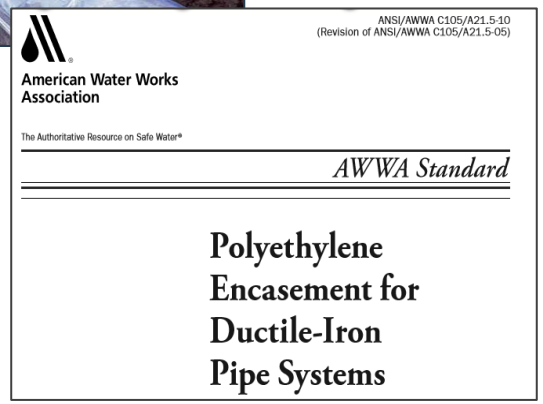
# Corrosion and Its Control, Polyethylene Encasement (V-Bio®)

# Peoria, AZ

**Peoria, Arizona**
**February 16, 2022**




City of Peoria

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(www.dipra.org)

# DIPRA Member Companies

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

AMERICAN DUCTILE IRON PIPE

CANADA PIPE

US PIPE

McWANE DUCTILE

# Regional Engineer Program

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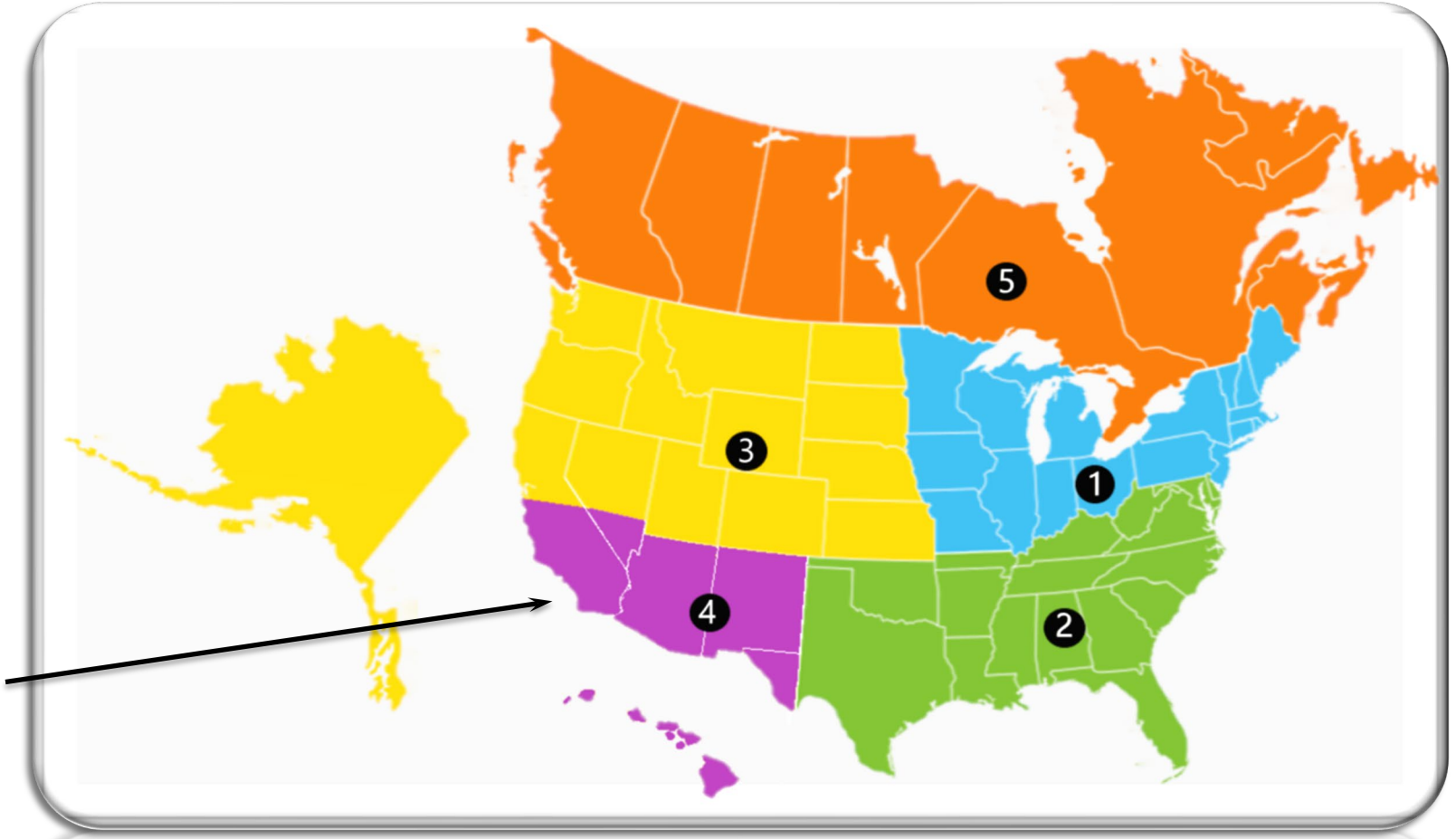
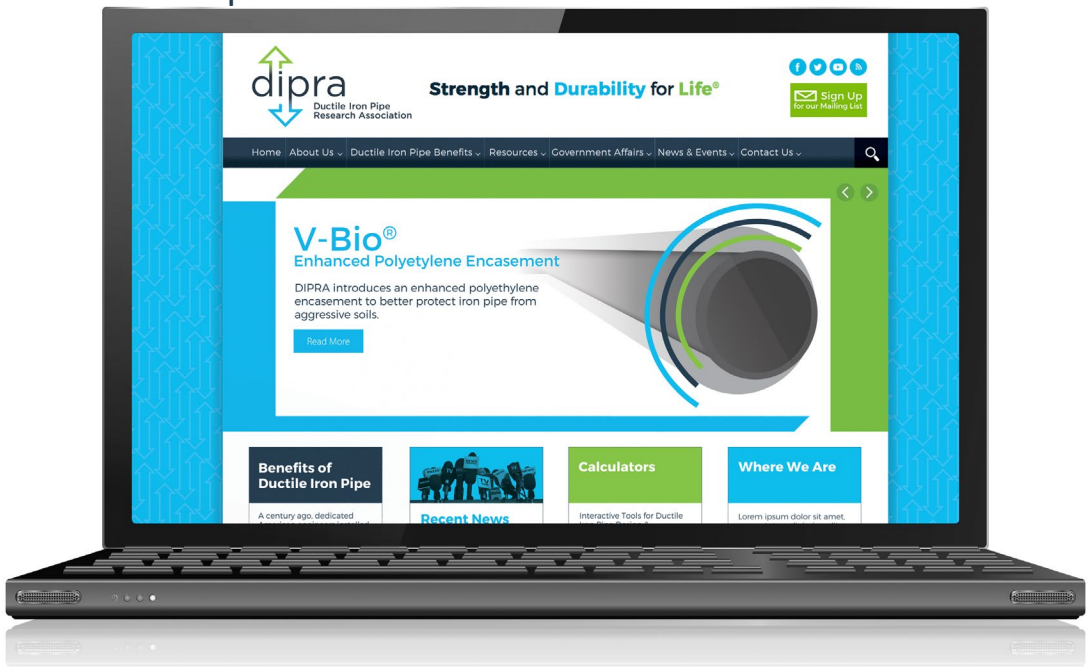



Jeffrey Butters
Region 4
Regional Engineer
AMPP/NACE Cert.

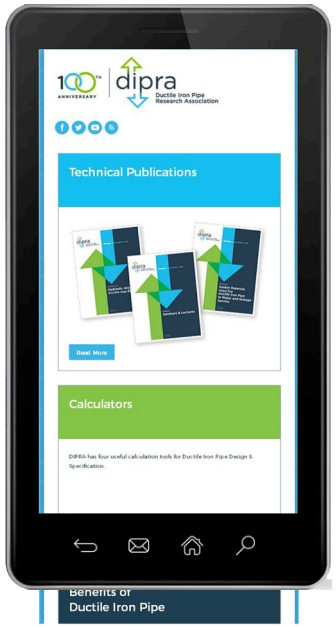
# DIPRA Website

- www.dipra.org

Desktop




Mobile



# DIPRA Website

## (www.dipra.org)

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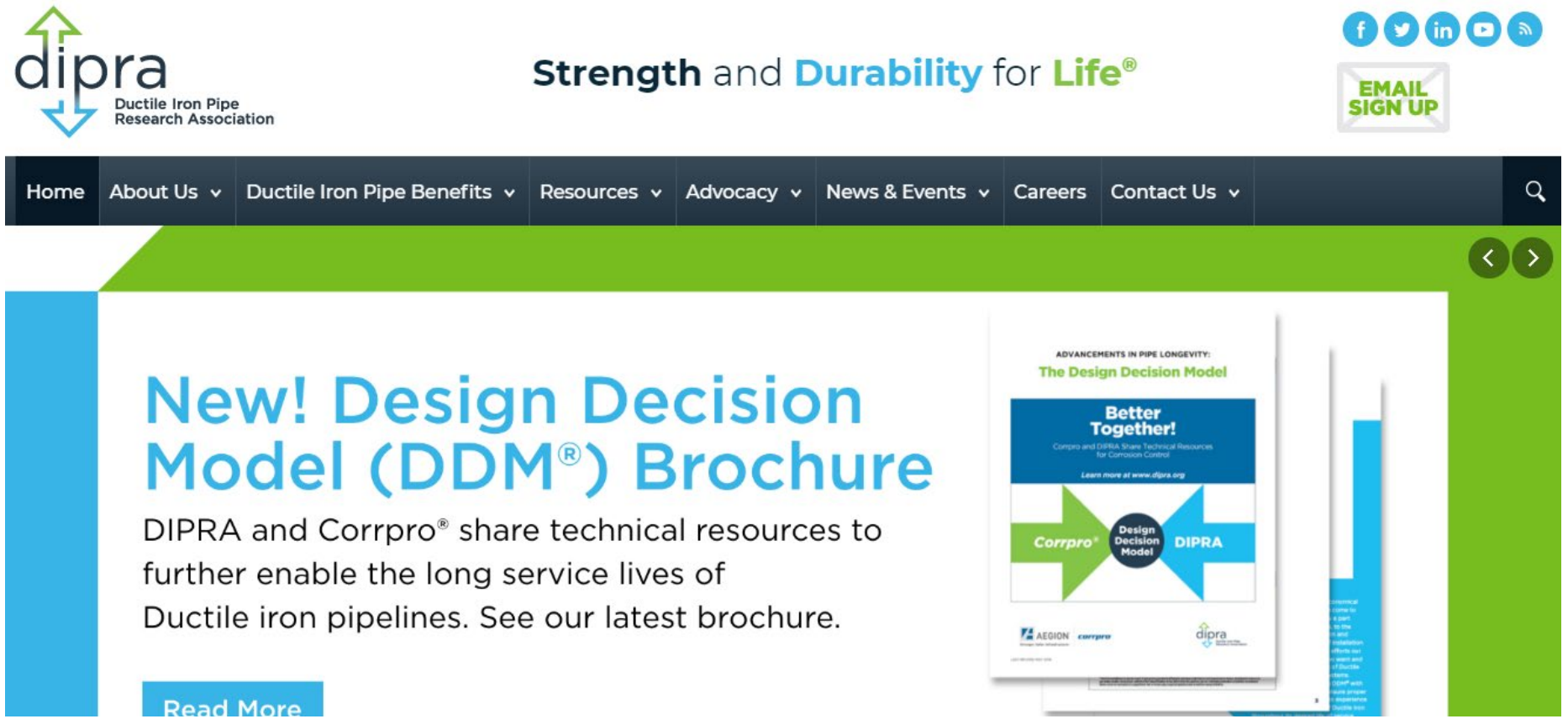

# DIPRA Technical Publications

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## Corrosion Control

- The Design Decision Model™ for Corrosion Control of Ductile Iron Pipe
- Cast Iron Pipe Century Club
- Cement-Mortar Linings for Ductile Iron Pipe
- Linings Available for Ductile Iron Pipe
- Polyethylene Encasement: Effective, Economical Protection for Ductile Iron Pipe in Corrosive Environments
- Stray Current Effects on Ductile Iron Pipe
- The Effect of Overhead AC Power Lines Paralleling Ductile Iron Pipelines


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# DIPRA Publications

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# Versailles, France

## (Installed 1664)

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# Century Club

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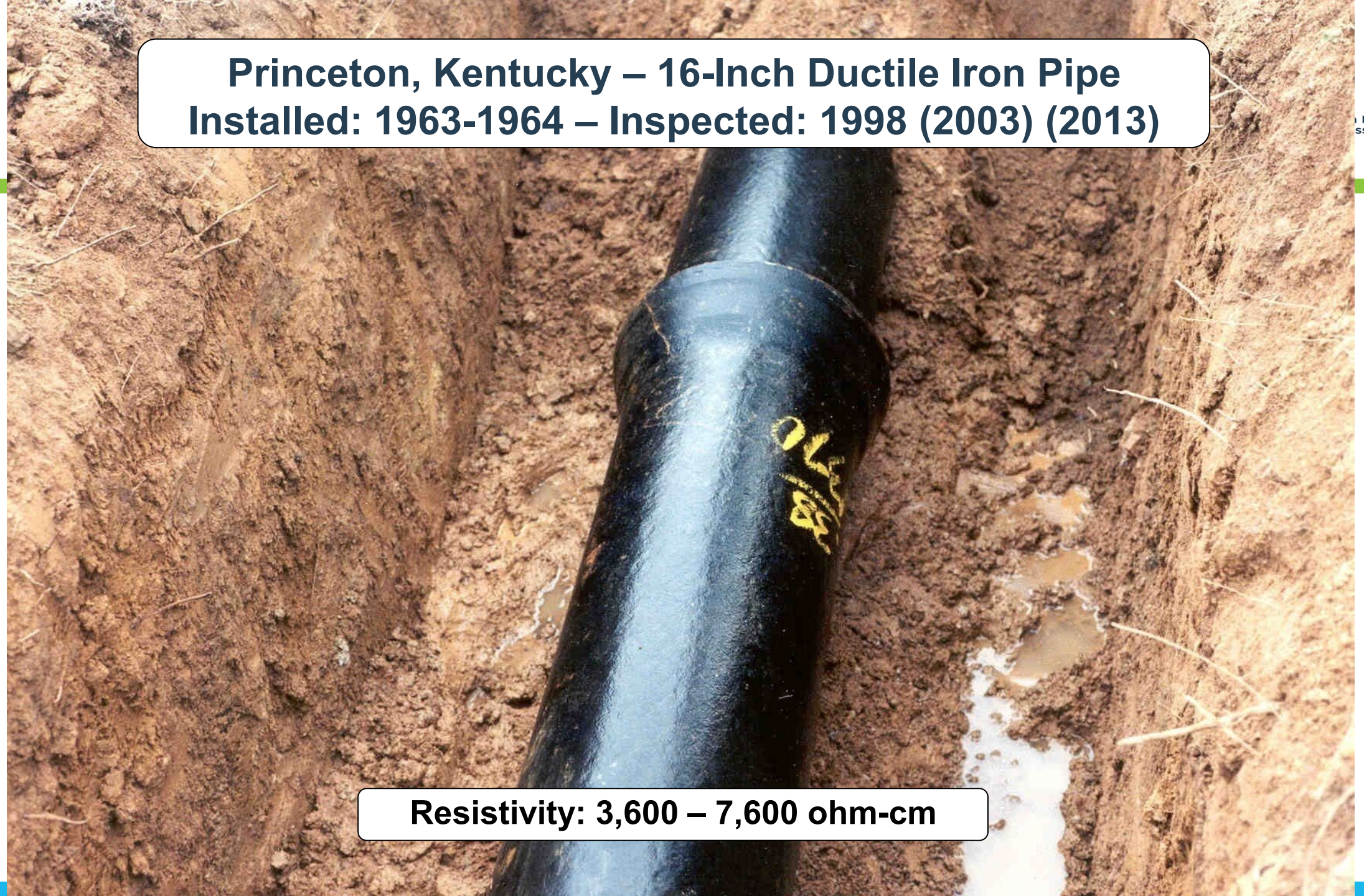
- The Cast Iron Pipe Century Club recognizes water utilities with Cast Iron mains that have provided service for 100 years or more.  530 in US.


