Aegion's Pressure Pipe Technologies

OTCO Procrastinator's Workshop

AEGION®

Stronger. Safer. Infrastructure.®

Infrastructure Solutions
Underground Solutions, Inc.
Introductory Capabilities








AEGION®

Stronger. Safer. Infrastructure.™

AEGION Maintains Infrastructure

Aegion provides services and solutions to protect, strengthen and maintain pipelines, refineries, bridges, and other infrastructure.

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AEGION includes Three Platforms

INFRASTRUCTURE SOLUTIONS

Replace, rehabilitate and strengthen municipal and industrial pipelines, as well as public and commercial structures worldwide.

CORROSION PROTECTION

Safeguard the world's water, oil, gas and mining resources, including the integrity of the pipelines and other structures.

ENERGY SERVICES

Deliver engineering, procurement, construction maintenance and turnaround services to oil and gas facilities with a best-in-class safety culture.

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Pipeline Infrastructure

Infrastructure Solutions

Water & wastewater pipeline rehabilitation
Structural strengthening



Corrosion Protection

Pipeline corrosion prevention
Oil, gas and mining



Energy Services

Facility maintenance services



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MARKETS & APPLICATIONS

Oil & Gas

- Crude oil and oil emulsion
- Sour and wet
- Water injection and disposal systems
- Offshore
- CO2 production and injection

Mining

- Tailings
- Concentrate
- Acid lines
- Water lines

Industrial

- Chemical slurries
- Sodium carbonate
- Corrosive effluents
- Caustics
- Brine

Municipal

- Pressure sewer mains
- Raw water transmission
- Potable water transmission*

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Pressure Pipe Capabilities

- Rehabilitation
- Structural or Semi-Structural design
- ANSI/NSF 61 certified
- New construction
- Minimally disruptive

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What AEGION Companies = Infrastructure Solutions?

INFRASTRUCTURE SOLUTIONS

Insituform® an AEGION company

FYFE® an AEGION company

FIBRWRAP® an AEGION company

united an AEGION company

Underground Solutions® an AEGION company

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Insituform - Cured-In-Place Pipe

- Developed in 1971 by Insituform, cured-in-place pipe (CIPP) is a trenchless technology
  - Initially used in sewers
  - InsituMain® CIPP uses modified properties to make it suitable for the drinking water market
  - End product is a joint less, pipe-within-a-pipe that protects against spills, breaks and pipe leakage
- The InsituMain® system is suitable for the following applications:
  - Distribution and transmission mains
  - Cooling water lines
  - Fire water mains
  - Industrial pressure applications
  - Sewage force mains

Over 25,000 miles of CIPP have been installed by Insituform crews around the world

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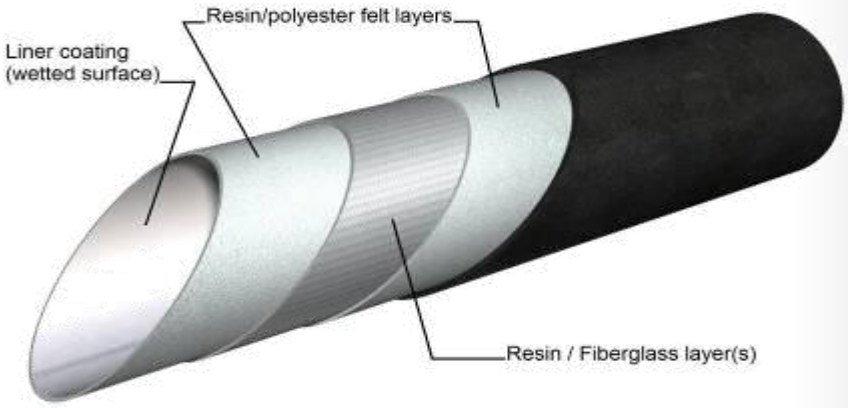
CIPP Fiber-reinforced composite structure

- 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 72”
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

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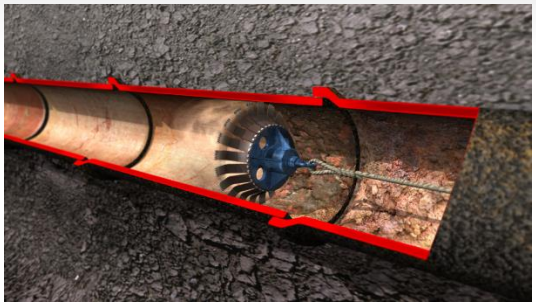
InsituMain® CIPP installation



Step 1:
If required, setup bypass and excavate pits to provide access to the existing pipeline. Clean the pipeline and inspect using closed circuit TV (CCTV).

Step 2:
Install the InsituMain system liner into the host pipe using water pressure. After curing with hot water, the pipe is cooled and the ends are cut. Following hydrostatic pressure testing, post-installation CCTV inspections are also completed.

Step 3:
Reconnect lined sections to the existing system using standard pipe fittings. Finally, restore excavation pits and remove temporary bypass, if applicable.

