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Ductile Iron Pipe
Research Association

# What's New with DI Pipe?

March 30, 2023

Environmental
OTCO
Since 1964
Training Center

# DIPRA Member Companies

- AMERICAN Ductile Iron Pipe
  Birmingham, AL
- Canada Pipe Company, LTD.
  Hamilton, Ontario
- McWane Ductile
  Coshocton, OH
- United States Pipe and
  Foundry Company
  Birmingham, AL

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# Ductile Iron Pipe

**Strength** and **Durability** for **Life**

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DUCTILE IRON PIPE

# Strength and Durability for LiFe®

From its inception more than 100 years ago, DIPRA has provided accurate, reliable, and essential engineering information about cast iron — and now Ductile iron — pipe to a wide variety of utilities and consulting engineers.

Resources

Ask an Enginee

## How Can We Help You?

ABOUT DIPRA | CALCULATORS | ABOUT DUCTILE IRON PIPE | DIPRA E-NEWSLETTERS

TECHNICAL RESOURCES | NEWS | ASK AN EXPERT | ADVOCACY

C104/A21.4

Cement-Mortar Linings

C105/A21.5

Polyethylene Encasement

C110/A21.10

Ductile-Iron and Gray-Iron Fittings

C111/A21.11

Rubber-Gasket Joints

C115/A21.15

Flanged Ductile-Iron Pipe

C116/A21.16

Fusion-Bonded Coatings for Fittings

C150/A21.50

Thickness Design

C151/A21.51

Ductile-Iron Pipe, Centrifugally Cast

C153/A21.53

Ductile-Iron Compact Fittings

C600

Installation of Ductile-Iron Water Mains

# Learning Objectives

- History
- Manufacture, Features and Design
- Installation & HDD
- Sustainability
- Corrosion Control - V-Bio Polyethylene & Design Decision Model (DDM)

# Versailles, France

**(Installed 1664)**

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# Century Club

- The Cast Iron Pipe Century Club recognizes water utilities with Cast Iron mains that have provided service for 100 years or more.  583 in US and Canada

# BURIED NO LONGER:

## Confronting America's Water Infrastructure Challenge

American Water Works Association

The Authoritative Resource on Safe Water®

www.awwa.org/infrastructure

# Buried No Longer

## Average DI life (LSL) – 110 years

LSL = Relatively Long Service Life

Figure 5, p. 8

# To Achieve a Century of Service from your DI Pipe…

- Design
- Installation
- Corrosion Control
- O & M

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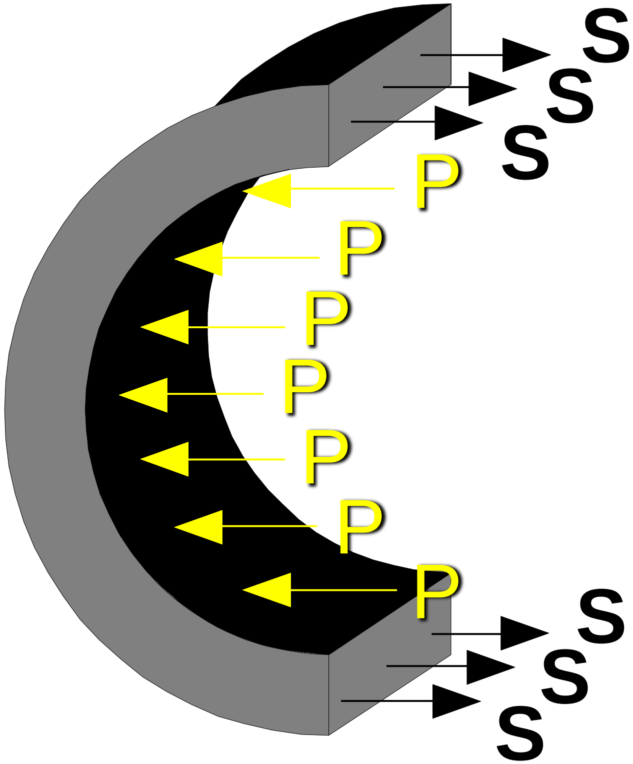
# Thickness Design
# of
# Ductile Iron Pipe

## (From ANSI/AWWA C150/A21.50)

# Internal Pressure




$$t = \frac{P_i D}{2S}$$

$t$ = Wall Thickness (in.)

$P_i$ = Design Pressure (psi)

= $2 ( P_w + P_s )$

$P_w$ = Working Pressure (psi)

$P_s$ = Surge Pressure (psi)

= 100 psi

$D$ = Outside Diameter (in.)

$S$ = Hoop Stress

= 42,000 psi (min.)

# Pipe Wall Thickness

**ANSI/AWWA C150/A21.50**

12-inch Pressure Class 350

Design Pressure = 2(350 + 100) = 900 psi

**INTERNAL PRESSURE DESIGN**

**0.14"**

**SERVICE ALLOWANCE**

**0.08"**

**CASTING TOLERANCE**

**0.06"**

**TOTAL THICKNESS** **0.28"**

# Nominal Thicknesses for Standard Pressure Classes of DIP
## (From Table 5 of ANSI/AWWA C150/A21.50)

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| Pipe Size (in.) | Outside Diameter (in.) | Pressure Class | | | | |
|---|---|---|---|---|---|---|
| | | 150 | 200 | 250 | 300 | 350 |
| | | Nominal Thickness (in.) | | | | |
| 3 | 3.96 | -- | -- | -- | -- | 0.25* |
| 4 | 4.80 | -- | -- | -- | -- | 0.25* |
| 6 | 6.90 | -- | -- | -- | -- | 0.25* |
| 8 | 9.05 | -- | -- | -- | -- | 0.25* |
| 10 | 11.10 | -- | -- | -- | -- | 0.26 |
| 12 | 13.20 | -- | -- | -- | -- | 0.28 |
| 14 | 15.30 | -- | -- | 0.28 | 0.30 | 0.31 |
| 16 | 17.40 | -- | -- | 0.30 | 0.32 | 0.34 |
| 18 | 19.50 | -- | -- | 0.31 | 0.34 | 0.36 |
| 20 | 21.60 | -- | -- | 0.33 | 0.36 | 0.38 |
| 24 | 25.80 | -- | 0.33 | 0.37 | 0.40 | 0.43 |
| 30 | 32.00 | 0.34 | 0.38 | 0.42 | 0.45 | 0.49 |
| 36 | 38.30 | 0.38 | 0.42 | 0.47 | 0.51 | 0.56 |
| 42 | 44.50 | 0.41 | 0.47 | 0.52 | 0.57 | 0.63 |
| 48 | 50.80 | 0.46 | 0.52 | 0.58 | 0.64 | 0.70 |
| 54 | 57.56 | 0.51 | 0.58 | 0.65 | 0.72 | 0.79 |
| 60 | 61.61 | 0.54 | 0.61 | 0.68 | 0.76 | 0.83 |
| 64 | 65.67 | 0.56 | 0.64 | 0.72 | 0.80 | 0.87 |

* Calculated thicknesses for these sizes & pressure classes are less than those shown above. Presently, these are the lowest nominal thicknesses available in these sizes.

# From Table 15 of ANSI A21.50
# Special Thickness Classes of Ductile Iron Pipe

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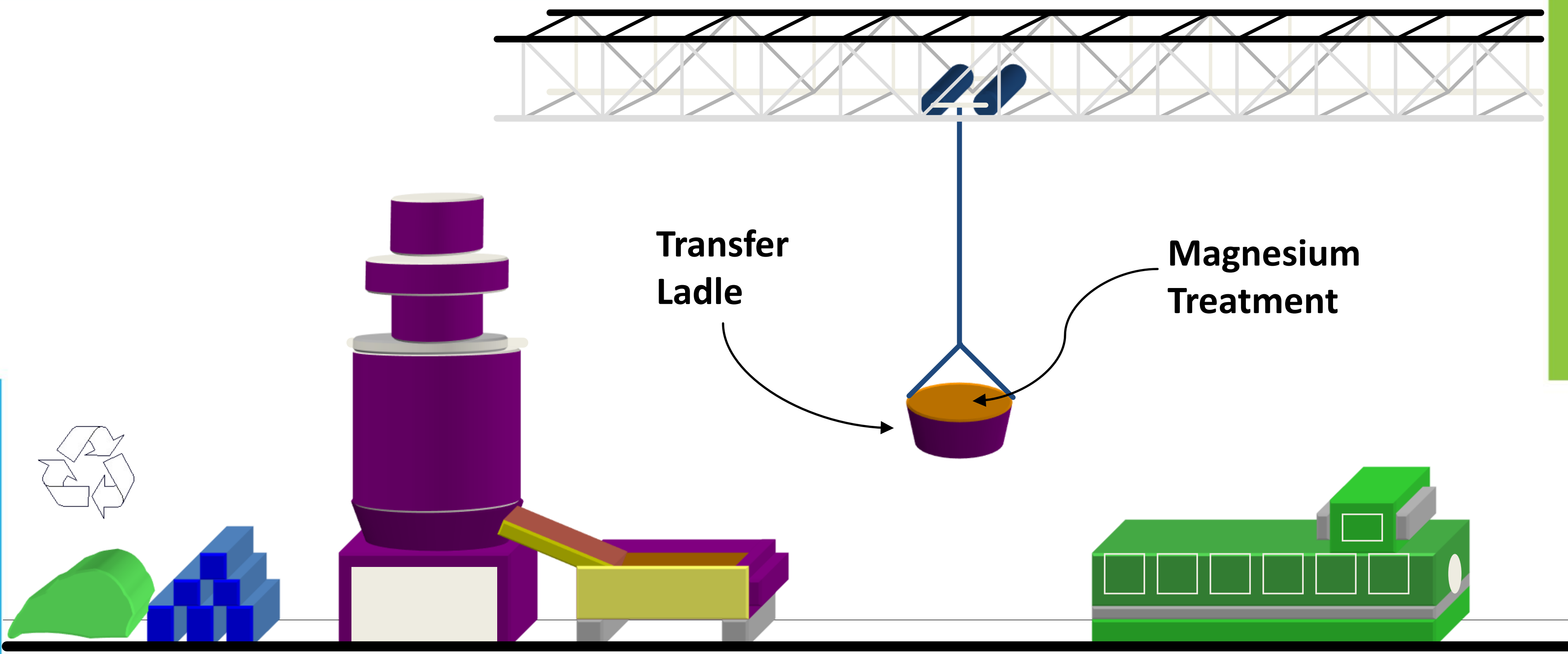
| Pipe Size in. | Outside Diameter in. | Thickness Class | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
| | | Thickness - in. | | | | | | |
| 3 | 3.96 | - - | 0.25 | 0.28 | 0.31 | 0.34 | 0.37 | 0.40 |
| 4 | 4.80 | - - | 0.26 | 0.29 | 0.32 | 0.35 | 0.38 | 0.41 |
| 6 | 6.90 | 0.25 | 0.28 | 0.31 | 0.34 | 0.37 | 0.40 | 0.43 |
| 8 | 9.05 | 0.27 | 0.30 | 0.33 | 0.36 | 0.39 | 0.42 | 0.45 |
| 10 | 11.10 | 0.29 | 0.32 | 0.35 | 0.38 | 0.41 | 0.44 | 0.47 |
| 12 | 13.20 | 0.31 | 0.34 | 0.37 | 0.40 | 0.43 | 0.46 | 0.49 |
| 14 | 15.30 | 0.33 | 0.36 | 0.39 | 0.42 | 0.45 | 0.48 | 0.51 |
| 16 | 17.40 | 0.34 | 0.37 | 0.40 | 0.43 | 0.46 | 0.49 | 0.52 |
| 18 | 19.50 | 0.35 | 0.38 | 0.41 | 0.44 | 0.47 | 0.50 | 0.53 |
| 20 | 21.60 | 0.36 | 0.39 | 0.42 | 0.45 | 0.48 | 0.51 | 0.54 |
| 24 | 25.80 | 0.38 | 0.41 | 0.44 | 0.47 | 0.50 | 0.53 | 0.56 |
| 30 | 32.00 | 0.39 | 0.43 | 0.47 | 0.51 | 0.55 | 0.59 | 0.63 |
| 36 | 38.30 | 0.43 | 0.48 | 0.53 | 0.58 | 0.63 | 0.68 | 0.73 |
| 42 | 44.50 | 0.47 | 0.53 | 0.59 | 0.65 | 0.71 | 0.77 | 0.83 |
| 48 | 50.80 | 0.51 | 0.58 | 0.65 | 0.72 | 0.79 | 0.86 | 0.93 |
| 54 | 57.56 | 0.57 | 0.65 | 0.73 | 0.81 | 0.89 | 0.97 | 1.05 |