Neihart, Montana – 12-Inch Cast Iron Pipe
Installed: 1892 – Inspected: 1992
Member: Cast Iron Pipe Century Club
Resistivity: 2,520 ohm-cm


Princeton, Kentucky – 16-Inch Ductile Iron Pipe
Installed: 1963-1964 – Inspected: 1998 (2003) (2013)
Resistivity: 3,600 – 7,600 ohm-cm

# Century Club

## (California)

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| Location | Utility | Year Inducted | Oldest Pipe |
|---|---|---|---|
| Benicia | City of Benicia | 1991 | 1887 |
| Imperial Beach | California-American Water Company, Coronado District | 1991 | 1888 |
| Los Angeles | L. A. Department of Water & Power | 1985 | 1885 |
| Merced | The City of Merced | 1989 | 1889 |
| Monrovia | City of Monrovia | 2008 | 1908 |
| Monterey | California-American Water Company | 1988 | 1885 |
| Oakland | East Bay Municipal Utility District | 1982 | 1876 |
| Pasadena | Pasadena Water & Power Department, Water Division | 1987 | 1887 |
| Sacramento | Sacramento Water Department | 1954 | 1854 |
| San Bernardino | City of San Bernardino Municipal Water Department | 2017 | 1909 |
| San Francisco | San Francisco Water Department | 1958 | 1859 |
| San Jose | San Jose Water Works | 1981 | 1878 |
| San Luis Obispo | City of San Luis Obispo | 2007 | 1888 |
| Santa Barbara | The City of Santa Barbara | 1991 | 1886 |
| Santa Cruz | City of Santa Cruz Water Department | 1997 | 1890 |
| Santa Rosa | Santa Rosa Utilities Department | 1994 | 1893 |
| Sonora | Pacific Gas & Electric Company, Water Systems Department | 1965 | 1852 |
| Stanford | Stanford University | 1989 | 1888 |

100 Years
CENTURY CLUB
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# Sesquicentennial Club

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- The Cast Iron Pipe Sesquicentennial Club recognizes water utilities with Cast Iron mains that have provided continuous service for 150 years or more.  21 In US.

# Sesquicentennial Club

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Huntsville, AL
Mobile, AL
Washington DC
Louisville, KY
Boston, MA
Detroit, MI
St. Louis, MO
Albany, NY
Buffalo, NY

Troy, NY
Utica, NY
Cincinnati, OH
Allentown, PA
Columbia, PA
Lancaster, PA
Philadelphia, PA
Pittsburgh, PA

York, PA
Nashville, TN
Lynchburg, VA
Richmond, VA
Winchester, VA
Halifax, NS
Montreal, QC
Quebec City, QC

# Sesquicentennial Club

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**Louisville, KY - October 2010**

# External Soil Corrosion

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# Galvanic Corrosion Cell

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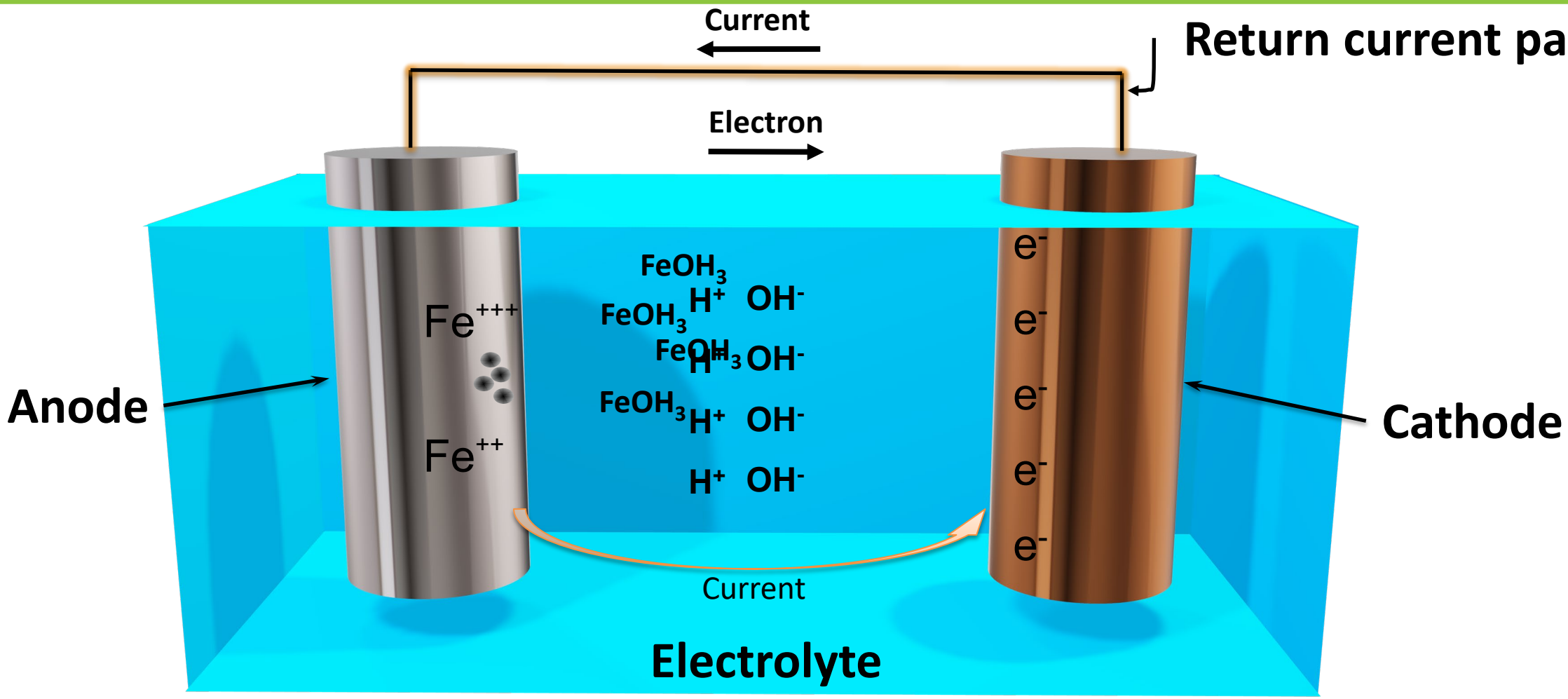

# The underground pipe corrosion cell . . .

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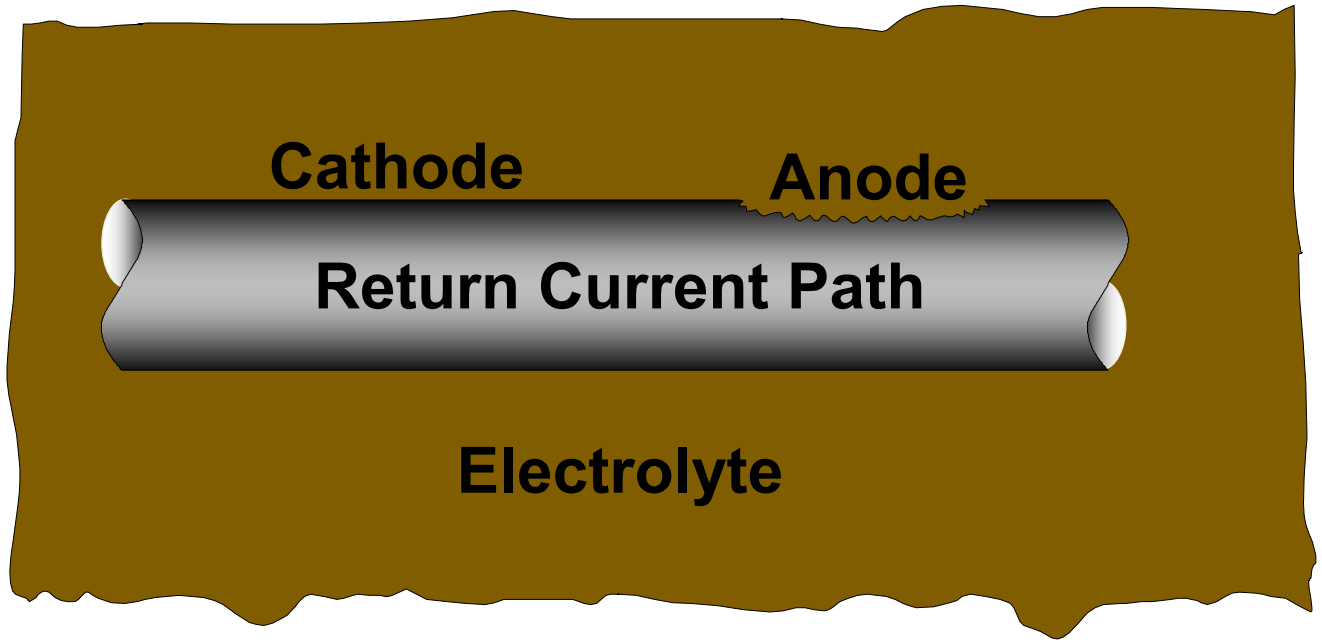

# Ductile Iron Pipelines are Electrically Discontinuous

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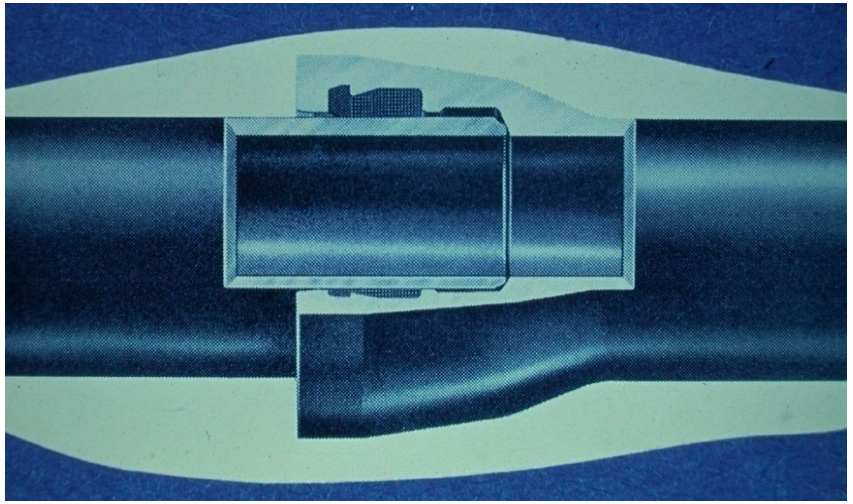
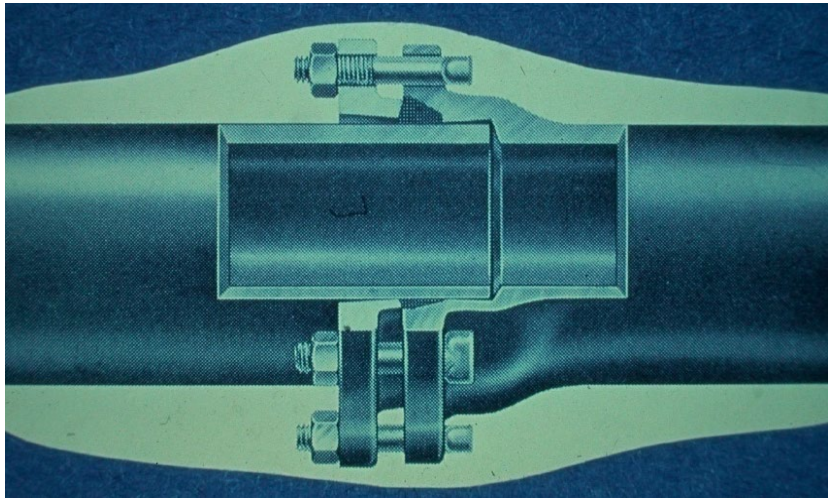


Push-on Joint



Mechanical Joint

# Sources of Stray Current

- Impressed current cathodic protection systems
- Electric transit systems
- Arc-welding equipment
- Direct current transmission systems
- Grounding electrical systems to pipe

# Impressed Current Cathodic Protection

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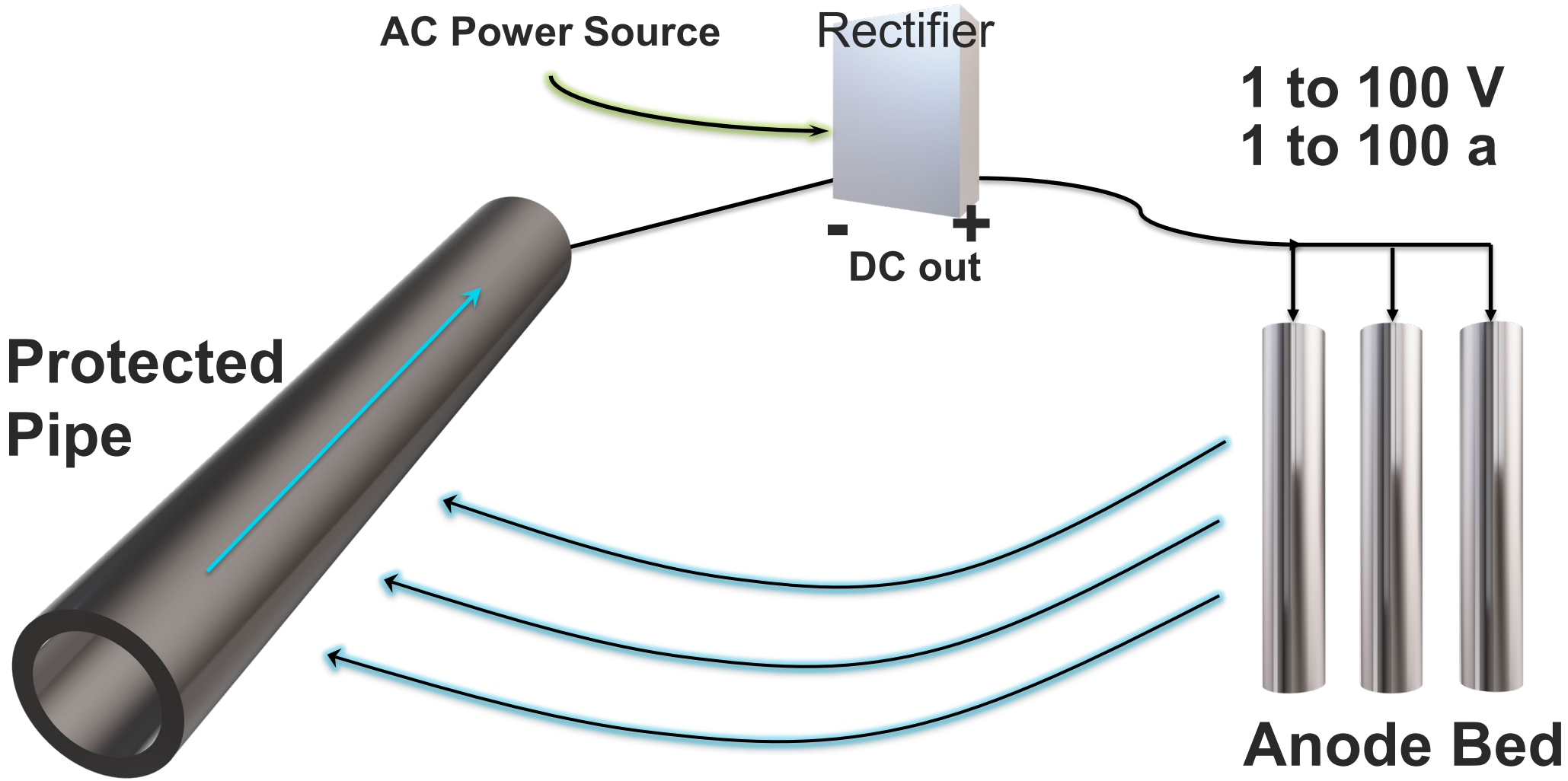