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InsituMain® CIPP installation

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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

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West Palm Beach 48” Force Main project – Installation Site

West Palm Beach 48” Force Main project – Completed Liner Shot

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West Palm Beach 48” Force Main project – Connected and Tested

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United Pipeline Systems - HDPE (Thermoplastic) Lining Systems

- **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

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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

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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
- 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

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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
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

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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

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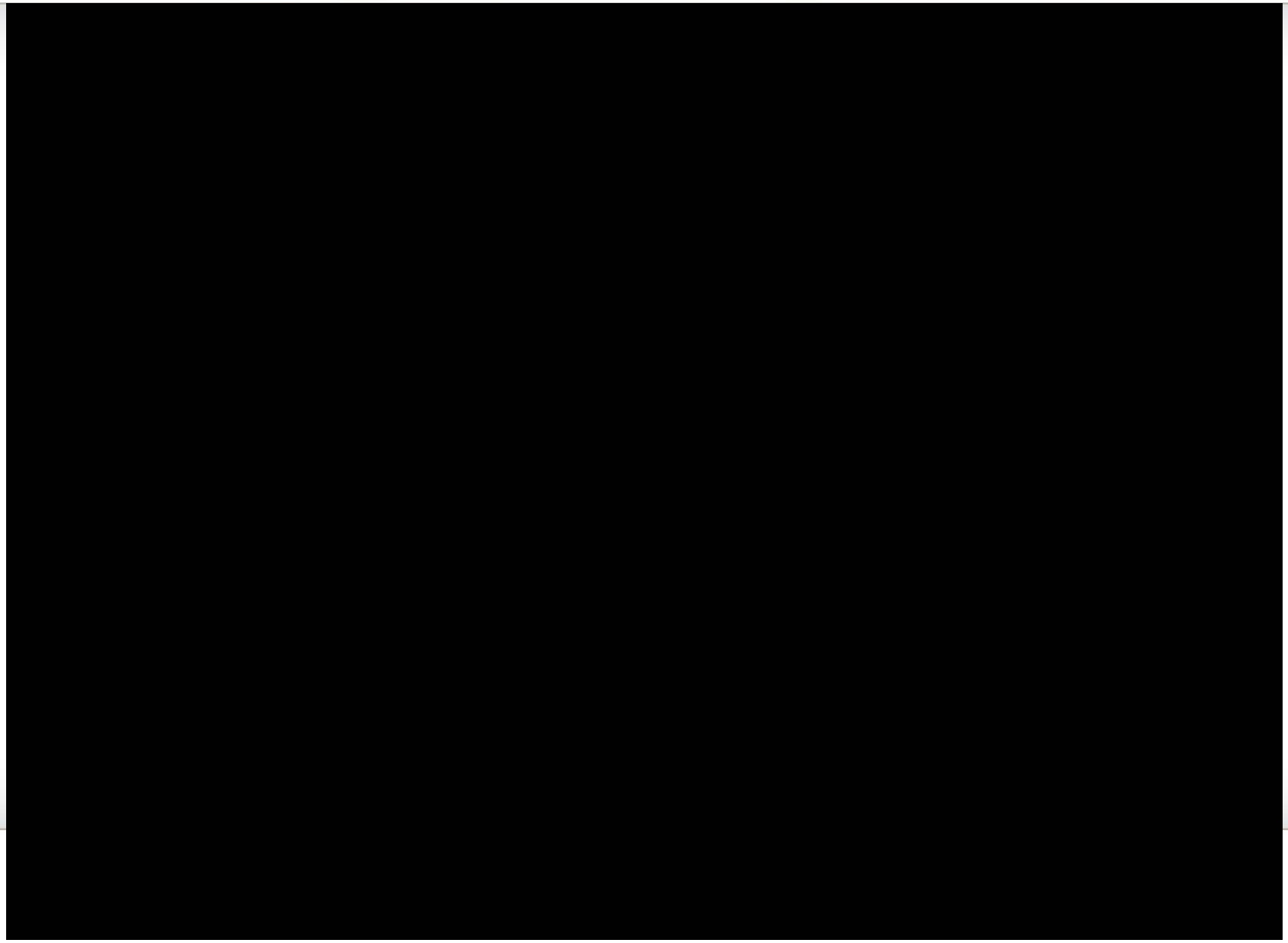
Tyfo® Fibrwrap® system installation



Installation of Tyfo® Fibrwrap® system allows pipe to withstand operating and transient pressures as well as gravity loads

- Washington Suburban Sanitary Commission discovered numerous sections of its 66-inch pipeline had broken pre-stressed wires and were structurally unsound
- WSSC determined traditional remove and replace method was not practical
- Tyfo® Fibrwrap® system allowed for a shortened construction schedule, minimal curing time and immediate return to service

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Underground Solutions – Fusible PVC Pipe Systems

- **Fusible PVC® Pipe – Leak free, restrained joint, PVC pipe system**
  - Trenchless installations that reduce contractor costs
  - Rehabilitation capabilities for pressure pipe applications
- **Over 10,000,000 feet in service**
  - In 50 states, Canada, Latin America, New Zealand, Australia
  - Over 10,000 Projects (HDD, Slipline, Pipe Burst, Open-Cut)
- **Pipe meets relevant industry pipe standards**
  - AWWA C900, C605, NSF-61, PPI-TR2, ASTM Cell Class 12454
  - Utilizes standard waterworks fittings