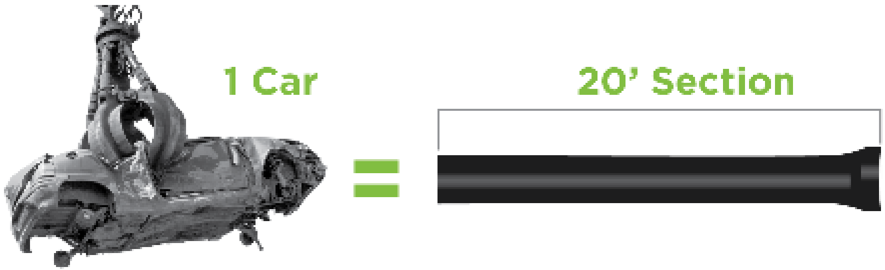
# Manufacturing



# Casting Machine

# Manufacturing

# Sustainable Infrastructure




One standard length of 24-inch Ductile Iron Pipe can contain up to one recycled car's worth of Iron.

- Ductile Iron Pipe
  - Up to 95% recycled content
  - One standard length of Ductile Iron Pipe can contain up to one recycled car's worth of Iron
  - 100% recyclable

# Magnesium Treatment

- Iron:

  Molten at 2,500° F

- Magnesium:

  Vaporizes at 2,050° F

# Photomicrographs

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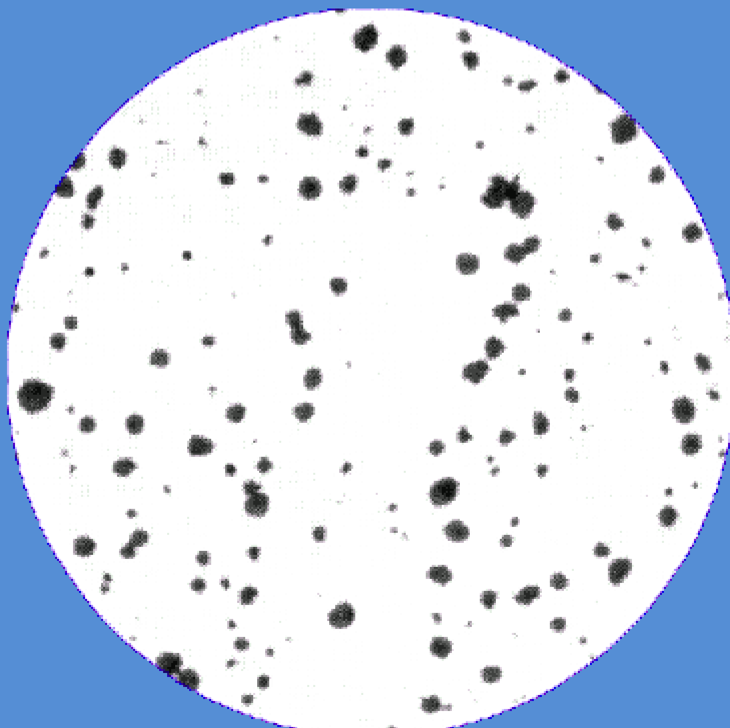
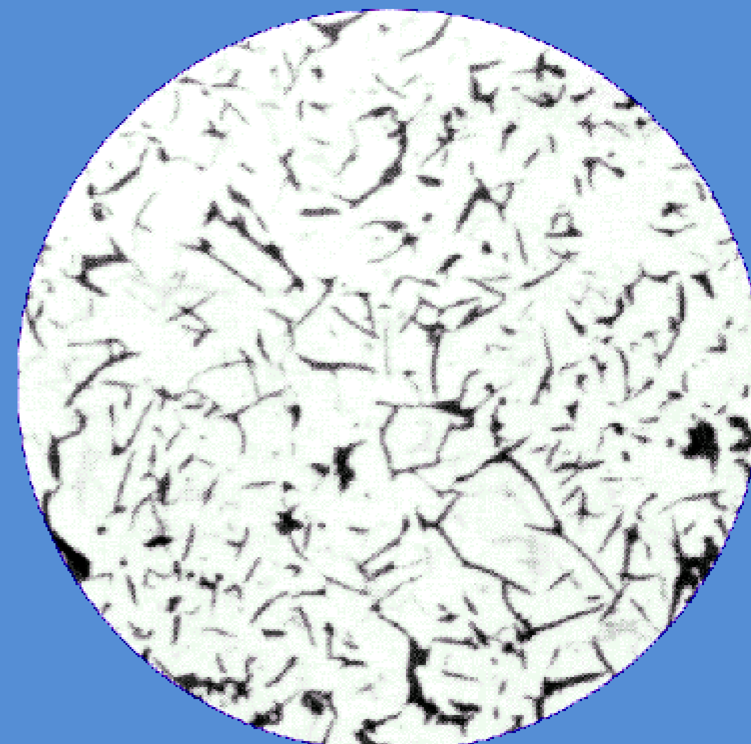
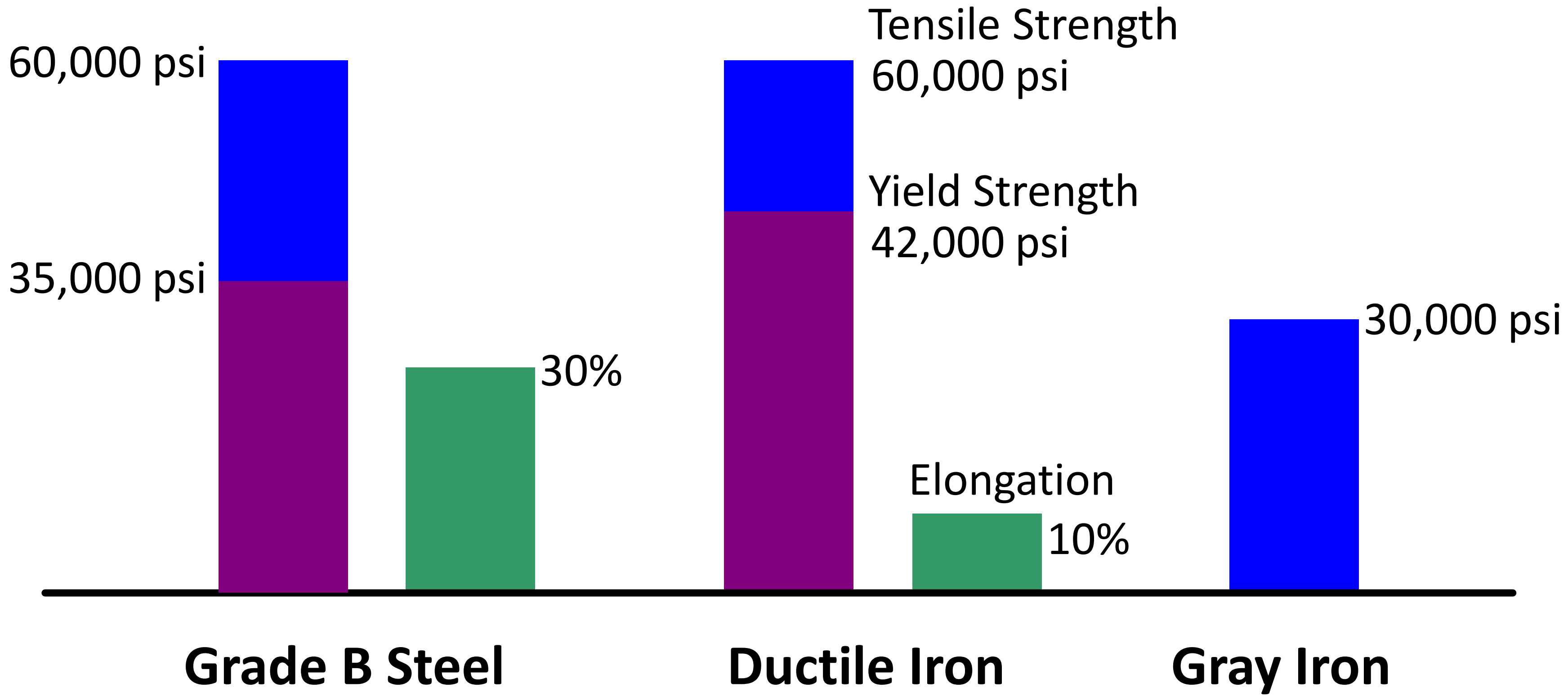


