LF HDD
- GA DOT Crossings
- Potable, RCW, WW



Florida Installation Base Summary

- >850 Projects
- >1.6 Million LF
- HDD, J&B, Slipline, OC, Pipe Burst
- 4"-36", 7020 LF HDD
- FDOT Crossings
- Potable, RCW, WW, RW



Alabama Installation Base Summary

- 30+ Projects
- HDD, Slipline, OC, Pipe Burst, Jack and Bore
- Potable, WW



Trenching Operation



Pipe Installation



Henry County, AL USDA

Water System Improvements

- ~5000 LF of 6" & 8" Fusible PVC
- Horizontal Directional Drill
- Engineer – Poly Inc.
- GC – Hilton Cooper Contracting
- HDD Sub Contractor – Weaver Directional



Elba, AL Water System Improvements

Phase I and Phase II

- 7550 LF of 6" & 8" Fusible PVC
- Horizontal Directional Drill
- Jack and Bore Carrier Pipe
- Engineer – CDG Engineers
- GC – Brunson Nichols and R&B Contracting
- HDD Sub Contractor – Poire Underground



Dothan, AL and Greenville, AL

Dothan, AL Pipe Burst

- 360 LF of 12" Fusible PVC®
- Pipe Burst
- Engineer – Barge Design Solutions
- GC – Blankenship



Greenville, AL Force Main

- 500 LF of 16" Fusible PVC®
- Horizontal Directional Drill
- Engineer – Goodwyn Mills & Cawood
- GC – L&K Contracting



Horizontal Directional Drilling with Fusible C-905® PVC

Horizontal
Directional
Drilling

9 Mile Rd. Water and Sewer Upgrades

- 1,935 LF 12" DR 18 Fusible PVC® pipe green, 16" DR 25 Fusible C-905® pipe blue
- 1,935 LF 16" DR 25 Fusible PVC® pipe green, 18" DR 25 Fusible PVC® pipe green, 24" DR 25
- Engineer – Rebol-Battle
- GC – Roads Inc.
- HDD Sub Contractor – Gator Boring



FP&L– Port Saint Lucie, FL 7,000' 30" DR21 Fusible PVC™ HDD

Horizontal
Directional
Drilling

Client: Florida Power and Light

- **Twin 7,000 linear feet of 30" DR21 Fusible PVC™**
- **Design Engineer – Power Engineers**
- **HDD Contractor - Mears Group, Houston, TX**



Sliplining with Fusible PVC™ - Montgomery, AL

Sliplining

Atlanta Hwy Force Main Slipline Repair Water Works & Sanitary Sewer Board of Montgomery

- Slipline 20" Ductile Iron Pipe
- 800' linear feet of 16" DR25 Fusible PVC™
- Engineer: Montgomery WWSSB
 - Tim Logiotatos, PE
- Contractor: CJ Faulk Construction
- Underground Solutions provided Fusible PVC™, Fusion Services