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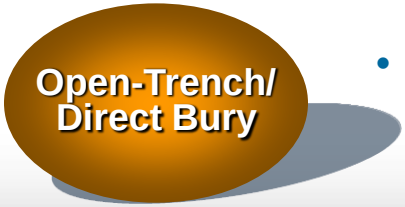
Fusible PVC Pipe Applications

- **55% of UGSI Fusible PVC® pipe installed by directional drilling techniques**
  - Pulls of over 7,000 ft accomplished with 30” pipe

- **25% of UGSI Fusible PVC® pipe installed in slip lining applications**
  - Pull of over 7,000 ft accomplished with 14” pipe

- **5% of UGSI Fusible PVC® pipe installed in pipe bursting applications**
  - Pulls of over 2,000 ft accomplished with 8” and 10” pipe



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

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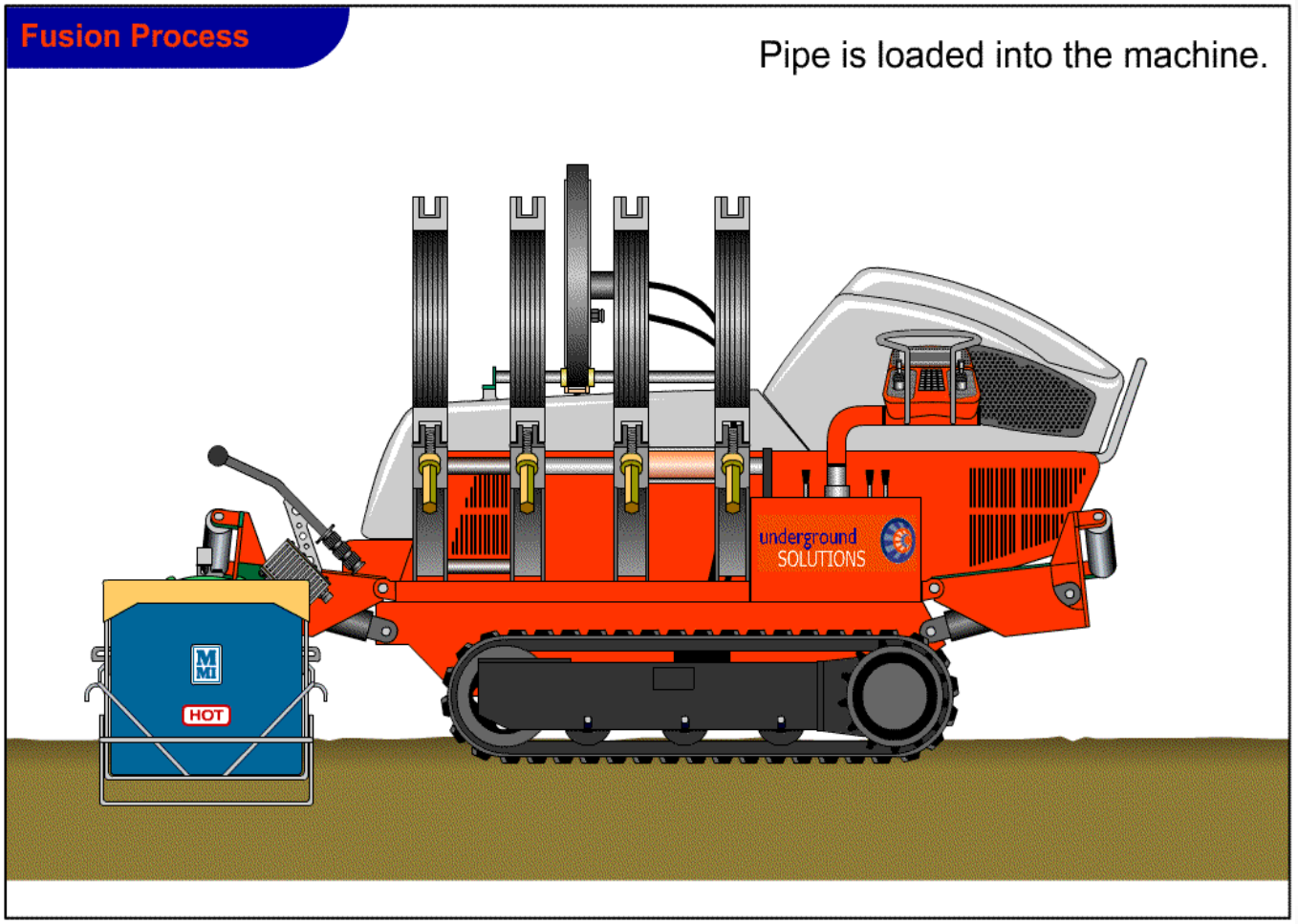
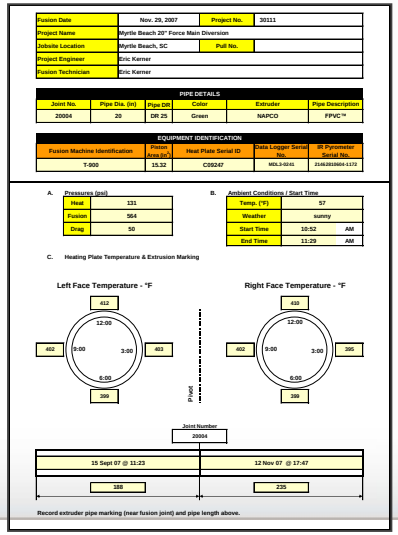
Fusible PVC Fusion Process