Ductile Iron



Gray Iron

# Comparative Strength
## (Minimum Standard Values)



# Ductile Iron Pipe

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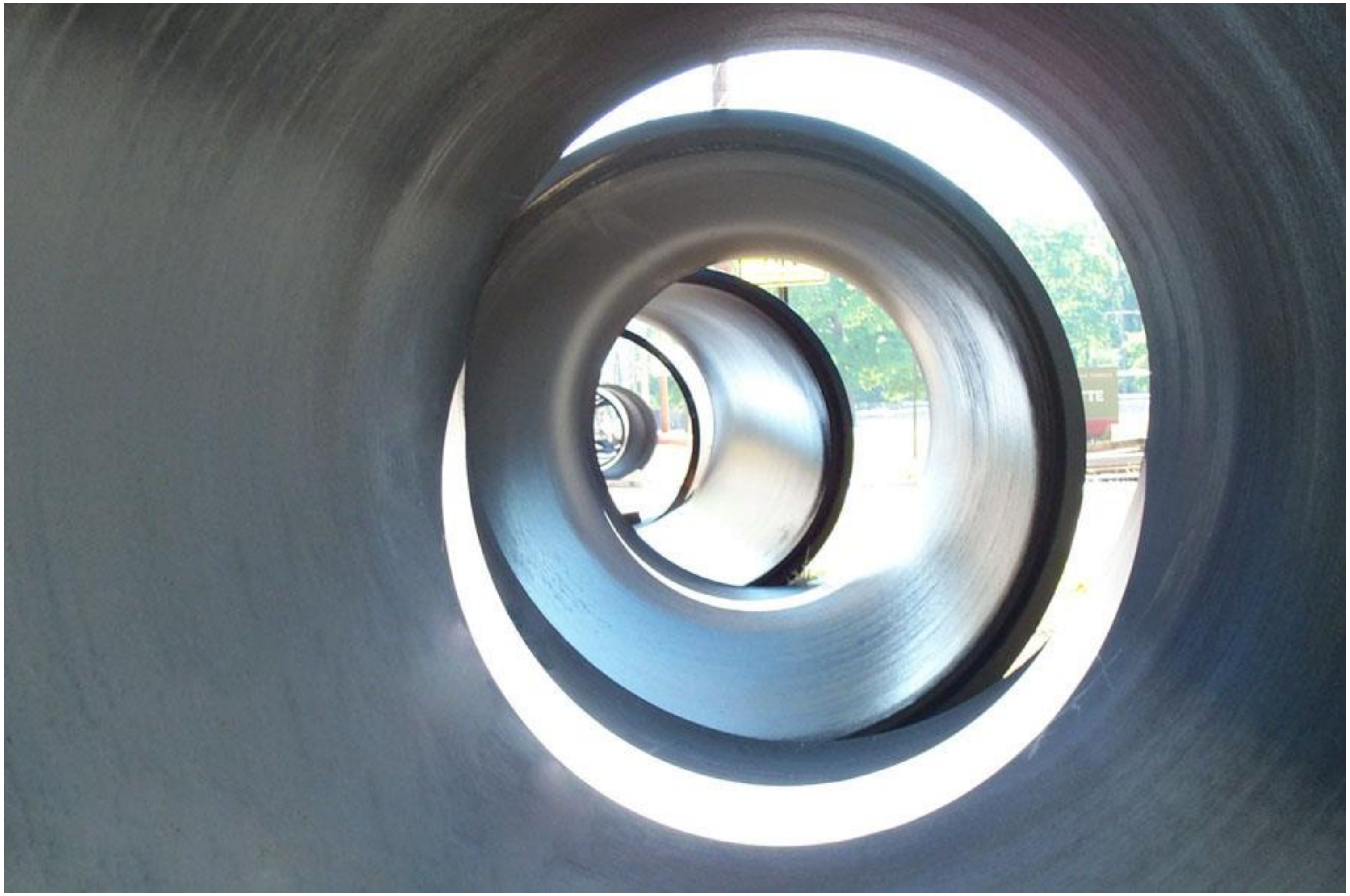
| | |
|---|---|
| Diameters: | 3- to 64-inch |
| Rated Working Pressures: | up to 350 psi* |
| Lengths: | 18 to 20 feet |

* Ductile iron pipe is available for higher working pressures; check with the pipe manufacturer.

# Cement Mortar Lining

# Cement Mortar Lining



# Cement Mortar Lining



# Cement Mortar Lining

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## Conclusion

Cement-mortar-lined Ductile Iron pipe has a service record unequalled in the water works industry. Since first field-applied to Gray Iron pipe in 1922, cement-mortar lining has undergone numerous manufacturing improvements.

Today, cement-mortar lining is applied either by the centrifugal process or the projection method, thus maintaining excellent quality control of the cement-mortar and lining operation. The linings produced by these methods are dense, smooth, and offer very little frictional resistance to the flow of water.

Cement-mortar-lined Ductile Iron pipe provides a Hazen-Williams flow coefficient, or "C" value, of 140 — a realistic value that is maintained over the life of the pipe. This standard lining, which is furnished in accordance with ANSI/AWWA C104/A21.4, continues its tradition of dependable, trouble-free service.

## References


[1] Helton, B., "Cracks and Looseness in Cement Linings of Cast Iron and Ductile Iron Pipe and Fittings," unpublished.
[2] Wagner, E.F., "Autogenous Healing of Cracks in Cement-Mortar Linings for Gray-Iron and Ductile-Iron Water Pipe," *Journal AWWA*, June 1974.
[3] Kennedy, Jr., H., "The New Ductile Iron Pipe Standards," *Journal AWWA*, November 1976.


## Table 1

**Flow Tests of Cement-mortar-lined Gray and Ductile Iron Pipe**

| Location | Size Inches | Length Feet | Age Years | Hazen-Williams C |
|---|---|---|---|---|
| Alma, MO | 6 | 23,800 | 1 | 137 |
| Birmingham, AL | 6 | 473 | new | 147 |
| Bowling Green, OH | 20 | 45,600 | 1 | 143 |
| Casper, WY | 12 | 500 | new | 141 |
| Charleston, SC | 6 | 300 | new | 145 |
| Chicago, IL | 36 | 7,200 | 1 | 147 |
| Cleveland, TN | 20 | 31,400 | 2 | 144 |
| Colorado Springs, CO | 20 | 7,000 | 3 | 137 |
| Concord, NH | 14 | 500 | new | 151 |
| Copperas Cove, TX | 8 | 28,100 | 1 | 144 |
| Corder, MO | 8 | 21,400 | 1 | 145 |
| Corpus Christi, TX | 36 | 74,000 | new | 145 |
| Fitchburg, MA | 20 | 500 | 1 | 142 |
| Gary, IN | 20 | 8,000 | 1 | 140 |
| Greensboro, NC | 30 | 848 | 3 | 148 |
| Hartford, CT | 16 | 800 | 1 | 149 |
| New Orleans, LA | 12 | 37,300 | 1 | 141 |
| Newton, IA | 20 | 27,300 | 1 | 144 |
| Safford, AZ | 10 | 23,200 | 2 | 145 |
| Simpsonville, SC | 16 | 27,700 | 1 | 137 |
| St. Louis, MO | 30 | 17,700 | new | 151 |
| Univ. of Illinois | 6 | 400 | new | 151 |
| Green Bay, WI | 16 | 1,149 | 1 | 138 |

## Table 2

**Flow Tests of Cement-mortar-lined Gray and Ductile Iron Pipe After Extended Periods of Service**

| Location | Size Inches | Length Feet | Age Years | Hazen-Williams C |
|---|---|---|---|---|
| Baltimore, MD | 12 | 909 | 18 | 136 |
| Birmingham, AL | 6 | 473 | 6 | 141 |
| | 6 | 473 | 14 | 138 |
| | 6 | 473 | 17 | 133 |
| Catskill, NY | 16 | 30,825 | 25 | 136 |
| Champaign, IL | 16 | 3,920 | 12 | 137 |
| | 16 | 3,920 | 22 | 139 |
| | 16 | 3,920 | 28 | 145 |
| | 16 | 3,920 | 36 | 130 |
| Charleston, SC | 6 | 300 | 12 | 146 |
| | 6 | 300 | 16 | 143 |
| | 8 | 300 | 51 | 131 |
| | 8 | 300 | 59 | 130 |
| | 8 | 300 | 77 | 130 |
| | 12 | 500 | 15 | 145 |
| | 12 | 500 | 25 | 136 |
| Chicago, IL | 36 | 7,200 | 12 | 151 |
| Concord, NH | 12 | 500 | 13 | 143 |
| | 12 | 500 | 29 | 140 |
| | 12 | 500 | 36 | 140 |
| Danvers, MA | 20 | 500 | 31 | 135 |
| | 20 | 500 | 38 | 133 |
| Greenville, SC | 30 | 87,400 | 13 | 148 |
| | 30 | 87,400 | 20 | 146 |
| | 30 | 50,700 | 19 | 148 |
| | 30 | 50,700 | 25 | 146 |
| Greenville, TN | 12 | 500 | 13 | 134 |
| | 12 | 500 | 29 | 137 |
| | 12 | 500 | 36 | 146 |
| Knoxville, TN | 10 | 500 | 16 | 134 |
| | 10 | 500 | 32 | 135 |
| | 10 | 500 | 39 | 138 |
| Manchester, NH | 12 | 550 | 5 | 142 |
| | 12 | 550 | 21 | 135 |
| | 12 | 1,955 | 45 | 133 |
| Memphis, TN | 10 | 1,070 | 31 | 135 |
| Orange, CA | 6 | 1,004 | 26 | 140 |
| Safford, AZ | 10 | 23,200 | 16 | 144 |
| S. Burlington, VT | 24 | 1,373 | 8 | 138 |
| Seattle, WA | 8 | 2,686 | 29 | 139 |
| Tempe, AZ | 6 | 1,235 | 24 | 144 |
| Tacoma, WA | 8 | 2,257 | 16 | 136 |
| Wister, OK | 18 | 3,344 | 30 | 139 |

# DIPRA Flow Tests
# Hazen-Williams Coefficient – C-Factor

Figure 4: Plot of C-Factor Results

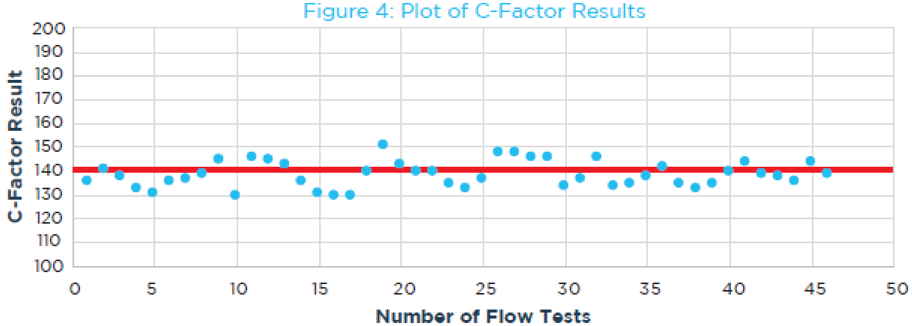
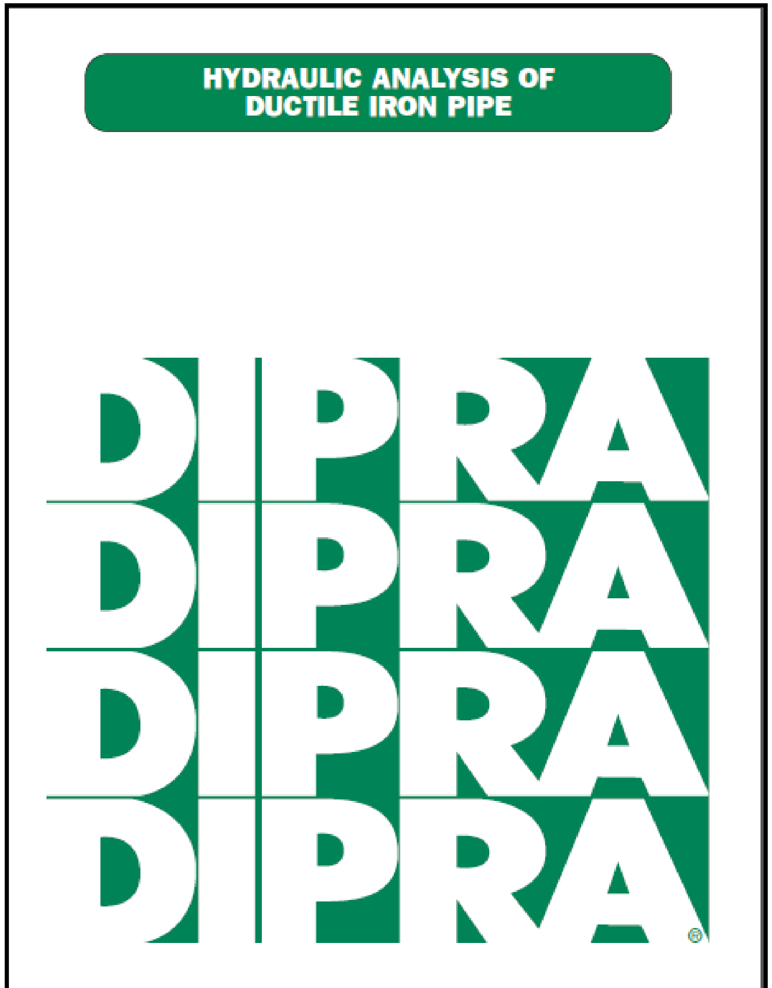



