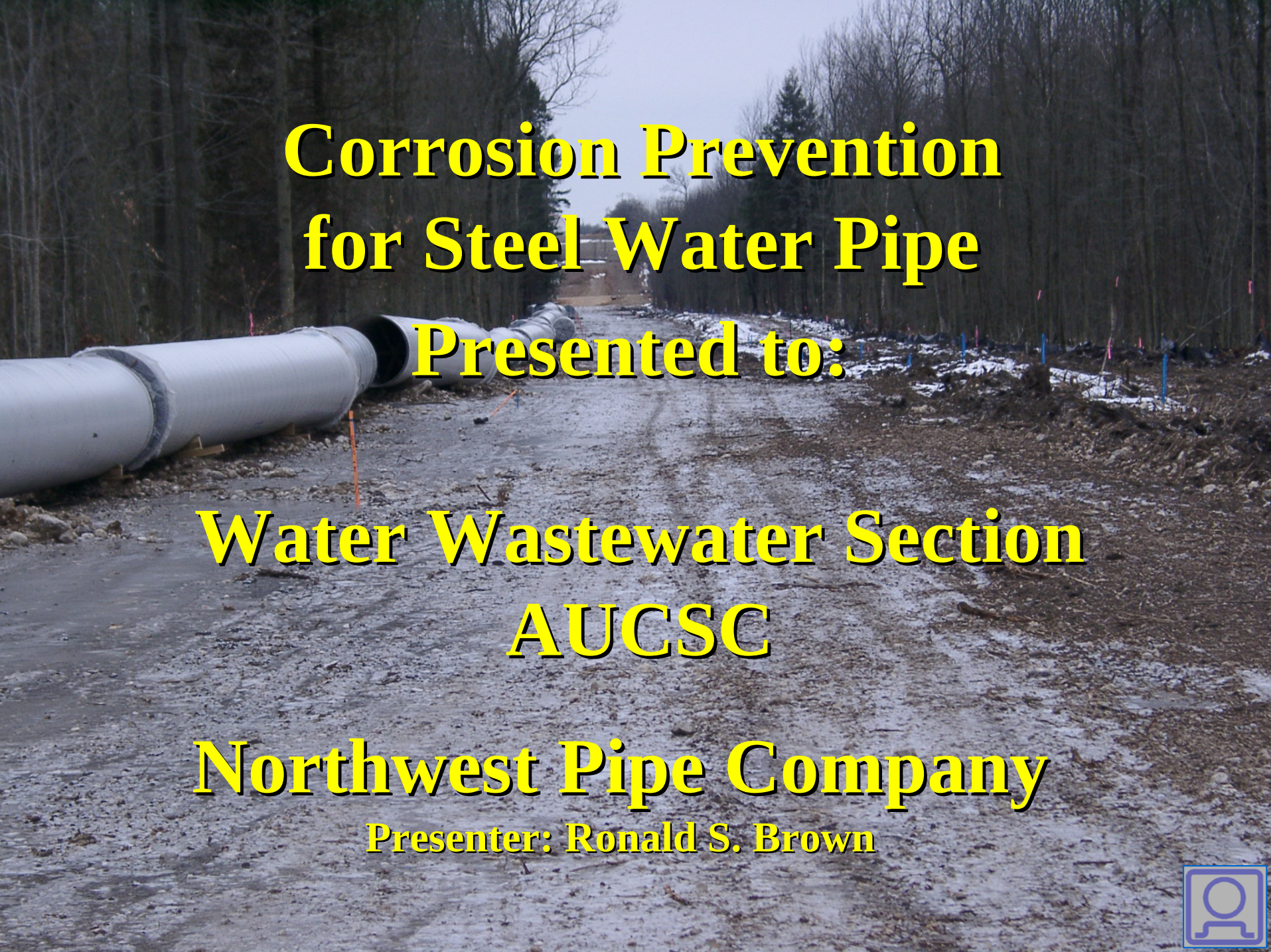


Corrosion Prevention for Steel Water Pipe

Presented to:

Water Wastewater Section AUCSC

Northwest Pipe Company

Presenter: Ronald S. Brown

Steel Water Pipe Corrosion Prevention

Presentation Overview

- History
- Applications
- Steel Pipe Manufacturing
- Pipe Coatings-Importance
- Corrosion Prevention, Asset Mgt.

April 2007
Vol. 53, No. 2

Applications

Water Transmission

History and Overview-

Manufacturing Capabilities

- Spiral welded pipe
  - 17” to 156” diameter
  - Lengths up to 60’
  - 0.105” to .875” wall thickness
- Rolled & welded pipe
  - ≥42” X 2.0”
- Linings and coatings
  - CML, epoxy, polyurethane, & paint systems
  - CMC, CTE, tape, Pritec®, epoxy, polyurethane, & paint
- End treatments
  - Welded & non-welded gasket joints


KOMATSU
PC650
9/7/1999 11:00am

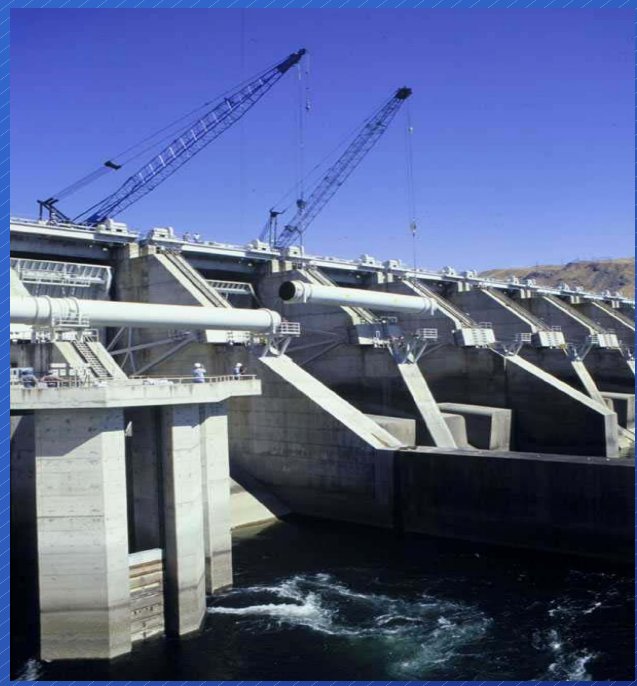
Applications

Water transmission pipe

Gasketed joint

Applications

Power Plant



Long Spans

Applications

Horizontal Directional Drilling


SA04404
MK-7'S
APR 22 2004


Link-Belt
FMC

Engineered Systems

Field fit-ups

Secaucus NJ 72” Lock-Bar Pipe – 1919. (Riveted Pipe 1904)


10/18/06 conduit #2 dresser
coupling north end sta. 16+20

Applications

Sanitary Force mains with push-on, restrained or flanged joints

Corrosion Protection

Polyurethane Lining


FIELD TOP
CENTERLINE
Northwest Pipe Company
Parkersburg Facility
NORTHWEST PIPE CO.
HR HALL, INC.
43.35X.259 WALL
PC 92-A
DATE 02-17-05