The Fusible PVC® Fusion Process Is Tightly Controlled

- Qualified fusion technicians are trained and re-trained 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
  - Joint data reviewed off-line as well by QA/QC
- Fusion conditions logged by technician and “as-built” fusion joint record is developed for owner as necessary



Fusion Date	Nov. 29, 2007	Project No.	30111
Project Name	Myrtle Beach 20" Force Main Diversion		
Jobsite Location	Myrtle Beach, SC	Pull No.	
Project Engineer	Eric Kerner		
Fusion Technician	Eric Kerner		

PIPE DETAILS					
Joint No.	Pipe Dia. (in)	Pipe DR	Color	Extruder	Pipe Description
20004	20	DR 25	Green	NAPCO	FPVC™

EQUIPMENT IDENTIFICATION				
Fusion Machine Identification	Fusion Area (in²)	Heat Plate Serial ID	Data Logger Serial No.	IR Pyrometer Serial No.
T-900	15.32	C09247	MDL3-0241	21662810604-1172

A. Pressures (psi)

Heat	131
Fusion	564
Drag	50

B. Ambient Conditions / Start Time

Temp. (°F)	57	
Weather	sunny	
Start Time	10:52	AM
End Time	11:29	AM

C. Heating Plate Temperature & Extrusion Marking

Left Face Temperature - °F

Right Face Temperature - °F

Joint Number: 20004

15 Sept 07 @ 11:23	12 Nov 07 @ 17:47
388	235

Record extruder pipe marking (near fusion joint) and pipe length above.

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Fusible PVC Pipe Mechanical Property Advantages

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	110,000[4]	130,000[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)

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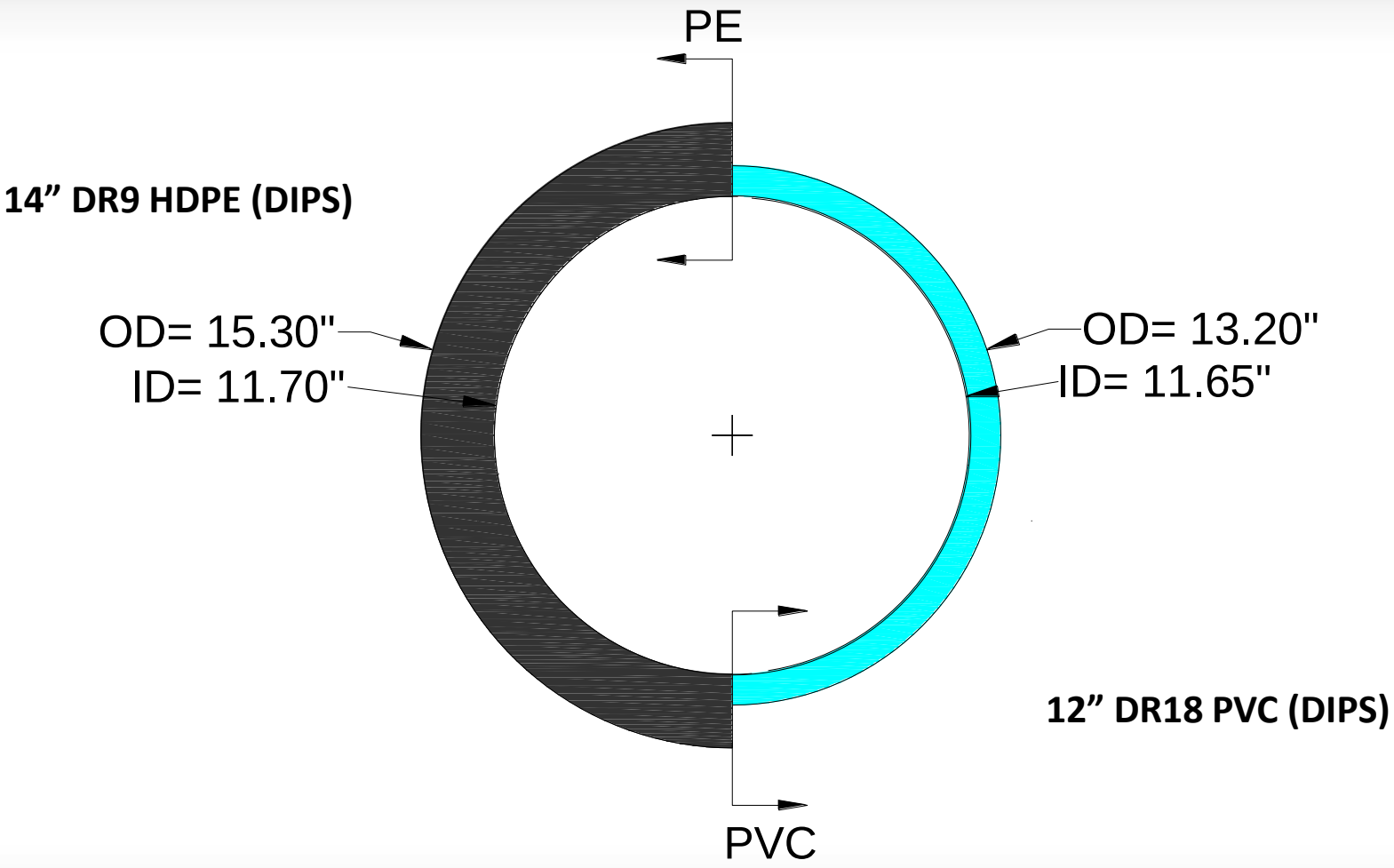
PVC is Stronger and Requires Less Wall Thickness