*Figure 4: Flow test results from Table 2 – the basis for C of 140 for Cement-Mortar Lined Ductile Iron Pipe.*

| Location | Size (Inches) | Length (Feet) | Age (Years) | Hazen-Williams C |
|---|---|---|---|---|
| Baltimore, MD | 12 | 909 | 18 | 136 |
| Birmingham, AL | 6 | 473 | 6 | 141 |
| | 6 | 473 | 14 | 138 |
| | 6 | 473 | 17 | 133 |
| Blackwood, NJ | 12 | 1546 | 11 | 131 |
| Catskill, NY | 16 | 30,825 | 25 | 136 |
| Champaign, IL | 16 | 3,920 | 12 | 137 |
| | 16 | 3,920 | 22 | 139 |
| | 16 | 3,920 | 28 | 145 |
| | 16 | 3,920 | 36 | 130 |
| Charleston, SC | 6 | 300 | 12 | 146 |
| | 6 | 300 | 16 | 143 |
| | 8 | 300 | 51 | 131 |
| | 8 | 300 | 59 | 130 |
| | 8 | 300 | 77 | 130 |
| | 8 | 300 | 97 | 140 |
| | 12 | 500 | 15 | 145 |
| | 12 | 500 | 25 | 136 |
| Chicago, IL | 36 | 7,200 | 12 | 151 |
| Concord, NH | 12 | 500 | 13 | 143 |
| | 12 | 500 | 29 | 140 |
| | 12 | 500 | 36 | 140 |

# Hydraulic Analysis



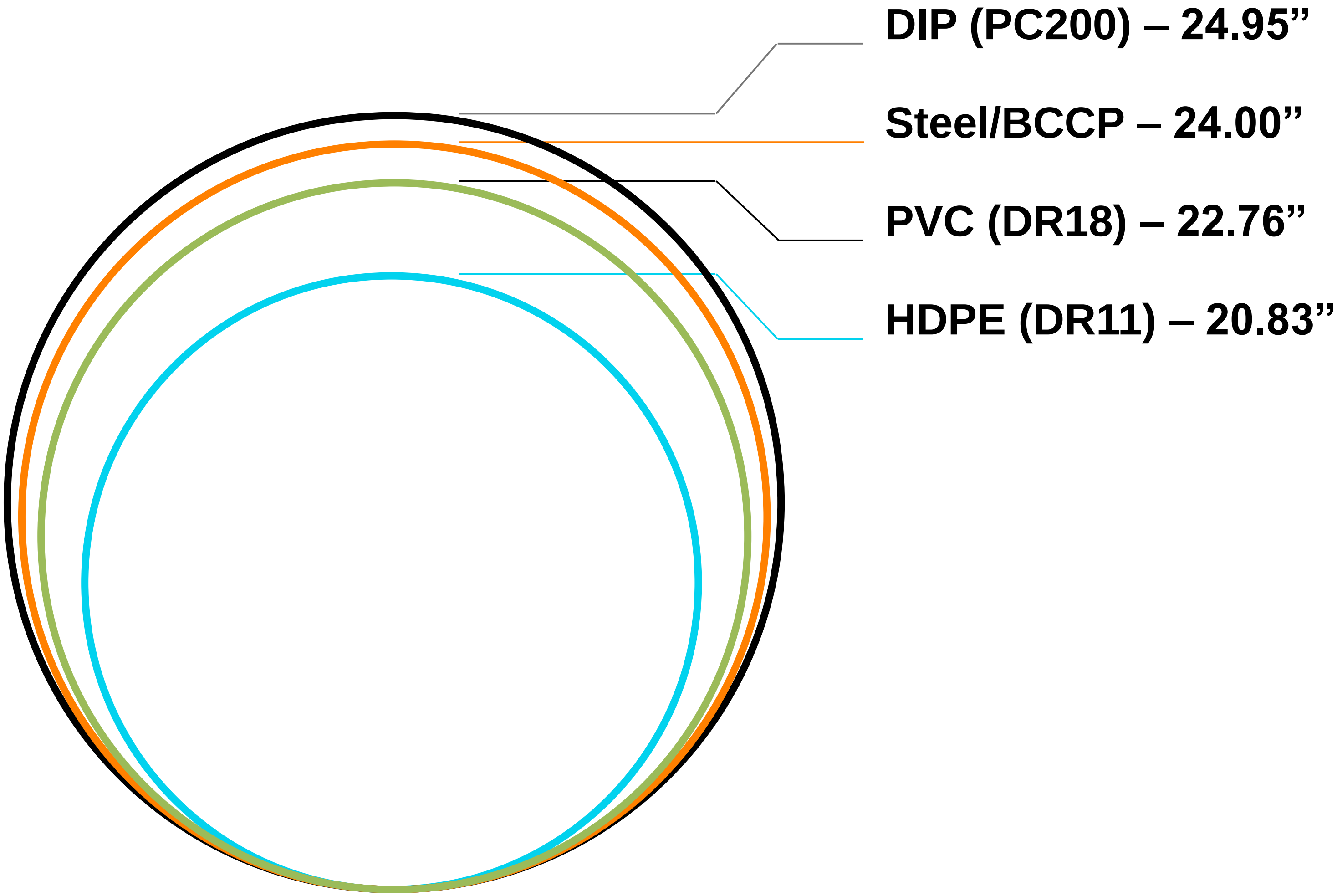
# Energy Use

- Hazen-Williams "C Factor" is based n smoothness of the inside pipe wall.
- But is it the most important factor in selecting an energy efficient pipe material?

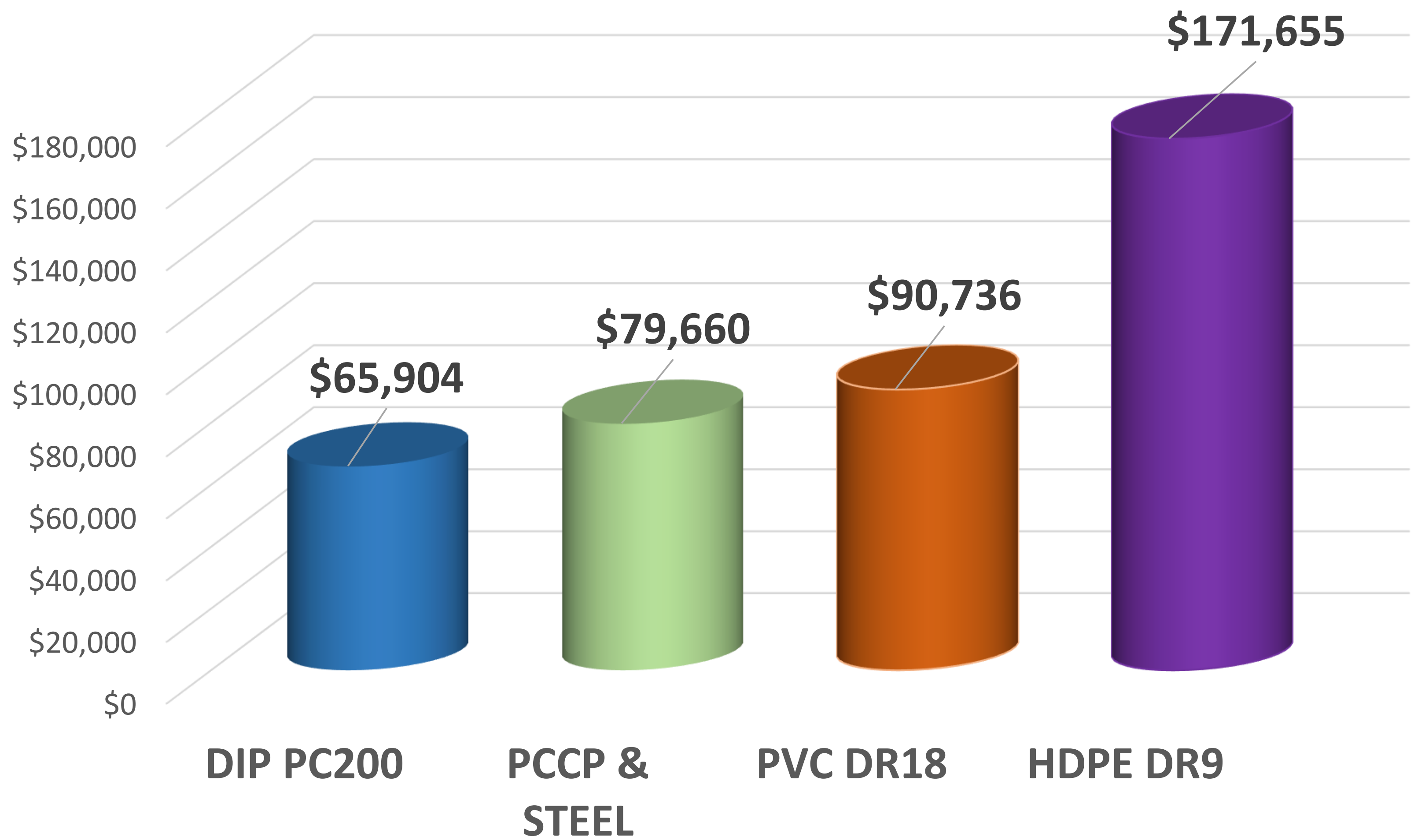
## C Factors

| Material Type | Hazen-Williams C Factor |
|---|---|
| Ductile Iron | 140 |
| pccp/bccp | 140 |
| steel | 140 |
| pvc | 150 |
| hdpe | 155 |

