Ductile Iron Pipe Research Association

Achieving a Century of Service

Pacific Northwest Section AWWA

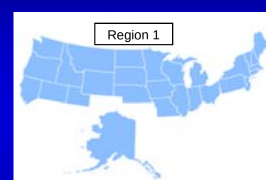
May 7, 2014

DIPRA 1915 CIPRA

DIPRA Member Companies

American Cast Iron Pipe Company
Canada Pipe Company Ltd.
Atlantic States
CLOW
McWane
PSCIPCO
U.S. Pipe

Regional Engineer Program



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Regional Director

NACE Certified Corrosion Specialist

DIPRA Website

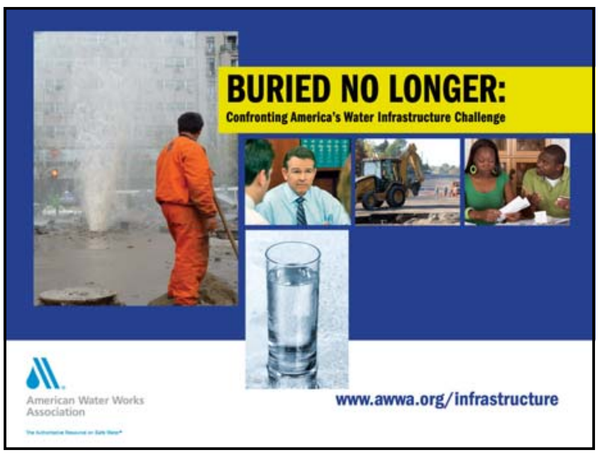
(www.dipra.org)

AWWA Standards

ANSI/AWWA C104/A21.4	Cement-Mortar Linings
ANSI/AWWA C105/A21.5	Polyethylene Encasement
ANSI/AWWA C110/A21.10	Ductile-Iron and Gray-Iron Fittings
ANSI/AWWA C111/A21.11	Rubber-Gasket Joints
ANSI/AWWA C115/A21.15	Flanged Ductile-Iron Pipe
ANSI/AWWA C116/A21.16	Fusion-Bonded Epoxy Coatings for Fittings
ANSI/AWWA C150/A21.50	Thickness Design
ANSI/AWWA C151/A21.51	Ductile-Iron Pipe, Centrifugally Cast
ANSI/AWWA C153/A21.53	Ductile-Iron Compact Fittings
ANSI/AWWA C600	Installation of Ductile-Iron Water Mains

Versailles, France

Installed 1664



Buried No Longer

"this report…constitutes the most thorough and comprehensive analysis ever undertaken of the nation's drinking water infrastructure renewal needs."

p. 5

Figure 5: Average Estimated Service Lives by Pipe Materials (average years of service)

Derived Current Service Lives (Years)	CI	CICL (LSL)	CICL (SSL)	DI (LSL)	DI (SSL)	AC (LSL)	AC (SSL)	PVC	Steel	Conc & PCCP
Northeast Large	130	120	100	110	50	80	80	100	100	100
Midwest Large	125	120	85	110	50	100	85	55	80	105
South Large	110	100	100	105	55	100	80	55	70	105
West Large	115	100	75	110	60	105	75	70	95	75
Northeast Medium & Small	115	120	100	110	55	100	85	100	100	100
Midwest Medium & Small	125	120	85	110	50	70	70	55	80	105
South Medium & Small	105	100	100	105	55	100	80	55	70	105
West Medium & Small	105	100	75	110	60	105	75	70	95	75
Northeast Very Small	115	120	100	120	60	100	85	100	100	100
Midwest Very Small	135	120	85	110	60	80	75	55	80	105
South Very Small	130	110	100	105	55	100	80	55	70	105
West Very Small	130	100	75	110	60	105	65	70	95	75

LSL indicates a relatively long service life for the material resulting from some combination of benign ground conditions and evolved laying practices etc.
SSL indicates a relatively short service life for the material resulting from some combination of harsh ground conditions and early laying practices, etc.