AWWA Standards Conformance

- Steel water pipe per M-11 Design Guide
  - C200--Manufacturing Standard
- Fabrication/fittings
  - C208
- Flanges
  - C207
- Linings & coatings : C205, C209, C210, C214, C216, C218, C222

Design Criteria

Welded Steel Pipe - AWWA C-200

Northwest Pipe Company

Pressure Class Design

AWWA DESIGN GUIDE--M-11

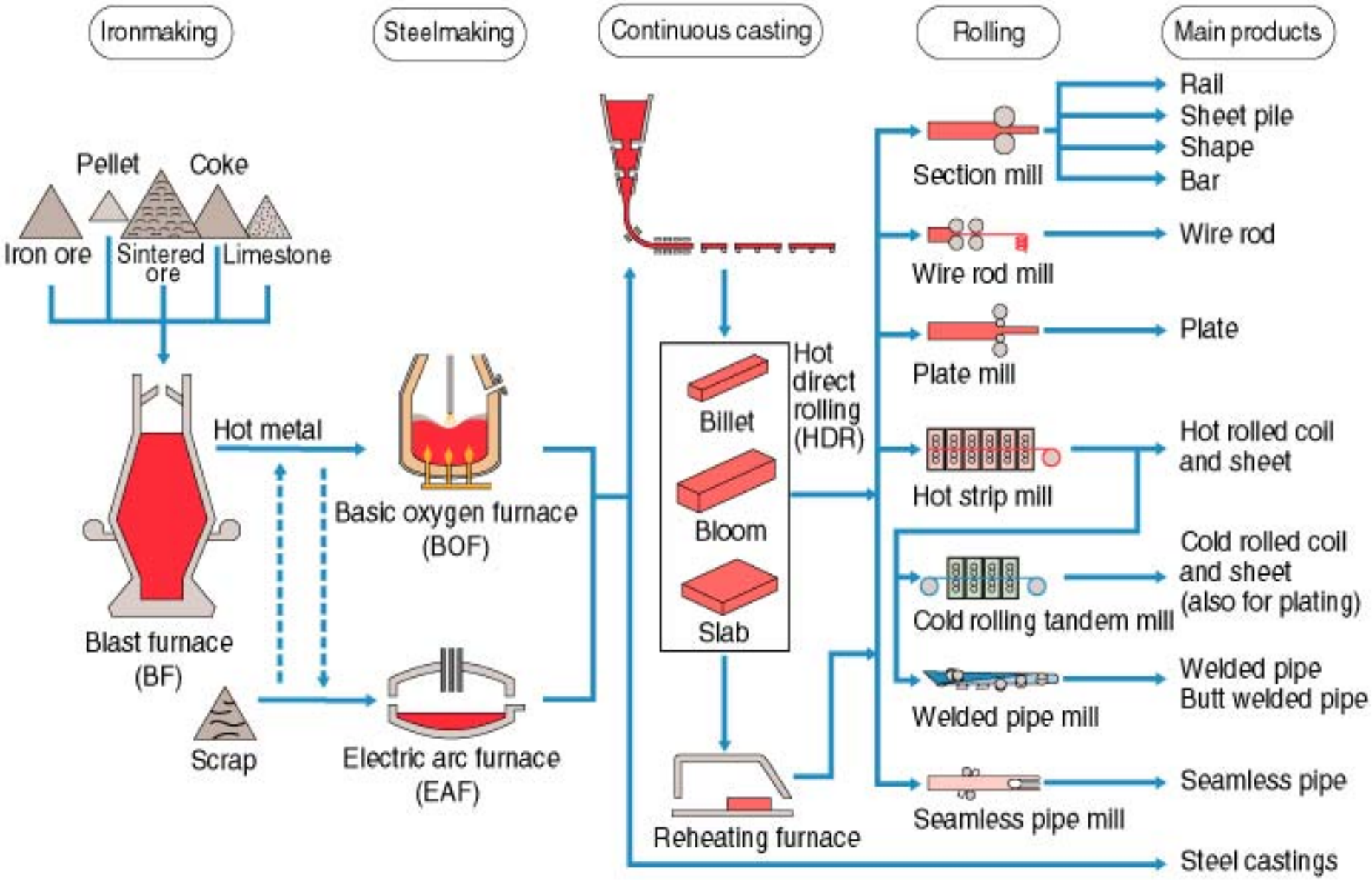
1. Internal pressure
2. Handling
3. External load
4. Joints both push-on and restrained
5. Corrosion protection

Northwest Pipe Company

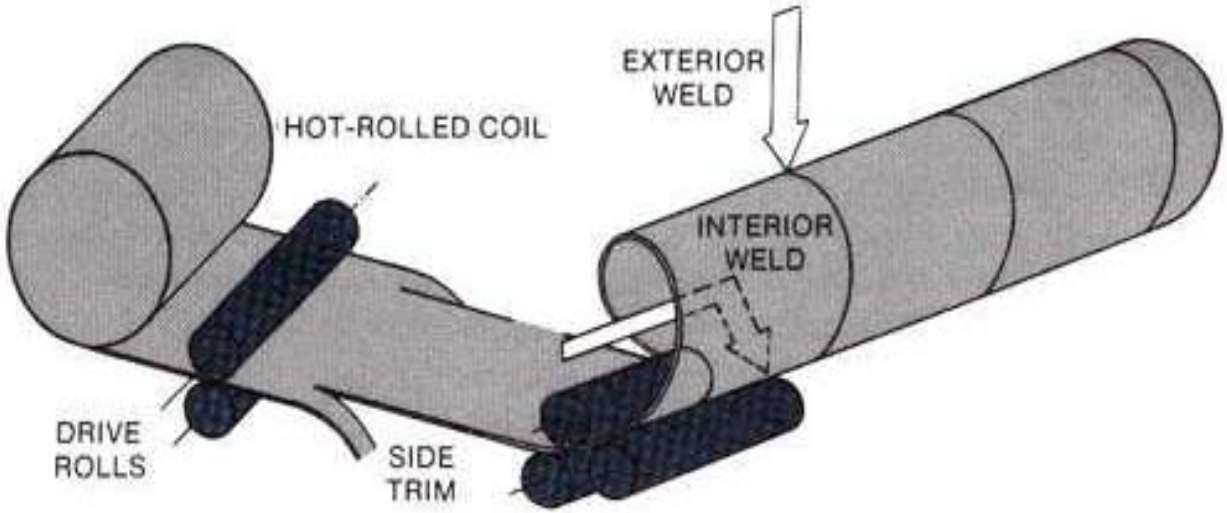
Steel

C200 Steel Grades	Yield Point psi
ASTM A1011 GR 30-70	30,000-70,000
ASTM A1018 GR 30-70	30,000-70,000
ASTM A139 GR B,C,D,E	35,000-52,000
ASTM A570 GR 33-50	33,000-50,000
ASTM A36	36,000

2A Manufacturing Process for Iron and Steel



Back to Basics of Design...