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# AC Overhead Power Line Right-of-Ways

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# Effect of Overhead AC Power Lines

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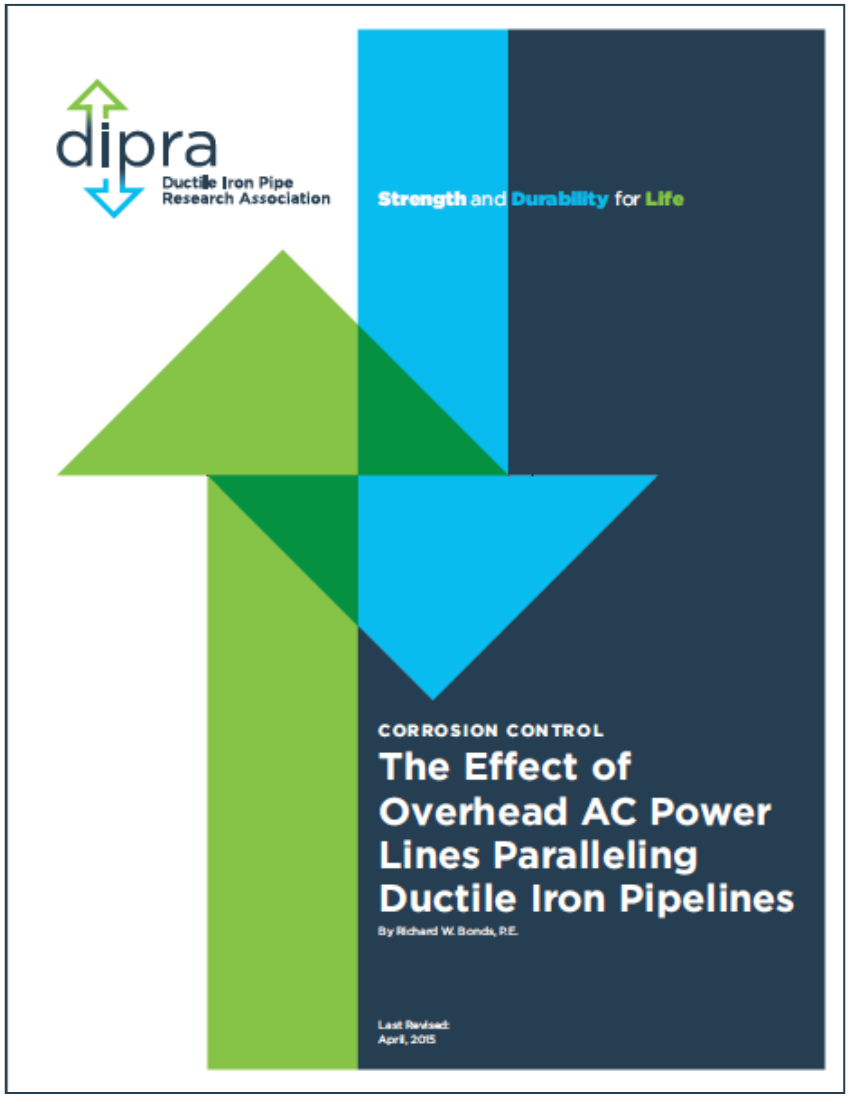

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# 10-Point System

# Soil Evaluation Parameters

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- Resistivity
- Redox
- pH
- Sulfides
- Moisture

# 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 |

*3 points should be added if low or negative redox and sulfides are present

# Corrosive Environments

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- Coal
- Cinders
- Swamps
- Expansive Clays
- Peat Bogs
- Mine Wastes
- Landfill Areas
- Alkali Soils

# DIPRA Corrosion Research

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- 1928 – Strength of Corrosion Products
- 1940 – Coatings
- 1949 – Bolt Corrosion
- 1952 – Coatings and Loose Polyethylene
- 1963 – Field Investigations (on-going)
- 1971 – Stray Current
- 1989 – Copper Service
- 1999 – Elevated Temperature
- 2000 – Effect of Chloramines on Gasket Materials
- 2002 – Rate of Corrosion

# DIPRA Test Sites

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# DIPRA Test Sites

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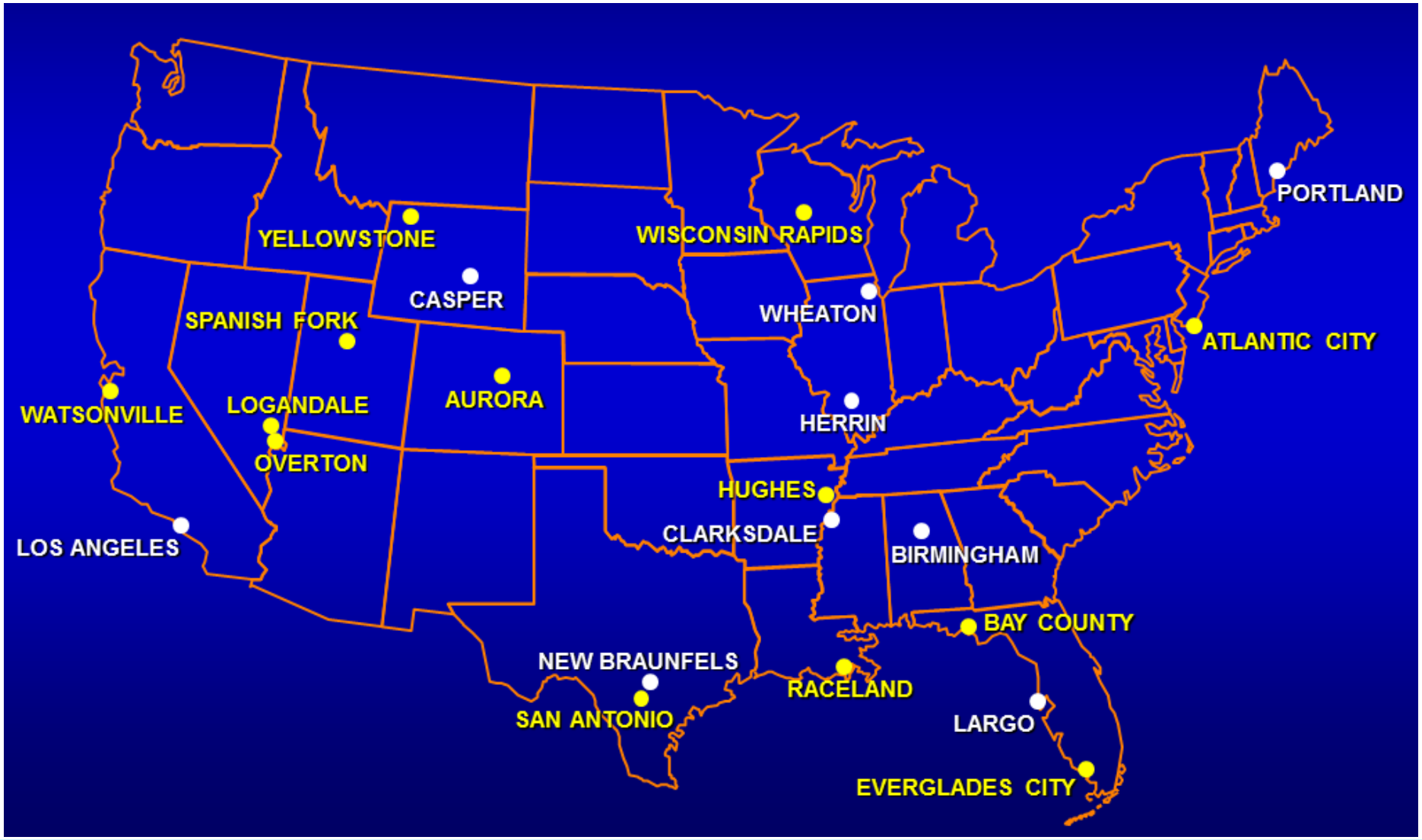

# DIPRA Test Site Data

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| LOCATION | RESISTIVITY | pH | SULFIDES | REDOX |
|---|---|---|---|---|
| Atlantic City, NJ | 66 | 7.0 | positive | -240 |
| Birmingham, AL | 400 | 7.0 | ------ | ------ |
| Casper, WY | 350 | 8.0 | negative | +96 |
| Everglades City, FL | 150 | 7.2 | positive | -150 |
| Herrin, IL | 4,440 | 4.7 | negative | +205 |
| Lombard, IL | 2,500 | 7.3 | trace | +90 |
| Overton, NV | 188 | 7.9 | negative | +200 |
| Raceland, LA | 1,000 | 7.2 | trace | +140 |
| Spanish Fork, UT | 720 | 7.5 | negative | +140 |
| Watsonville, CA | 1,040 | 6.2 | trace | +180 |
| Wisconsin Rapids, WI | 6,000 | 3.5 | positive | +210 |

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# DIPRA Research

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# DIPRA – Bolt Study

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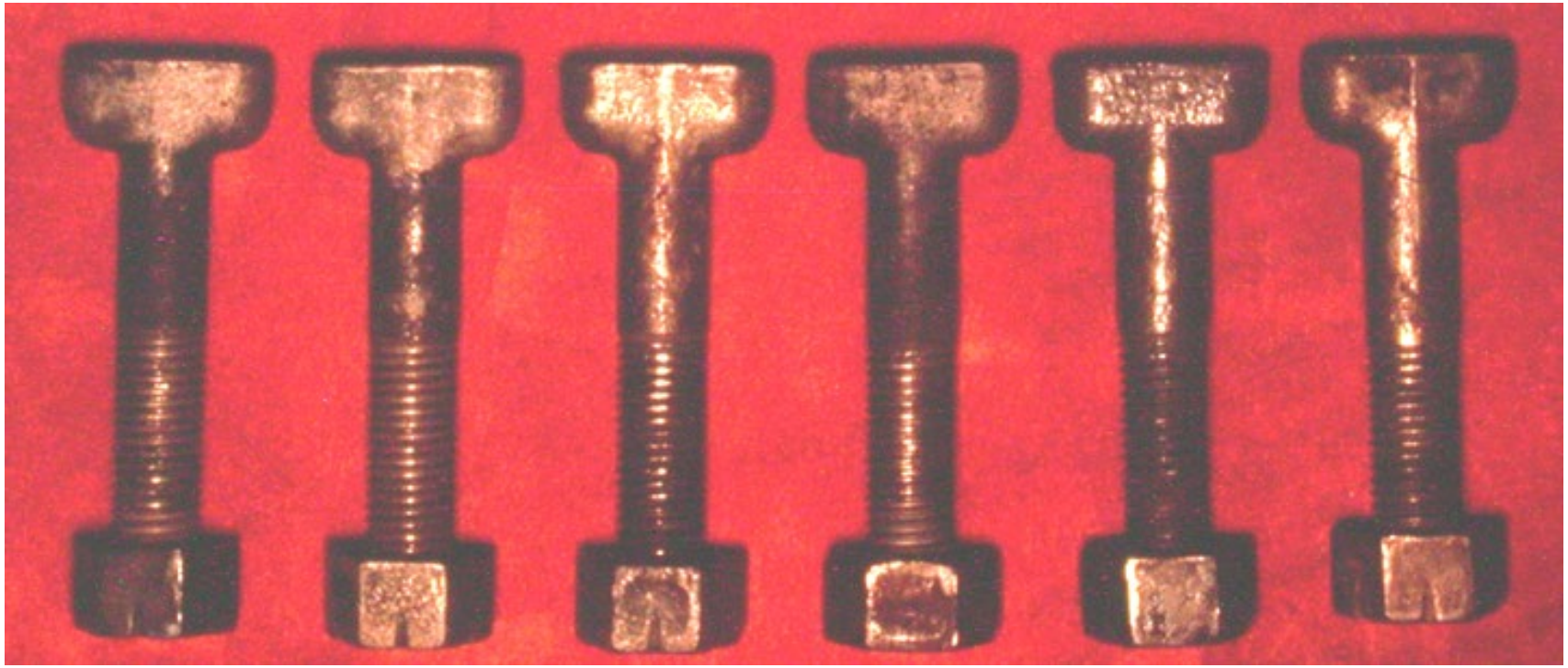

# Everglades Test Site

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# CIPRA - 1952
# Polyethylene Protection Study

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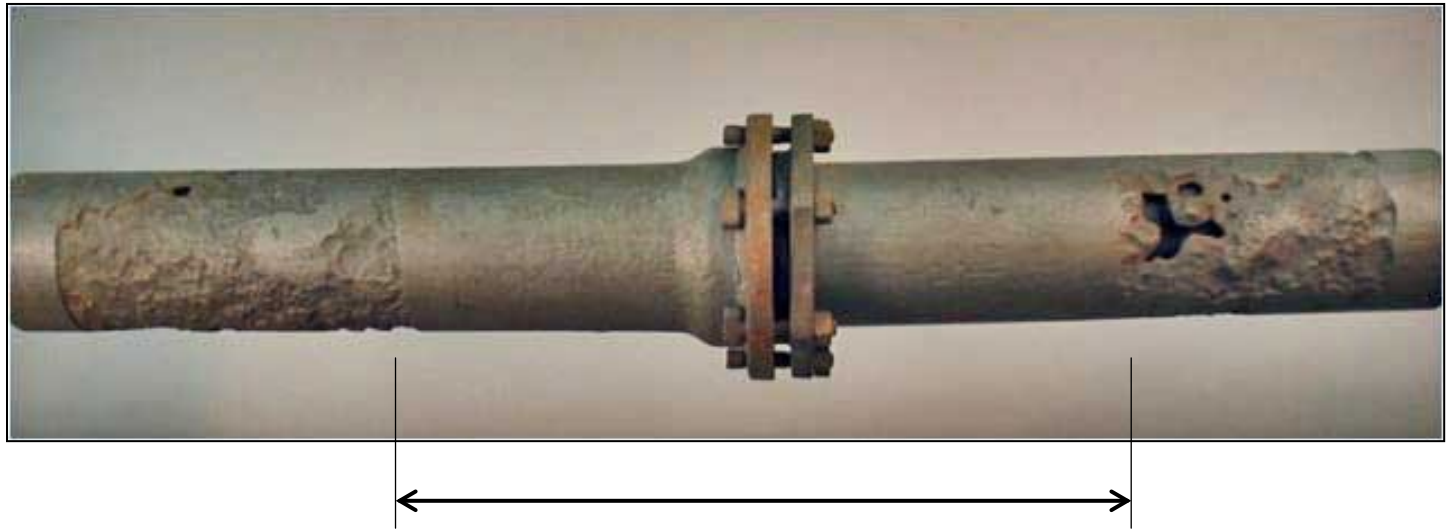
## Everglades City, FL - 6” Gray Cast iron
## 18 years exposure



