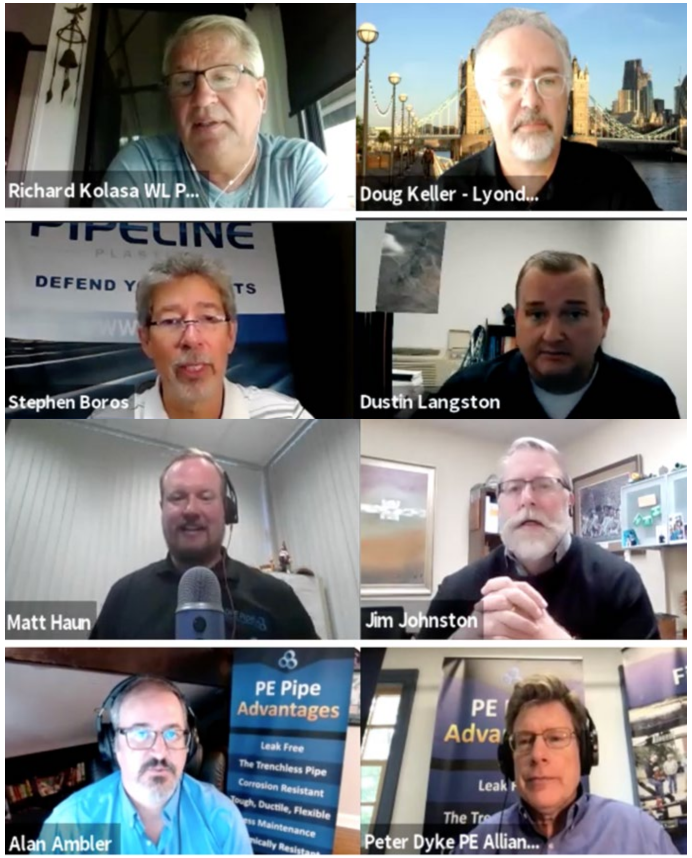
HDPE Above Ground Applications

www.pepipe.org

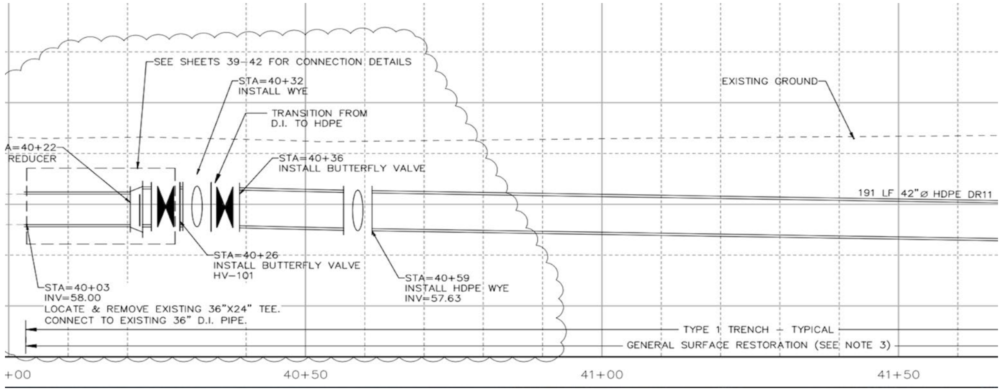
Free Resources

dlandy@pepipe.org

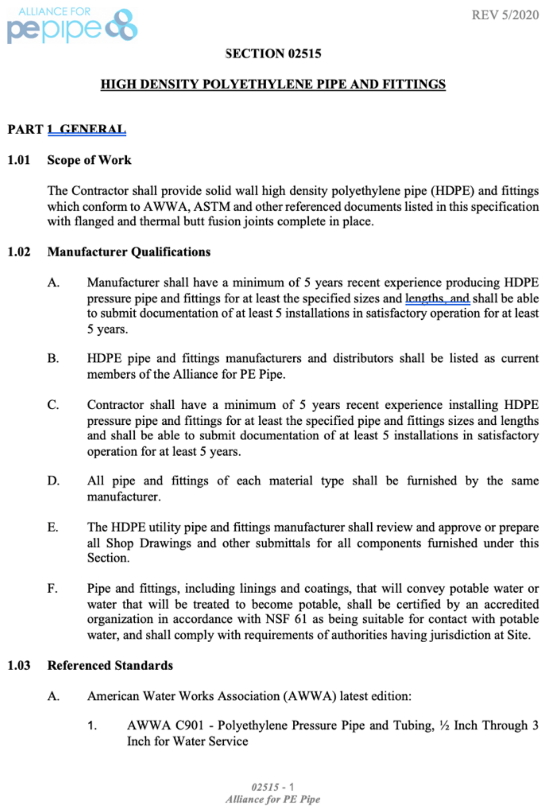
Schedule A Seminar



Project Review & Assistance



Spec Writing / Editing



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REV 5/2020

SECTION 02515

HIGH DENSITY POLYETHYLENE PIPE AND FITTINGS

PART 1 GENERAL

1.01 Scope of Work

The Contractor shall provide solid wall high density polyethylene pipe (HDPE) and fittings which conform to AWWA, ASTM and other referenced documents listed in this specification with flanged and thermal butt fusion joints complete in place.

1.02 Manufacturer Qualifications

A. Manufacturer shall have a minimum of 5 years recent experience producing HDPE pressure pipe and fittings for at least the specified sizes and lengths, and shall be able to submit documentation of at least 5 installations in satisfactory operation for at least 5 years.

B. HDPE pipe and fittings manufacturers and distributors shall be listed as current members of the Alliance for PE Pipe.

C. Contractor shall have a minimum of 5 years recent experience installing HDPE pressure pipe and fittings for at least the specified pipe and fittings sizes and lengths and shall be able to submit documentation of at least 5 installations in satisfactory operation for at least 5 years.

D. All pipe and fittings of each material type shall be furnished by the same manufacturer.

E. The HDPE utility pipe and fittings manufacturer shall review and approve or prepare all Shop Drawings and other submittals for all components furnished under this Section.

F. Pipe and fittings, including linings and coatings, that will convey potable water or water that will be treated to become potable, shall be certified by an accredited organization in accordance with NSF 61 as being suitable for contact with potable water, and shall comply with requirements of authorities having jurisdiction at Site.

1.03 Referenced Standards

A. American Water Works Association (AWWA) latest edition:

1. AWWA C901 - Polyethylene Pressure Pipe and Tubing, ½ Inch Through 3 Inch for Water Service

02515 - 1
Alliance for PE Pipe

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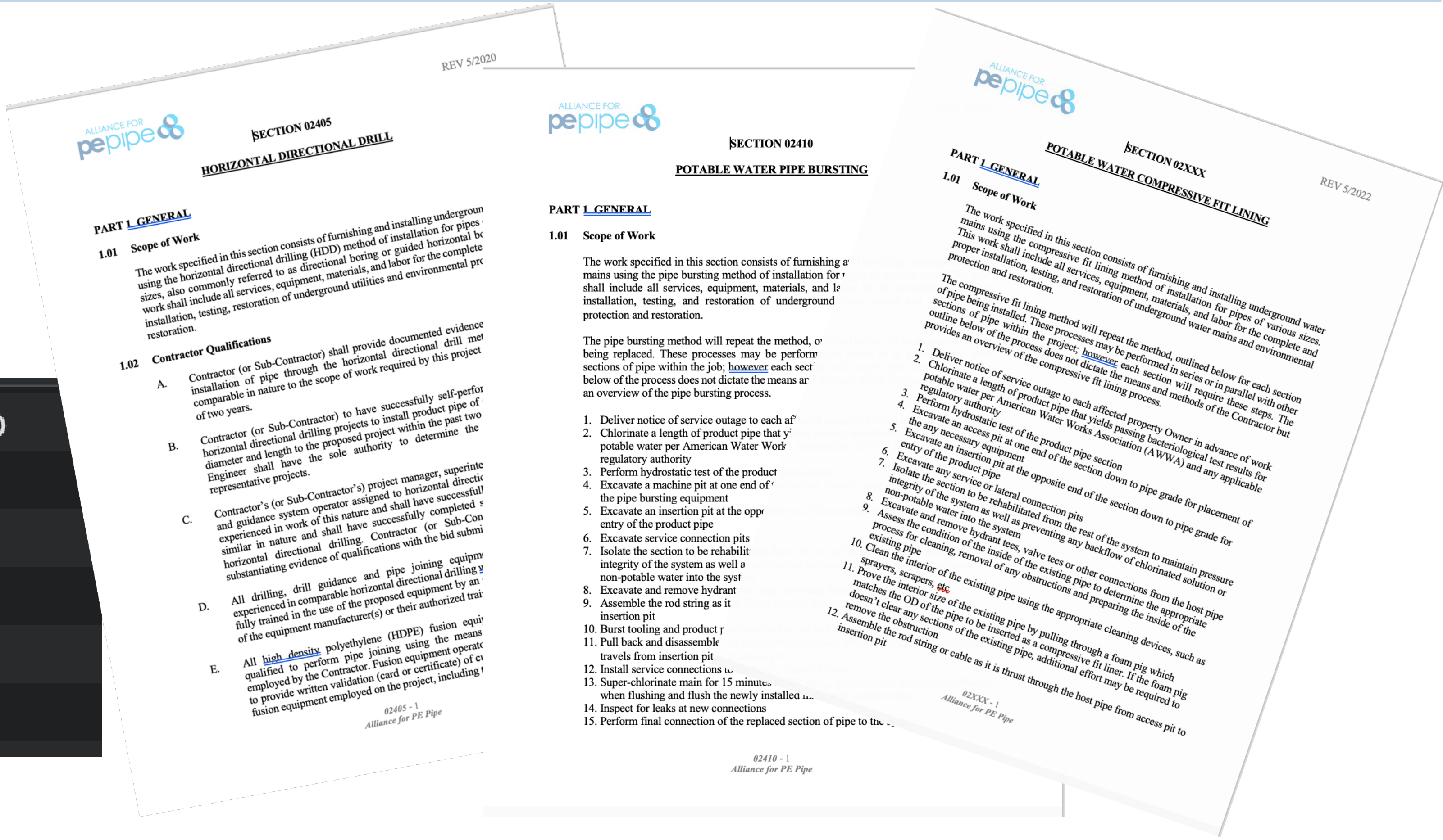
Specifications

dlandy@pepipe.org

1. AllianceforPEPipeSpecsinWORD copy.zip
2. ExcavationBackfillandCompaction.docx
3, PolyethylenePipeandFittings.docx
4. PipeBursting.docx
5. HorizontalDirectionalDrill.docx
6. CompressiveFitlining.docx