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Important to Design with both DR and Safety Factor

Dimension Ratio - Pressure Class Rating					
PVC		HDPE 3608 / 3408		HDPE 4710	
SF = 2.0		SF = 2.0		SF = 1.59	
DR	Pressure Rating (PSI)	DR	Pressure Rating (PSI)	DR	Pressure Rating (PSI)
DR 14	305	DR 7.3	255	DR 7.3	317
DR 18	235	DR 9	200	DR 9	250
DR 21	200	DR 11	160	DR 11	200
DR 25	165	DR 13.5	128	DR 13.5	160
DR 32.5	125	DR 17	100	DR 17	125
DR 41	100	DR 21	80	DR 21	100

Lower Design Factors Increases Risk of Failure and Lowers Life Expectancy

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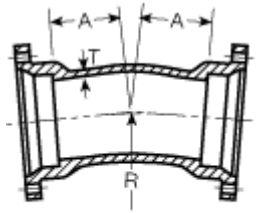
Fusible PVC is Compatible with Standard Fittings

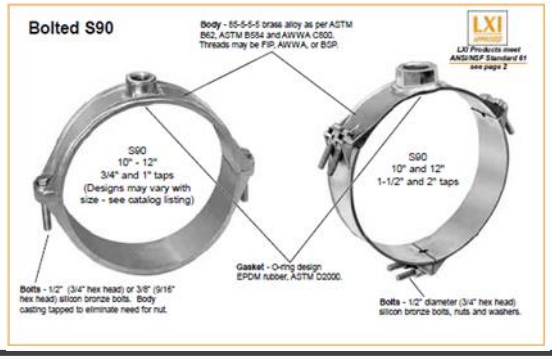
Connecting to Fittings

Mechanical Joint Fittings:



MJ and MJ

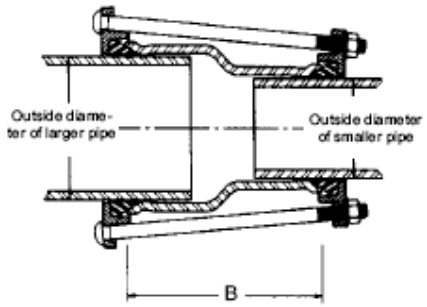
Tapping:



Connecting to Pipe

Same Piping Size:

Different Piping Size:



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

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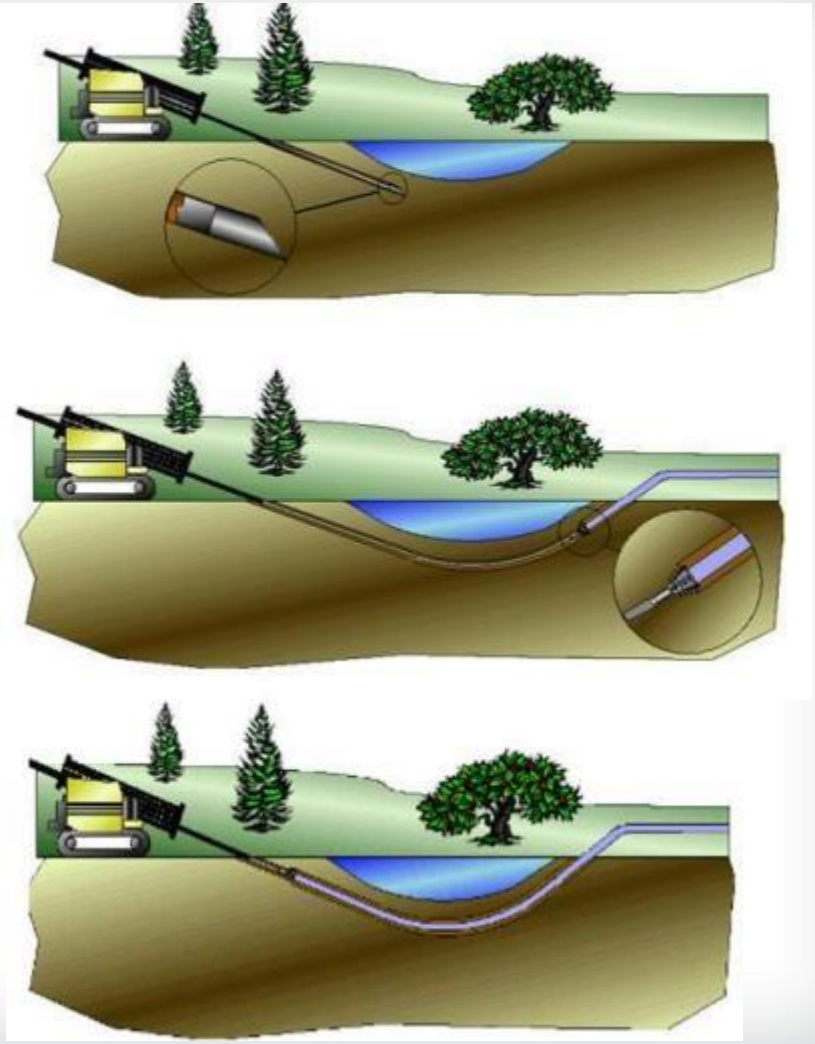
HDD Trenchless Installation Method