Spiral Welded Pipe Photos

Rolled & Welded Pipe Photo

Return to Engineered Systems

Additional Services

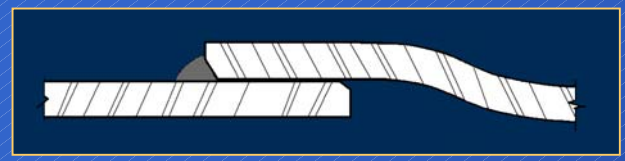
Hydro Testing

- AWWA & ASTM Standards
  - 75% of yield of steel

Joint Systems

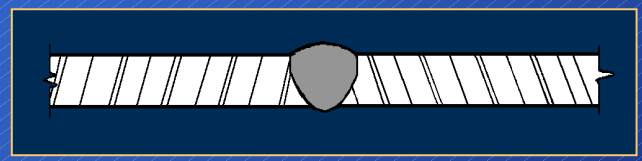
Typical Pipeline Joints

O-ring Joint



Lap Joint

Butt Strap Joint



Butt Weld Joint

Joint Systems

Bell and Spigot Lap Weld

- **Used for higher pressures or other critical locations**
- **Bell can be mitered for greater angular deflection**
- **Restrained, providing economical thrust resistance**
- **Can be welded ID or OD**

Engineered Systems

Joint Systems

Bell and Spigot O-ring

- **Economical push-together assembly**
- **Suitable for typical operating pressures**
- **Can accommodate some angular deflection**
- **Non-restrained**
- **Rolled groove provides economy**

American Water Works Association

July 2006 Volume 98 Number 7

AWWA 1881–2006 125th Anniversary 125 Years of Safe Water

Journal

Using main break data to MANAGE YOUR ASSETS

FIGURE 3 Recorded causes of failure

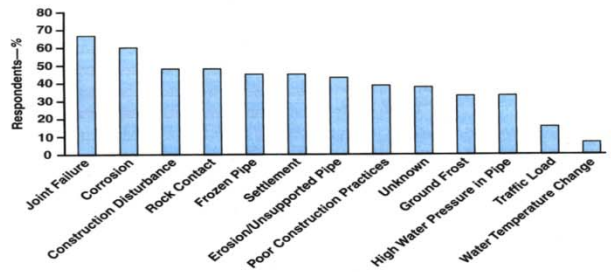
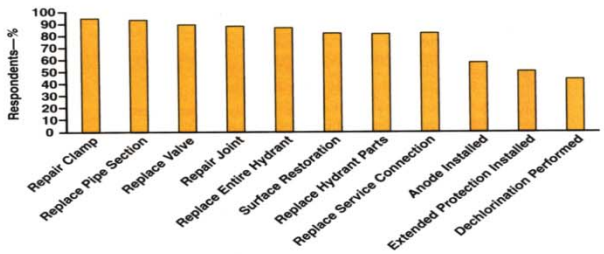


FIGURE 4 Repair activities recorded



1) Corrosion Is a Natural Process:

Underground corrosion of iron or steel pipes is often viewed as an unusual condition which occurs as a result of unusual circumstances and environments. The question is often asked—"will it or won't it corrode?" In response, we must accept the fact that when iron or steel is placed in underground, we should expect corrosion. The energy imparted to a metal when it is refined wants to be released and the metal wants to revert to the ore from which it was derived. Iron is not found in its refined state in nature. Therefore, an underground iron or steel pipe is essentially in an unstable state and can be expected to eventually become iron ore (rust).

Thus, the question is not one which asks whether or not corrosion will occur, but rather is one which is concerned with the rate of corrosion. How long will it be before the first leak occurs? How long will it be before pipe replacement becomes necessary?"

2) All Ferrous Metals Corrode at the Same Rate:

Tests performed by the National Bureau of Standards at more than 150 sites nationwide over a period of more than 50 years and as reported in "Underground Corrosion," Circular C-579 by Melvin Romanoff[1] shows that the ferrous metals including cast iron, carbon steel, wrought iron and ductile iron corrode at essentially the same rate underground. The apparent corrosion resistance of cast iron pipe is attributed to the fact that graphitized cast iron can retain its appearance as a pipe even though much of the iron is gone.

Factors Contributing to Corrosion

- Dissimilar Soils
- Coupling to Dissimilar Metals
- Coupling of Old Pipe / New Pipe
- Differential Aeration
- Dissimilar Surface Conditions
- Stray Current

CORRPRO
COMPANIES INC

Basic Considerations

Corrosion Control--Slow down rate--defined service/design life

Corrosion Protection /Prevention

- **Pipelines will operate indefinitely without failures from natural or manmade corrosive environments.**

Protection of taxpayer and/or owner investment –ASSET MANAGEMENT

- **The pipeline will operate continuously for as long as needed with the lowest full life-cycle cost.**

How can we protect our pipeline infrastructure for 100 plus year design life?

- High-quality coatings
- Electrical continuity—for gasket joints
- Test stations
- Cathodic protection- Use an independent NACE corrosion specialist who will follow NACE SP0169 standards
- **ISOLATION** of dissimilar pipe systems if needed

“Control of External Corrosion on Underground or Submerged Metallic Piping Systems”

NACE Standard SP0169-2002

“This standard presents acknowledged practices for the control of external corrosion on buried or submerged steel, cast iron, ductile iron, copper, and aluminum piping systems.”

Cathodic Protection Definition (NACE International)

“ A technique to reduce the corrosion of a metal surface by making that surface the cathode of an electrochemical cell ”

Types of Cathodic Protection

- Galvanic
  - Current supplied by metal more anodic than the structure (pipe)
  - Naturally occurring current flow
- Impressed Current
  - Current supplied by electrical device to convert AC to DC current
  - Forced current flow--through rectifiers and groundbeds

EXTERIOR COATINGS

Expectations of a coating

- Long term protection from Corrosion, MIC, stray currents
- Tight bond to surface (adhesion)
- Ease of Installation/Maintenance or Repair
- Compatible with Cathodic Protection
- Cost effective

Design Criteria

Corrosion Protection

- Cementitious--Coatings
  - Raises pH
- Bonded Dielectric Coating
  - Eliminates all corrosion including Stray Current Migration
  - Eliminates Oxygen & Water migration,eliminates corrosion

Steel Water Pipe

Exterior Coatings

Common Coatings seen in U.S.