# Actual Inside Diameters



# Annual Pumping Cost

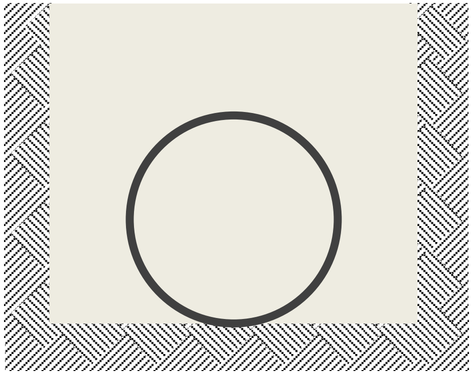


# Installation

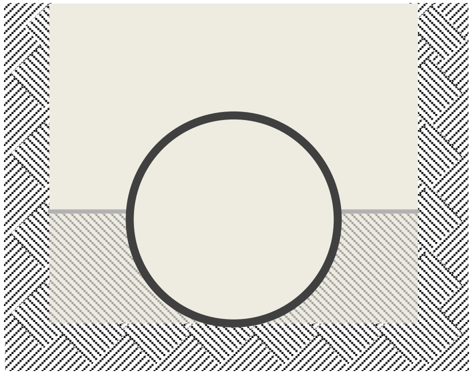
# Operation

# Maintenance

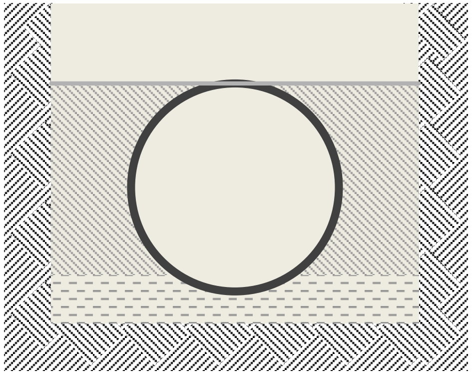
# Laying Conditions



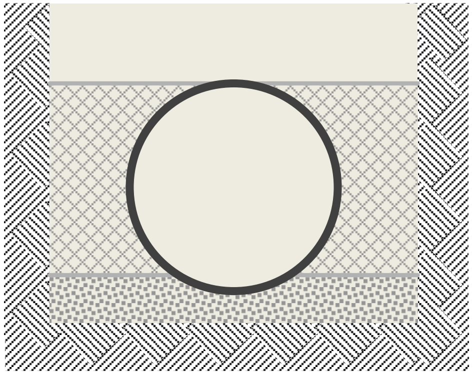
Type 1



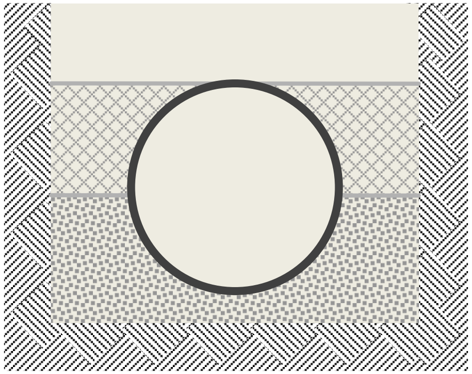
Type 2



Type 3

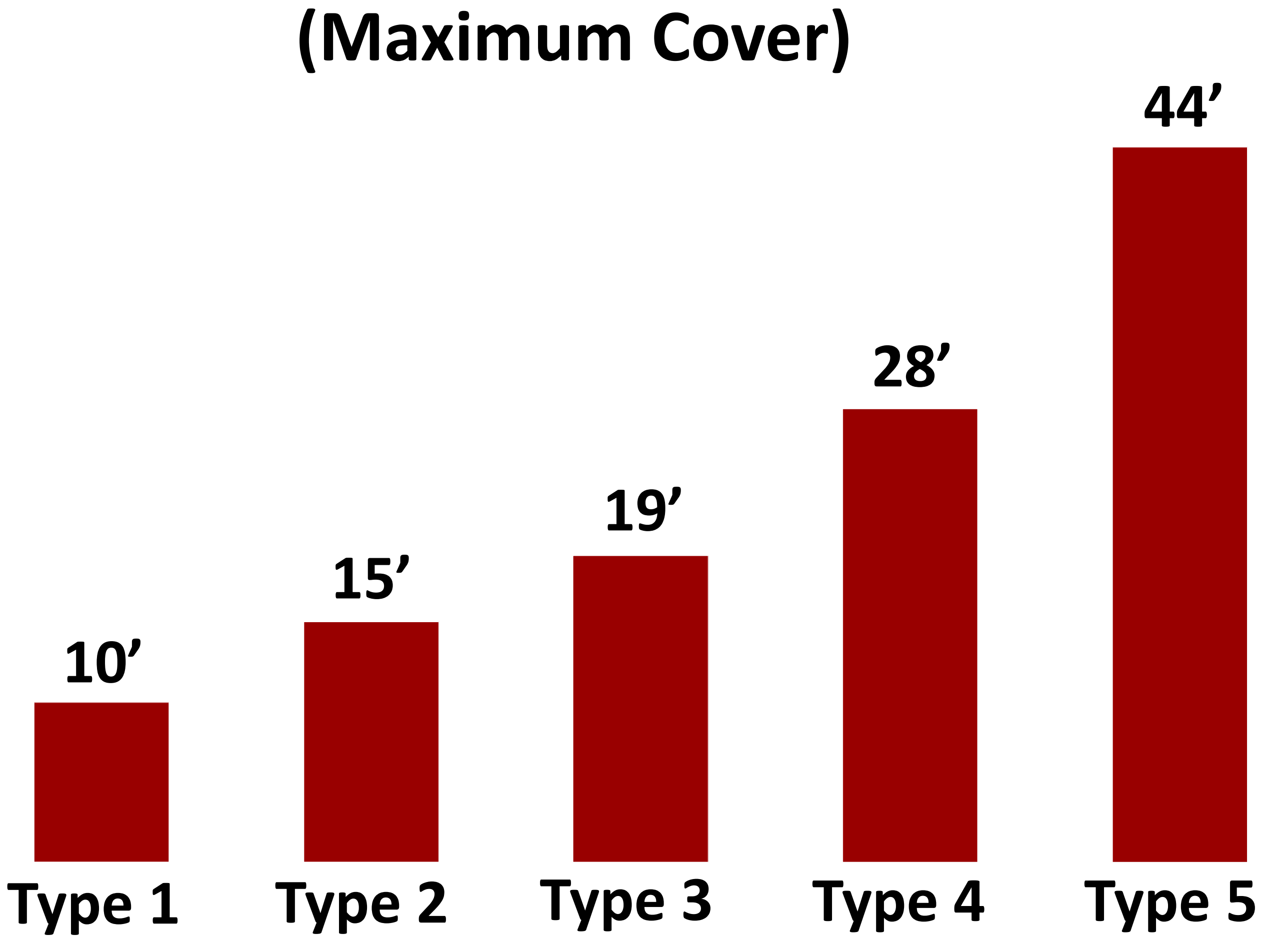


Type 4

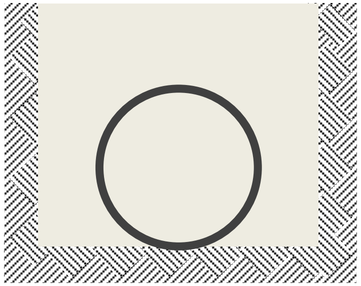


Type 5

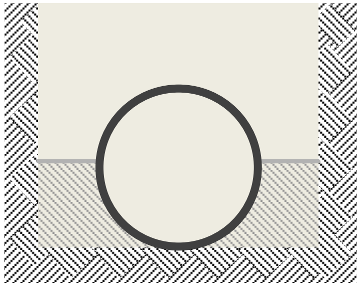
# Effect of Laying Condition on 12 in. PC 350 DIP



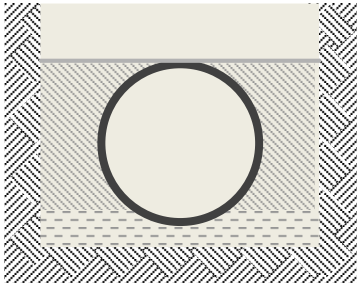
# From Table 2 of ANSI A21.50
## Descriptions for Standard Laying Conditions



**Type 1** **Flat-bottom trench. Loose backfill.**



**Type 2** **Flat-bottom trench. Backfill lightly consolidated to centerline of pipe.**



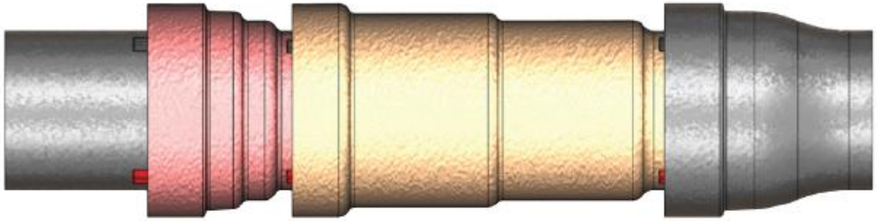
**Type 3** **Pipe bedded in 4-in. minimum loose soil. Backfill lightly consolidated to top of pipe.**

# Available Joints

- Push-On
- Mechanical
- Restrained
- Flanged
- Grooved and Shouldered
- Ball and Socket (River Crossing)
- Seismic

# Ductile Iron Pipe Seismic Joints

**AMERICAN Earthquake Joint System**
**6”, 8”, 12”, 16”, 20” & 24”**
**Deflection: 6º - 8º**
**Extension: ± 2.4”**



**McWane Seismic Flex Coupling®**
**4” – 24”**
**Deflection: 10º - 11½º**
**Extension: ± 5.33”**

**US Pipe TR-XTREME®**
**6”, 8” 12” & 16”**
**Deflection: 3º - 4º**
**Extension: ± 1.45”**

Carmel, Indiana

(40 feet of 12-inch)

# San Marcos, Texas

1,200’ – 30”

## Pittsfield Twp, MI

**30,000 feet - 8inch**

North American Society for Trenchless Technology (NASTT)
No-Dig Show 2012

Nashville, TN
March 11-15, 2012

Paper A-1-05

# COMBINING TWO TRENCHLESS TECHNOLOGIES INTO AN 8 MILE WATER MAIN REPLACEMENT/REHABILITATION PROJECT

Damien R. Wetzel, P.E.[1], and Craig A. Lyon[2]

[1] Stantec, Ann Arbor, MI
[2] Pittsfield Charter Township, Ann Arbor, MI

**ABSTRACT:** Pittsfield Charter Township is a 37,000 resident community outside the City of Ann Arbor, Michigan. In the 1960's, water service was provided to 600 parcels in the Washtenaw Heights Subdivision via cast iron water main. In less than 50 years, the water main deteriorated to a level that resulted in frequent breaks. The Washtenaw Heights Subdivision is a well established neighborhood with mature trees along the entire road right-of-way. The Township conducted pipeline locating, subsurface utility engineering, and condition assessment prior to any alternative analysis. Once the existing conditions were fully understood, alternative analysis was conducted between replacement and rehabilitation of the water main. Alternatives analyzed were open cut, pipe bursting, horizontal directional drilling, slip lining and cured-in-place lining, including analysis of multiple materials in each

## 5. CONSLUSION AND LESSONS LEARNED

By October 2010 over 30,000 feet of 8-inch ductile iron pipe was installed using HDD and over 10,000 feet of 12-inch water main was rehabilitated using CIPP. All the water main installed for this project was tested and accepted by November 2010.