## 4-mil polyethylene encased

| | |
|---|---|
| **Resistivity:** | **400 ohm-cm** |
| **Redox:** | **- 35 mV** |
| **pH:** | **7.1** |
| **Sulfides:** | **Positive** |
| **Soil Moisture:** | **Saturated** |

# A Solution –
# Both Economical and Effective

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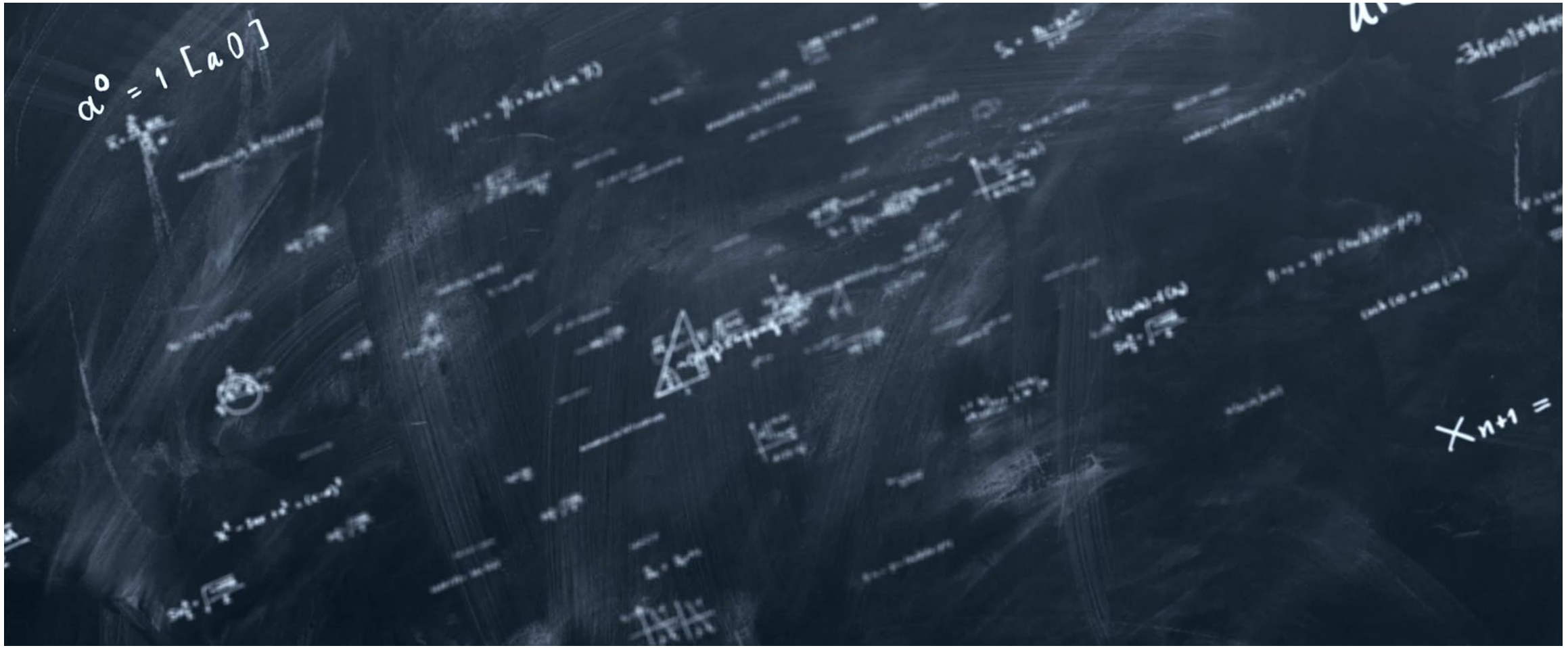

# ANSI/AWWA C105/A21.5

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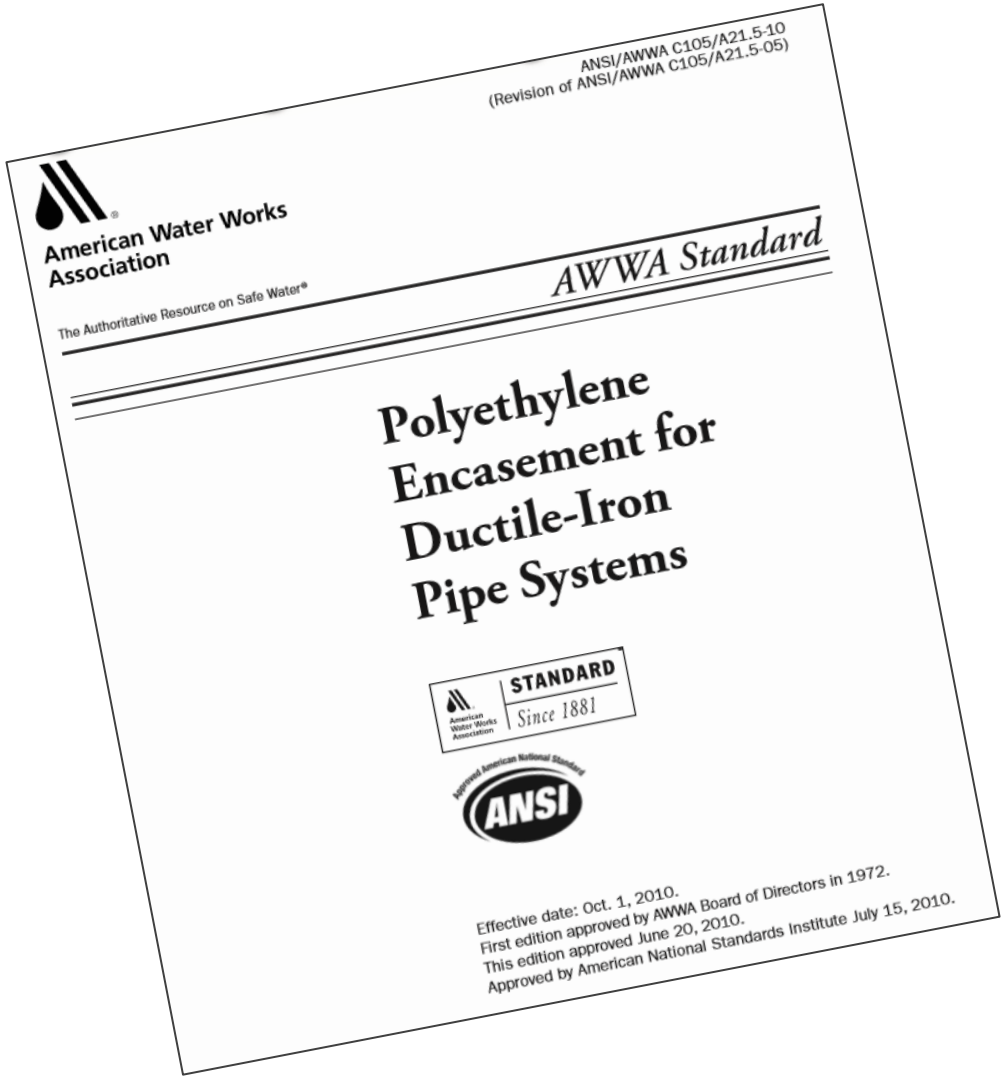

ANSI/AWWA C105/A21.5-10
(Revision of ANSI/AWWA C105/A21.5-05)

American Water Works Association

The Authoritative Resource on Safe Water®

AWWA Standard

Polyethylene Encasement for Ductile-Iron Pipe Systems

STANDARD
Since 1881

ANSI

Effective date: Oct. 1, 2010.
First edition approved by AWWA Board of Directors in 1972.
This edition approved June 20, 2010.
Approved by American National Standards Institute July 15, 2010.

# Polyethylene Encasement

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# Polyethylene Encasement

## History of Development

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**1952 - Research initiated**

**1958 - First installation**

**1972 - First standard issued**

**20 years of research**

# Polyethylene Encasement Installation

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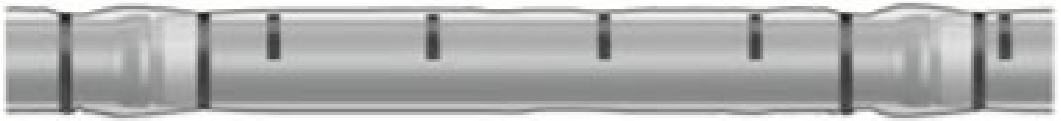
**Method A**

**Method B**

**Method C**



***Modified*** **Method A**

# Polyethylene Encasement Installation

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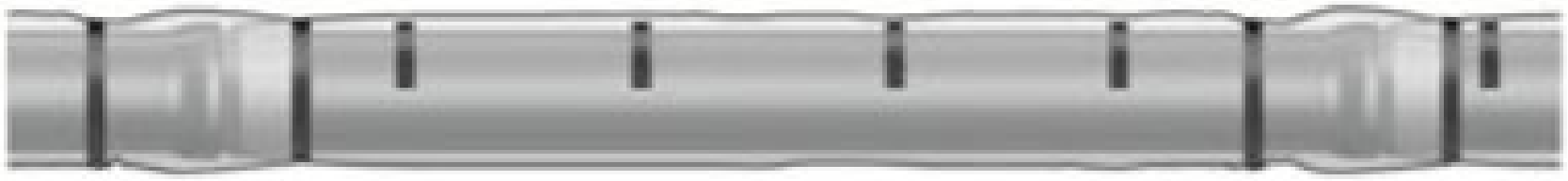

***Modified*** **Method A**

# Polyethylene Encasement Installation

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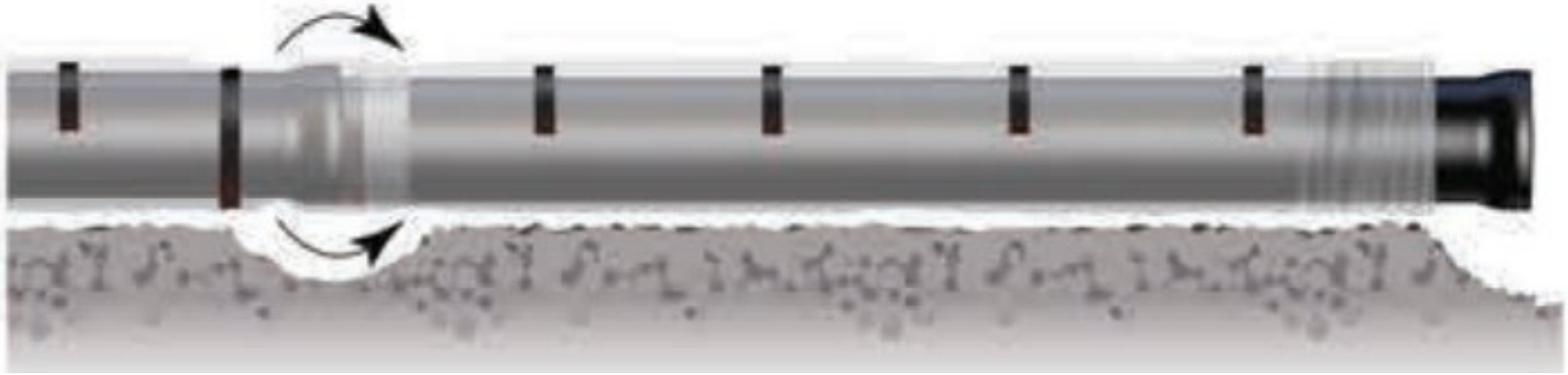

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# Polyethylene Encasement Installation

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# Polyethylene Encasement (Wet Trench) Installation

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# Encasement of Appurtenances

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# Casings

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# Polyethylene Encasement

## (V-Bio® Enhanced with Additional Colored Layer)

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# Tapping

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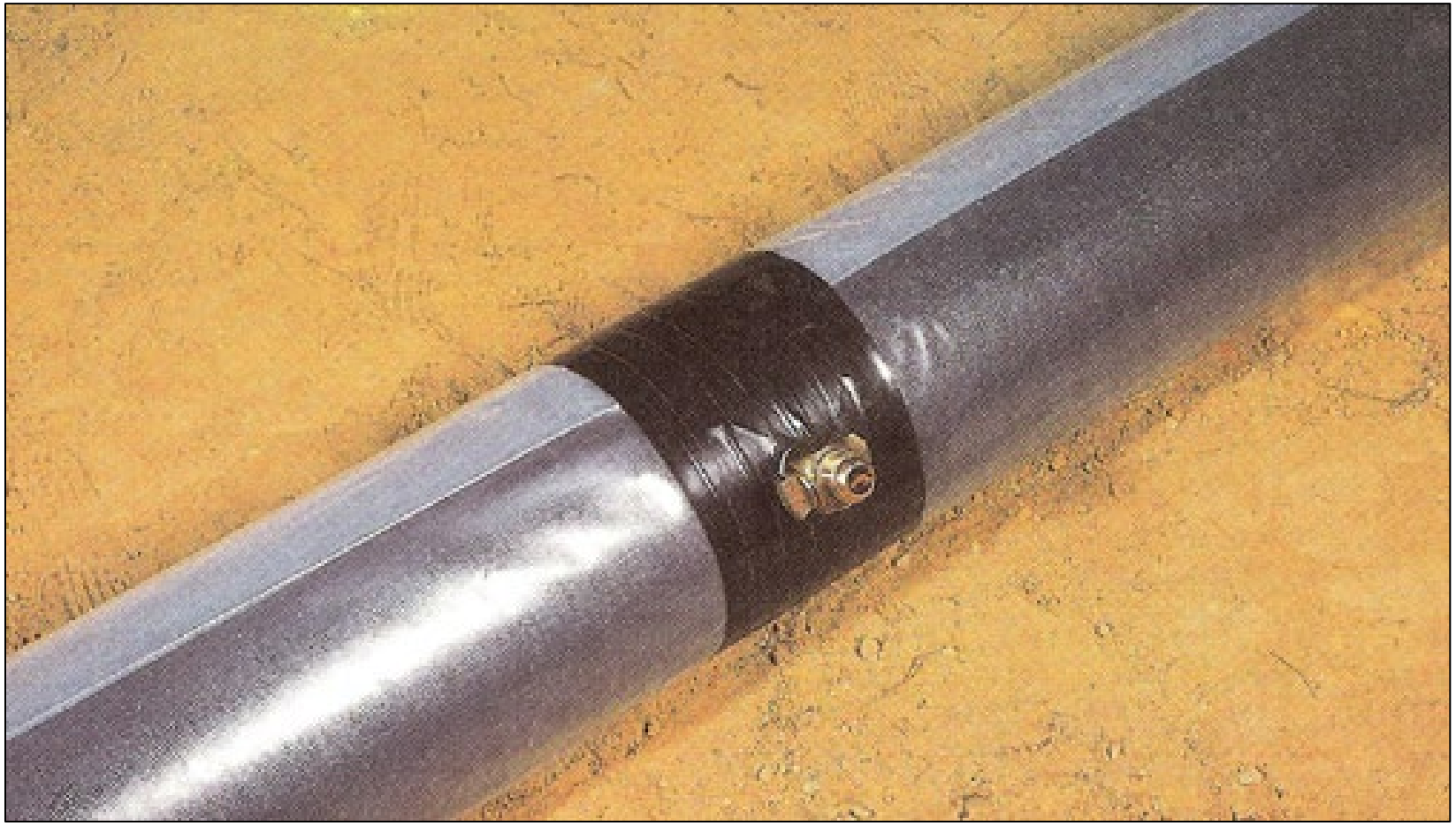