Horizontal Directional Drilling

- Guided pilot hole is drilled along a bore path
- Drilling fluids are injected into the hole to stabilize and lubricate
- Back reamer is used to enlarge the pilot hole
  - Multiple passes are required to accommodate pipe OD
  - Drilled bore hole is typically enlarged to 1.5 x OD of new pipe
  - Fusible PVC® is pulled through the bore hole



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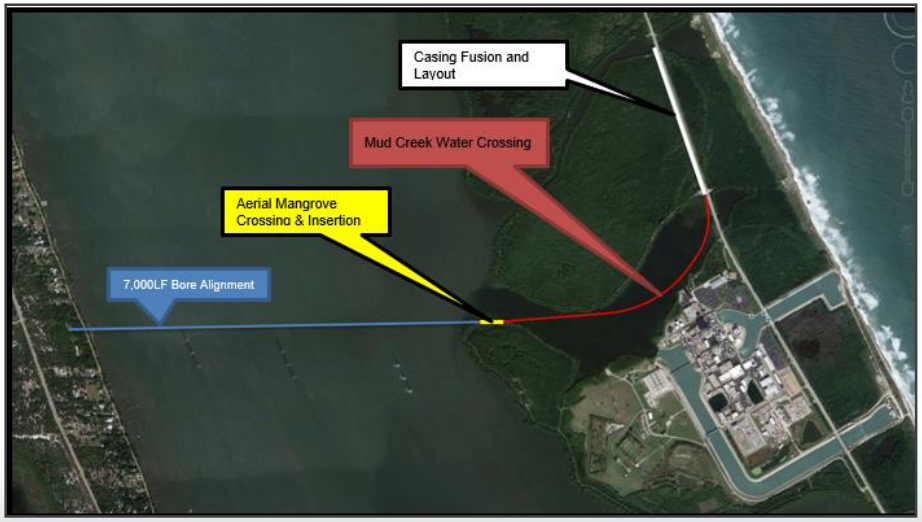
HDD Installation – Florida Power & Light

- 2 -7,020 LF HDD installs of 30” DR21 Fusible PVC Casing
- St. Lucie, FL 230kV Underground Transmission Project
- Design Engineer – Power Engineering, St. Louis, MO
- HDD Contractor - Mears Group, Houston, TX
- 2016 Trenchless Project of the Year



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Perrysburg: 16” Force Main; HDD

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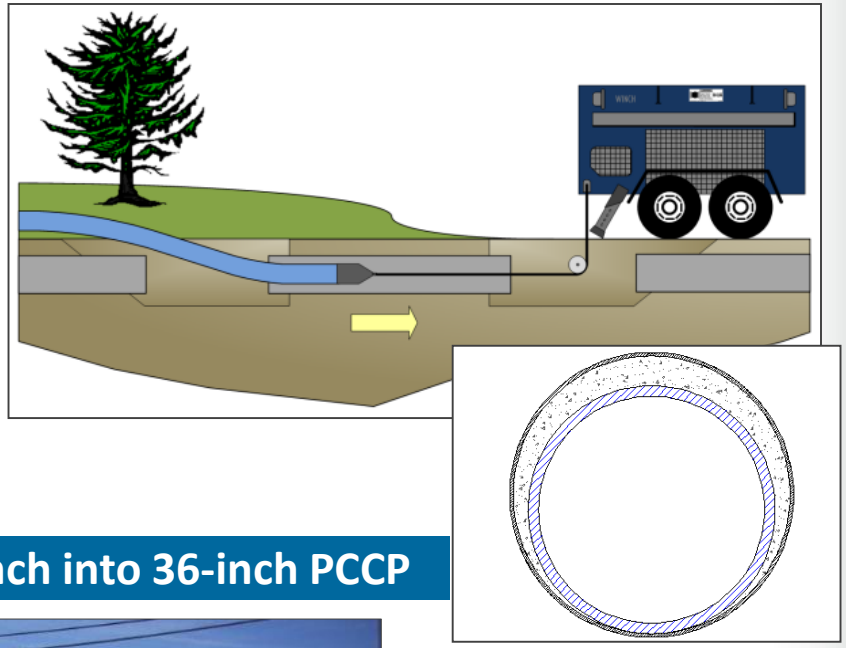
Fusible PVC® Maximizes Flow for Structural Slipline Installations