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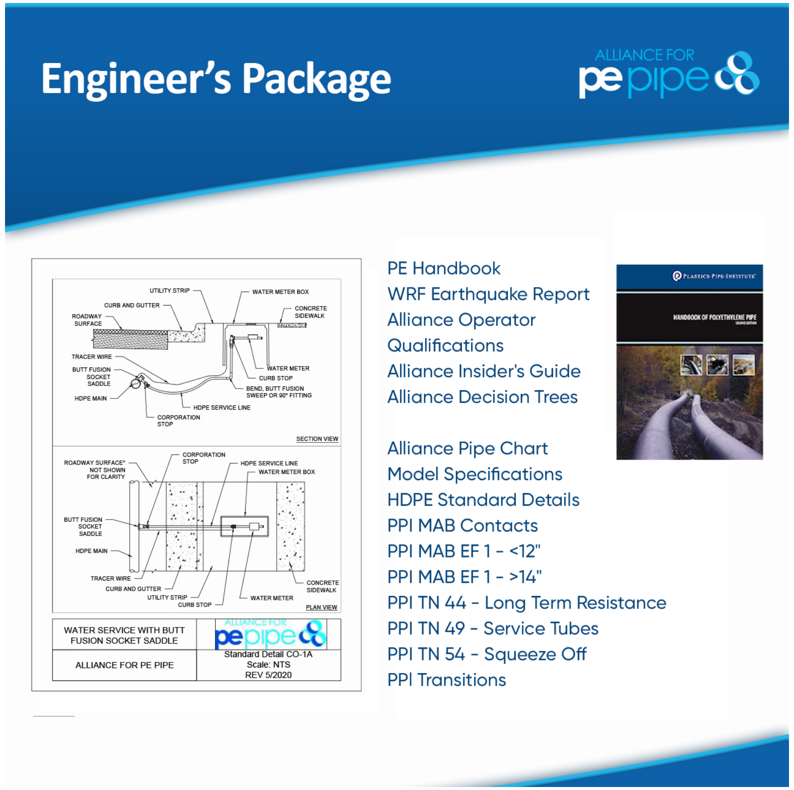
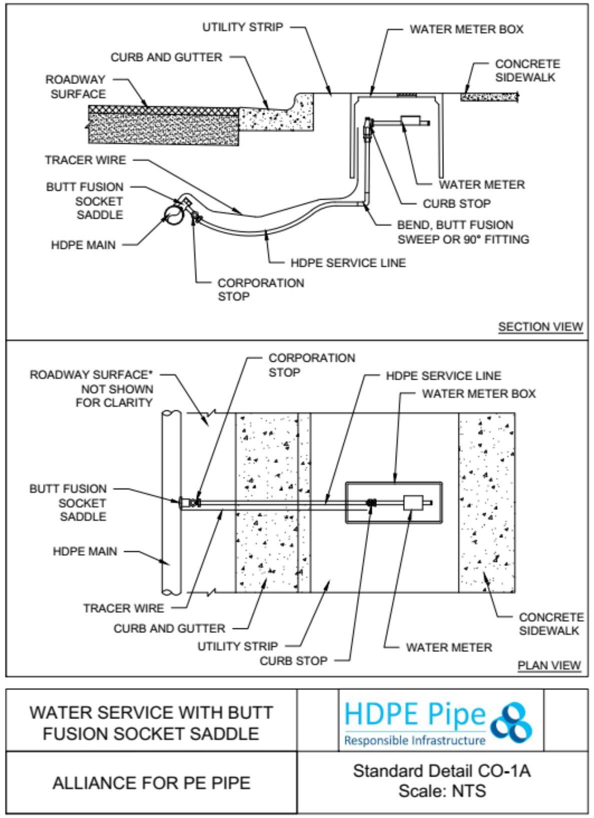
Engineer's Package



Standard Details



Case Studies

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Training

SINCE 1981
McELROY UNIVERSITY℠

https://www.mcelroy.com/website/university/

INTEGRITY FUSION
ACADEMY
ELECTROFUSION INSTALLATION TRAINING

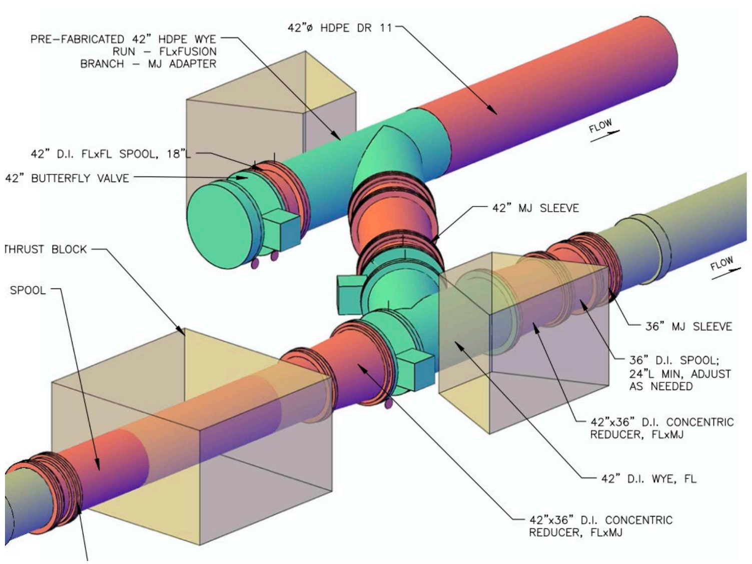
https://integrityfusion.com/training-academy/

Today's Presentation

Joining HDPE

Material Properties

Applications & Design



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Joining HDPE: Method 1 - Butt Fusion

1. *CLEAN IT*
2. *SHAVE IT*
3. *HEAT IT*
4. *FUSE IT*

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Joining HDPE: Method 1 - Butt Fusion