# Tapping

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# Saddle Taps

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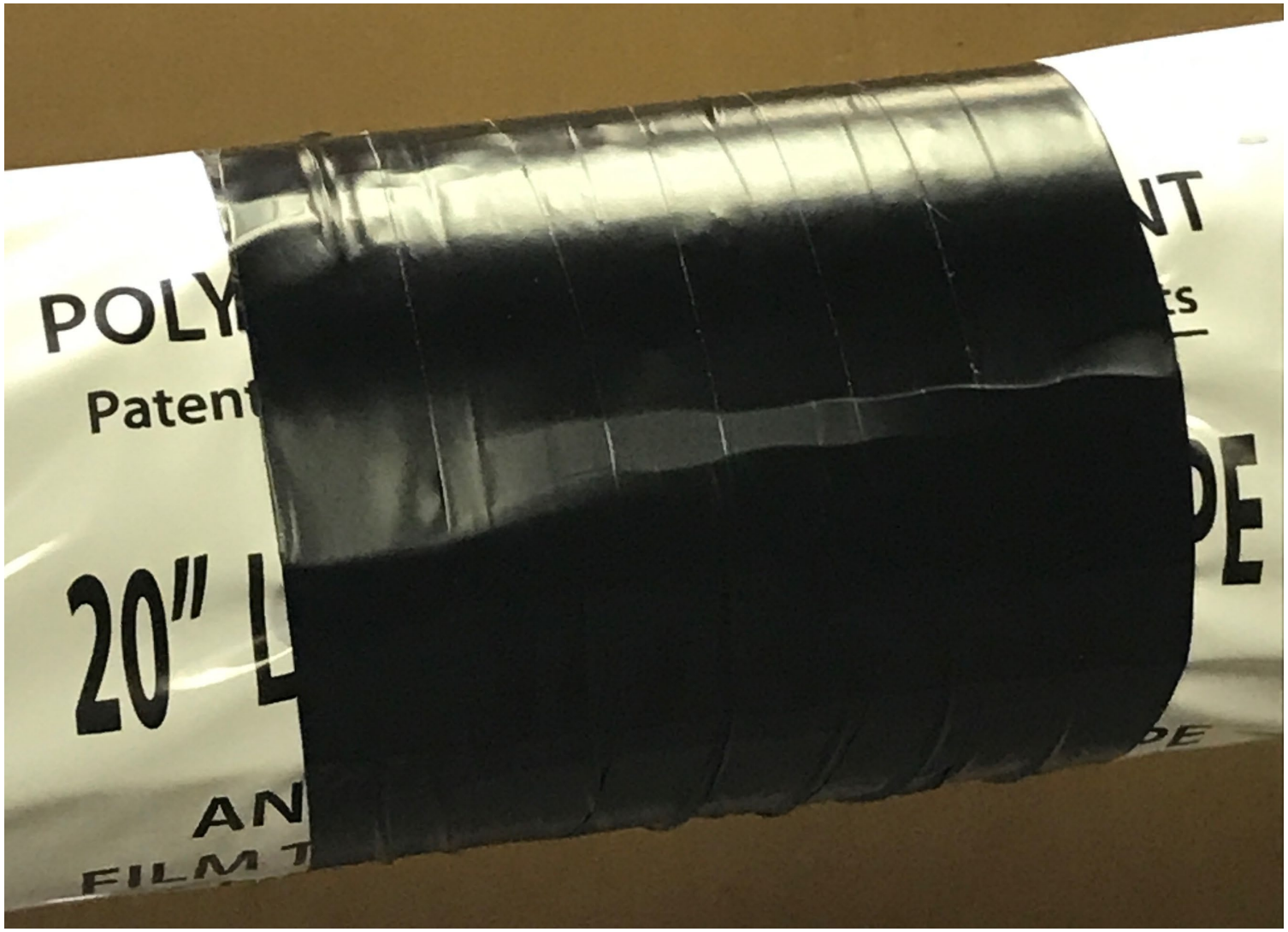

# Saddle Taps

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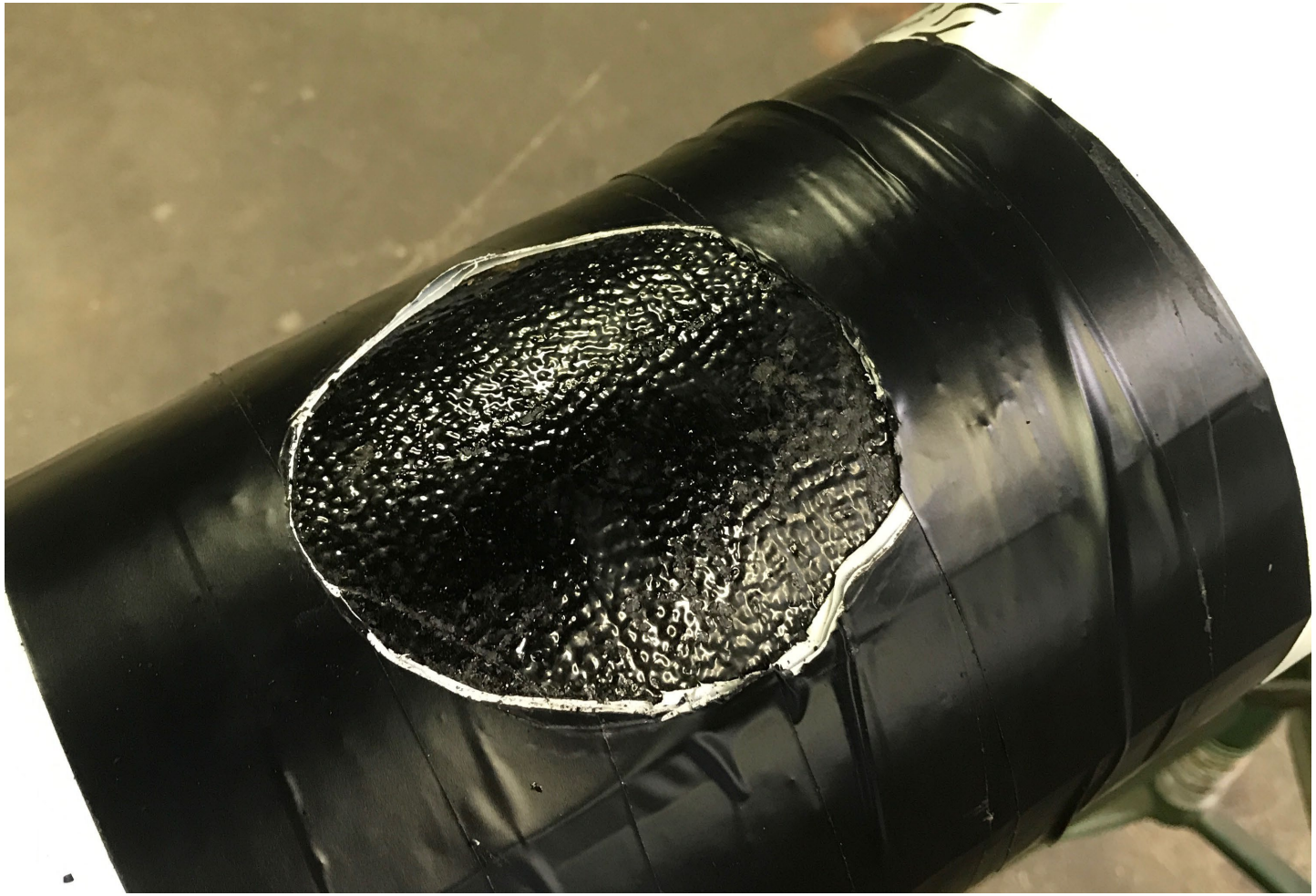

# Saddle Taps

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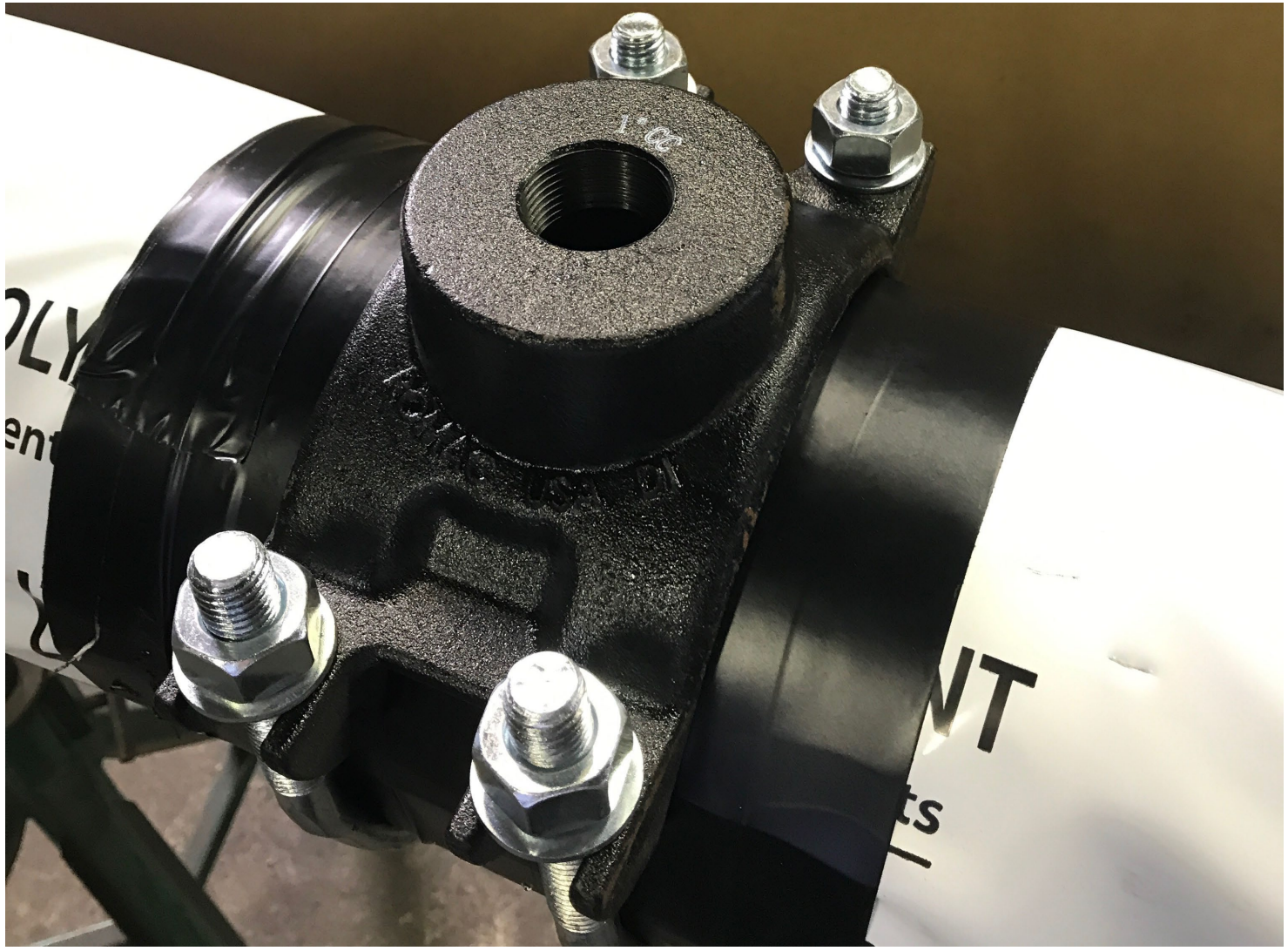


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# Saddle Taps

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# Polyethylene Encasement Investigations

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Lafourche Parish, Louisiana – 4-Inch Cast Iron Pipe
Installed: 1958 – Inspected: 2013
Resistivity: 480 ohm-cm
pH: 6.8
Redox: - 30 mV
Sulfides: Positive
Chlorides: Positive
Saturated


Lafourche Parish, Louisiana – 4-Inch Cast Iron Pipe
Installed: 1958 – Inspected: 2013
Resistivity: 480 ohm-cm
pH: 6.8
Redox: - 30 mV
Sulfides: Positive
Chlorides: Positive
Saturated

Peen Pat

Lafourche Parish, Louisiana – 4-Inch Cast Iron Pipe
Installed: 1958 – Inspected: 2013

Resistivity: 480 ohm-cm
pH: 6.8
Redox: - 30 mV
Sulfides: Positive
Chlorides: Positive
Saturated

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# Peen Patt

**Lafourche Parish, Louisiana – 4-Inch Cast Iron Pipe**
**Installed: 1958 – Inspected: 2013**

**Resistivity: 480 ohm-cm**
**pH: 6.8**
**Redox: - 30 mV**
**Sulfides: Positive**
**Chlorides: Positive**
**Saturated**

# Lafourche Parish, Louisiana

## (Clear, Low Density (8-mil) Polyethylene)

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# Lafourche Parish, Louisiana

## (Clear, Low Density (8-mil) Polyethylene)

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| Parameter | Tested | Min.* |
|---|---|---|
| Tensile Strength at Break (psi) | 2,104 | 1,200 |
| Elongation at Break (%) | 518 | 300 |