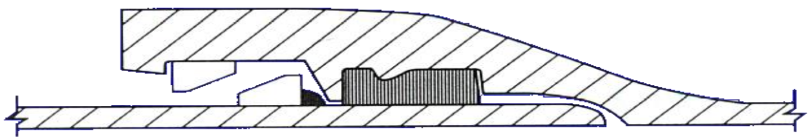
At completion of the project the top three Township priorities were met. Considering safety was the number one priority; Township employees, Stantec staff and both contractors had zero lost time injuries (LTI) on the project. By avoiding long trenches and reducing construction traffic in the roads, typically associated with open cut excavation, many hazards were removed from the construction site. The second Township priority of tree preservation was accomplished by only removing only six trees on a project with tree lined streets; the community was extremely satisfied with the minimal impact to the existing trees and environment. The amount of road restoration costs saved by CIPP and HDD saved the Township an estimated $600,000, not to mention the constructability issues associated with open cutting a corridor congested with multiple utilities.

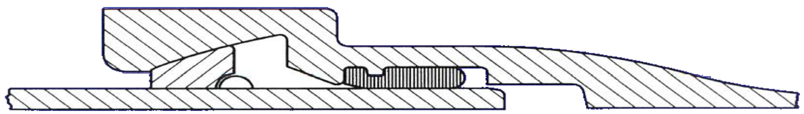
One of the primary concerns at the beginning of the project was to ensure that the polyethylene encasement made it through HDD process. While excavating the new water main to install 550 taps our concerns were put to rest when not a single instance was observed where the polyethylene encasement had been pulled or torn from the pipe, confirming that when properly installed, polyethylene encasement is a reliable measure for corrosion protection in HDD applications.

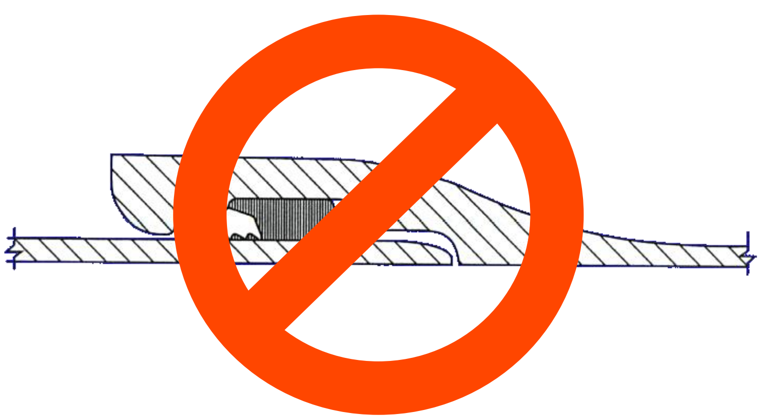
# Meridian, MS
# 1,640’ of 36”

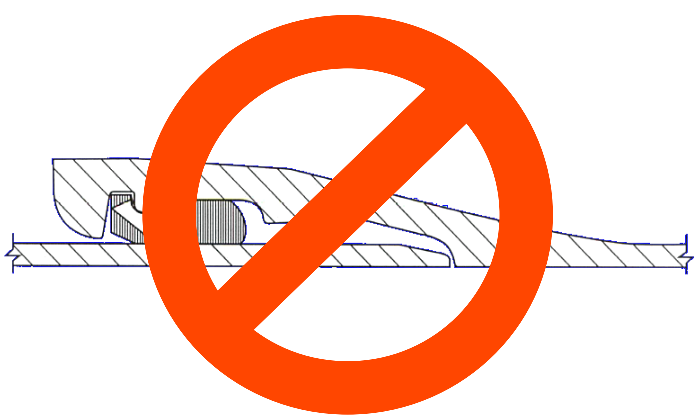
Ductile Iron Pipe Research Association

# DI Restrained Joints for HDD









# 75 Years of Research

dipra
Ductile Iron Pipe
Research Association

# Corrosion and corrosion control of iron pipe:

## 75 years of research

Iron was known to humans in prehistoric ages, and there is ample evidence of its use in early history. Human ability to cast pipe probably developed from or coincided with the manufacture of cannons, which occurred as early as 1313. There is an official record of cast-iron pipe manufactured at Siegerland, Germany, in 1455 for installation at the Dillenburg Castle.

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### POLYETHYLENE ENCASEMENT FOR CORROSION CONTROL

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# Pipe Investigation
# Princeton, Kentucky

# 10 Point Soil Evaluation

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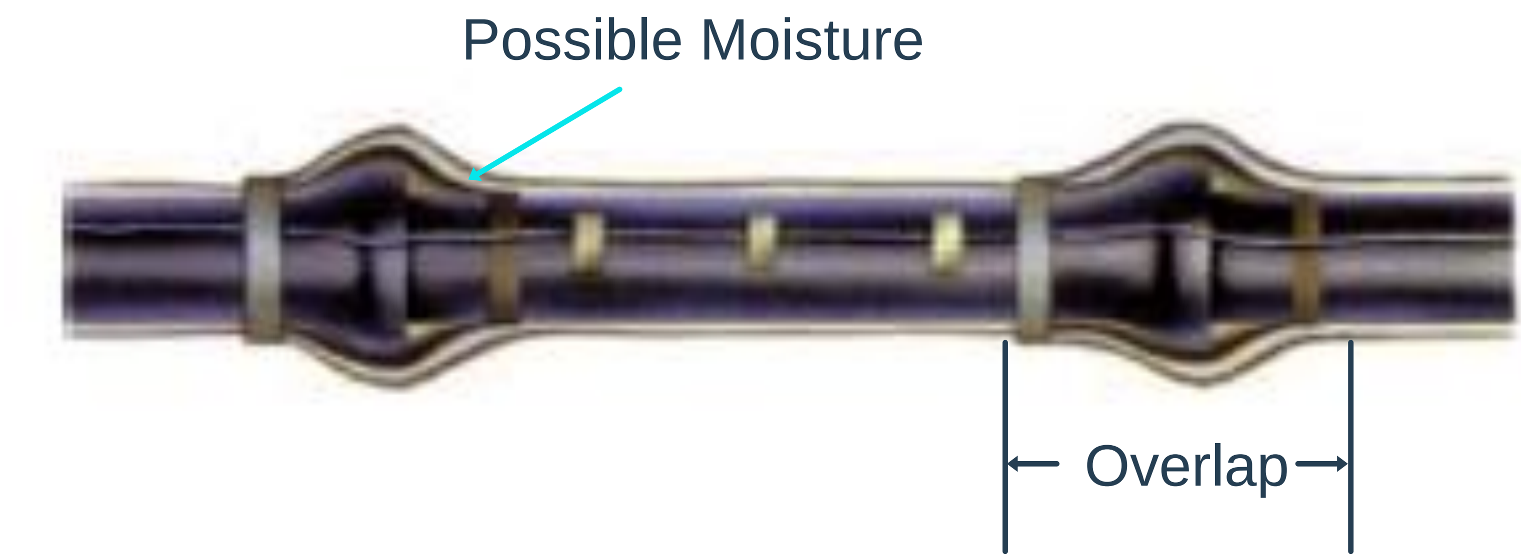
| | | |
|---|---|---|
| Resistivity - ohm-cm (based on water-saturated soil box): | | |
| | < 1,500 | 10 |
| | ≥ 1,500 - 1,800 | 8 |
| | > 1,800 - 2,100 | 5 |
| | > 2,100 - 2,500 | 2 |
| | > 2,500 - 3,000 | 1 |
| | > 3,000 | 0 |
| pH: | | |
| | 0 - 2 | 5 |
| | 2 - 4 | 3 |
| | 4 - 6.5 | 0 |
| | 6.5 - 7.5 | 0* |
| | 7.5 - 8.5 | 0 |
| | > 8.5 | 3 |
| Redox potential: | | |
| | > +100 mV | 0 |
| | +50 to +100 mV | 3.5 |
| | 0 to +50 mV | 4 |
| | Negative | 5 |
| Sulfides: | | |
| | Positive | 3.5 |
| | Trace | 2 |
| | Negative | 0 |
| Moisture: | | |
| | Poor drainage, continuously wet | 2 |
| | Fair drainage, generally moist | 1 |
| | Good drainage, generally dry | 0 |

# Polyethylene Encasement



Los Angeles, CA – 47 Years

Latham, NY – 47 Years

Chicago, IL – 44 Years

Sterling, CO – 41 Years

# Lafourche Parish, Louisiana
# 4 inch Cast Iron Pipe

# Lafourche Parish, Louisiana
# 4 inch Cast Iron Pipe

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# Lafourche Parish, Louisiana
# 4 inch Cast Iron Pipe

# Lafourche Parish, Louisiana
# 4 inch Cast Iron Pipe

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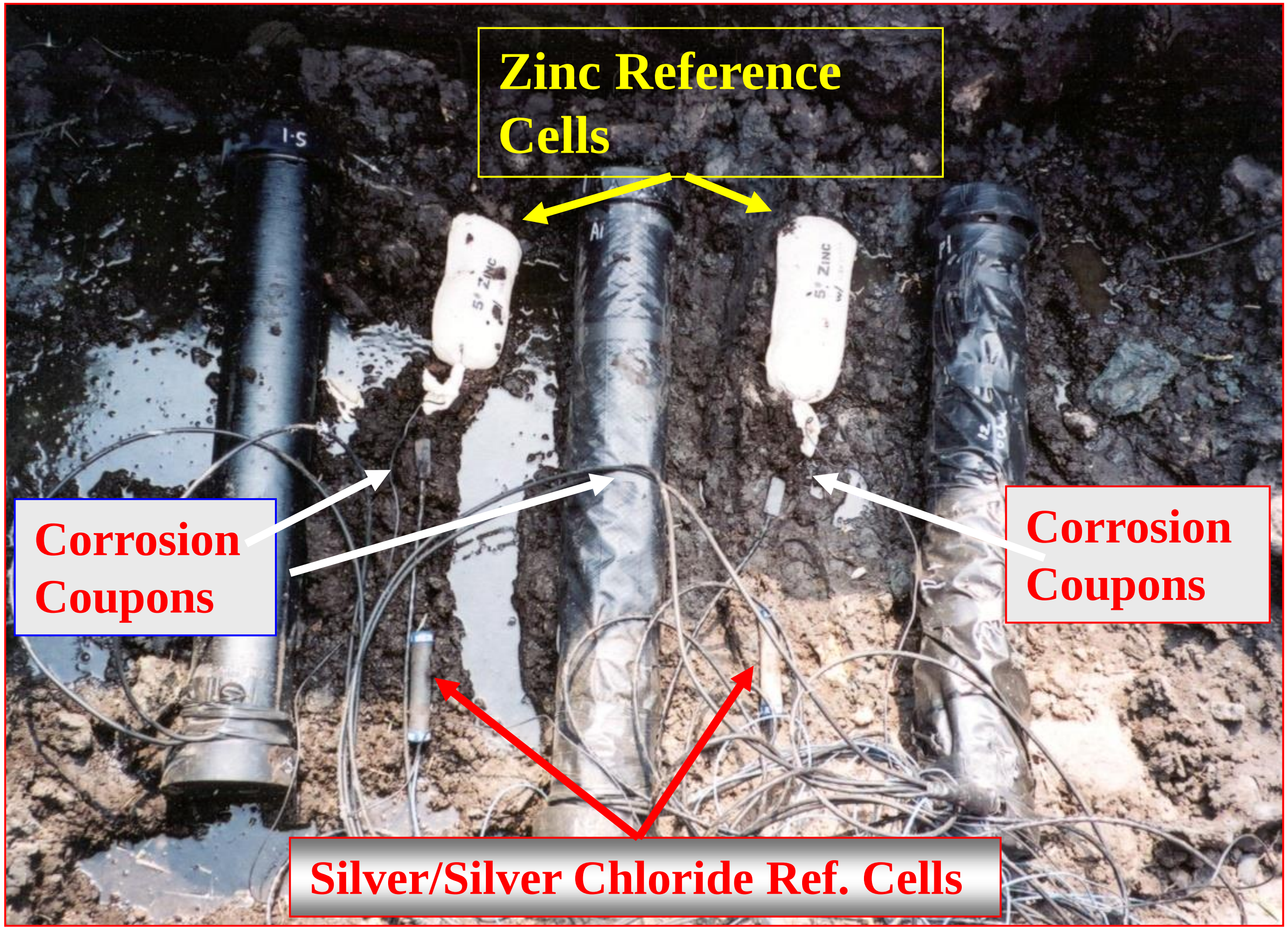
# DIPRA Test Sites