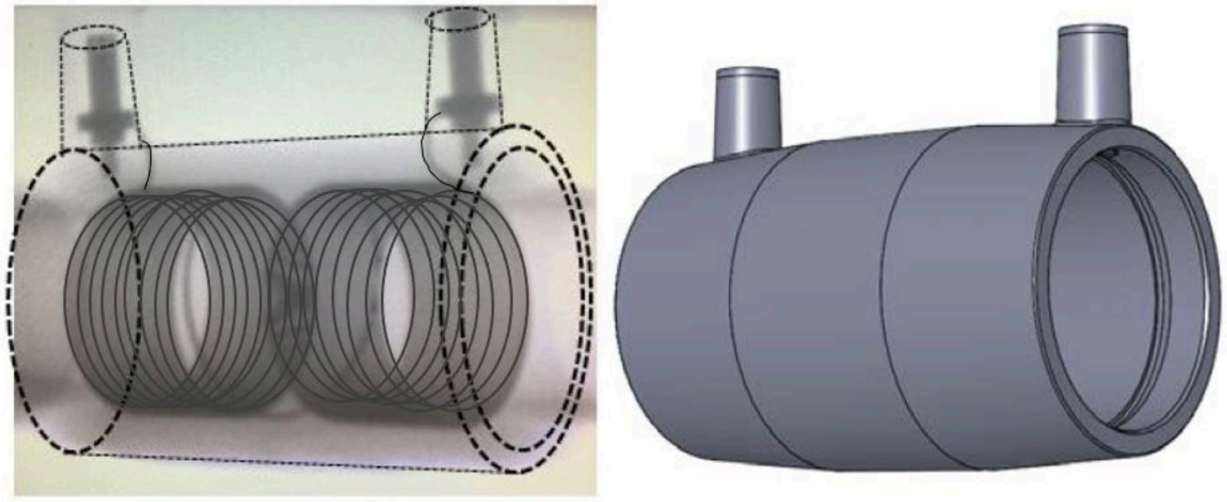
Joining HDPE: Method 1 - Butt Fusion

Butt Fusion Forensics

ALLIANCE FOR pepipe

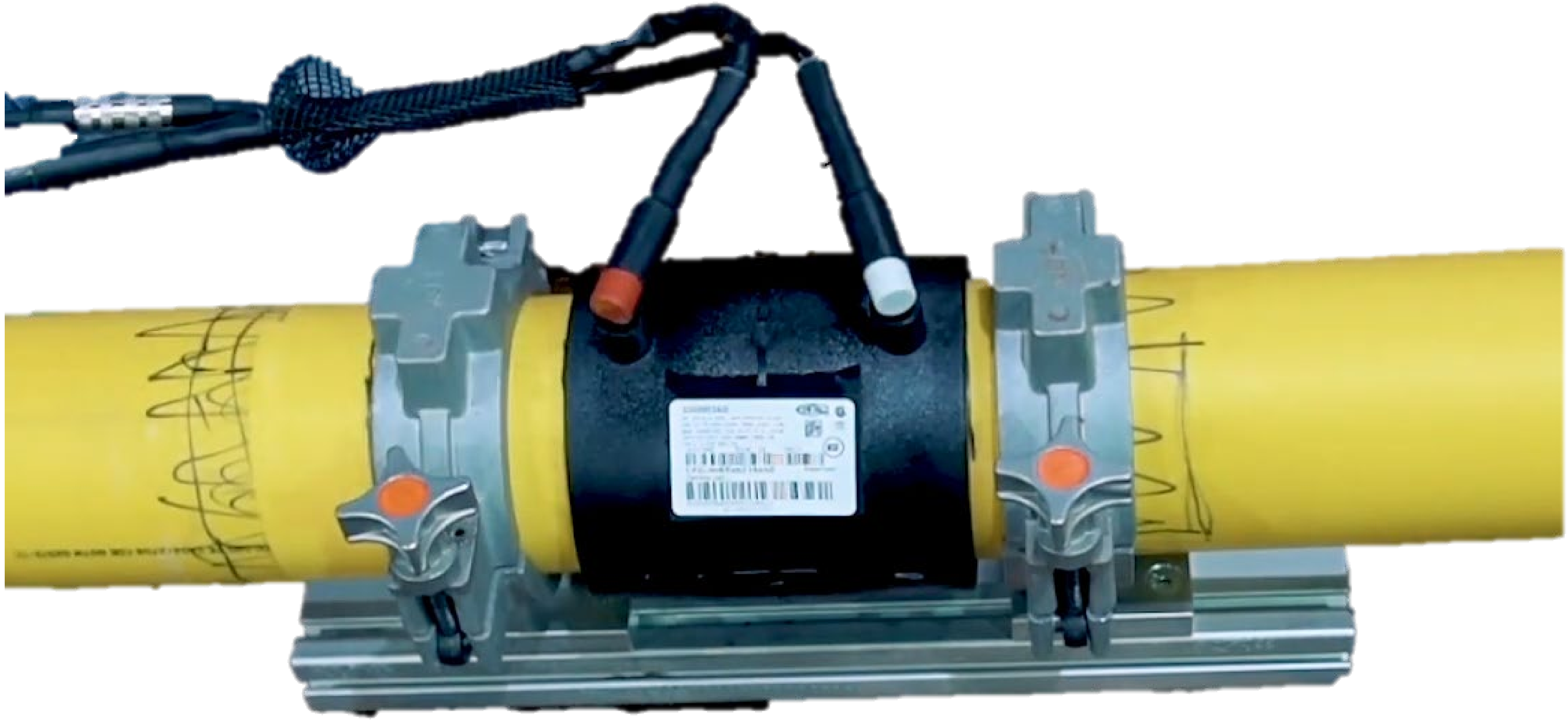
Joining HDPE: Method 2 - Electrofusion

Resistance Wire Heating Coil



ALLIANCE FOR pe pipe

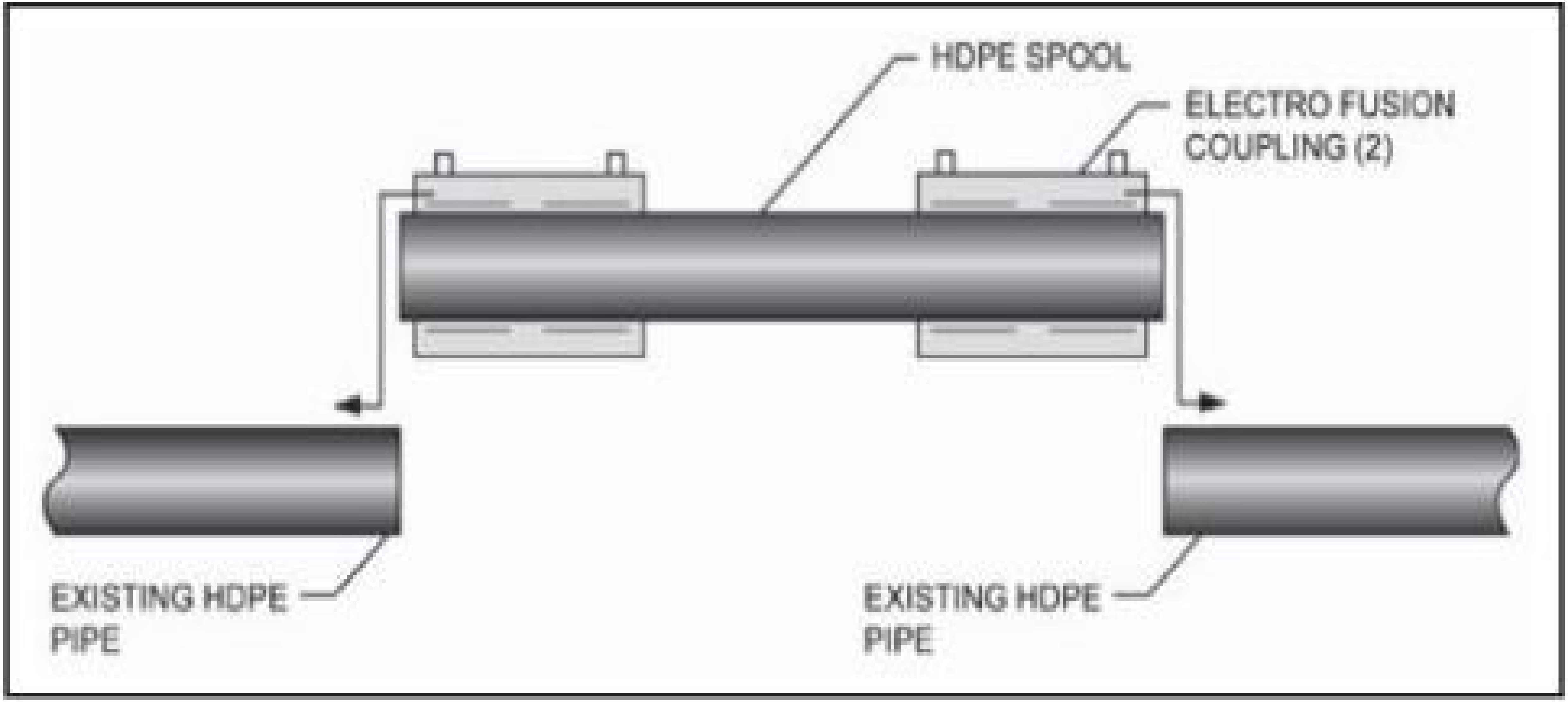
Joining HDPE: Method 2 - Electrofusion



1. CLEAN IT
2. PEEL IT
3. CLEAN IT
4. FUSE IT

ALLIANCE FOR pepipe

Joining HDPE: Method 2 - Electrofusion



Joining HDPE: Method 2 - Electrofusion

Electrofusion Coupler

Branch Saddles

Threaded Branch Saddles

Electrofusion 90° Elbow

Electrofusion Equal Tee

Electrofusion Reducer

Flex Restraint

Electrofusion 45° Elbow

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Joining HDPE: Method 3 - Couplers

Small Repairs where cutting out section of pipe is needed

Insert Stiffener Recommended

External Restraint needed if the Coupler is not Restrained

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Repair – Mechanical Spool

Large Field Repair Option

Inserts Recommended and Restraint Required

Good Option in Challenging conditions where fusion is difficult

Application #1: Irrigation

Application #2: Mining

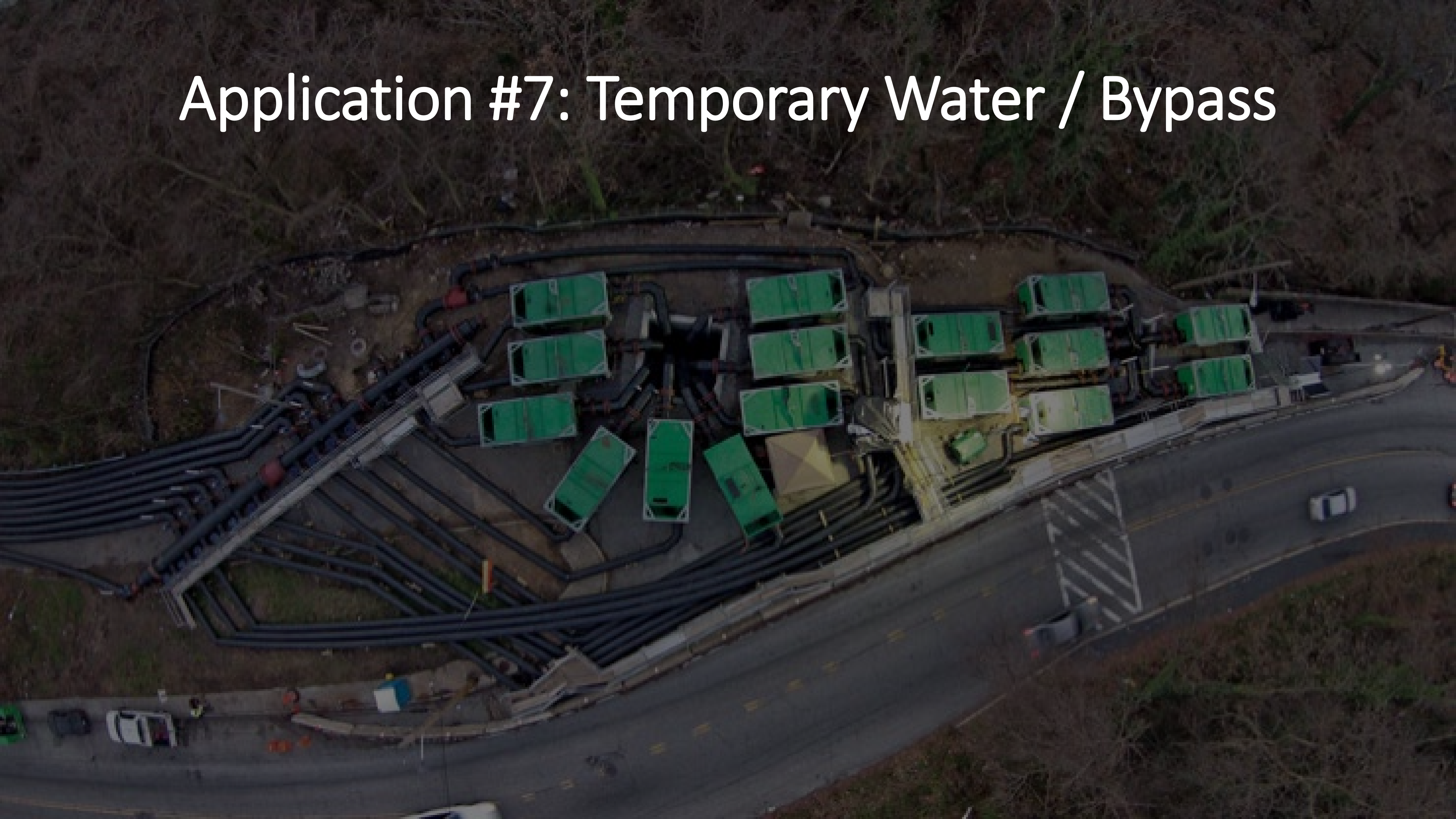
Application #3: Industrial

Application #4: Bridge Crossings


Application #5:
Environmentally
Sensitive Areas

Application #6: Outfalls, Intakes, Dredging

Application #7: Temporary Water / Bypass



Materials Properties

Thermal effects

UV Protection

Sag/deflection

Poisson's Effect

Restraint

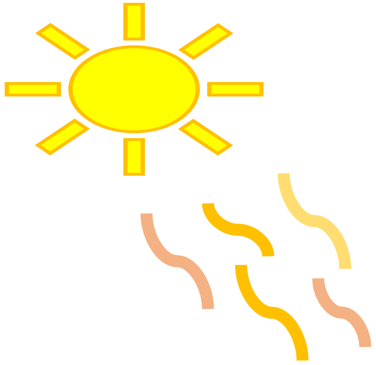
#1: Thermal Effects - Expansion/Contraction

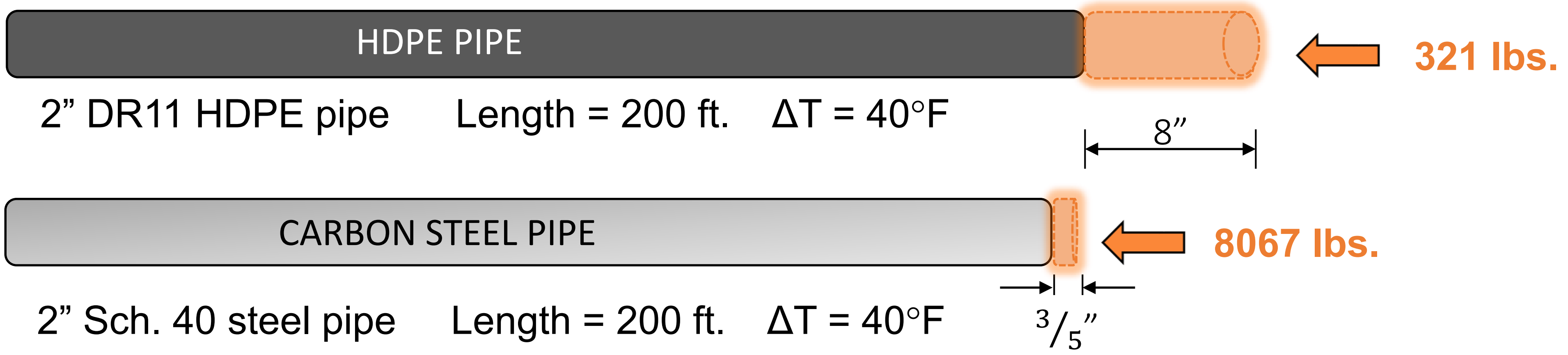
Thermal Expansion and Contraction

- PE expands and contracts at a rate of about 1 in/10°F/100 ft
- However, PE requires a much smaller force to restrain expansion and contraction compared to other materials