* Minimum values as set forth in AWWA C105-72

Tested Values from 2013 Inspection

# Polyethylene Encasement Investigations

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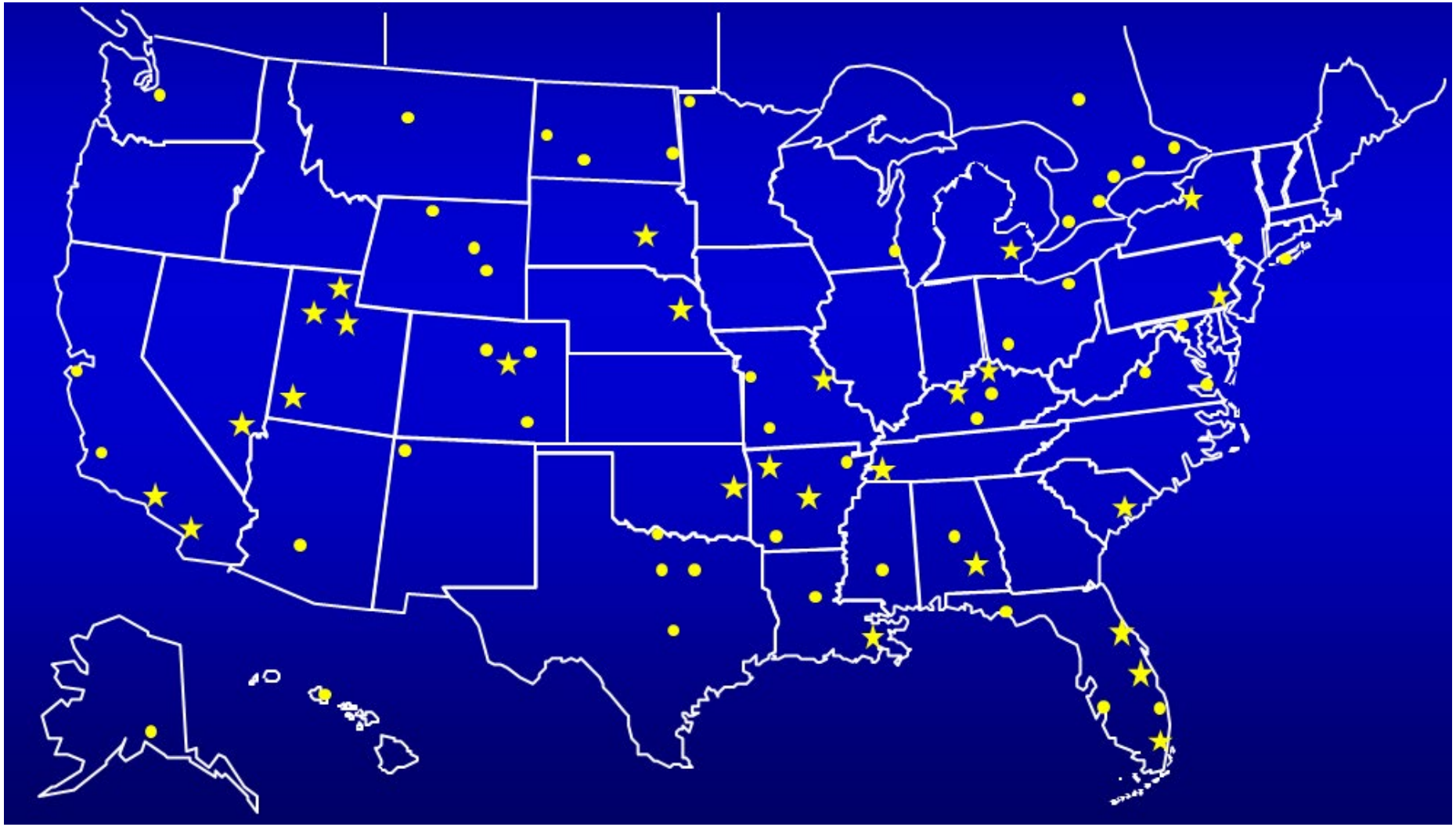

# Polyethylene Film Comparison

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| | Linear Low-Density | HDCL |
|---|---|---|
| Minimum Thickness (mil) | 8 | 4 |
| Dielectric Strength (V/mil) | 800 | 800 |
| Tensile Strength (psi) | 3,600 | 6,300 |
| Elongation (%) | 800 | 100 |
| Impact Resistance (g) | 600 | 800 |
| Tear Resistance (gf) | 2,550 | 250 |

# Corrosion Probes

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# Florida Everglades Corrosion Testing
## (above ground monitoring)

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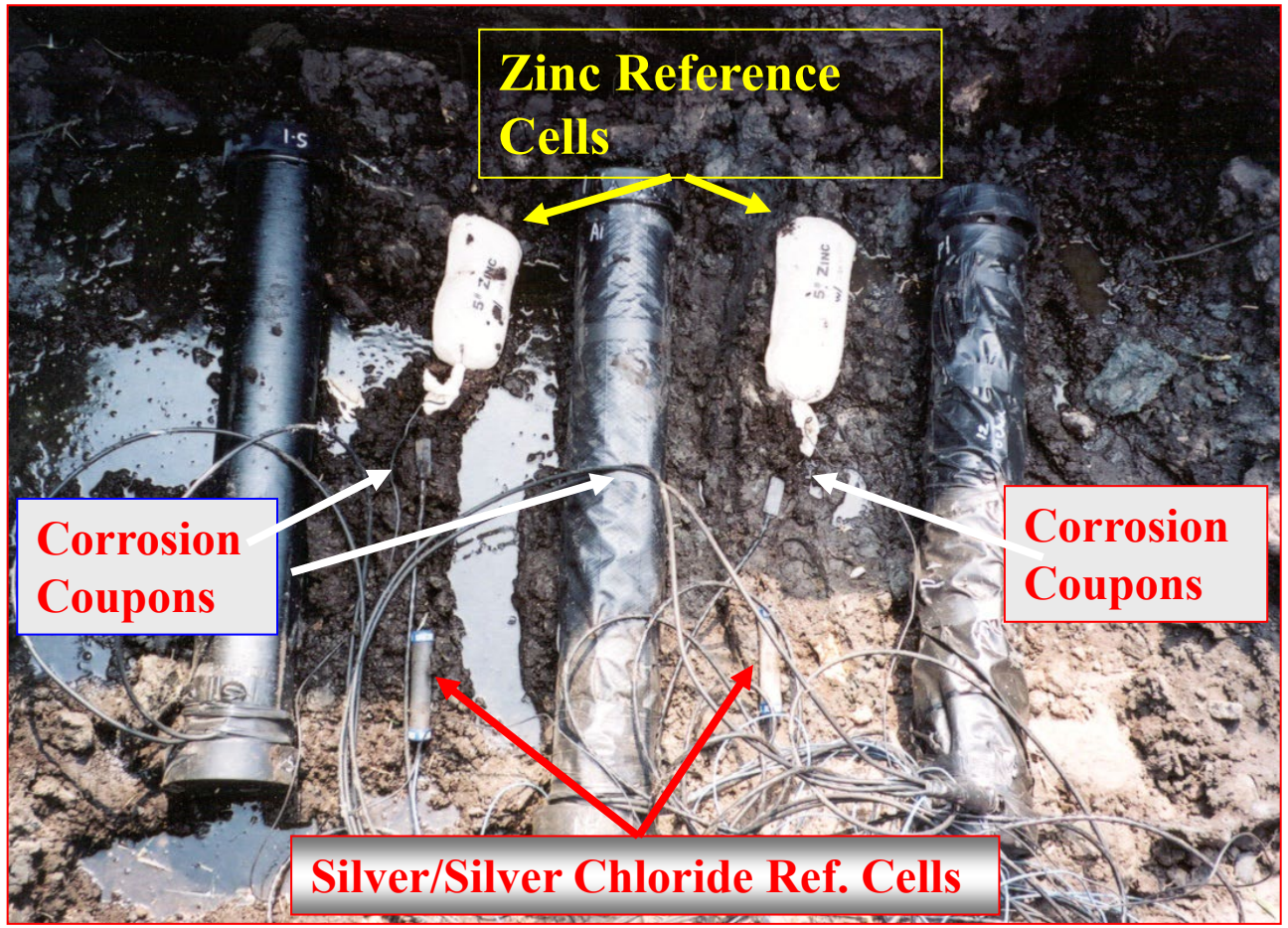


# Corrosion Probes under Polyethylene Encasement

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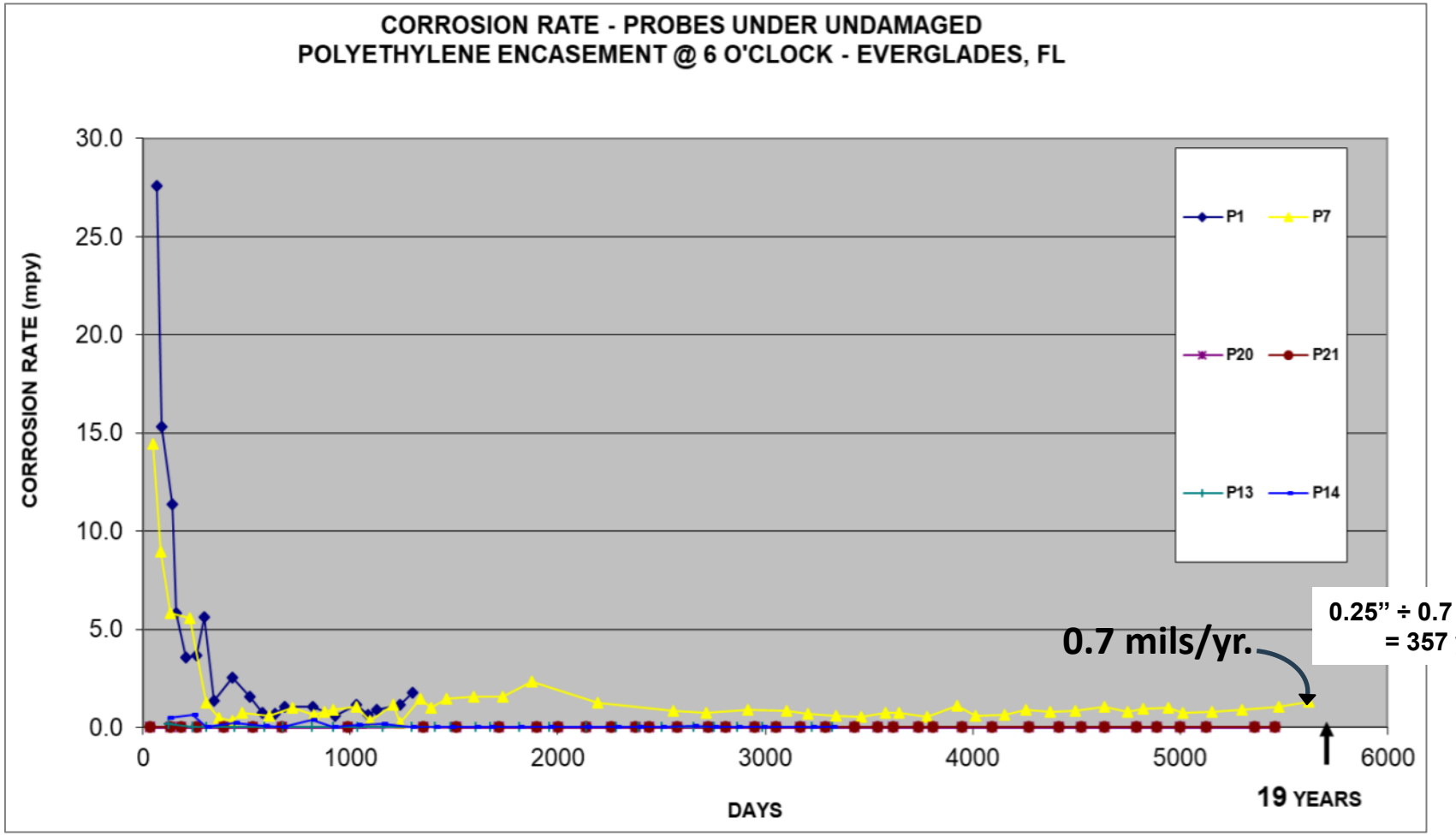

# *V-Bio*® Polyethylene Encasement

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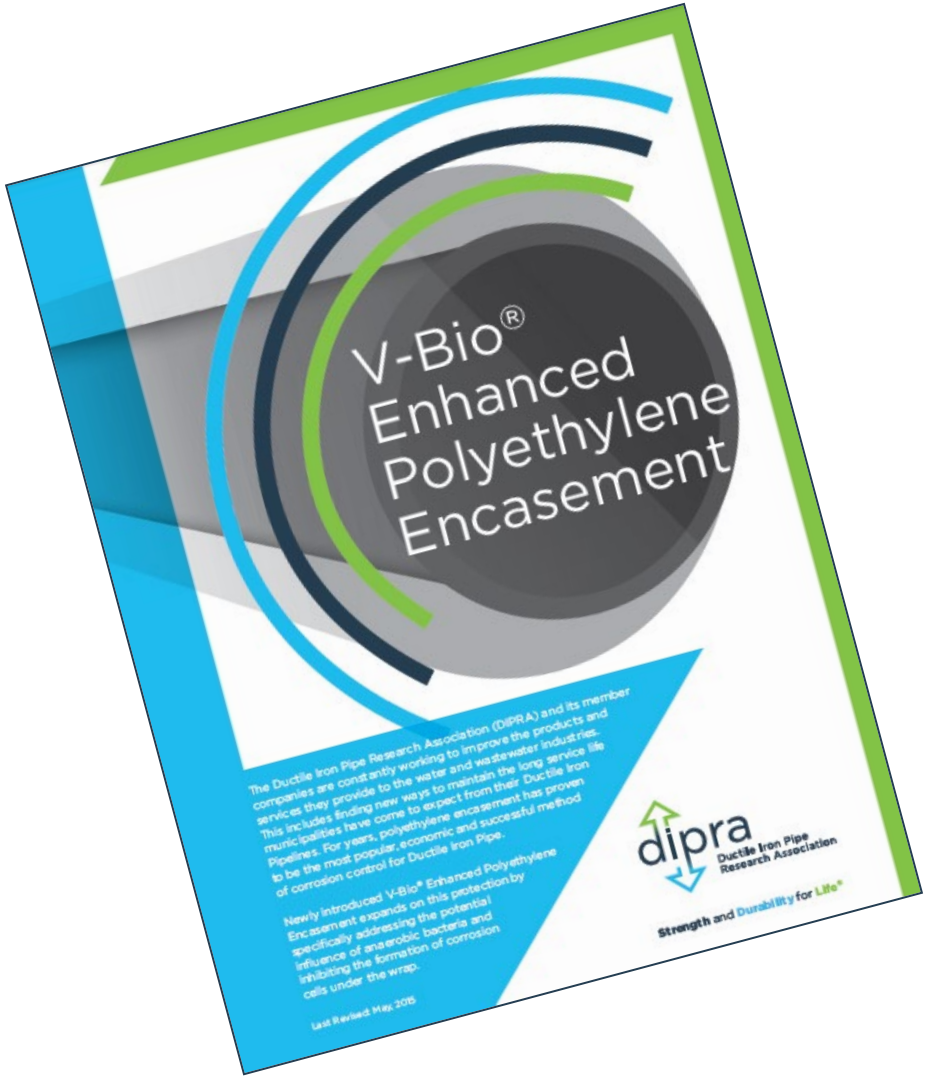

# RECOMMENDED ADDITIONAL RESEARCH

(Polyethylene Encasement with an Anti-microbial & Corrosion Inhibitor in film - V-BIO™ )

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Research Association

# *V-Bio*® Polyethylene Encasement

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# Corrosion Probes under *V-Bio*™ Polyethylene Encasement