- **Dielectrics**
  - PE Tape (80 mils)30” up
  - Spray-applied Systems
    - Polyurethane (25 mils)
    - Epoxies (16 mils)
    - Zinc (4 mils)
  - Wax Tapes
  - Fusion Bond Epoxy (12 mils) API pipe—not avail for spiral weld pipe
  - Coal Tar Enamel (3/32”)
- **Cement Mortar or grout** (¾” thick)

Steel Water Pipe

Common AWWA Standards

Pipe Cylinder
- AWWA C200 - Manufacture
- AWWA M11 - Design

Flanges
- AWWA C207

Welding
- AWWA C206

Fittings
- AWWA C208

Linings
- AWWA C205 - Cement Mortar
- AWWA C210 - Epoxy
- AWWA C602 - Field Applied Mortar
- AWWA C222 - Polyurethane

Coatings
- AWWA C203 - Coal Tar Enamel
- AWWA C205 - Cement Mortar
- AWWA C209 - Joint Tape
- AWWA C210 - Epoxy
- AWWA C214 – Tape
- AWWA C215 - Pritec
- AWWA C216 - Heat Shrink Sleeves
- AWWA C218 - Exposed Paint Systems
- AWWA C222 - Polyurethane

Corrosion Protection

Coatings--per AWWA Criteria

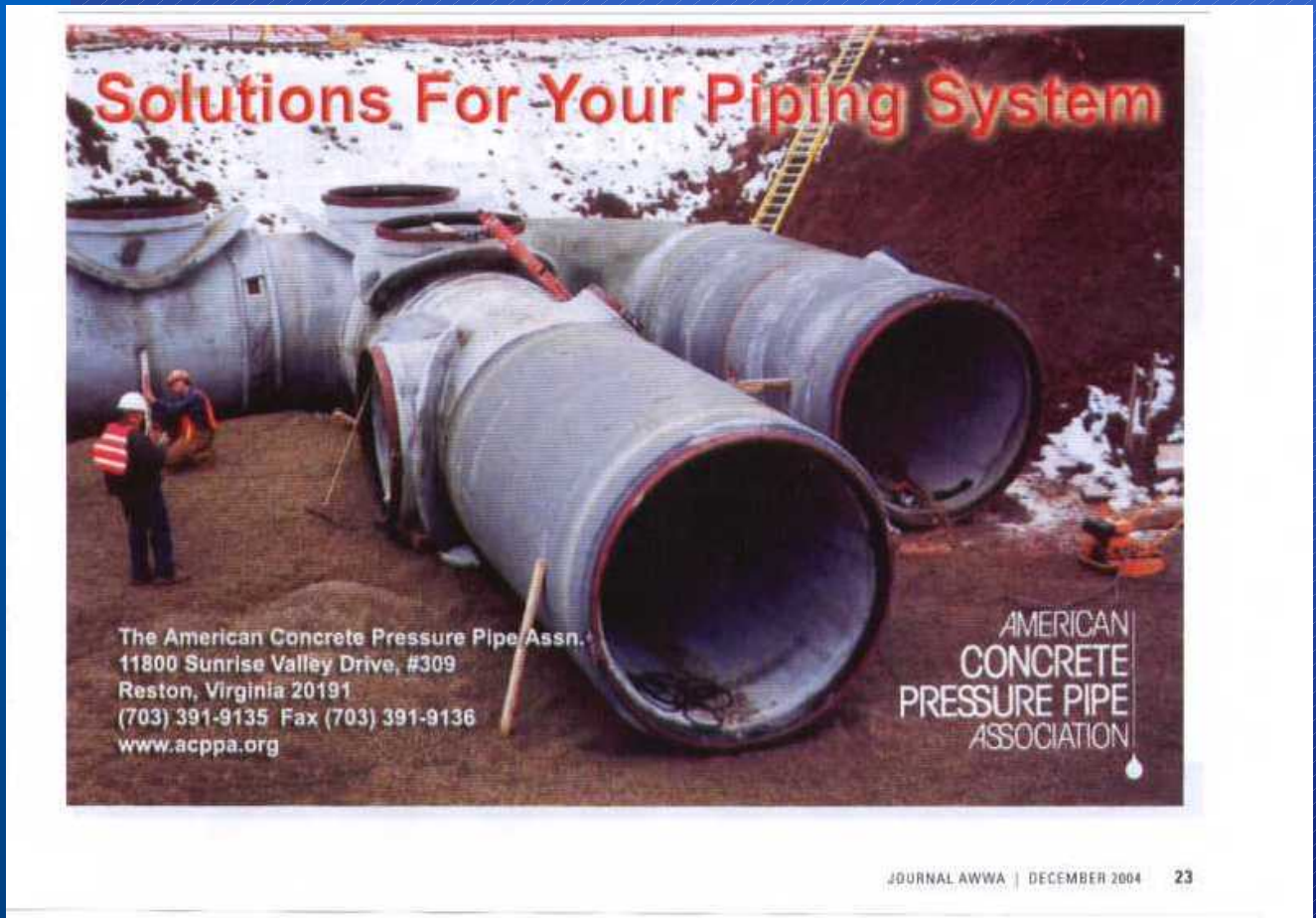
- Cement--C205
- Dielectric
  - Bonded PE Tapes--C214
  - Paint systems
    - Epoxies-C210
    - Polyurethane-C222

Diversity of Materials Requirements

C-210	16 mil	400 lb/sq in	Vapor Trans	RPO 188	1978
C-213	12 mil	Knife test	NA	RPO 490	1979
C-214	50-80 mil	200 oz/in width	0.20%	6000 V min	1983
C-215	49-69 mil	NA	0.20%	RPO 274	1988
C-216	40-60 mil	8 lbs/lin in	Vapor Trans	Required	1989
C-217 wax	40 mil	NA	Vapor Trans	NA	1990
C-218	3.5 -14 mil	V cut	NA	NA	1991
C-222	20-25 mil	750-2000 psi	3.00%	RPO 188	1999
C-224 nylon	24-40 mil	2000 psi	2.70%	RPO 188	2001
C-225	50-75 mil	32 ft lb/ in width	0.20%	RPO 188	2003

All above standards require a min SSPC SP 6 /NACE 3 blast cleaning

Familiar Knowledge ?



Field Joint Coating per AWWA C-205

Place diaper around pipe

Assemble joint and pour soupy cement mixture from one side of diaper

Expectations of a lining

- Good Flow Characteristics
- Protects Pipe from Corrosion and Abrasion
- Ease of Installation/Maintenance
- Cost effective

Corrosion Protection

Linings

- Cement
- Paint systems
  - Epoxies
  - Polyurethane

Steel Water Pipe

Interior Linings

Cement Mortar Lining

- Stulls used for shipping and handling
- Joint recess usually pointed
- Easily repaired and modified in the Field
- Low Cost

Interior Joint Grouting

Pack joint with grout

Remove excess grout

Polyurethane coatings

- AWWA C-222
- 25 mils Thickness
- Extremely abrasion resistant
- sensitive to blast and temperature
- Good dielectric strength
- More costly