Piping Material	Coefficient of Thermal Expansion (α), in/in-°F	Elastic Modulus* (E), psi	Stress, psi ($\sigma = \alpha E \Delta T$)
^Carbon Steel	6.5×10^{-6}	29×10^{6}	188.5 x ΔT
^Stainless Steel	9.9×10^{-6}	28×10^{6}	277.2 x ΔT
Polyethylene	80×10^{-6}	0.065×10^{6}	5.2 x ΔT

*Polyethylene uses a time and temperature-dependent modulus of elasticity. Modulus shown in this table is for 10 hours at 73°F
^Values for carbon steel and stainless steel obtained from www.engineeringtoolbox.com





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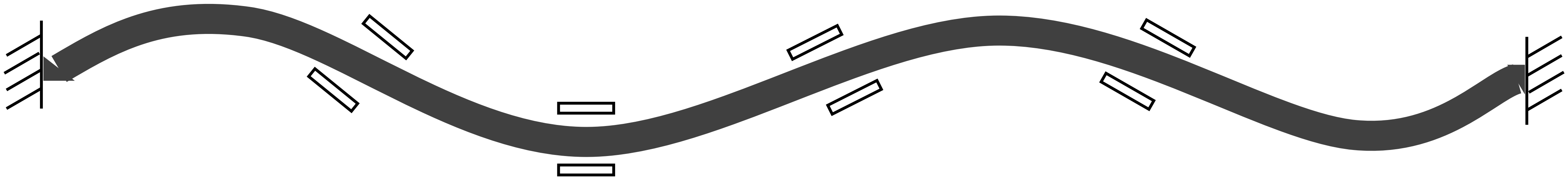
#1: Thermal Effects - Expansion Loops

Lateral Deflection Expansion Loop



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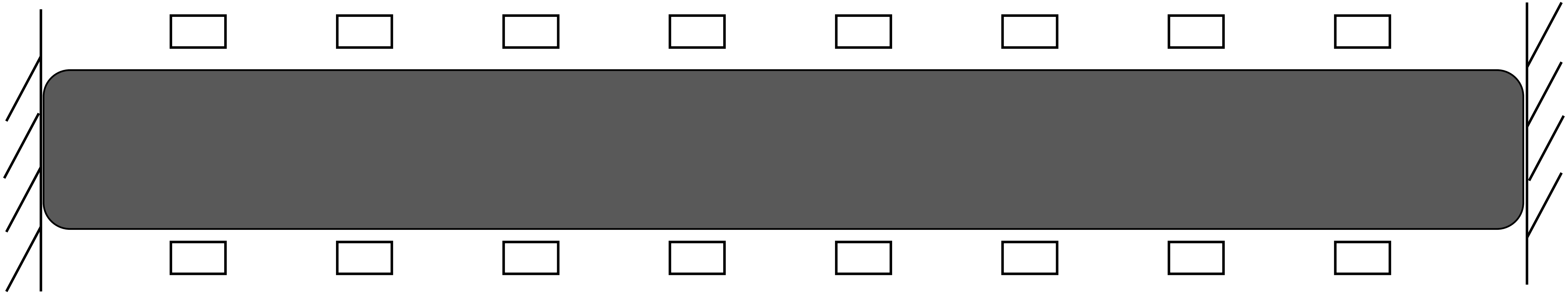
#1: Thermal Effects - Expansion Loops

Lateral Deflection Expansion Loop

ALLIANCE FOR pepipe

#1: Thermal Effects - Expansion Loops

Anchored and Guided System



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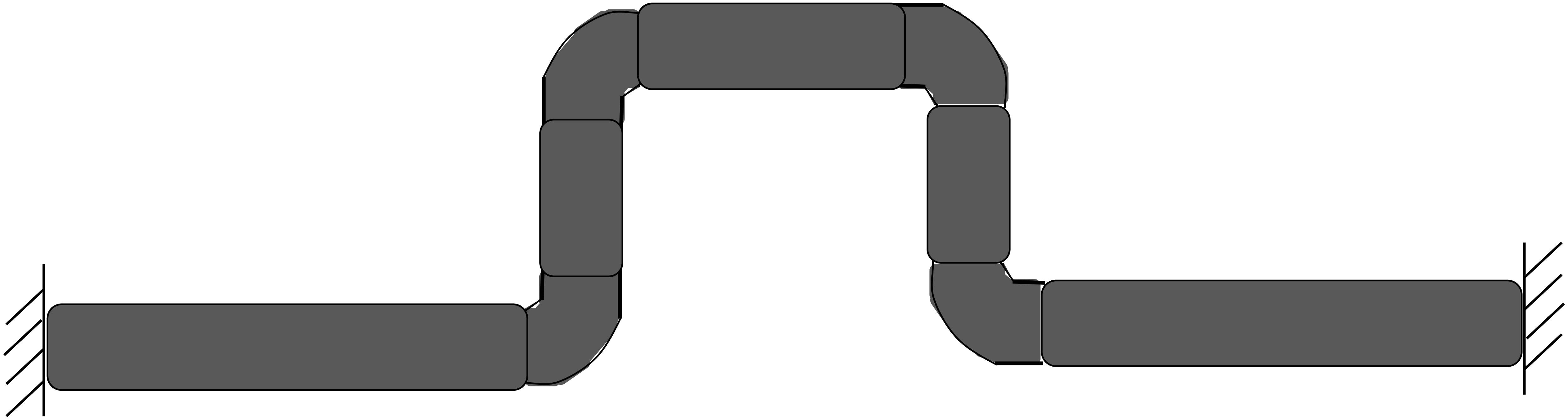
#1: Thermal Effects - Expansion Loops

Anchored and Guided System

ALLIANCE FOR pepipe

#1: Thermal Effects - Expansion Loops

Conventional Expansion Loop



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#2: UV Radiation

Figure 1: Surface discoloration of PVC pressure

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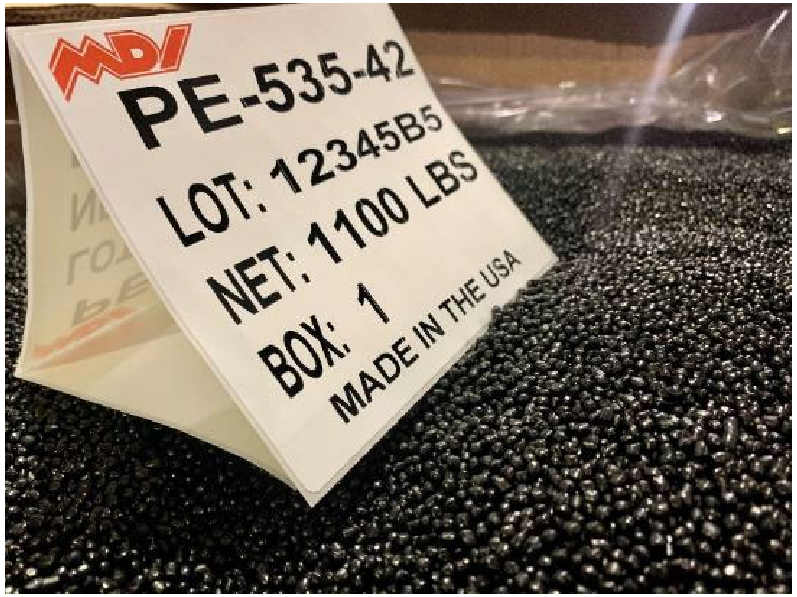
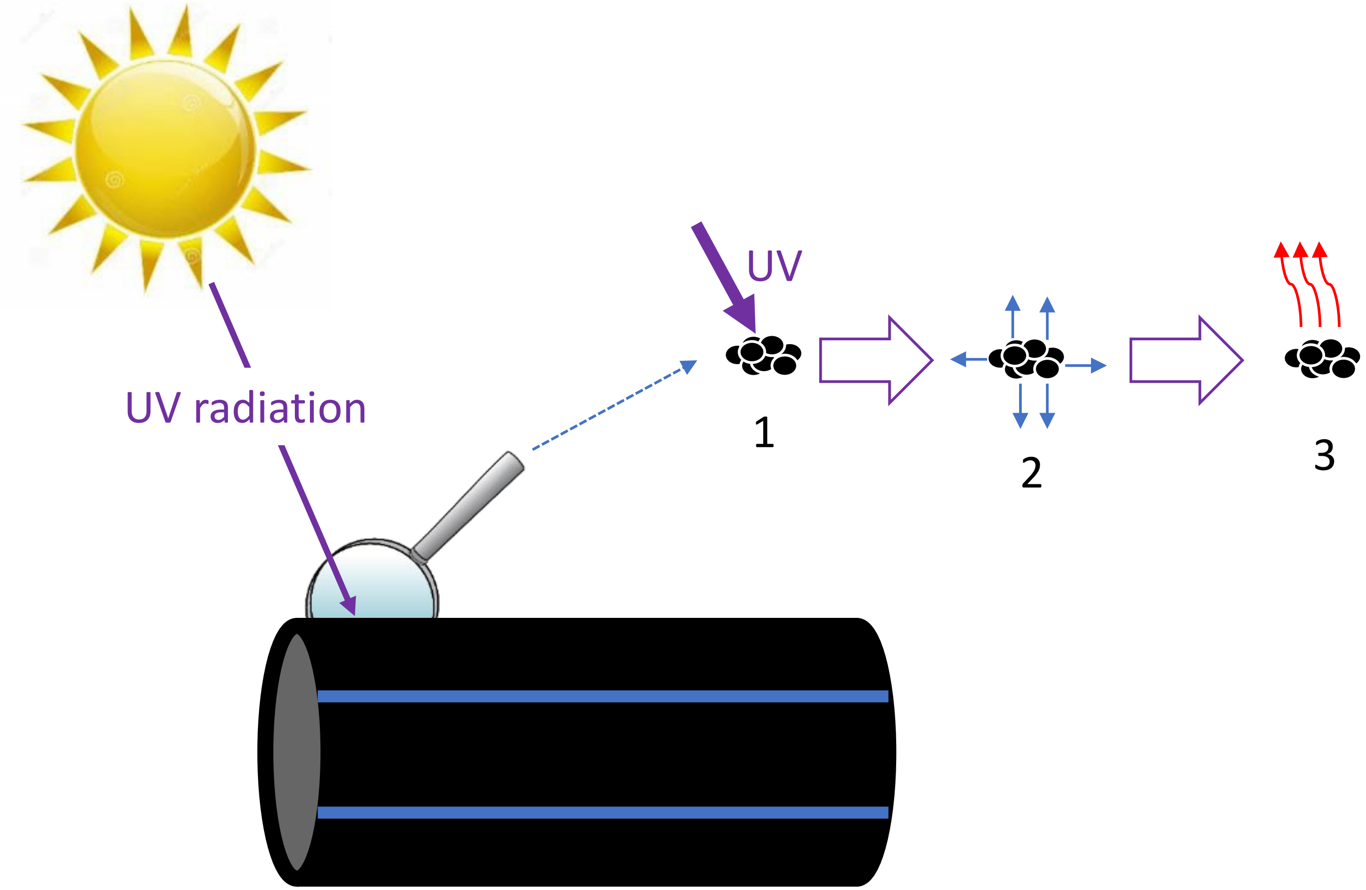
#2: UV Radiation - Carbon Black