# Low profile Ductile Iron Probe

## (with annealing oxide)

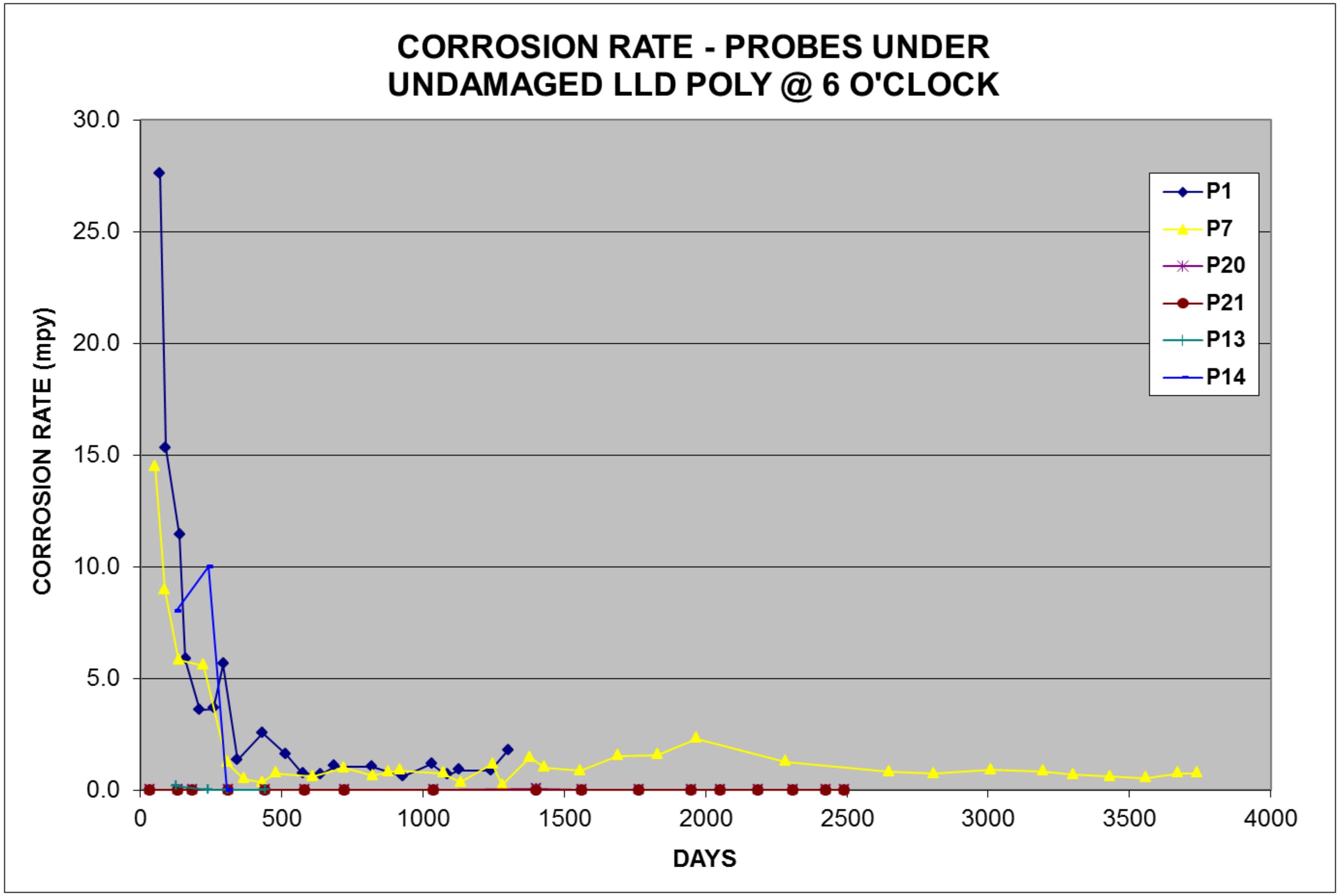
# Florida Everglades Corrosion Testing

## (above ground monitoring)




# Polyethylene Encasement

## V-Bio research



# V-Bio™ Polyethylene

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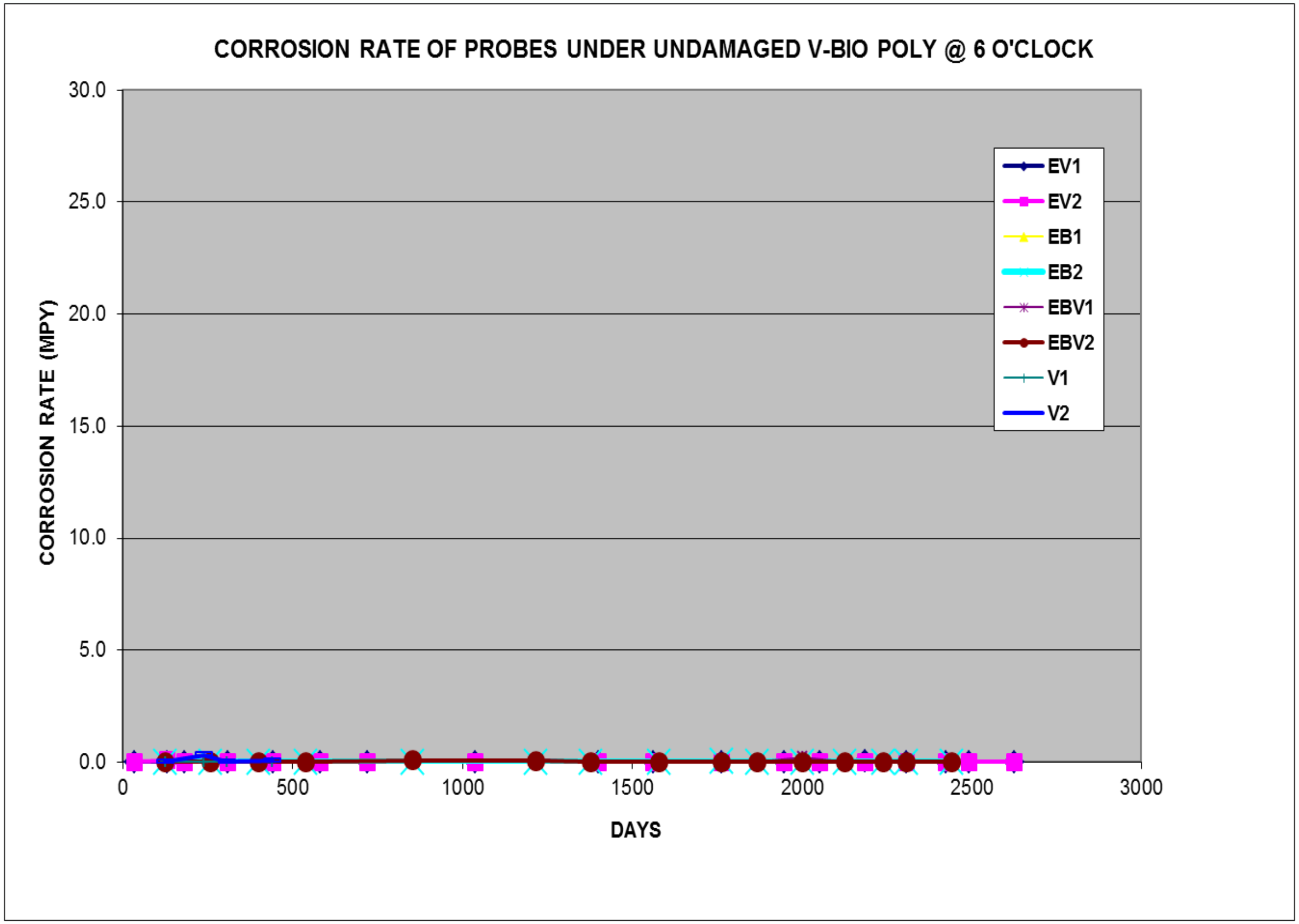
# Polyethylene Encasement

## V-Bio research




WARNING

# Polyethylene Encasement

Method A

Method B

Method C

Modified Method A

# V-Bio Modified Method A


KOMATSU

# The Design Decision Model® (DDM®)

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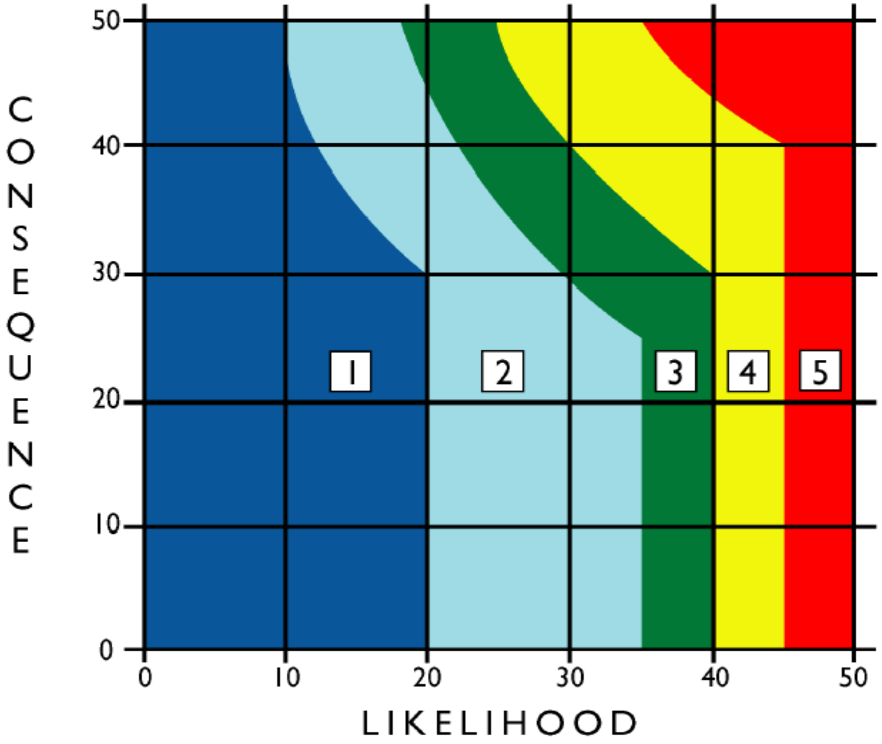
# Design Decision Model®