Corrosion Protection

POLYURETHANE COATING--AWWA C222


Top
MAY 22 2004

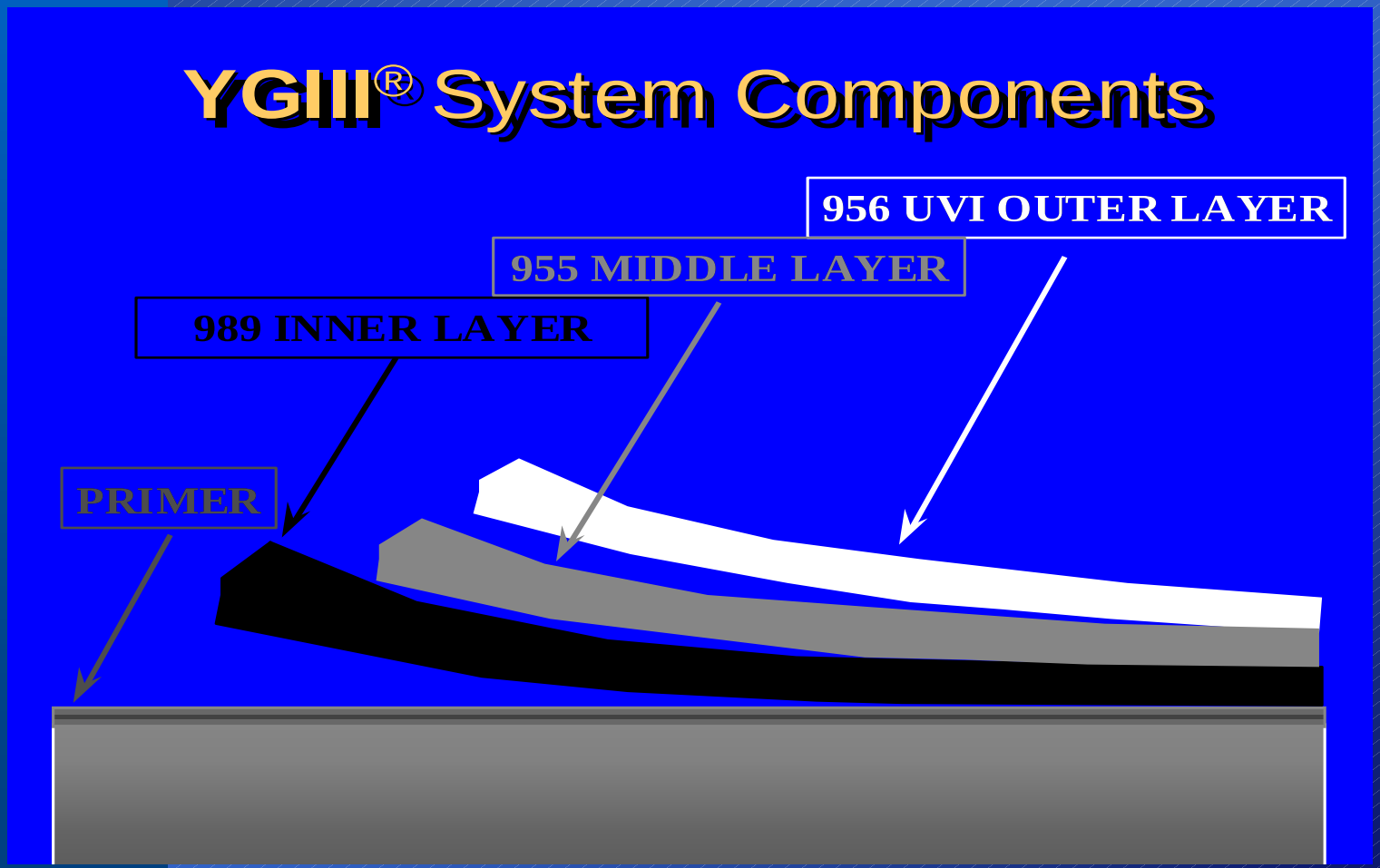
Polyurethane Coating Repair AWWA C-222

Repair coating if necessary

PAINTED COATINGS

Epoxies
Zinc Rich Paints
Primers

AWWA C214-Machine Applied Polyethylene Tape



Linings and Coatings

Tape Coating

Steel Water Pipe

Exterior Coatings

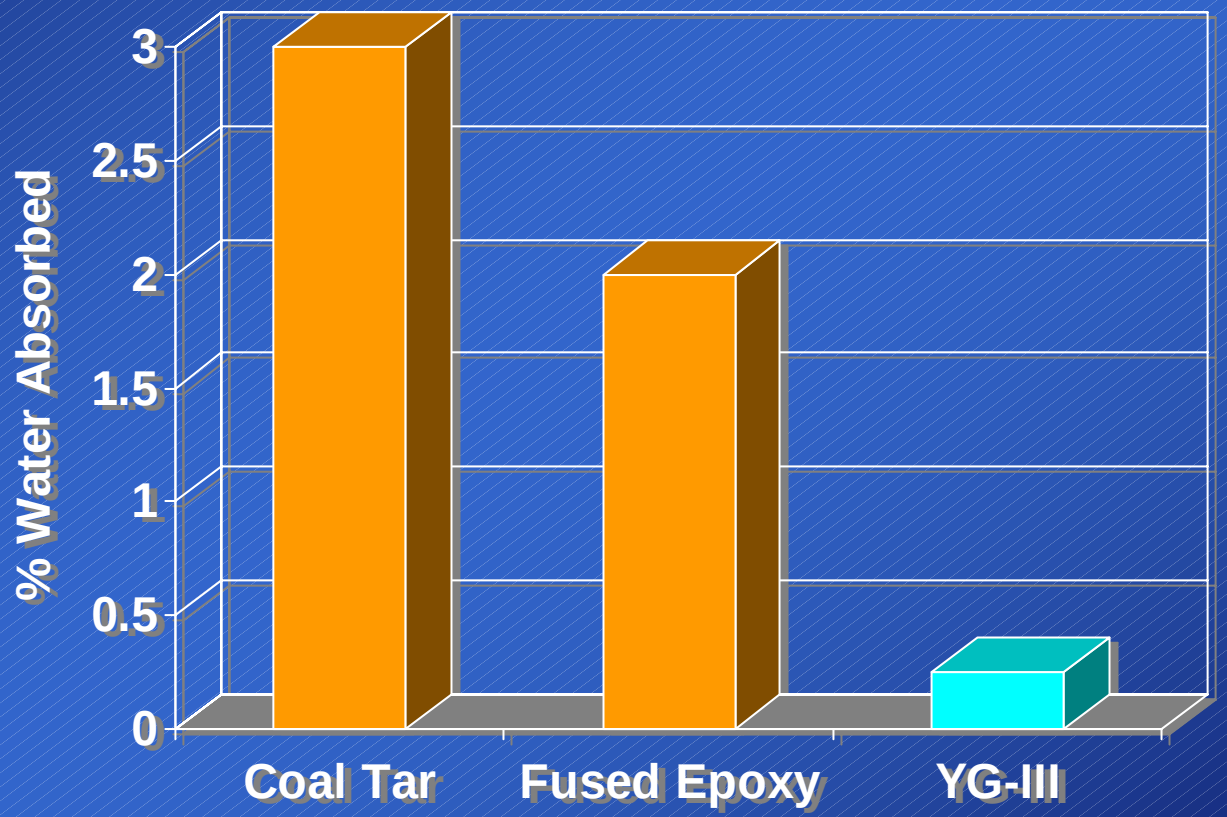
AWWA C214 Tape

- 80-mil, three-layer factory applied system
- Effective as dielectric coating
- Ease of field use
- 25+ year history in water industry (50 oil & gas)
- Low Cost

Advantages of Shop Applied Multi-Layered Coatings ,per AWWA C214

- Proven long-term Performance
- Highest Dielectric Strength
- World Class Coating System
- Utilized on High-Pressure Oil & Gas TM
- Impermeable to Oxygen & Water
- Low Cathodic Protection Current Requirements
- Adhesion to primed steel--exceeds 300 oz/in
- Cathodic Disbondment Results G8--.25 in radius
- Easily Repaired on the jobsite--with field tape
- PE backings--identical to landfill liners--