Goal: Protect polymer chains on a molecular level

Solution: 2% carbon black protects from UV radiation for an indefinite time



#2: UV Radiation

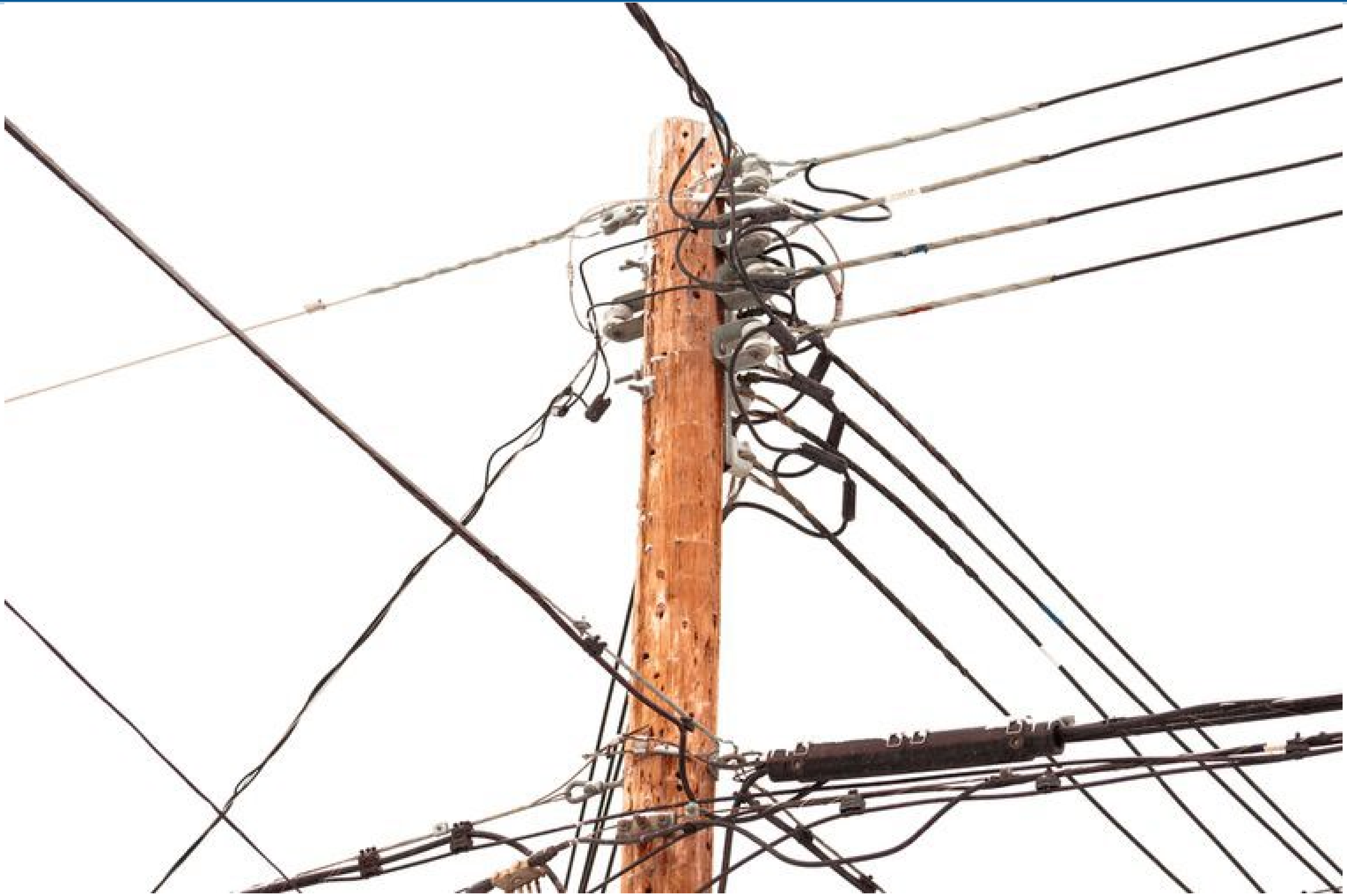


1. UV radiation strikes particles
2. Particles react to the UV energy by vibrating
3. Particles are constrained, and the vibrations are converted to heat

#2: UV Radiation - PROOF

Existing telephone lines protected by carbon black

Have been installed for well over 50 years

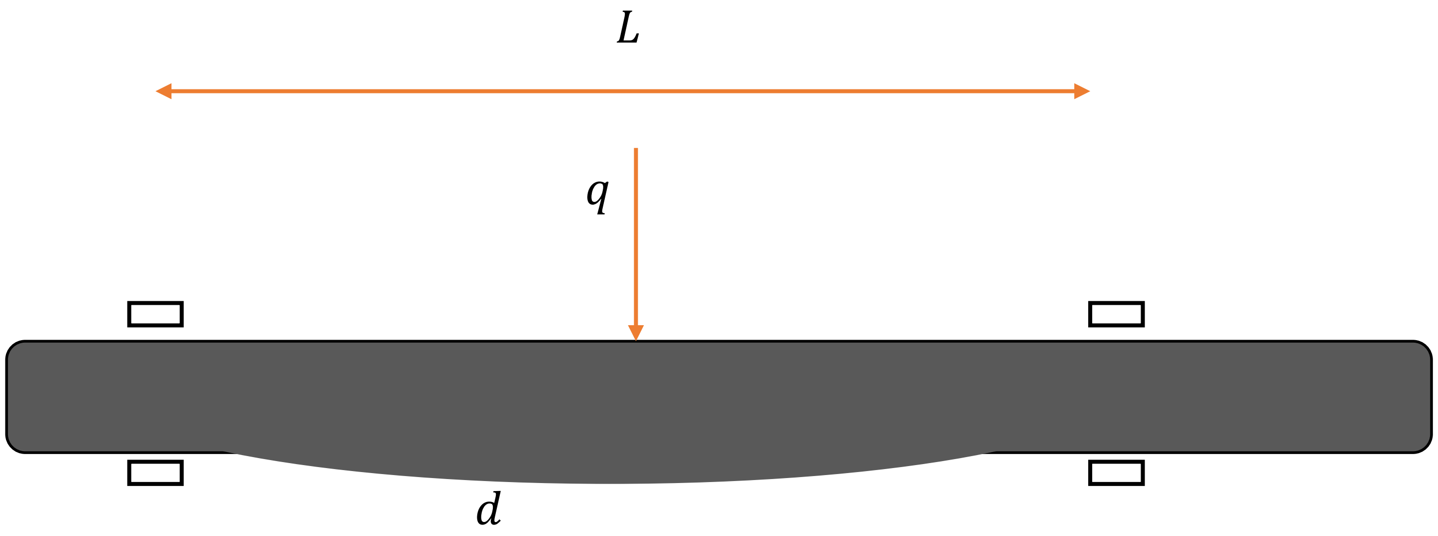


#3: Vertical Deflection

Center-to-center span length

Load per unit length

Beam deflection analysis based on limiting deflection



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#3: Vertical Deflection - Span Length

Determine Max allowable bending stress

- PPI provides maximum allowable bending stress (σ_m) as 1/2 (non pressure) and 1/8 (pressure) operating pressure
- OD, ID, weight of pipe
- Density of internal fluid
- Deflection coefficient Table 2
- Apparent long-term modulus of elasticity at average long-term temperature
- Moment of Inertia

$$Lmin = \sqrt{\frac{3\,(OD^4 - ID^4)\sigma_m \pi}{8qOD}}$$

$$q = \frac{W}{12} + \frac{\pi \sigma_{fluid} (ID)^2}{6912}$$

$$d = \frac{f q L^4}{E_L I}$$

$$I = \left(\frac{\pi}{64}\right)(OD^4 - ID^4)$$

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#3: Vertical Deflection

10-inch (10.75 OD) DR11 pipe

σ_m *= 100 psi (bending stress)*

L min. calc = 13.45'