8 BURIED NO LONGER: CONFRONTING AMERICA'S WATER INFRASTRUCTURE CHALLENGE

Buried No Longer - Average DI Life

SSL – 56 years
LSL– 110 years

SSL = Relatively Short Service Life
LSL = Relatively Long Service Life

Figure 5, p. 8

Buried No Longer - Average Pipe Life

SSL = Relatively Short Service Life based upon some combination of harsh ground conditions and early laying practices

LSL = Relatively Long Service Life based upon some combination of benign ground conditions and evolved laying practices

Figure 5, p. 8

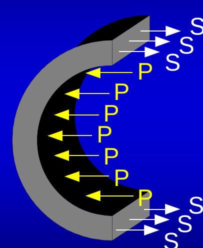
To Achieve a Century of Service from your DI Pipe…

- Design
- Installation
- Corrosion Control
- O & M

Thickness Design of Ductile Iron Pipe

From ANSI/AWWA C150/A21.50

Internal Pressure - DIP



$$t = \frac{P\,(D)}{2\,S}$$

D = Outside Diameter

P = $2(P_w + P_s)$

P_w = Max. Working Pressure

P_s = Surge Pressure

S = Min. Allowable Yield = 42,000 psi

t = Required Thickness

Total Calculated Thickness

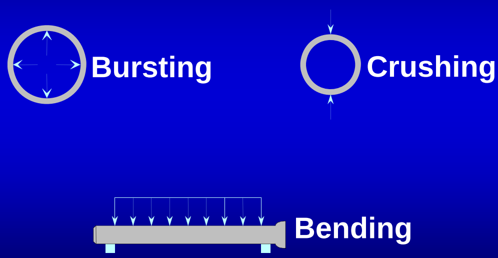
Net Thickness plus Service Allowance plus Casting Tolerance

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

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

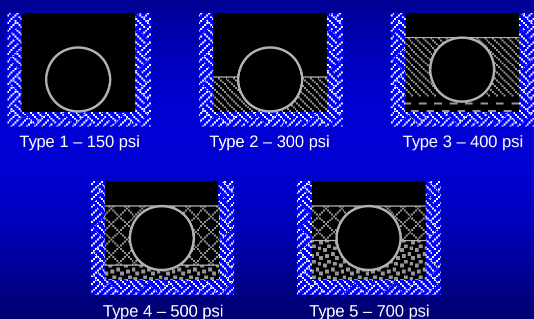
* Calculated thickness for these sizes & pressure classes are less than those shown above. Presently, these are the lowest nominal thickness available in these sizes.

Forces Acting on Pipe



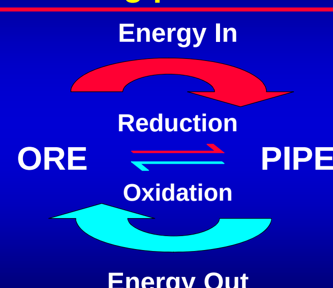
Ductile Iron Beam Strength

Laying Conditions

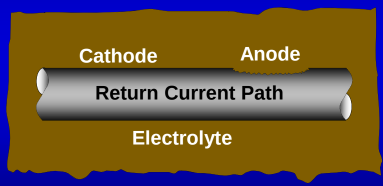


Corrosion Control For Ductile Iron Pipe

Corrosion is a naturally occurring phenomenon



The underground pipe corrosion cell . . .



DIPRA Research Examples

- 1928 – Strength of Corrosion Products
- 1940 – Coatings
- 1949 – Bolt Corrosion
- 1952 – Coatings and Loose Polyethylene
- 1971 – Stray Current
- 1989 – Copper Service

DIPRA Test Sites

DIPRA Research

10 Point Soil Evaluation

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

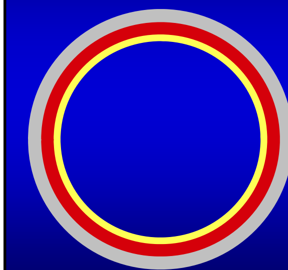
Corrosive Environments

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

Corrosion Control Methods

- Additional Wall Thickness
- Trench Improvements
- As-manufactured
- Polyethylene Encasement
- Cathodic Protection

Total Calculated Thickness



Net Thickness plus
Service Allowance plus
Casting Tolerance

Everglades Test Site

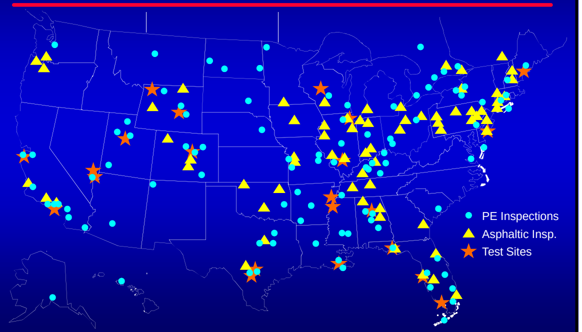
Everglades, FL – 6-inch D.I.P
Exposure 4.25 years