Water Absorption
ASTM G-62



Method of Delivery

- Flat Bed Truck
- Vans
- Rail
- Barge

Stringing/Storing Pipe

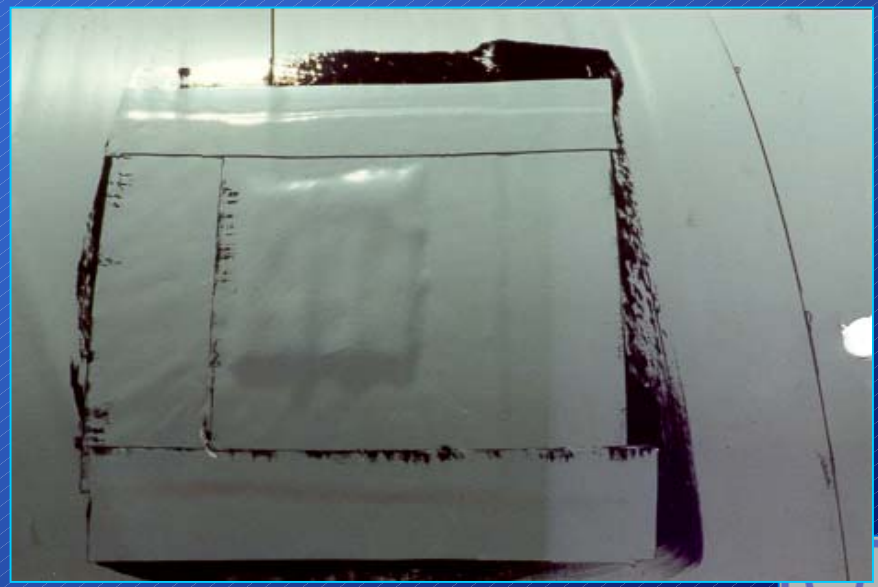
- String pipe in accordance with the supplied lay diagram/schedule
- Place pipe on dirt berms, padded boards, or sand bags

Pre-Installation Prep Work

- **Inspect factory applied coating**
  - Visual
  - Mechanically with Holiday testing equipment

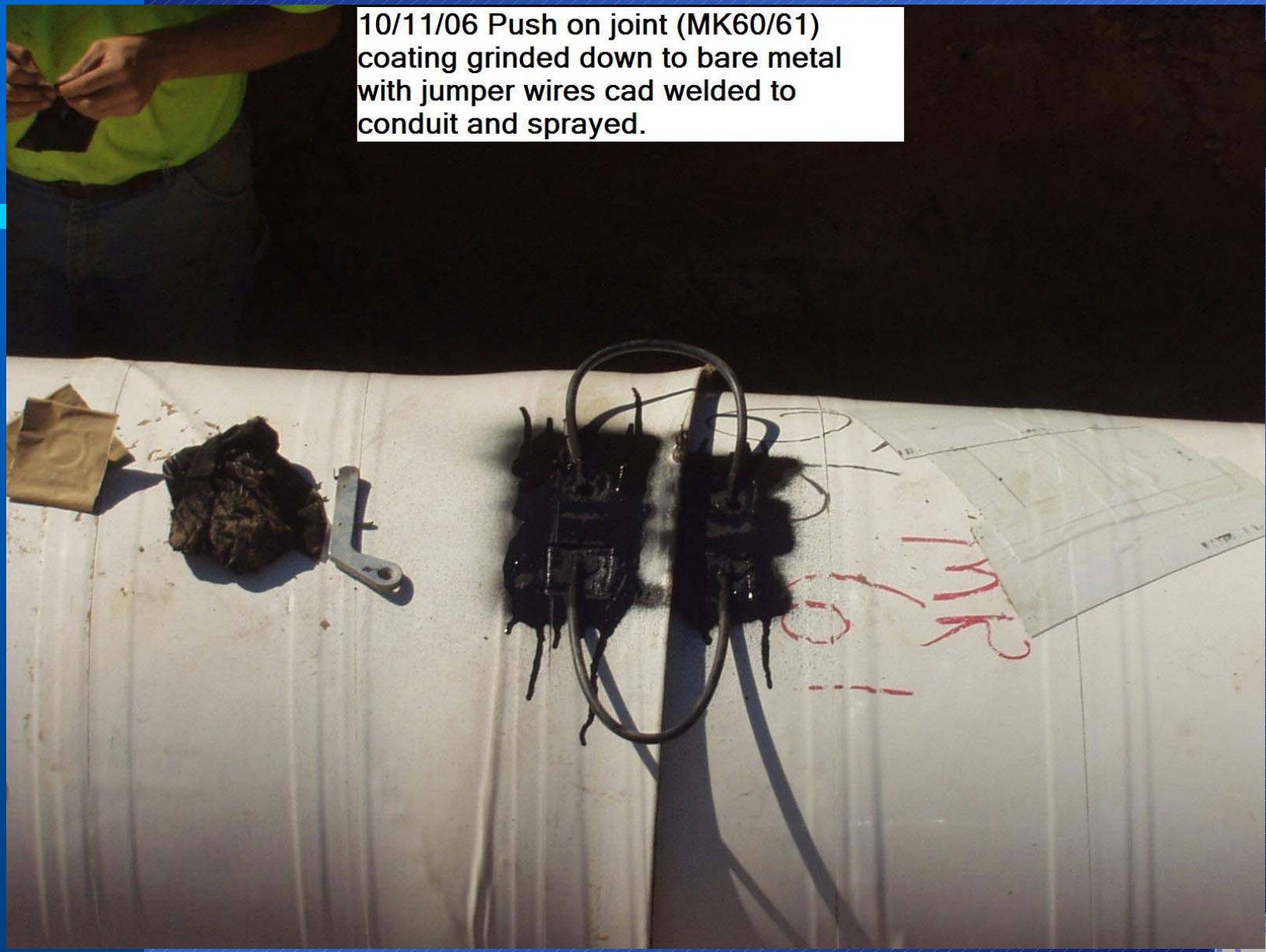
Polyethylene Coating Repair AWWA C-209

Repair coating if necessary



Joint Completion

- **Joint bonding**
  - **Gasketed joints**
  - **Electrical continuity**
  - **Allows monitoring**
  - **Provides for future CP**


10/11/06 Push on joint (MK60/61)
coating grinded down to bare metal
with jumper wires cad welded to
conduit and sprayed.

10/18/06 30" cross over on conduit #2.