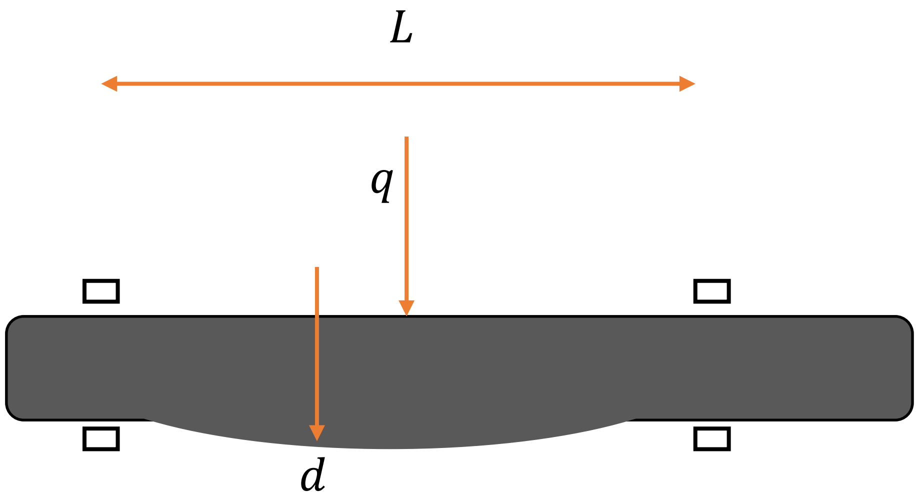
L recommended = 12' restraint intervals

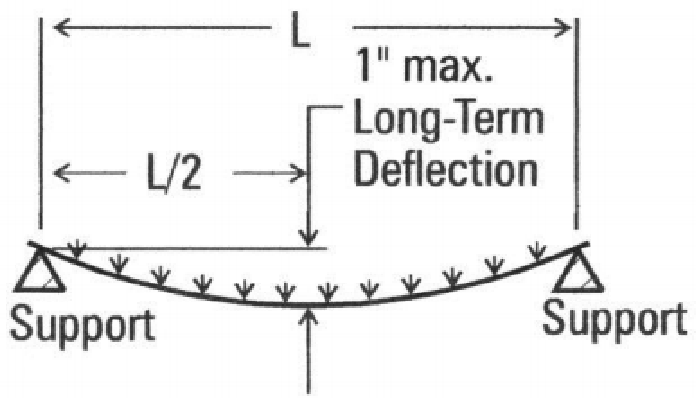
q = 3.23 lb/in

d = 0.00002896 in

$$Lmin = \sqrt{\frac{3\,(OD^4 - ID^4)\sigma_m \pi}{8qOD}}$$

$$d = \frac{fqL^4}{E_L I}$$





Vertical Deflection Is Well Understood & Easily Calculated

18" DR11 IPS with Restraint Every 10'			
	OD	18	inch
	ID	14.531	inch
	Weight (lb/ft)	36.403	lb/ft
Load per Unit Length			
	$q = W/12 + \pi\sigma(ID)^2/6912$		
W	Weight of pipe (lbs/ft)	36.403	lbs/ft
σ	Density of internal fluid (lb/ft^3)	62.4	lb/ft3
q	Load per unit length (lb/in)	9.02	lb/in
	Load per unit length (lb/ft)	**108.27**	**lb/ft**
Simple Beam Deflection Analysis			
	[illegible]		
d	**Deflection or sag (inches)**	[illegible]	[illegible]
f	Deflection Coefficient, Refer to Table 2	0.0026	
L	Span length (inches)	120	inch
q	Load per unity length (lb/in)	[illegible]	lb/ft
E_L	Apparent long-term modulus of elast[illegible]	[illegible]	psi
I	Moment of Inertia, $(pi/64)*(OD^4 - ID^4)$	[illegible]	in4
18" DR26 IPS with Restraint Every 10'			
	OD	[illegible]	[illegible]
	ID	[illegible]	[illegible]
	Weight (lb/ft)	[illegible]	[illegible]
Load per Unit Length			
	$q = W/12 + \pi\sigma(ID)^2/6912$		
W	Weight of pipe (lbs/ft)	16.286	lbs/ft
σ	Density of internal fluid (lb/ft^3)	62.4	lb/ft3
q	Load per unit length (lb/in)	9.11	lb/in
	Load per unit length (lb/ft)	**109.30**	**lb/ft**
Simple Beam Deflection Analysis			
	$d = fqL^4 / E_L I$		
d	**Deflection or sag (inches)**	**0.30**	**inch**
f	Deflection Coefficient, Refer to Table 2	0.0026	
L	Span length (inches)	120	inch
q	Load per unity length (lb/in)	109.30	lb/ft
E_L	Apparent long-term modulus of elasticity at average long-term temp	130000	psi
I	Moment of Inertia, $(pi/64)*(OD^4 - ID^4)$	1486.33	in4

TABLE B.2.1

Rate of Increasing Stress	Approximate Values of Apparent Modulus for 73°F (23°C)					
	For Materials Coded PE2XXX [1]		For Materials Coded PE3XXX [1]		For Materials Coded PE4XXX [1]	
	psi	MPa	psi	MPa	psi	MPa
"Short term" (Results Obtained Under Tensile Testing) [2]	100,000	690	125,000	862	130,000	896
"Dynamic" [3]	150,[illegible]psi (1,034 [illegible]) For All Designation Codes					

[illegible] Chapter 5 f[illegible] explanation of [illegible] PE [illegible] Designation Code. The X's designate any numeral that is [illegible] under this code.

(2) Under ASTM D638, "[illegible]tandard [illegible] Method for [illegible]nsile Properties of Plastics", a dog-bone shaped specimen is subjected to a [illegible] rate of p[illegible]. The "apparent [illegible]" under this method is the ratio of stress to strain that is achieved at a certain defined strain. This apparent modulus is of limited value for engineering design.

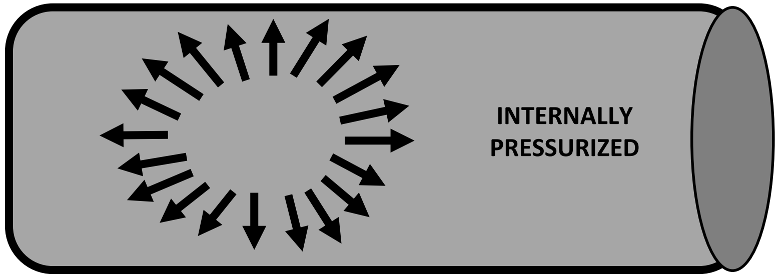
(3) The dynamic modulus is the ratio of stress to strain that occurs under instantaneous rate of increasing stress, such as can occur in a water-hammer reaction in a pipeline. This modulus is used as a parameter for the [illegible]puting of a localized [illegible] pressure that results from a water hammer event.

TABLE B.[illegible]2
[illegible] Compensating Multipliers for Determination of the Apparent Modulus of Elasti[illegible]y at Temperatures Other than at 73°F (23°C)
Equally Applicable to All Stress-Rated PE's
(e.g., All PE2xxx's, All PE3xxx's and All PE4xxx's)

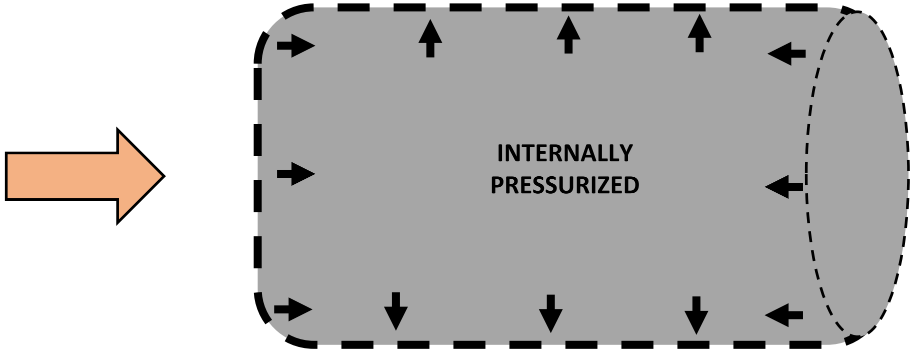
Maximum Sustained Temperature of the Pipe °F (°C)	Compensating Multiplier
-20 (-29)	2.54
-10 (-23)	2.36
0 (-18)	2.18
10 (-12)	2.00
20 (-7)	1.81
30 (-1)	1.65
40 (4)	1.49
50 (10)	1.32
60 (16)	1.18
73.4 (23)	1.00
80 (27)	0.93
90 (32)	0.82
100 (38)	0.73
110 (43)	0.64
120 (49)	0.58
130 (54)	0.50
140 (60)	0.43

18"-Deflection-FlowingFull | 18"-Deflection-Empty | 12"-Deflection-FlowingFull | 12"-Deflection-Empty | +

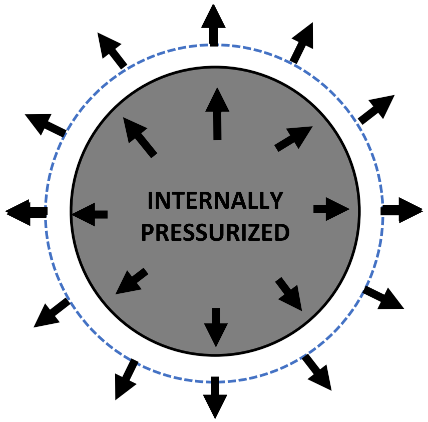
#4: Poisson’s Effect



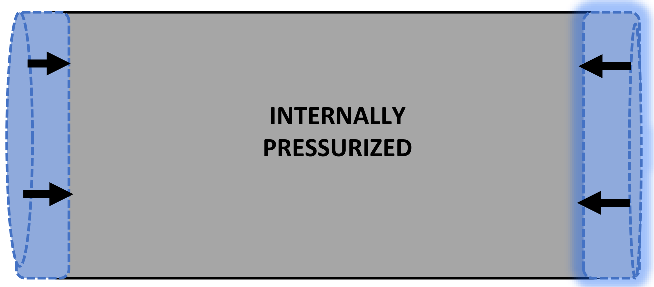
Pipe is pressurized



Pipe expands diametrically and contracts longitudinally



Expands diametrically



Contracts longitudinally

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#5: Restraint – MJ Adapter

Stout, heavy duty to fully restrain HDPE

HDPE naturally moves but force required is equally minimized

Does not require fully dry and sanitized conditions

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#6: Eliminate Unnecessary Fittings

Bend Radius

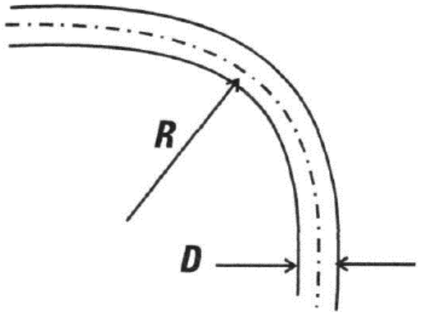
- Bend radius of PE pipe is limited by
  - Bending strain capacity
  - Resistance to kinking\

Longitudinal Wall Strain

  - Bend radius guidance limits longitudinal wall strain in the pipe to 2%
  - 2% longitudinal wall strain = bending ratio of 20

Kinking

- Longitudinal bending induces ovality
- Thicker wall pipes have higher kink resistance
- Minimum bend radius decreases as pipe increases thickness (and DR)



Pipe DR	Minimum Long-Term Bending Radius
≤ 9	20 x OD
11 – 13.5	25 x OD
17 - 21	27 x OD
26	34 x OD
32.5	42 x OD
Fitting or flange present in any bend	100 x OD