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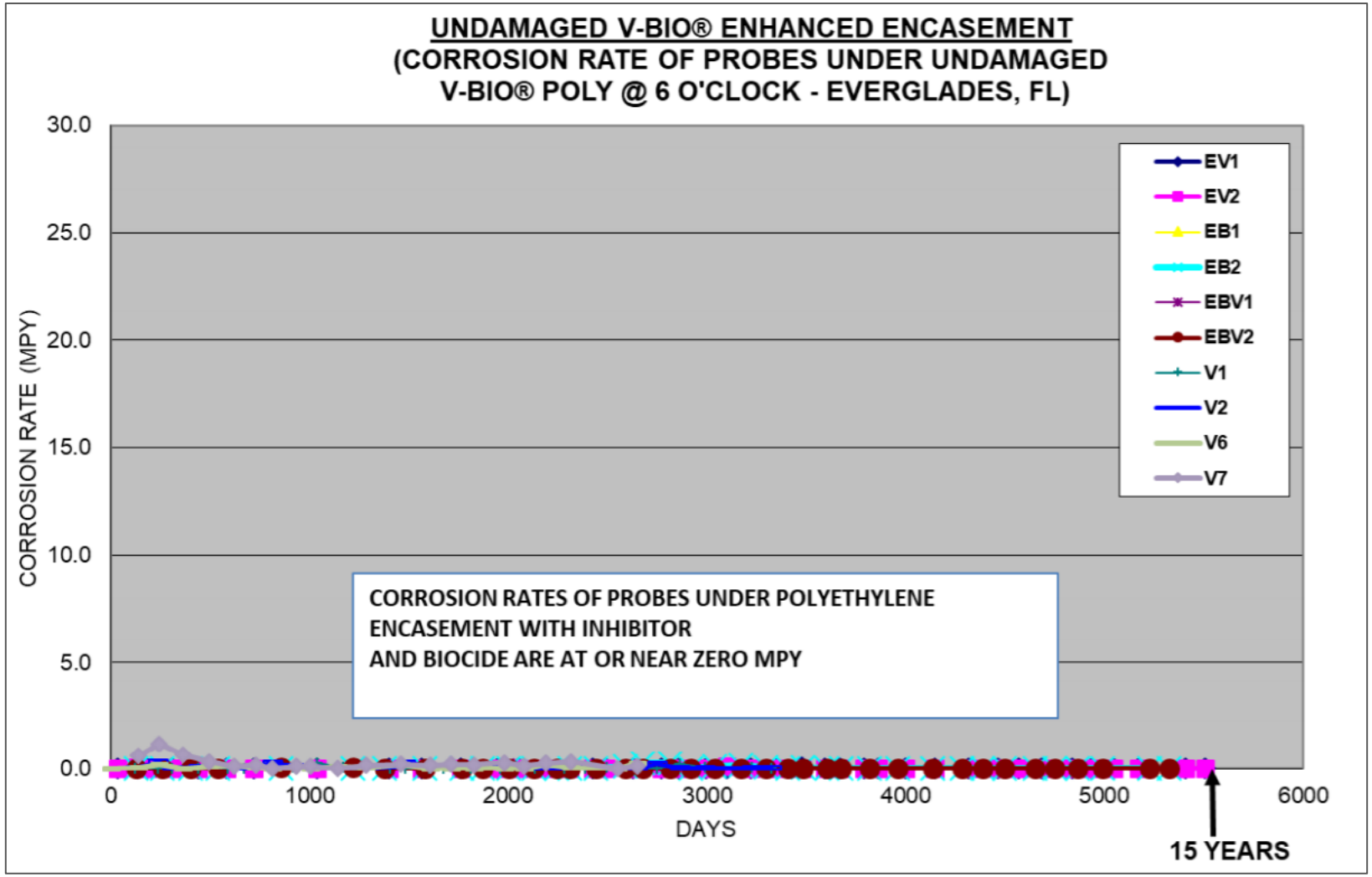

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# Design Decision Model (DDM®)

# The Design Decision Model® (DDM®)

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# Likelihood Factors

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- Resistivity
- Redox
- pH
- Sulfides
- Moisture Content
- Known corrosive environs
- Chlorides
- Bi-metallic connections
- Ground water influence

# Consequence Factors

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- Pipe Size
- Pipe Location
- Depth of Cover
- Alternative Water Supply?

# The Design Decision Model® (DDM®)

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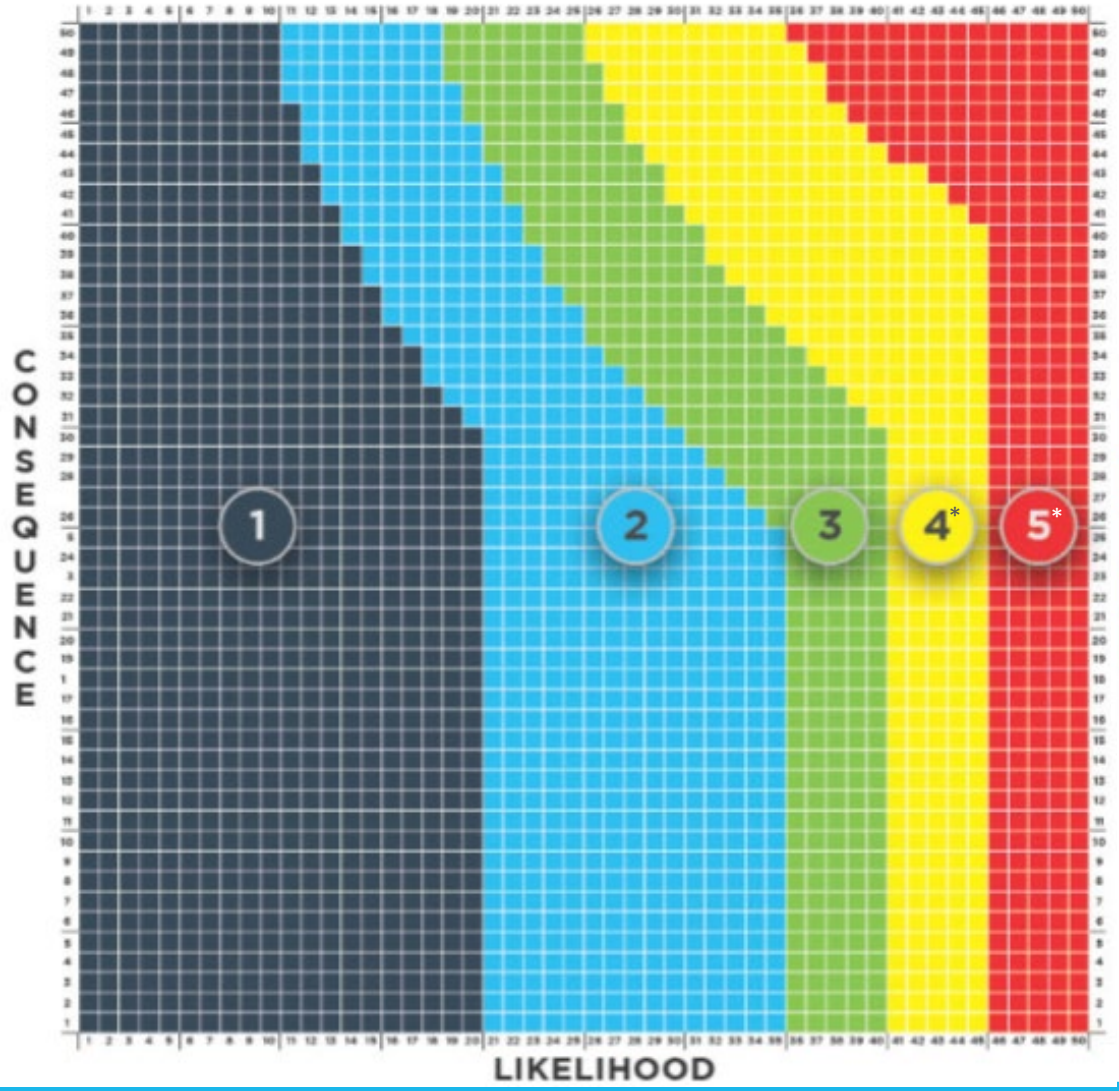


| Recommendations | |
|---|---|
| 1 | As manufactured with shop coat |
| 2 | V-Bio® Enhanced Polyethylene Encasement |
| 3 | V-Bio® Enhanced Polyethylene Encasement, or<br>V-Bio® Enhanced Polyethylene Encasement with Joint Bonds |
| 4 | V-Bio® Enhanced Polyethylene Encasement with Metallized Zinc Coating, or<br>V-Bio® Enhanced Polyethylene Encasement with Life Extension Cathodic Protection |
| 5 | V-Bio® Enhanced Polyethylene Encasement with Metallized Zinc Coating, or<br>V-Bio® Enhanced Polyethylene Encasement with Cathodic Protection |

* Recommendations in Zones 4 and 5 recognize a practical difference between distribution and transmission mains. Distribution mains are generally smaller sized pipes, with the final classification to be defined by the pipeline owner. Cathodic protection should be considered where external corrosion is a significant risk or where pipe repairs/replacements would be cost prohibitive.

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# Damaged Polyethylene
vs.
# Damaged Bonded Coatings
(Conventional DIP)

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- 3 test sites (Everglades, Nevada & Hughes)

- 6 year results
  - Accelerated pitting on bonded coatings
  - Not accelerated for polyethylene encasement

# Everglades Test Site

## (Zinc-coated Pipe with Damage & Damaged V-Bio®)

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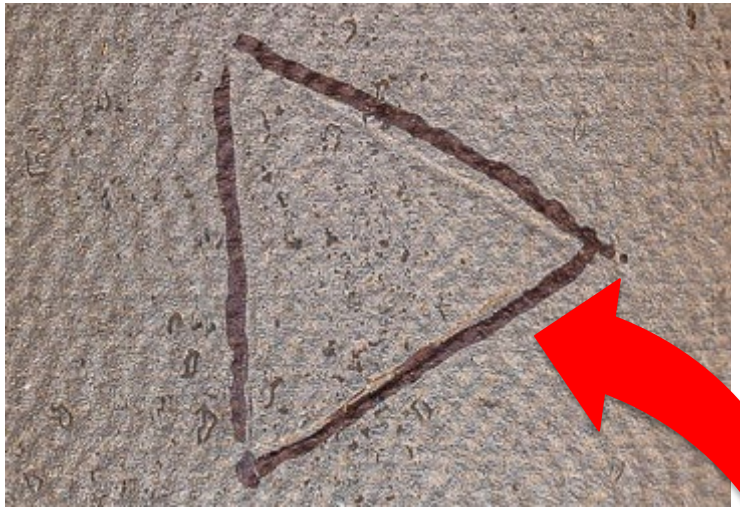
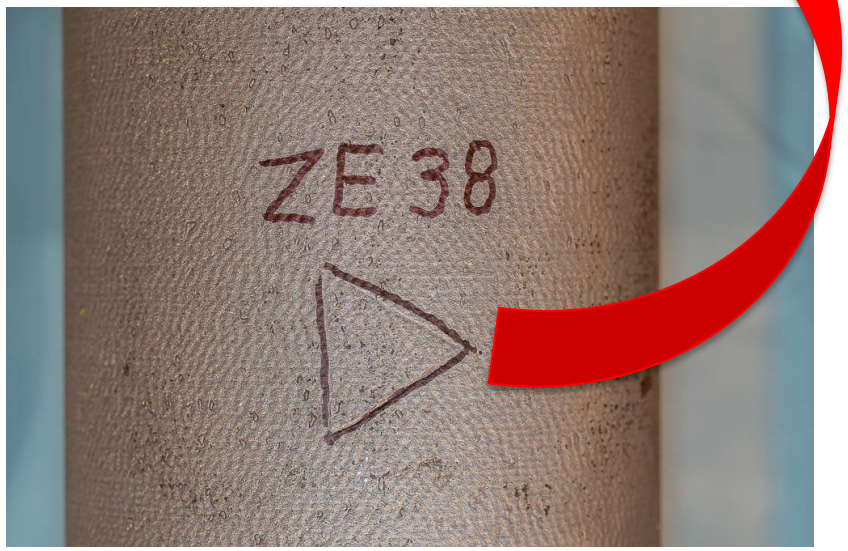
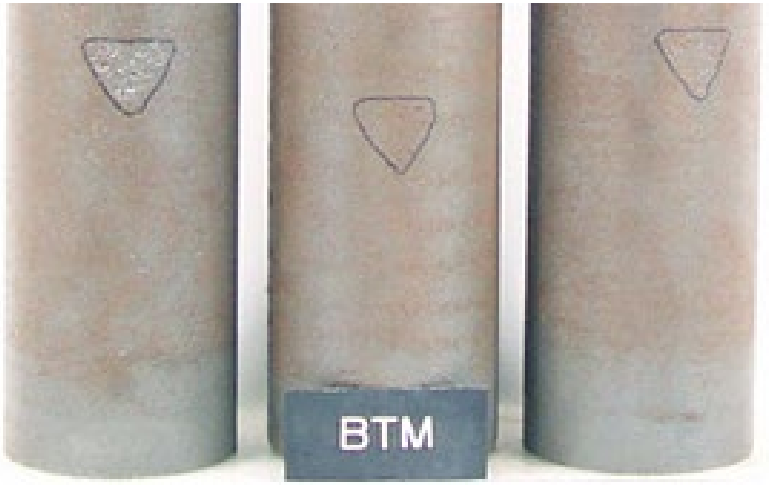






Polyurethane Coating




Polyethylene Encased

# Sacrificial Anode Cathodic Protection

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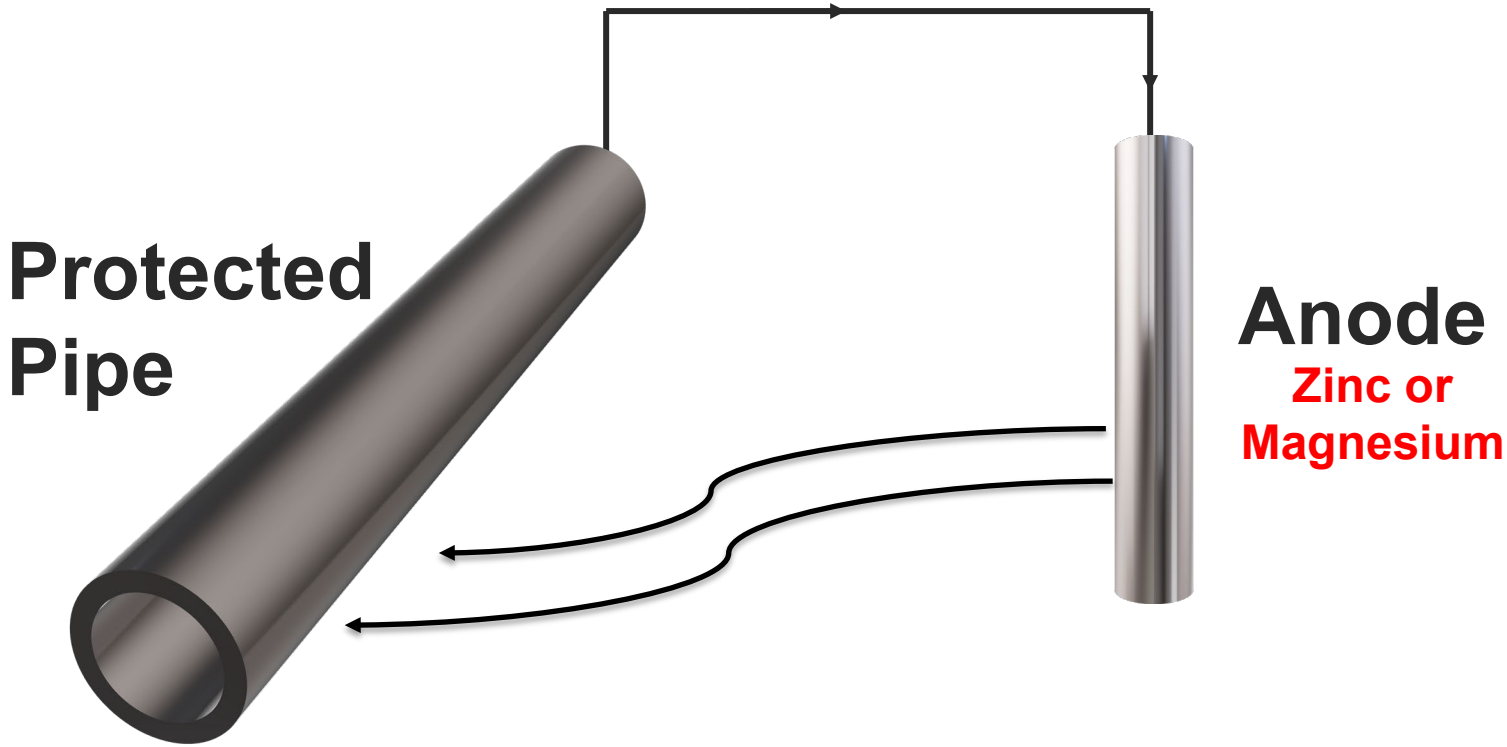