Fusible C-905[®] PVC Pipe – Rehab Failed 36" HDPE WM

Sliplining

**Client: Okaloosa County Water and Sewer
Crestview, FL**

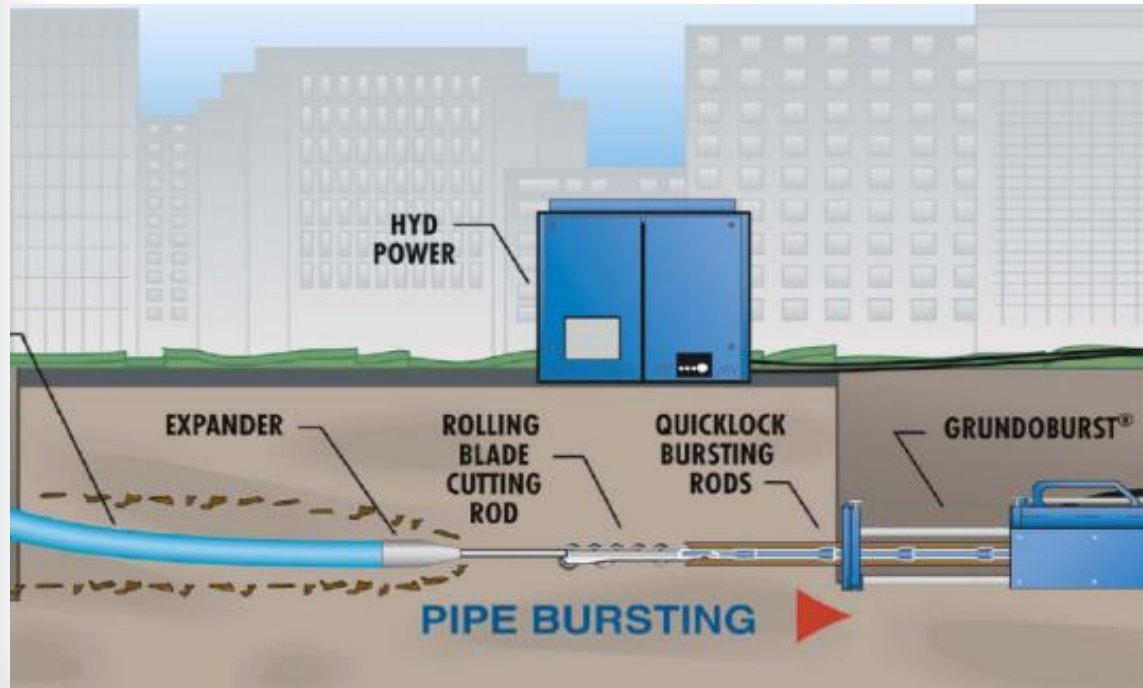
- 1400' 36" DR11 HDPE Water Transmission Main – Installed via HDD in 2005
- May 16th reported a leak
- HDPE line was Sliplined with 1,400' of 20" DR18 Fusible C-905[®] PVC
- Completed & Pressure Test May 22nd



Fusible PVC[®] Pipe Attached to the Bursting Head and Pulled into the Existing Pipe Alignment

Pipe Bursting

- Static Hydraulic Method is used
- Burst head is pulled through existing line - fracturing or cutting the pipe
- Fractured or split pipe is pushed into the surrounding soil
- New pipe is pulled in immediately behind the burst head
- Typically done in 300 - 500' increments (~1 hour pull-back)
- Utilizes existing alignment – less engineering cost to locate adjacent utilities
- Result in same or larger I.D. (upsizing) as old pipe



Pipe Bursting Waterline Replacement Program –Denver, CO Area

Pipe Bursting

Client: Consolidated Mutual Water Company

- ~200,000 LF of fused PVC
- 8", 6" and 4" DR 18
- Pipe Bursting and Joint Fusion - Self Performed by Utility Crews
- Most Lines Upsized
- Continuous Burst Lengths up to 2,100 LF
- \$48/LF versus \$115/LF for open-cut replacement



Candies Creek Force Main Project

Pipe Bursting

Client: Cleveland Utilities (TN)

- 3,640 LF
- 16" DR 18 FPVC
- 150 PSI Pressure Test
- Upsized 20 year old 14" DIP
- US HWY 27 ROW
- Portland Utilities Construction Co., LLC