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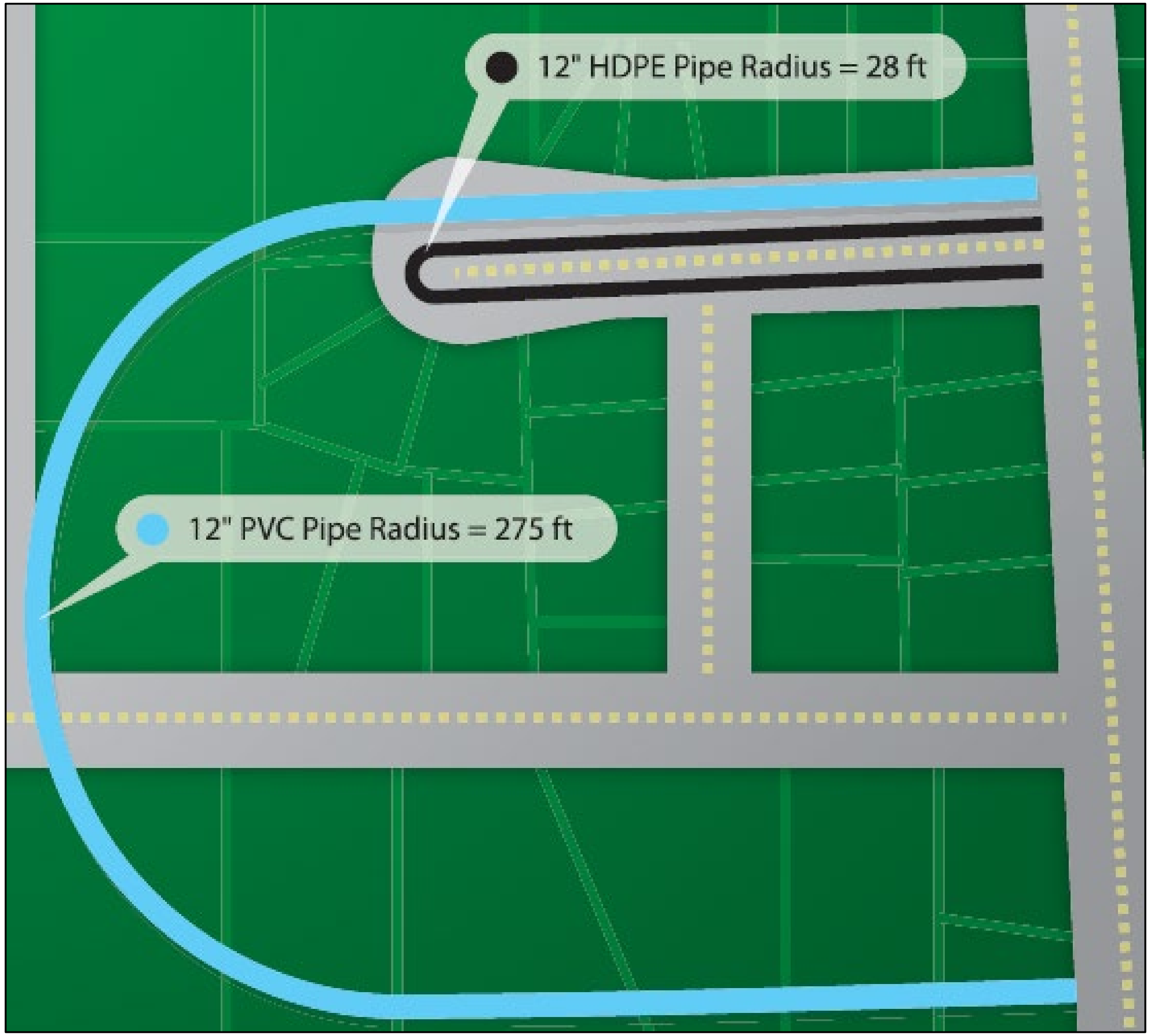
#6: Bend Radius



#1 – Irrigation

#1 – Irrigation: Advantages

Technical advantages of HDPE pipe

The methods briefly described above are used to install an HDPE golf irrigation system. Not included in those descriptions are the technical advantages in using HDPE pipe and fittings for golf irrigation applications. They include:

Pipe fatigue factor – When water surges take place within PVC pipe as sprinkler cycles turn on and off, the PVC pipe and fittings expand and contract ever so slightly. Due to the chemical composition of PVC, the material is weakened over time. With HDPE pipe, however, it contracts to its original size without weakening. For this reason, AWWA "derates" PVC pipe, stating that over time, the pressure the pipe can handle is reduced from its originally manufactured pressure rating. There is no such derating for HDPE pipe. The lifespan of PVC pipe is 25 to 30 years; HDPE pipe's is more than 50 years.

Flexibility – According to manufacturers' recommendations, larger diameter PVC pipe cannot be deflected (bent) more than 5 degrees. HDPE pipe has a bend radius of 25 times the diameter of the pipe with no detrimental effect to the pipe. This eliminates many of the fittings and thrust blocks required for PVC pipe installation, which in turn, reduces the number of potential main line breaks.

Leakage – Even the best installed PVC irrigation systems experience leakage at fitting and valve locations. With the butt-fusion technique for HDPE fittings and valves, the pipe and fittings become one monolithic unit, which eliminates leaky joints. This saves water and electrical costs as it eliminates pump cycling to maintain pressurization. Environmentally, as more courses choose to use effluent water for irrigation, less leakage means less worry about environmental breaches.

Freeze breaks – In colder climates, golf course personnel must drain as much water as possible from PVC pipe systems before winter to avoid the freezing and breaking of the irrigation system. HDPE pipe can be frozen solid and not break, although draining the irrigation system before winter is still recommended. Worry about breakage is eliminated with an HDPE system.

Going green – Most professionals in the golf industry are concerned about environmental issues – from the materials used to build the golf course to the inputs used to maintain them. The EPA has expressed concerns about PVC at various seminars and would like to see it disappear from the irrigation industry. HDPE pipe is 100 percent recyclable. GCI

ALLIANCE FOR pepipe

#1 – Irrigation: Ease of Installation

The life expectancy of pressurized PVC is roughly 15 years according to the Golf Course Builders Association of America.

#1 – Irrigation: Smaller Projects

Small/Turf/Golf Irrigation

- Landscaping installations
- Turf irrigation projects
- Crop/cattle irrigation
- Golf Courses (new and rehab)*

*replacing older pipes (AC, pvc, etc)

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#1 – Irrigation: Larger Projects

- Using HDPE helps prevent water loss due to evaporation and seepage in open canals
- Drought relief projects
- Used for salinity control projects

#1 – Irrigation: Larger Projects

- Corrosion resistant, flexibility, diameters, fused joints
- Zero leaks / Prevent Water Loss
- Faster installation & longer life

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#1 – Irrigation: Center Pivot

HDPE used on all new main lines for center pivots

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#2 – Mining

The most common use for pipe in the aggregate and mining industries is water management.

The design, construction, operation and maintenance rely on pipe systems that are rustproof, break-resistant, corrosion-free, and environmentally friendly.

From dewatering to tailings from the mill, pumps and pipework play a vital and integral part to keep fluids moving.

ALLIANCE FOR pepipe

#2 – Mining: Slurry

THE CHALLENGE

K+S Potash Canada (KSPC) recently opened a new greenfield potash mine in Bethune, Saskatchewan, CA with a projected production capacity of 2 million tons of potash. This site pumps and pipes highly abrasive materials including slurry and salt slurry as well as process water across miles of pristine territory. Wear resistance and the ability to design a custom solution led K+S to choose ISCO.

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#2 – Mining: Transmission

Above Ground

#2 – Mining: Transmission

Underground

#3 – Industrial: Applications

- Acid/Caustic Lines
- Organic Chemicals/Inorganic Chemicals
- Hazardous Waste
- Wastewater
- Process Water / Cooling Water
- Acid bath
- Barge loading
- unloading / Tank storage
- Dual Containment Piping Systems
- Aeration
- Liquor, bleaching, and caustic acid lines
- Pipe rehabilitation in both plant and out of plant piping
- Dredge piping
- Pit dewatering
- Fertilizer
- Power Plants, fresh water and discharge. Spent fuel slurry (fly ash and bottom ash)
- Semi Conductor

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#3 – Industrial: Acid & Chemical Lines

<u>Example - Acid/Chemical lines:</u>

- What makes HDPE a premier option?
  - Less expensive than GRP, stainless and other alloys
  - Less fragile & more durable than GRP
  - Fusion welded joints
  - Seismic advantages and flexibility in field
  - Dual containment options
- Check corrosion resistant (use PPI TR-19)

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#3 – Industrial

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#3 – Industrial: Cooling Water

Until recently, process cooling applications carrying cooling liquids have been dominated by three primary materials: polyvinyl chloride (PVC), type 304 or type 316 stainless steel, and carbon steel.1 Each of these materials offers specific advantages with regard to cost, corrosion resistance, strength or reduced long-term maintenance requirements; however, none of these materials possesses all of these benefits simultaneously.

HDPE Replaces Carbon Steel in Safety-Related Pipe System

Corrosion of steel water pipes in the safety-related piping systems of aging U.S. nuclear power plants is fast becoming a safety concern and a significant operational cost, not to mention an indication of potential future liability for nuclear utilities currently constructing new plants or retrofitting existing sites. According to the Electric Power Research Institute, the physical maintenance of degraded steel water pipe systems, combined with the operational costs of shutting a plant down during repairs, is already costing some nuclear utilities up to $25 million per year.

The problem is particularly sensitive when the water pipe systems in question are safety-related, such as the essential service water (ESW) systems that stand ready to cool a reactor when needed. In these systems, water-cooled secondary heat exchangers are used to maintain public safety and power generation continuity. Lost revenue from a system shutdown, which is likely when an ESW system fails, can be more than $1 million per day for a utility due to the expense of purchasing electricity on the open market to replace what was being generated by the plant.

Carbon steel pipe is the incumbent medium for transporting water to heat exchangers in ESW systems, but alternatives are being explored

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#3 – Industrial: Process Water

"Frack" water transfer. Alternative to trucking or reinjecting process water. Transfer it to another well and use it again.

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#4: Bridge Crossings or Piers

Keep pipe bending stress within limits

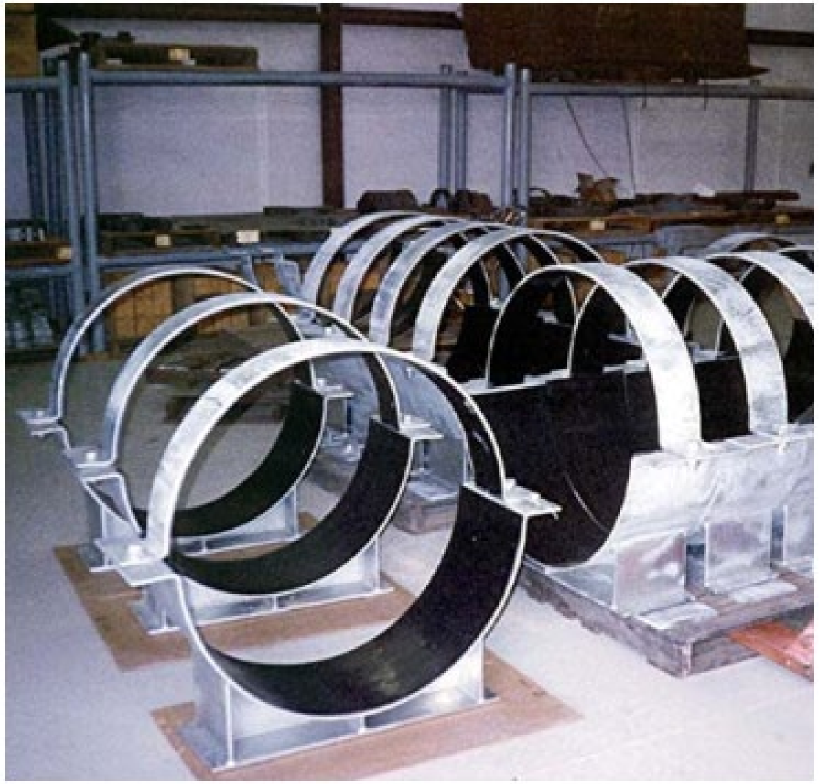
Limit deflection, if necessary

- Appearance
- Avoiding pockets or sumps
- Avoid interference with other pipes

Support spacing design

Anchor and support design

#4: Bridge Crossings or Piers



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#4: Anchor and Support Design