Joint Completion

Hand-applied tape

Heat-shrink sleeve

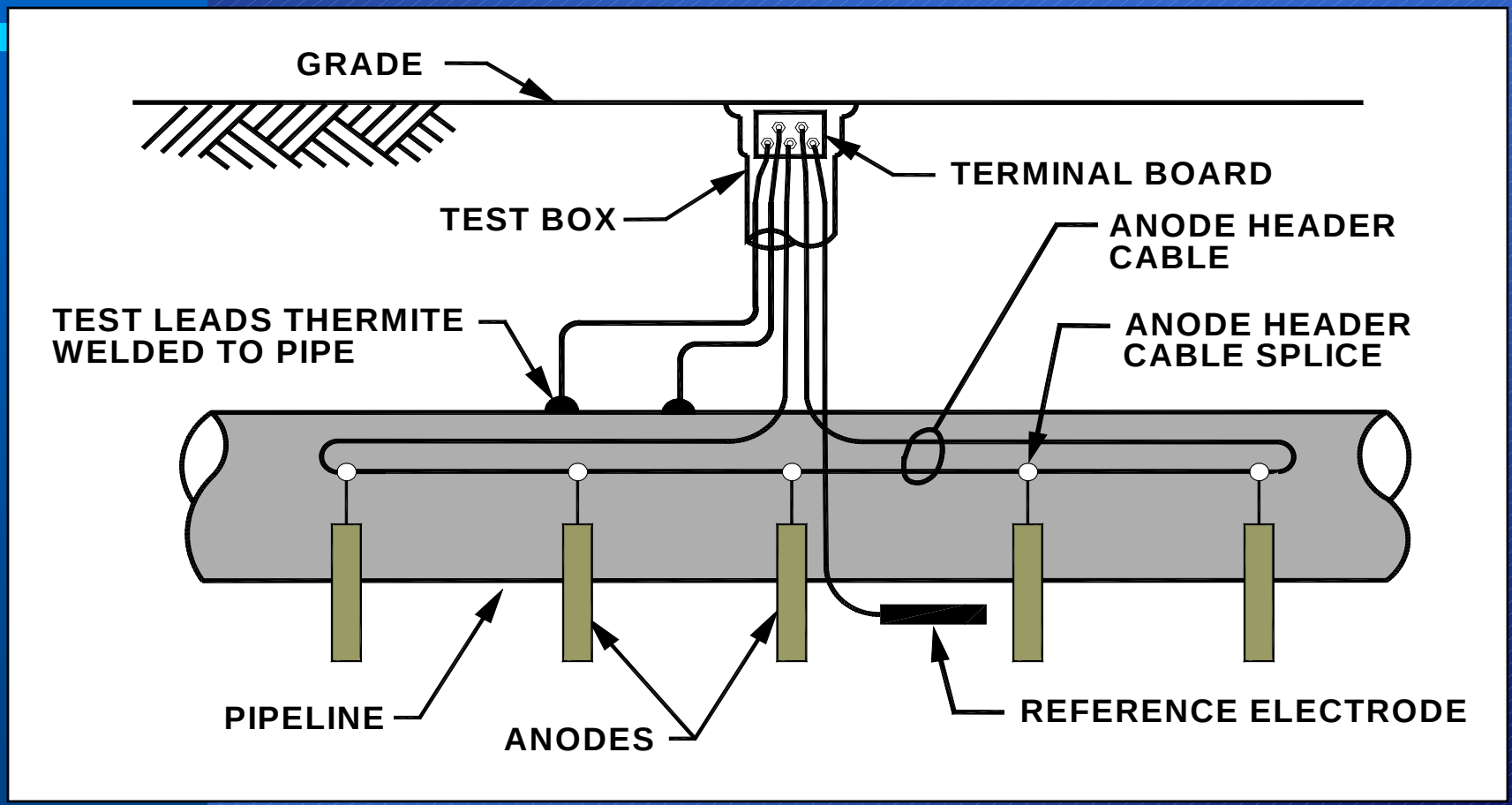
Return to Engineered Systems

Field Joint Coating Shrink Sleeves per AWWA C-216

Shrink Sleeves applied with propane torch


BESSEY

Corrosion Protection Methods in Any Soil Environment



ALL CATHODIC PROTECTION TEST STATIONS ARE NOT THE SAME!

NICKEL PLATED BRASS BINDING POSTS TO PREVENT CORROSION

TRANSPARENT DESIGN FOR FASTER VISUAL VERIFICATION

ANTI-SPIN GASKET HELPS PREVENT SPINNING ON THE RISER

SUPERGRIP EASY ON-OFF TOP EVEN WITH GLOVES

BINDING POSTS HOLD WIRE SECURE -UP TO 6 GAUGE

ENLARGED OPENING FOR MULTIPLE LARGE GAUGE WIRE

IN-STOCK FOR IMMEDIATE DELIVERY

T-3 MODEL SHOWN

Contact us for details on our complete line of testing equipment. Find out why our customers tell us they enjoy doing business with us.


10/12/06 36" steel conduit (3) installed with 2" conduit installed 2' east of 36" conduit anodes (circled in red) installed every 10' from 6+85-10+35.

In-Ground Performance

- Bell hole examinations
  - ✓ no coating degradation
- CP survey
  - ✓ 2 to 6 μA per ft^2
  - ✓ > 99.95% coating efficiency

Discussion Points

Current Requirements (12 3/4 ” Diameter Natural Gas Pipeline)

Year	Current Density (MicroAmps/Ft²)
1970	—
1971	2.4
1972	2.1
1973	2.5
1974	3.2
1975	1.7
1976	2.1

Construction: 1970; 180 miles of 12 3/4” diameter.