Fusible PVC® Advantages for Sliplining

- Utilizes same utility alignment
- Increased flow area for a given host pipe ID compared to similar pressure class HDPE
  Industry standard connections
- Simple, fast, inexpensive trenchless method

Sliplining Process:



Newport, RI – Emergency Forcemain Slipline – 30-inch into 36-inch PCCP

Sliplining

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Sliplining Project Considerations

Sliplining

- Video inspection of host pipe – condition, deflections, vertical profiles and stranded appurtenances
- Layout area for fused pipe – as well as entrance pit constraints – possibility for “fuse & pull” or in pit fusion
- Recommended difference between ID of host pipe and OD of Fusible PVC® pipe is about 2”
- Ability to dig out connections before sliplining
- Effect of abrasion on pipe surface – plastic 10% gouge depth before de-rating, steel corrosion coating degradation due to friction
- Traffic management – night activity or “fuse & pull” in tight areas

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City of Hamilton: 20” Water Main; Slipline of Existing 24” Line

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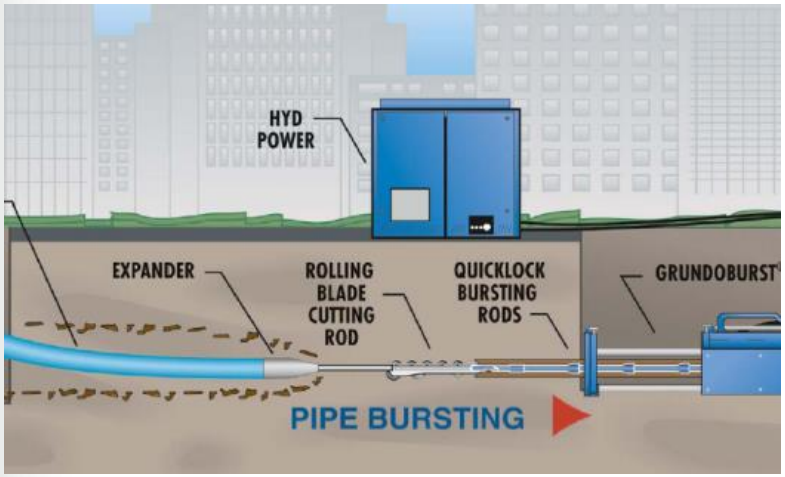
Fusible PVC® pipe is a Proven for Potable Water Pipe Bursting

Pipe Bursting Process:



Fusible PVC® Advantages for Pipe Bursting

- PVC pipe is a common, accepted small diameter water pipe material:
  - Same fittings, taps, and connections
  - Same labor skillset
  - Same operation and maintenance requirements
- Reduced upsize bursting effort required compared to similar ID/Pressure HDPE

CMW, Lakewood, CO – Over 30 miles of Potable Water Pipe Bursting

Pipe Bursting

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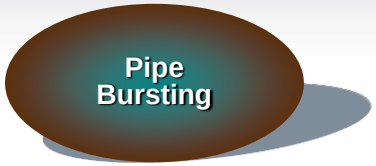
Considerations and Fusible PVC® Pipe Advantages



- Ductile iron, cast iron, asbestos-concrete and steel are typical water pressure pipe materials that are burst – high production rates are possible (project in Florida - 500 LF in 1 hour)
- Static hydraulic bursting/splitting method is used vs. pneumatic method (typically used in sewer work)
- High density of Fusible PVC® results in excellent scratch and abrasion resistance
- Isolation of pipe from burst hardware prevents rebound when force changes rapidly

Pipe Bursting Installation – City of Lee's Summit, MO

- Static Hydraulic Method for over 50,000 LF 6"DR18 & 5,100 LF 8"DR18 Fusible PVC® pipe
- Replaced 4" and 6" cast iron and ductile iron installed in the mid 1980's – 4" was upsized to 6" with 8" installed in some areas.
- Use of standard DI fittings to reconnect lines
- Significant savings versus previous open-cut replacement projects (>20% or more)

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McCandless Twp.:
12” FPVC®; Static pull water main pipe burst

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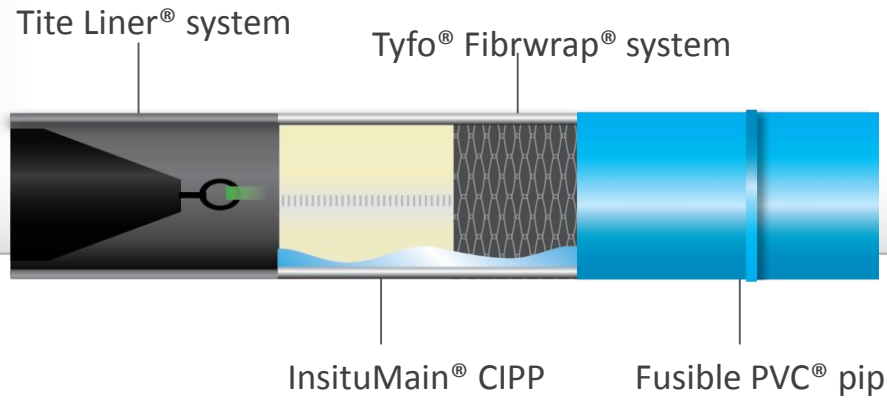
Our Portfolio – Summary