- Pipe support design varies and can help minimize deflections due to thermal or support spacing
- Cradle support should be ½-one pipe diameter and support 120° of pipe diameter
- Supports should have no sharp edges or burrs
- Heavy fittings or flanges should be supported for one full pipe OD on either side

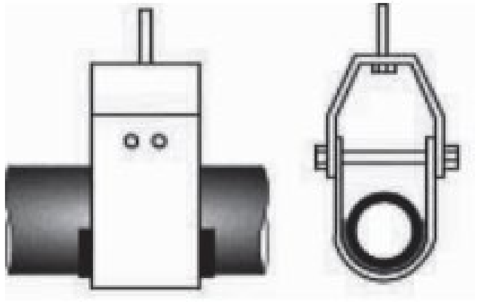

Figure 8.1 Pipe Stirrup Support

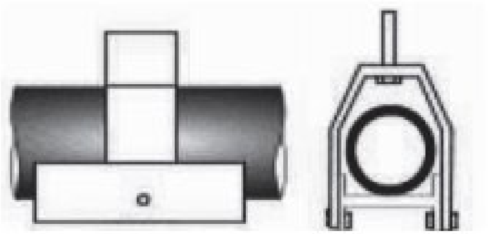

Figure 8.3 Suspended I-Beam or Channel-Continuous Support

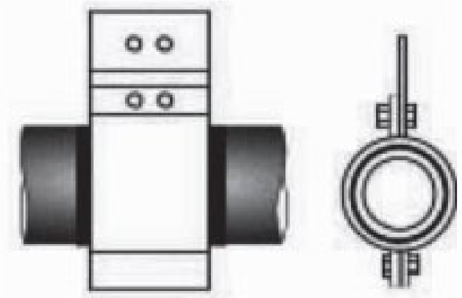

Figure 8.2 Clam Shell Support

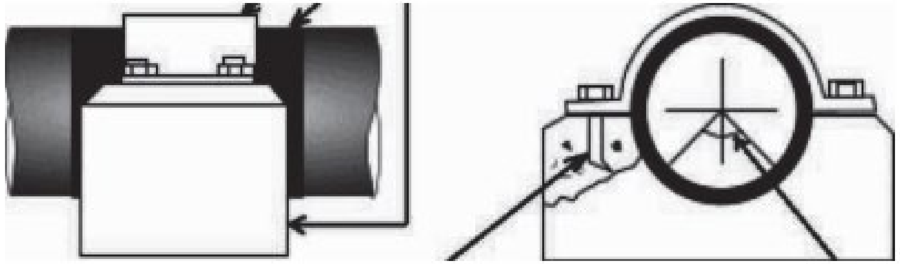

Figure 9 Typical Anchoring and Cradling Details

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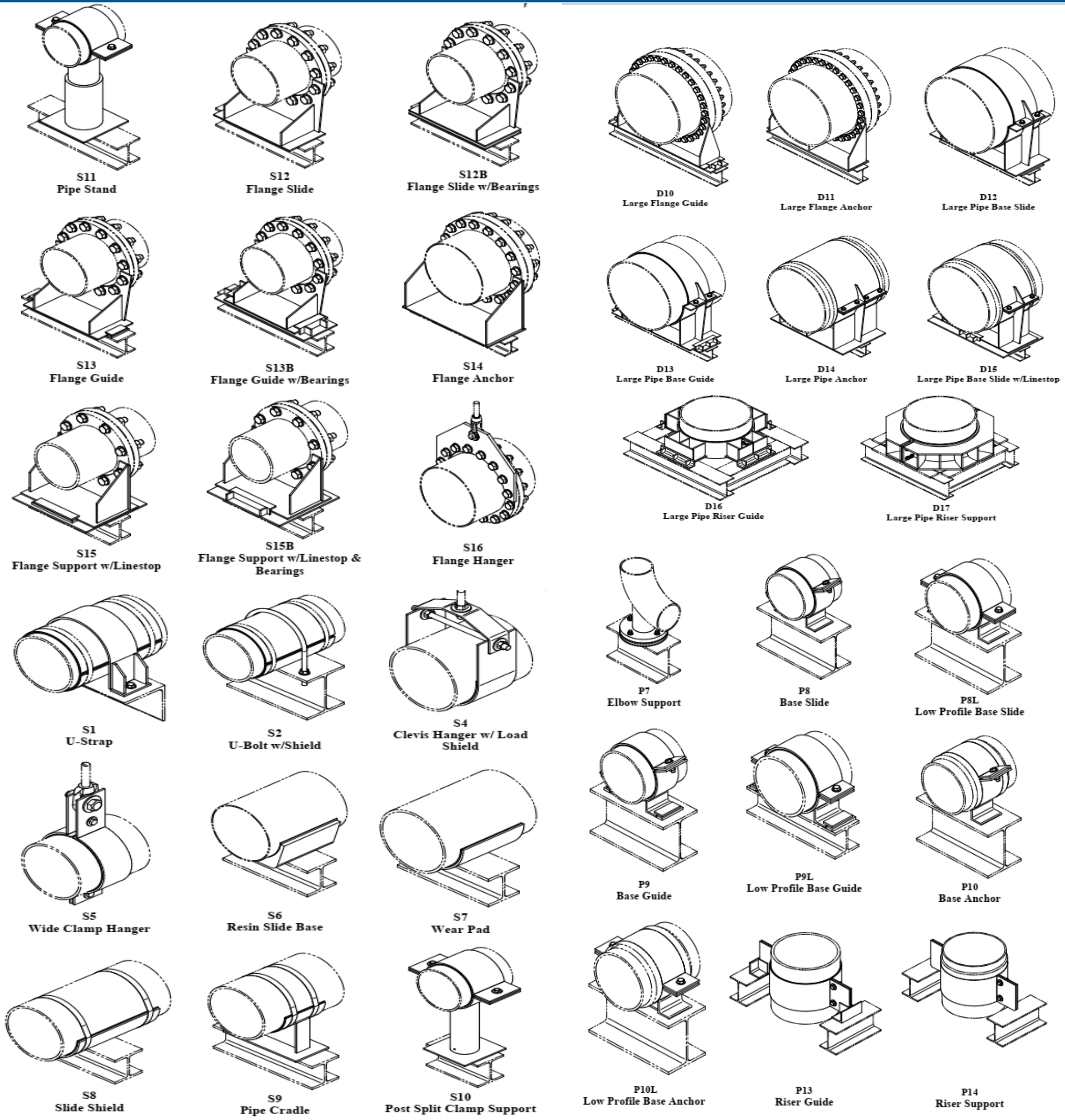
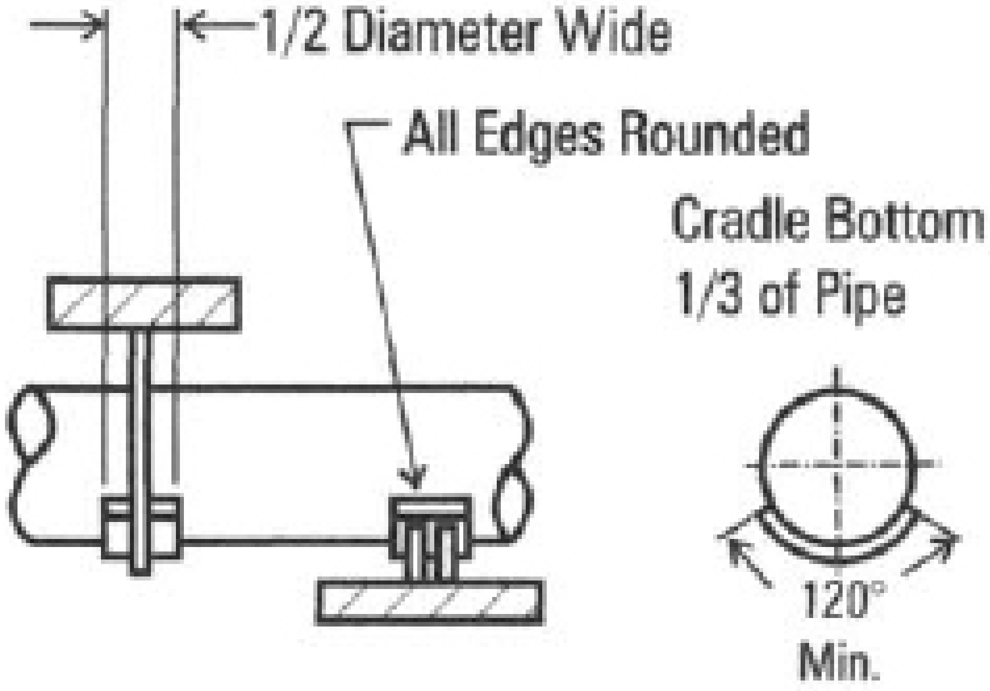
#4: Anchor and Support Design - Specialty





#5: Environmentally Sensitive Areas

San Lorenzo Valley
WATER DISTRICT

Terrain and minimized environmental impact pushed HDPE

Fire provided worse case operating scenario

Elected to replace infrastructure with HDPE & made same decision twice

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#6: Outfalls, Intakes, & Dredging

Dewatering / Dredge lines:

- Lake, Marina, Power Plant, Channels, Lagoons, Ponds, Rivers, Golf, Mines etc.
- What makes HDPE a premier option?
  - UV resistance
  - Durability & Flexability
  - Fusion welded joints
  - Seismic advantages and flexibility in field
  - Dual containment options
  - Use of pipe multiple times

- Check corrosion resistant (use PPI TR-19)

Chemical resistance, types of chemical attack on plastics, chemical resistance data table Chemical Resistance of Plastic Piping Materials (plasticpipe.org)

#6: Outfalls, Intakes, & Dredging

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#7: Temporary Water, Wastewater & Bypass

Temporary water and wastewater service during construction

Temporary bypass requires protection

Potable water requires disinfection

Gravity sewer requires submersible pump

#7: Temporary Water, Wastewater & Bypass

Potable Water

Connections require disinfection

2" HDPE service line can be re-used

Ductility and resiliency of material allows for repeated use for temporary bypass

Protect temporary bypass in place

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#7: Temporary Water, Wastewater & Bypass

Wastewater Water

Wastewater bypass pumping can be more complicated than rehabilitation design

Creative temporary pipeline locations can be productive and protective

Entrapped air still requires elimination

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#7: City of Baltimore Case Study

Rehabilitation of 4,690LF of 78-in PCCP using CIPP and CFRP

Required clean and dry environment

*Main bypass capacity of **156 mgd****

Eight lines, 45,000 LF of 24-inch HDPE

Three 24-in and two 18-inch fusion machines

16 Bypass pumping units

Low pressure bypass ~ 20 psi

**** 150 mgd services about 250,000 people***

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#7: City of Baltimore Case Study