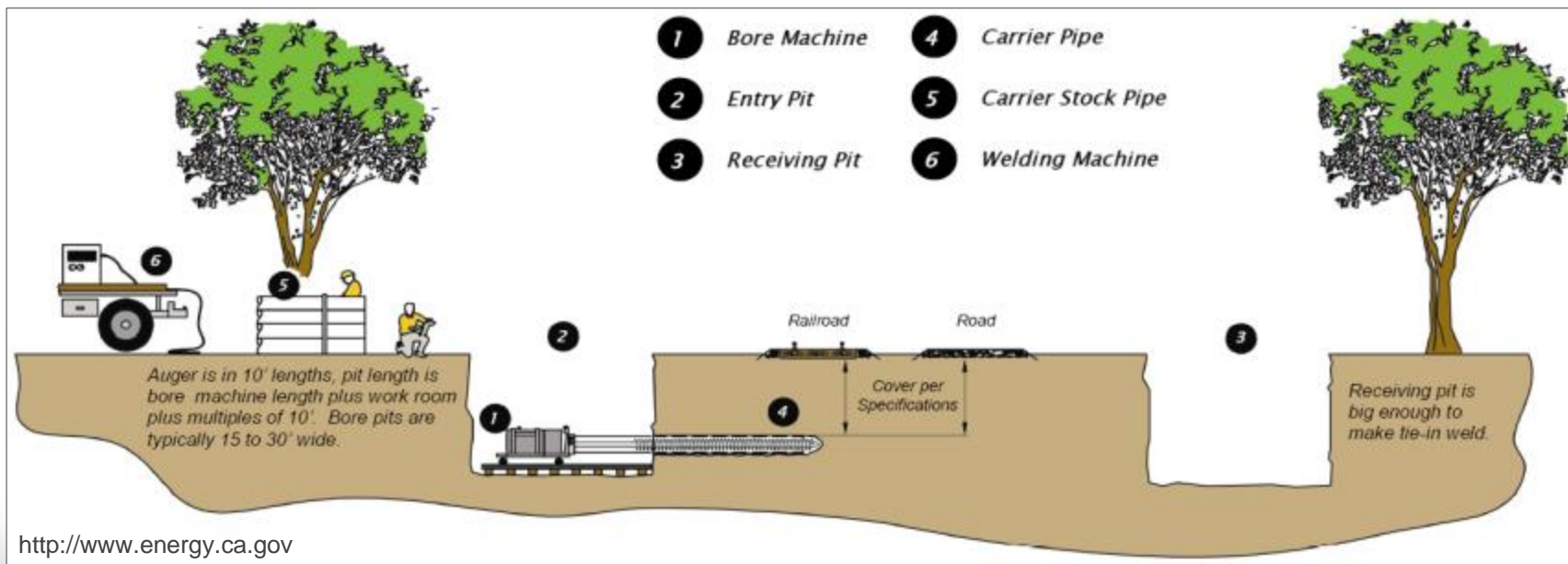
Fusible PVC® Pipe is Well Suited to Jack & Bore Installation

Jack & Bore

- Bore pits are dug on each side of the crossing
- Casing pipe is jacked into place while spoils are removed through the casing
- Fusible PVC® carrier pipe is installed inside of new casing



Anchorage, AK: 24" DR18
in 30" Steel Casing



Summary: Underground Solutions Fusible PVC[®] Pipe Lowers Project Costs and Lowers Project Risk

- Fusible C-900[®], Fusible C-905[®] & FPVC[®] pipe offer advantages over other pipe systems:
 - Tough, reliable thermoplastic material
 - Leak free, fused, restrained joint pipe system
 - Acceptance of standard PVC fittings and methods
- Fused PVC[®] pipe systems deliver lower costs:
 - High tensile strength allows for longer “pulls” in Sliplining, Pipe Bursting and HDD – superior productivity
 - Lower OD for specified flow (ID) means less spoils disposal and smaller fittings, valves & connections
 - Higher ID for specified OD (i.e. host pipe, bore) – optimal flow when OD constrained (sliplining, pipe bursting)
 - Lower overall project cost possible in open-cut projects due to:
 - Higher production rates
 - Less rework (no bell & spigot)
 - Restrained joint without costly mechanical restraint