Discussion Points

Current Requirements on a Product Pipeline

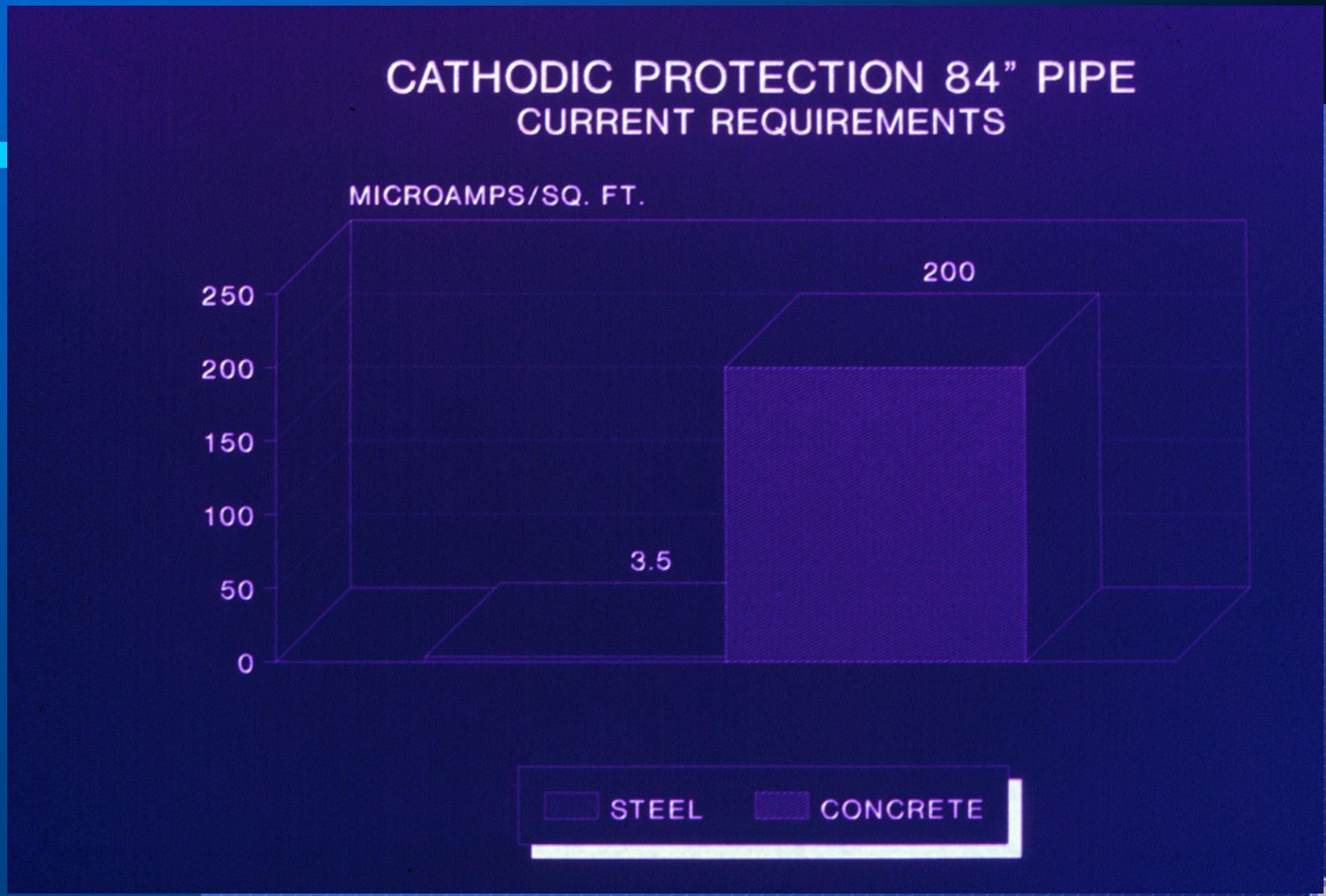
Pipe Diameter	20 in.
Total Length	146 miles
Length of Polyethylene Tape Coating Section	99 miles
Length of Coal-Tar Enamel Section	47 miles

Current Requirements 1974

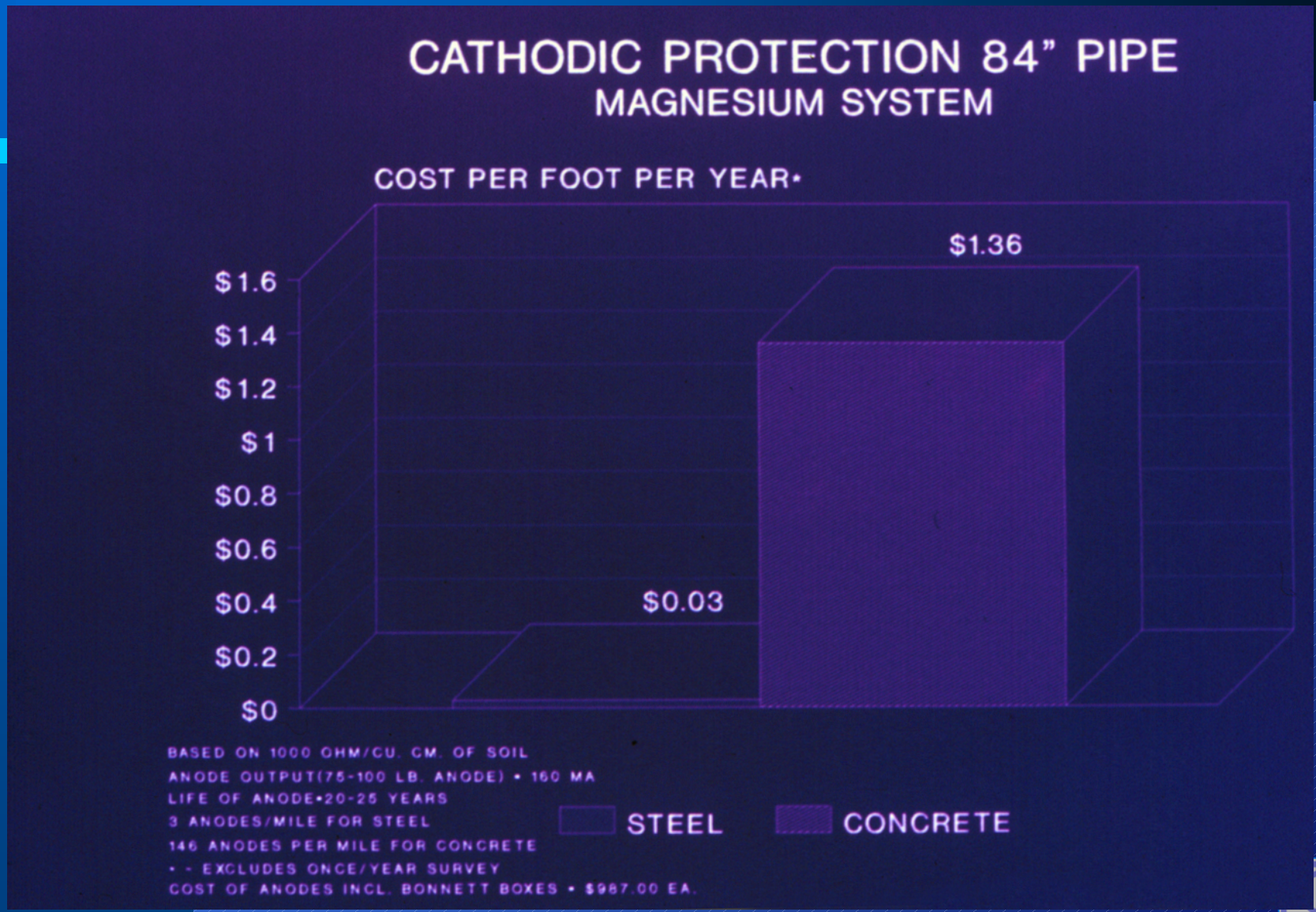
Polyethylene Tape	3.12 MicroAmps/Ft^2
Coal Tar Enamel	13.23 MicroAmps/Ft^2

Data provided by end-user.

Discussion Points



Discussion Points



Cost - to - Benefit Ratio

7 - to - 1

Save $7 for every $1 spent

Steel Water Pipe

Exterior Coatings

Polywrap not recommended

- Not tightly BONDED to pipe
- Easily damaged during installation – 8 mils
- Does not prevent moisture (perforations and joint leakage) from forming corrosion cell.
- Cathodic Shielding
- Encasement not a coating
- DOES NOT COMPLY WITH NACE SP01-69-02

Steel Water Pipe

Corrosion Engineering

Common Corrosion Protection Practices for Buried Pipe

- Use high-quality proven bonded coatings
- Assure electrical continuity with bonded joints or welding.
- Install test stations for periodic monitoring
- Use cathodic protection as specified by corr. report
- Isolate Pipelines as necessary

Corrosion Prevention for Steel Water Pipe