# In-Place Cathodic Protection

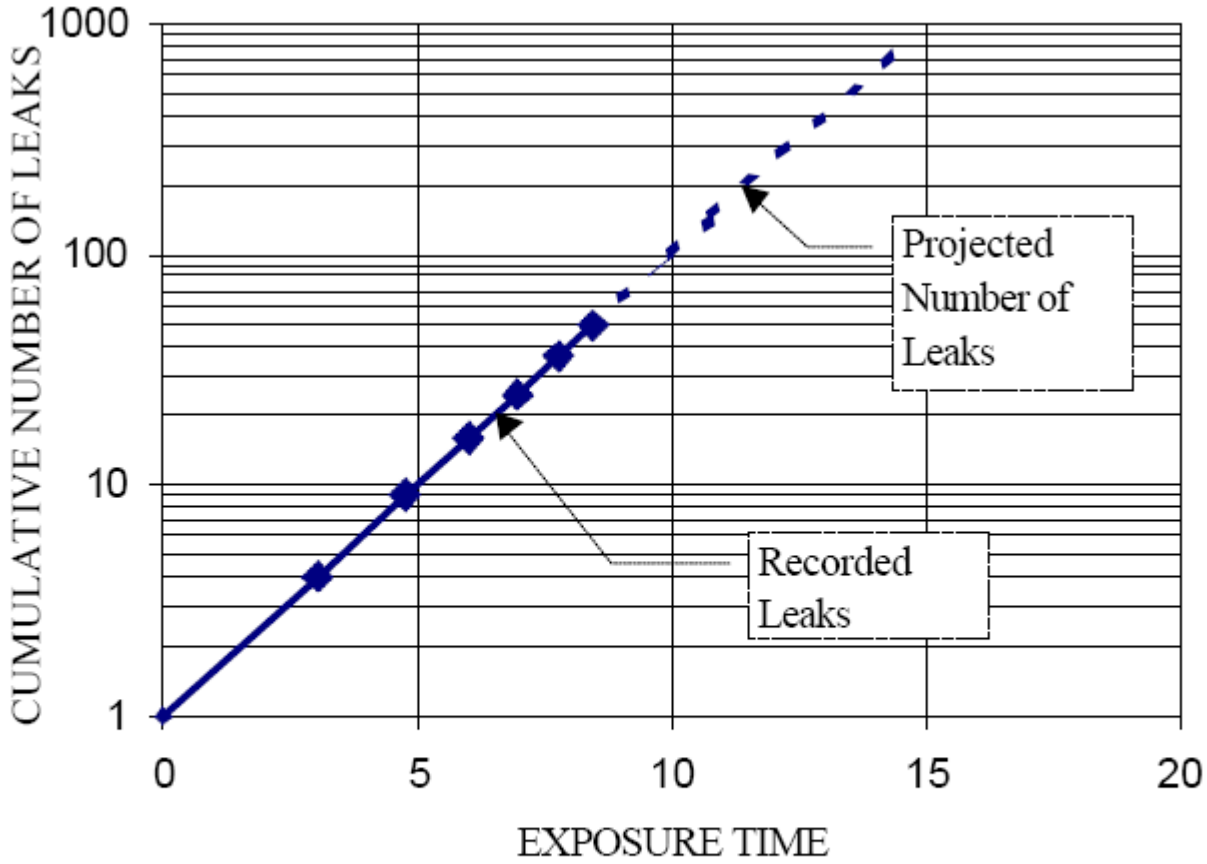


Figure 3. Typical cumulative leak frequency vs. time curve. The exponential leak rate is typical of corrosion processes.

# In-Place Cathodic Protection

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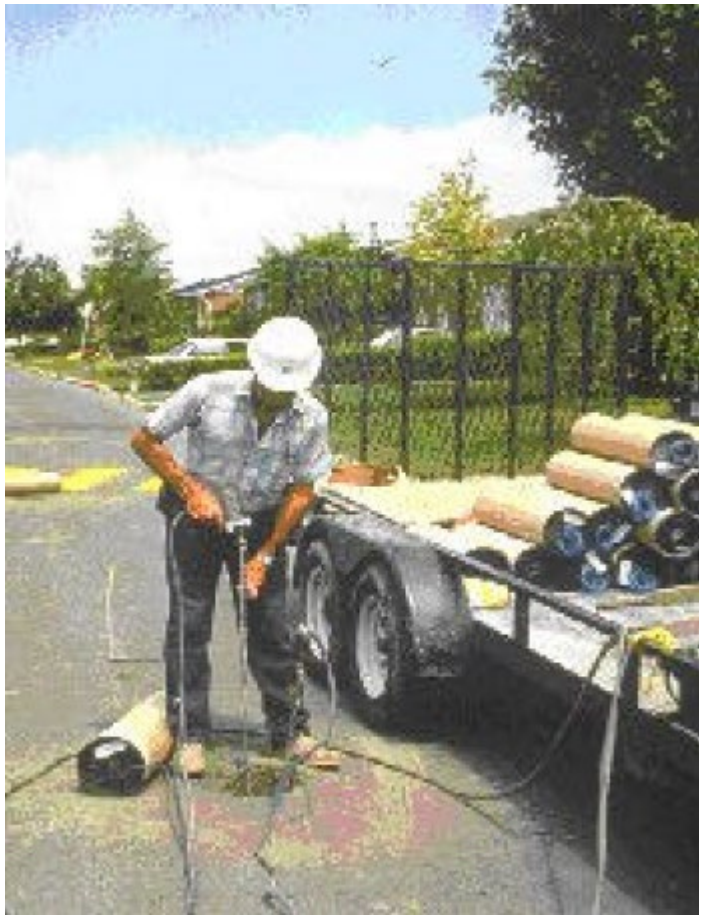
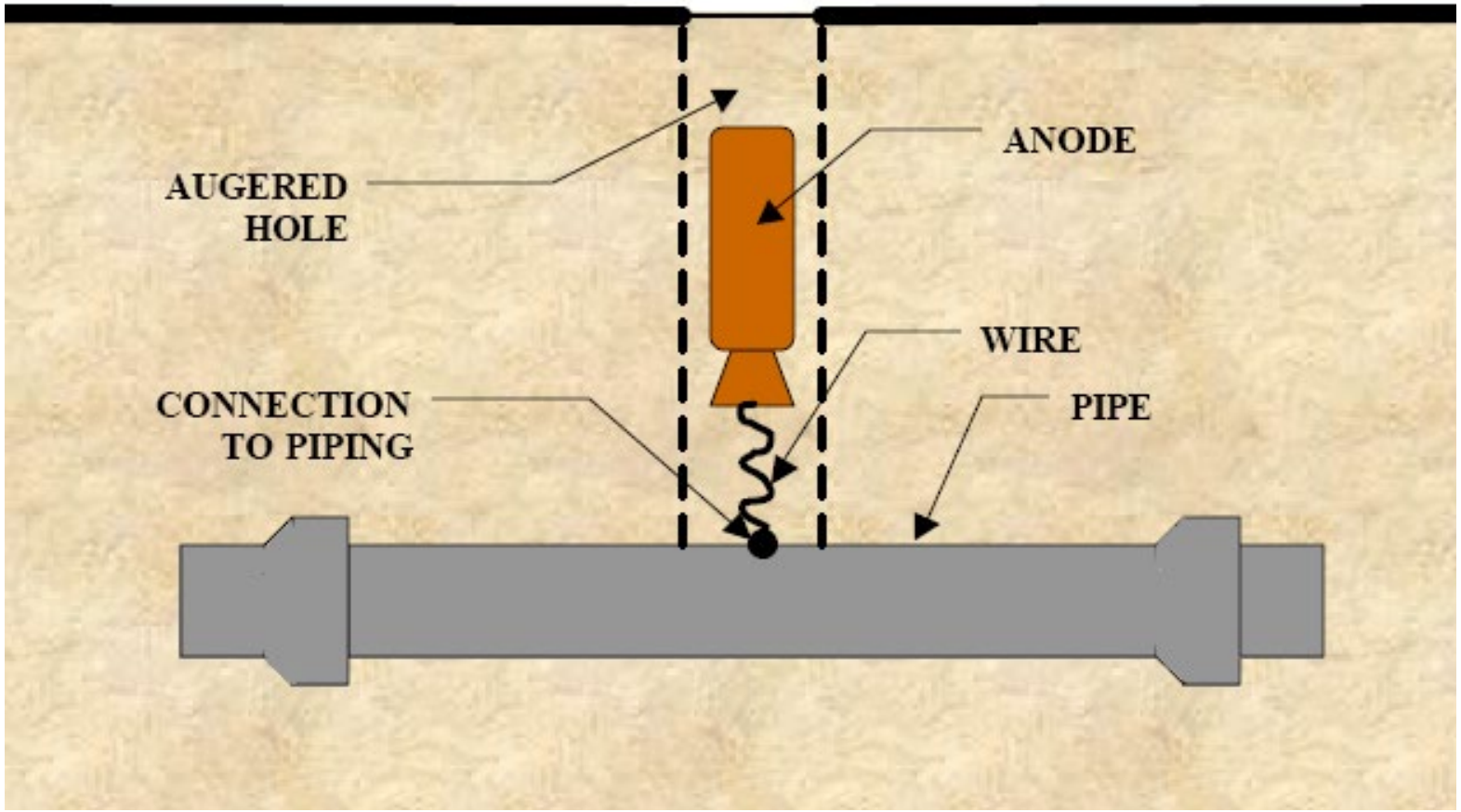
Using auger to drill anode holes



Attaching anode wire to pipe
using electrical resistance welding

# In-Place Cathodic Protection



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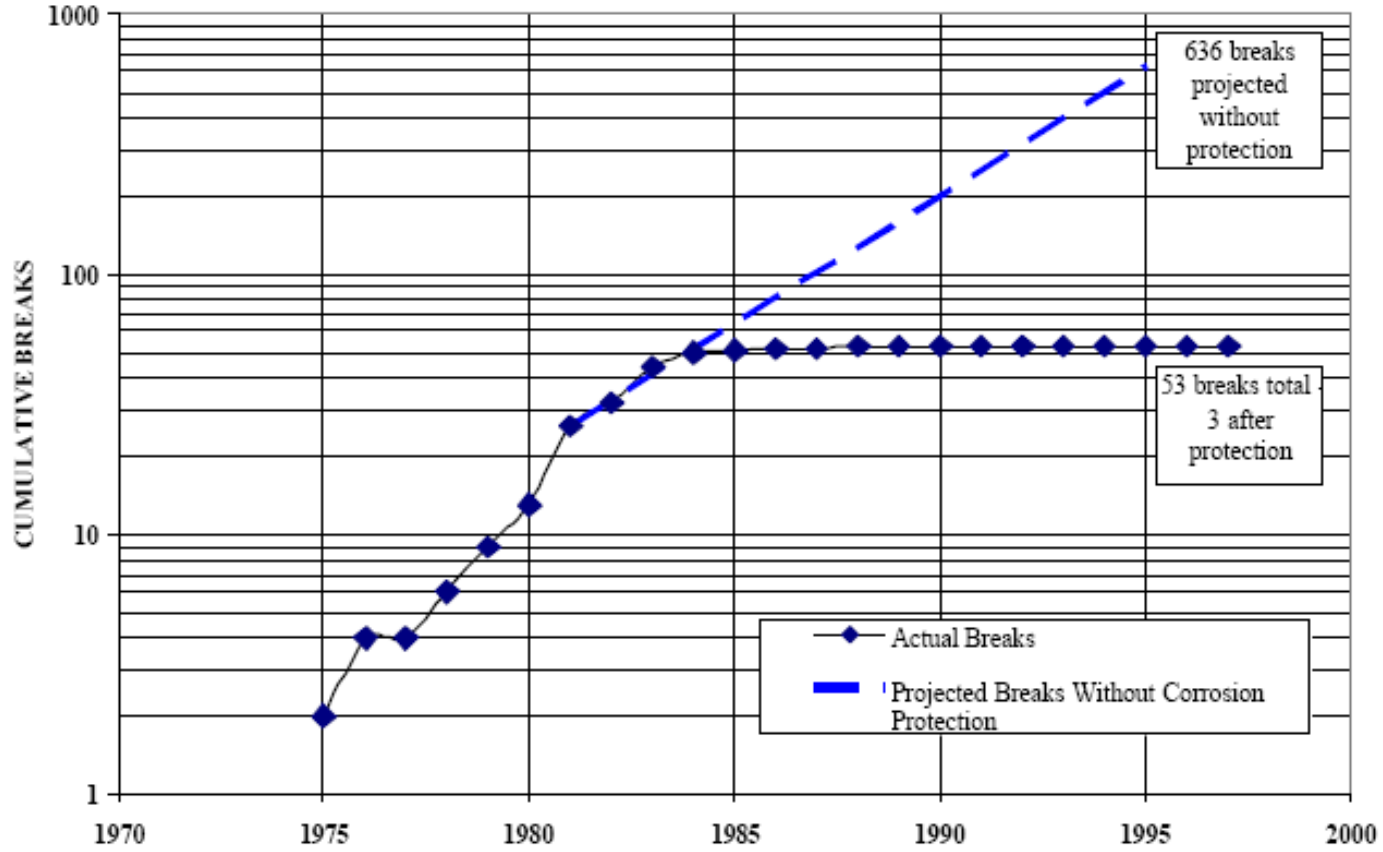


Figure 7. Cumulative number of breaks before and after anodes installed, Durham, Canada. Corrosion protection installed 1984 for a total of 1.1 miles of pipe

# Questions ?

# Thank you!


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Regional Engineer

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