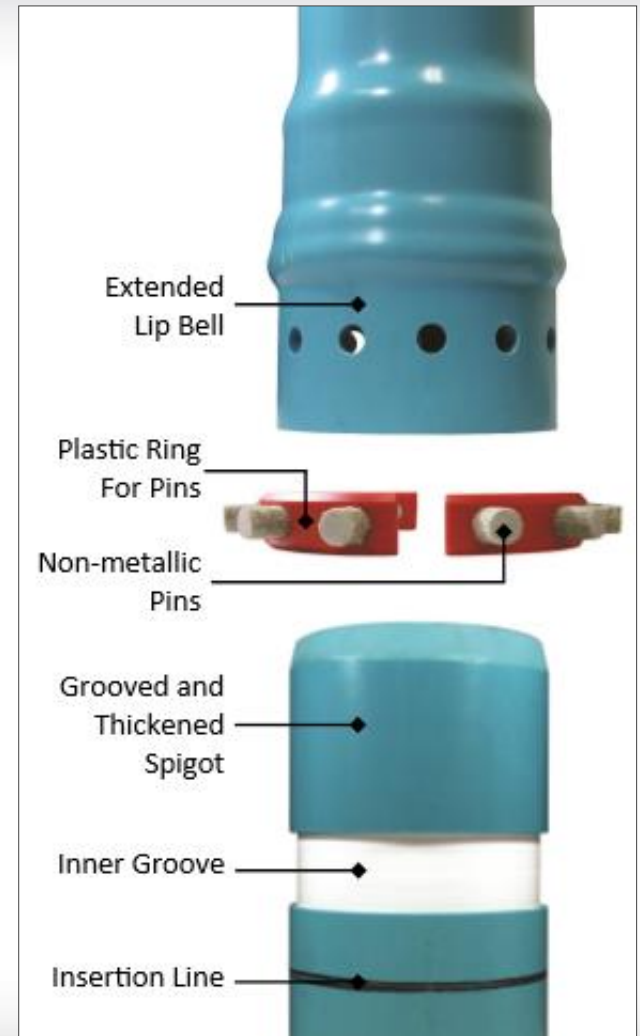
Underground Solutions: Bringing Innovation to the Underground Infrastructure Market

- Cartridge loaded restrained joint pipe system
- Trenchless installation modes reduce costs
- Rehabilitation capabilities for difficult high pressure water pipe applications
- Over 1.3 million feet installed since 2003
- Pipe meets relevant industry pipe standards
 - AWWA C900, C605, NSF-61, NSF-14, PPI-TR2, ASTM Cell Classification 12454
 - Utilizes standard PVC and ductile iron fittings
 - 8"DR18 and 12"DR18



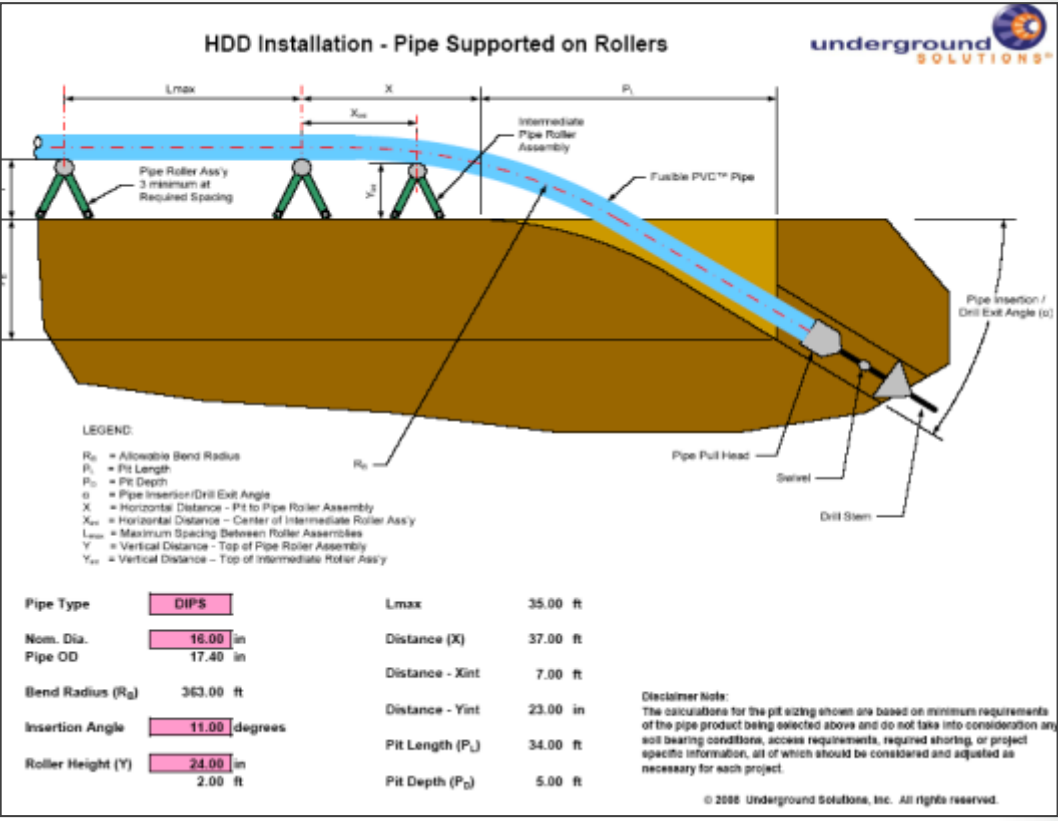
The restraining design is simple, robust and visible