Trench Material Improvements

75 Years of Research


Corrosion and corrosion control of iron pipe:
75 years of research

Polyethylene Encasement Inspections, Asphaltic Coated Inspections and DIPRA Test Sites



Non-corrosive Soils
Mean Deepest Pitting Rate

Pipe Condition	Number of Pipe	Mean Deepest Pitting Rate (in/yr)	Years to Penetration*
As-manufactured	43	0.0007	375
Polyethylene Encased	12	0.0000	Infinity

* Based on single deepest pit in each specimen, linear pitting rate and minimum pipe wall thickness of 0.25 inches

Polyethylene Encasement

Los Angeles, CA – 47 Years

Colonie, NY – 47 Years

Chicago, IL – 44 Years

Sterling, CO – 41 Years

Corrosive Soils
Mean Deepest Pitting Rate

Pipe Condition	Number of Pipe	Mean Deepest Pitting Rate (in/yr)	Years to Penetration*
Sandblasted	102	0.025	10
Bare	22	0.015	17
As-manufactured	103	0.010	24
Polyethylene Encased	151	0.00045	552

* Based on single deepest pit in each specimen, linear pitting rate and minimum pipe wall thickness of 0.25 inches

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

Polyethylene Encasement Investigations

Simulated Polyethylene Encasement Study

The pH of the moisture under the wrap tends to increase

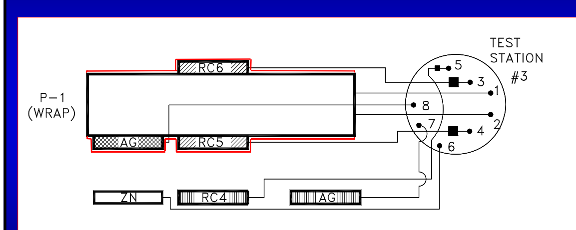
The dissolved oxygen within this moisture decreases very rapidly

Both tend to make the dominant, ultimate corrosion mechanism –

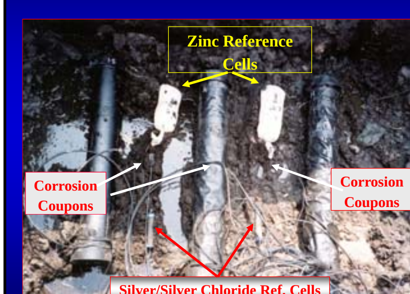
Surface Oxidation

Florida Everglades Corrosion Testing

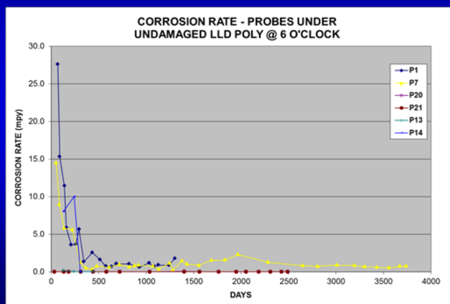
(above ground monitoring)



Florida Everglades Corrosion Testing



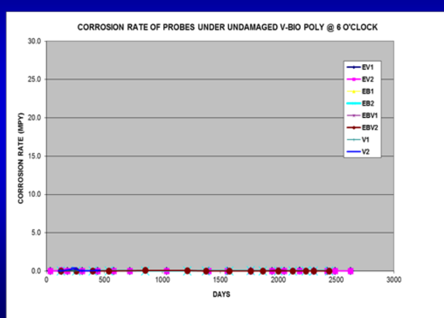
Corrosion Probes under Polyethylene Encasement



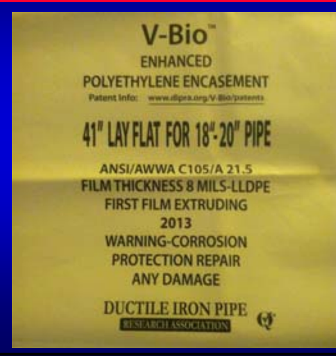
RECOMMENDED ADDITIONAL RESEARCH

(Polyethylene Encasement with Corrosion Inhibitor & Biocide in film - V-BIO)