AEGION PRESSURE PIPE CAPABILITIES

Product	Applications							Diameter	Max. Continuous Install Length	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""	1,200'	250 psi	X	X	up to 45°
Tite Liner®	*X	X	X	X	X	X		02" - 52"	5,000'	140 psi	X	X	up to 11.25°
Tyfo® Fibrwrap®	X	X	X	X	X			30" & Above	Unlimited	450 psi	X	X	Any
Fusible PVC®	X	X	X	X	X	X	X	04" - 36"	7,000'	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*



InsituMain® – Slight bends or offsets

Tite Liner – Long, straight runs

Tyfo® Fibrwrap® – Limited or problematic access

Fusible PVC® – Decreased capacity (sliplining), increased capacity (pipe bursting)

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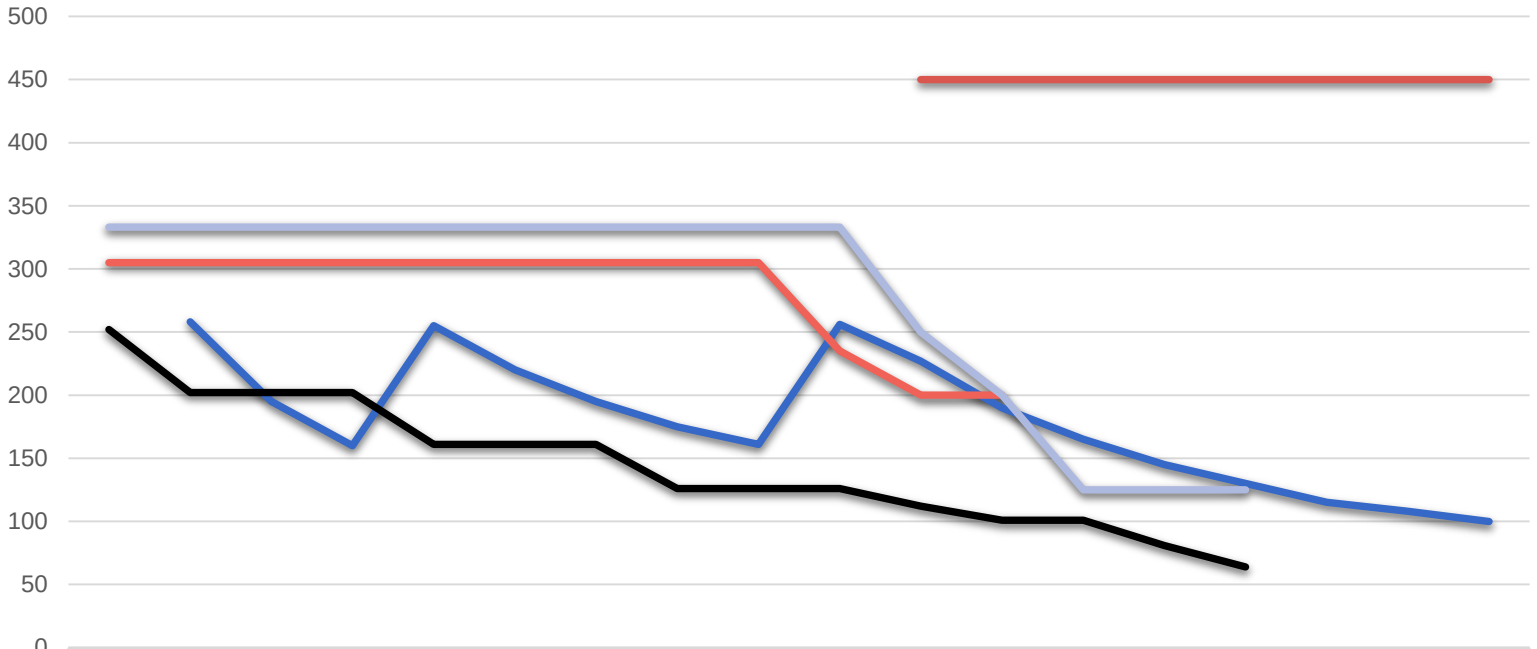
Aegion Pressure Pipe Capabilities

Aegion Product Matrix by Maximum Internal Operating Pressure



	4"	6"	8"	10"	12"	14"	16"	18"	20"	24"	30"	36"	42"	48"	54"	60"	66"	72"
InsituMain		258	195	160	255	220	195	175	161	256	227	190	165	145	130	115	108	100
Fusible PVC	305	305	305	305	305	305	305	305	305	235	200	200						
Tite Liner	252	202	202	202	161	161	161	126	126	126	112	101	101	81	64			
HDPE Slip Lining	333	333	333	333	333	333	333	333	333	333	250	200	125	125	125			
Tyfo											450	450	450	450	450	450	450	450

AEGION

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

- 30,000 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?

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