- 1. As-manufactured
- 2. VBio Polyethylene Encasement (VBio PE)
- 3. VBio PE or VBio PE with Bonded Joints
- 4. VBio PE with Metallized Zinc coating; or life-extension CP
- 5. VBio PE with Metallized Zinc Coating or Cathodic Protection (CP)

# To Achieve a Century of Service from your DI Pipe…

- Design
- Corrosion Control
- Installation
- O & M

# Nominal Thicknesses for Standard Pressure Classes of DIP
## (From Table 5 of ANSI/AWWA C150/A21.50)

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| Pipe Size (in.) | Outside Diameter (in.) | Pressure Class | | | | |
|---|---|---|---|---|---|---|
| | | 150 | 200 | 250 | 300 | 350 |
| | | Nominal Thickness (in.) | | | | |
| 3 | 3.96 | -- | -- | -- | -- | 0.25* |
| 4 | 4.80 | -- | -- | -- | -- | 0.25* |
| 6 | 6.90 | -- | -- | -- | -- | 0.25* |
| 8 | 9.05 | -- | -- | -- | -- | 0.25* |
| 10 | 11.10 | -- | -- | -- | -- | 0.26 |
| 12 | 13.20 | -- | -- | -- | -- | 0.28 |
| 14 | 15.30 | -- | -- | 0.28 | 0.30 | 0.31 |
| 16 | 17.40 | -- | -- | 0.30 | 0.32 | 0.34 |
| 18 | 19.50 | -- | -- | 0.31 | 0.34 | 0.36 |
| 20 | 21.60 | -- | -- | 0.33 | 0.36 | 0.38 |
| 24 | 25.80 | -- | 0.33 | 0.37 | 0.40 | 0.43 |
| 30 | 32.00 | 0.34 | 0.38 | 0.42 | 0.45 | 0.49 |
| 36 | 38.30 | 0.38 | 0.42 | 0.47 | 0.51 | 0.56 |
| 42 | 44.50 | 0.41 | 0.47 | 0.52 | 0.57 | 0.63 |
| 48 | 50.80 | 0.46 | 0.52 | 0.58 | 0.64 | 0.70 |
| 54 | 57.56 | 0.51 | 0.58 | 0.65 | 0.72 | 0.79 |
| 60 | 61.61 | 0.54 | 0.61 | 0.68 | 0.76 | 0.83 |
| 64 | 65.67 | 0.56 | 0.64 | 0.72 | 0.80 | 0.87 |

* Calculated thicknesses for these sizes & pressure classes are less than those shown above. Presently, these are the lowest nominal thicknesses available in these sizes.

# *Detroit, Michigan*
## *8-inch Ductile Iron Pipe*
### *Installed – 1974    Inspected - 1995*

| | |
|---|---|
| **Resistivity:** | **1,320 ohm-cm** |
| **pH:** | **7.4** |
| **Redox:** | **-113 mv** |
| **Sulfides:** | **Positive** |
| **Moisture:** | **Saturated** |


KFC

# Questions?

**Strength**

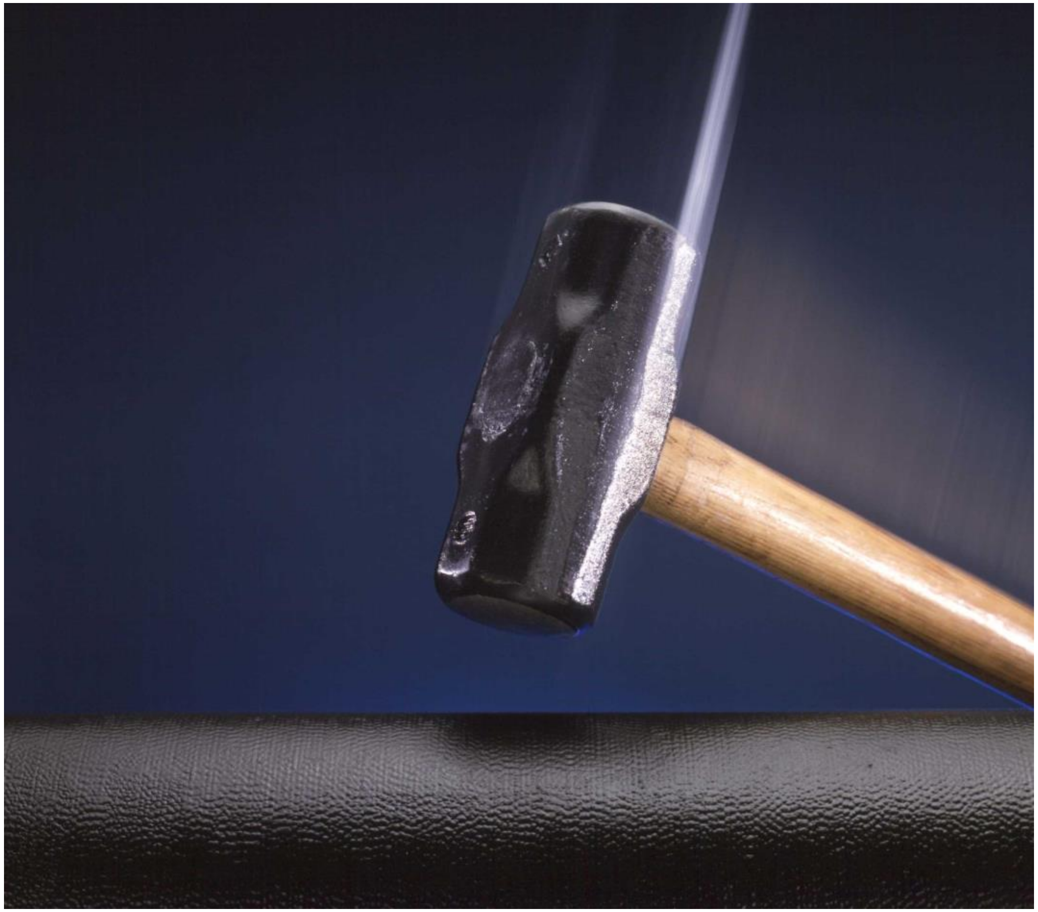
and

**Durability**

for

**Life**

www.dipra.org



# Thank you!


**Paul H. Hanson, PE**

Regional Director

**Ductile Iron Pipe Research Association**

10271 Normandy Ct.

Fishers, IN  46040

205.790.6704

phanson@dipra.org

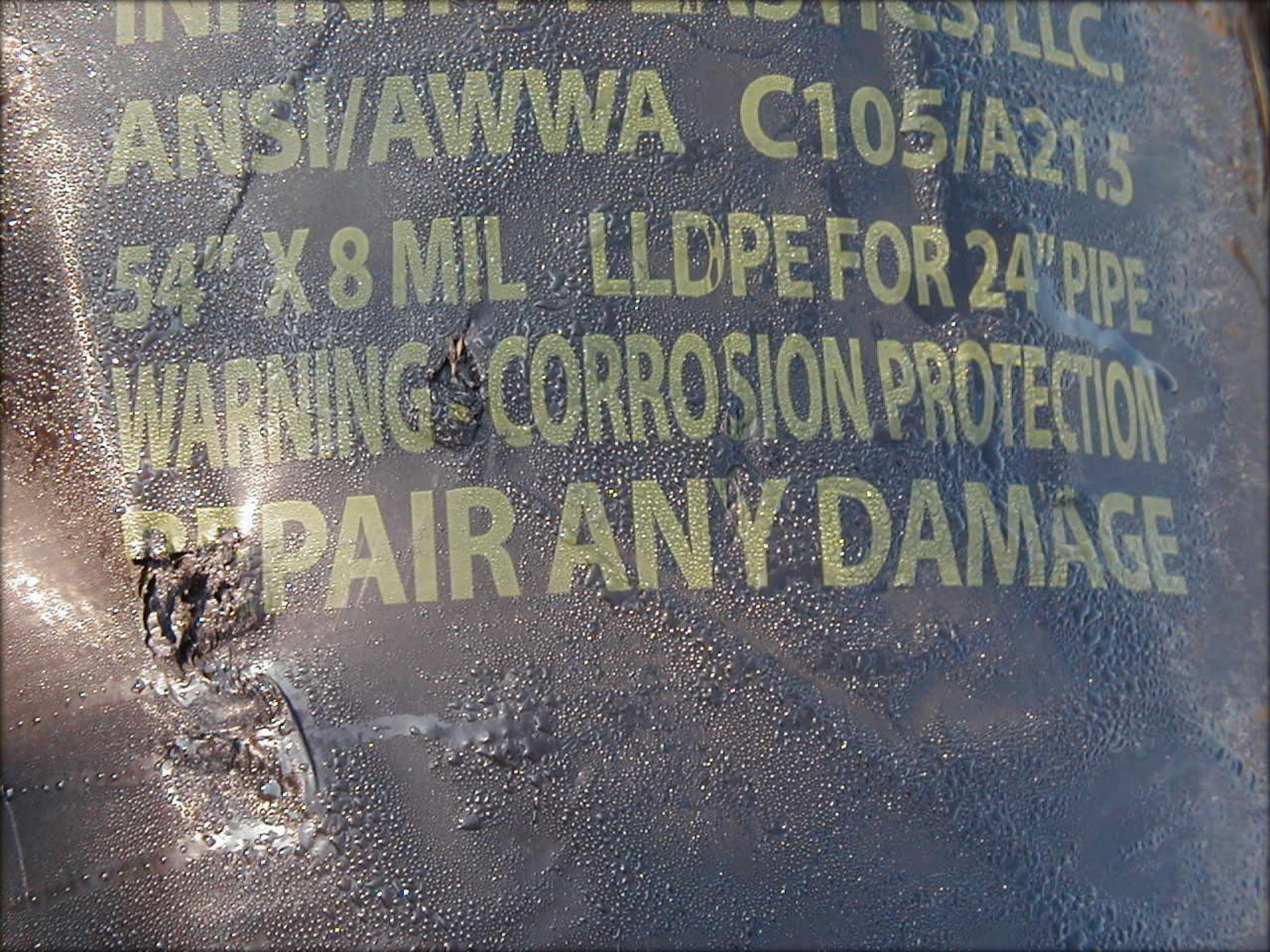
www.dipra.org


4,000

1,600

42,000

# 1922 First Cement Lined Cast Iron Pipe Charleston South Carolina


ANSI/AWWA C105/A21.5
54" X 8 MIL LLDPE FOR 24" PIPE
WARNING - CORROSION PROTECTION
REPAIR ANY DAMAGE

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# Damaged Polyethylene vs. Damaged Coatings

- 3 test sites (Everglades, Nevada & Hughes)
- 6 year results
  - Accelerated pitting on bonded coatings
  - Not accelerated for polyethylene encasement

# Everglades Test Site

**Polyethylene Encased**

**Polyurethane Coating**

# Damaged Polyethylene Encased DIP versus As-manufactured DIP

| Pipe Condition | Number of Specimens | Mean Deepest Pitting Rate |
|---|---|---|
| Damaged Polyethylene Encasement | 62 | 0.0125 in/yr |
| As-manufactured | 89 | 0.0247 in/yr |

**Damaged polyethylene encasement does not result in the concentrated corrosion cells that occur with damaged bonded coatings**