Corrosion Probes under *V-Bio* Polyethylene Encasement



V-Bio™ Polyethylene



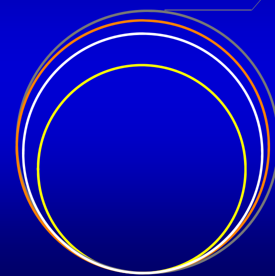
Advantages of Polyethylene Encasement

- Inexpensive
- Easily installed and repaired
- Eliminates concentration cells
- Yields to soil stresses
- Shields against stray current
- Does not deteriorate underground
- Passive protection system

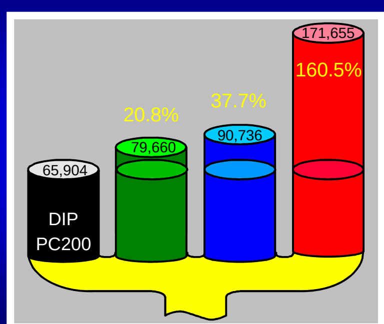
Hydraulics

- "C" Factor
- Inside Diameter

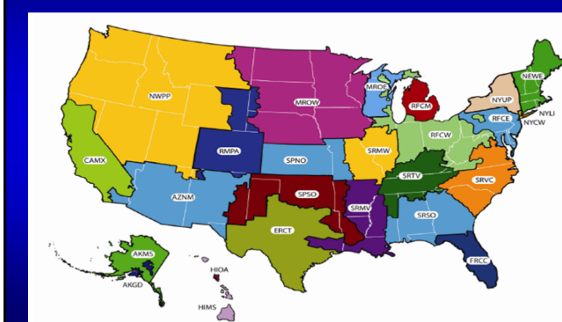
Actual Inside Diameters

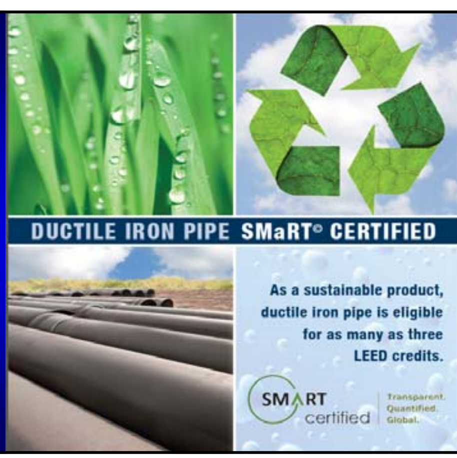


Annual Pumping Cost



Carbon Footprint





Buried No Longer – P. 17

Estimated Distribution of Mains by Material Over Time - 2000 - 2030

10" and smaller – DI 55%, PVC 45%

Larger than 10" – DI 60%, Steel 15% & PCCP 25%

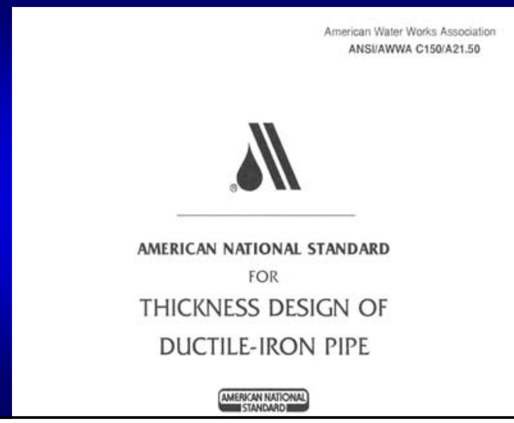
No SSL!

Buried No Longer

Average DI life (LSL) – 110 years

LSL = Relatively Long Service Life

Figure 5, p. 8


American Water Works Association
ANSI/AWWA C150/A21.50

AMERICAN NATIONAL STANDARD
FOR
THICKNESS DESIGN OF
DUCTILE-IRON PIPE

AMERICAN NATIONAL STANDARD

Nominal Thickness for Standard Pressure Classes of DIP

From Table 5 of ANSI/AWWA C150/A21.50

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Integrity isn't Expensive it's **PRICELESS**

Ductile Iron Pipe

The Right Decision