- CR = Corrosion Resistant
- Simple system eliminates metal components
- High strength composite pins lock the bell and spigot together
- Wide spigot groove simplifies alignment for installation
- Utilizes standard PVC bell



Underground Solutions Provides a Variety of Project and Engineering Assistance to Customers – Helps Ensure Project Success

- Project assistance includes:
 - Seasoned industry **construction managers** to help “kick-off” projects with owners and contractors
 - Calculation tools** for planning HDD, Sliplining, Pipe Bursting and Open-Cut projects
 - Handling instructions on **“Quick Cards”** for contractors in the field
 - Project management** for direct source of project information



Summary of Aegion Pressure Pipe Capabilities

AEGION PRESSURE PIPE CAPABILITIES

Product	Applications							Diameter	Thickness	Max Continuous Install Length	Max. Temp.	Max. Pressure	AWWA Classification		Bends
	Potable Water	Wastewater	Irrigation/ Raw Water	Fire Suppression	Industrial	Electric/ Fiber	Casing						Class III	Class IV	
InsituMain®	X	X	X	X	X			06" - 72"	5mm - 28.5mm +/-	1,200'	130°F	250 psi	X	X	up to 45°
Tite Liner®	*X	X	X	X	X	X		02' - 52'	DR 9 - DR 41	5,000'	140°F	140 psi	X	X	up to 11.25°
Tyfo® Fibrwrap®	X	X	X	X	X			30" and above	4mm - 20mm	Unlimited	150°F	450 psi	X	X	Any
Fusible C-900®	X	X	X	X	X	X	X	04" - 12"	DR 14, 18, 21, 25	7,000'	140°F	305 psi		X	N/A
Fusible C-905®	X	X	X	X	X	X	X	14" - 36"	DR 14, 18, 21, 25, 32.5	7,000'	140°F	305 psi		X	N/A
Fusible PVC®	X	X	X	X	X	X	X	04" - 36"	SCH40 or SCH80	7,000'	140°F	305 psi		X	N/A

Note: Pipe size and operating temperature may limit maximum pressure for a given application

*To be evaluated on a case by case basis

Aegion's experience and technologies allow us to partner with customers to determine the best solution for their challenges

- 50,000 miles of installed pipe around the world
- Professional engineers involved in every project
- Mobile installation crews
- 80+ years of combined experience in rehabilitation
- Industry-leading safety record
- Certified to ISO 9001:2008 standards

Questions?



AEGION[®]

Stronger. Safer. Infrastructure.[®]

Questions?

Underground Solutions, Inc.
Tallahassee, FL
Chad Andrews
229-378-0315

www.undergroundolutions.com
858-679-9551