Corrosion Control of Buried Piping

Presented By:
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Corrosion

Temporary Fix ?

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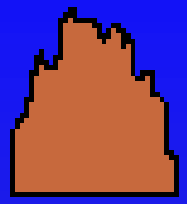
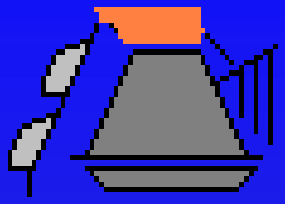
Corrosion - A Natural Process



IRON OXIDE



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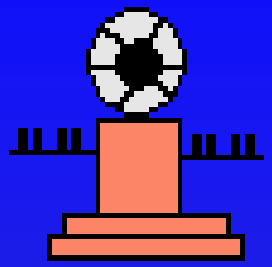
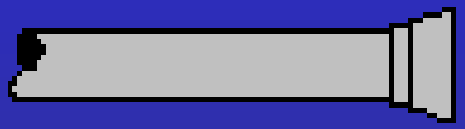
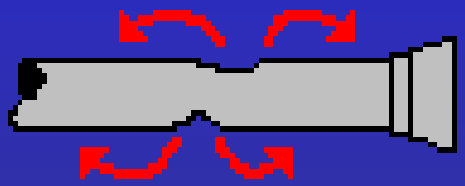


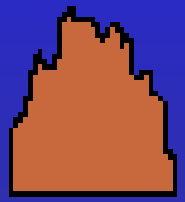
MILLING



IRON,STEEL,PCCP

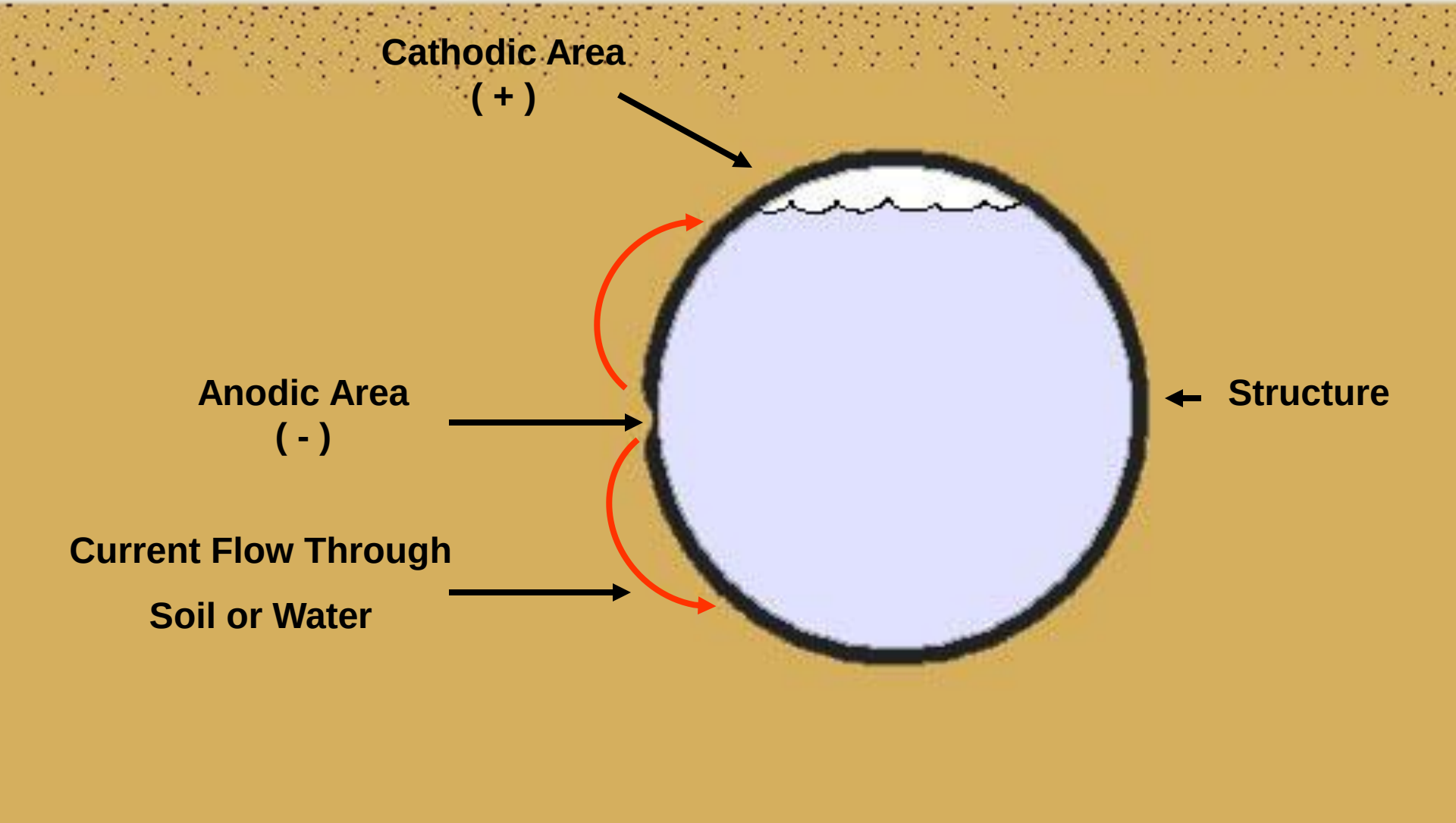


CORROSION

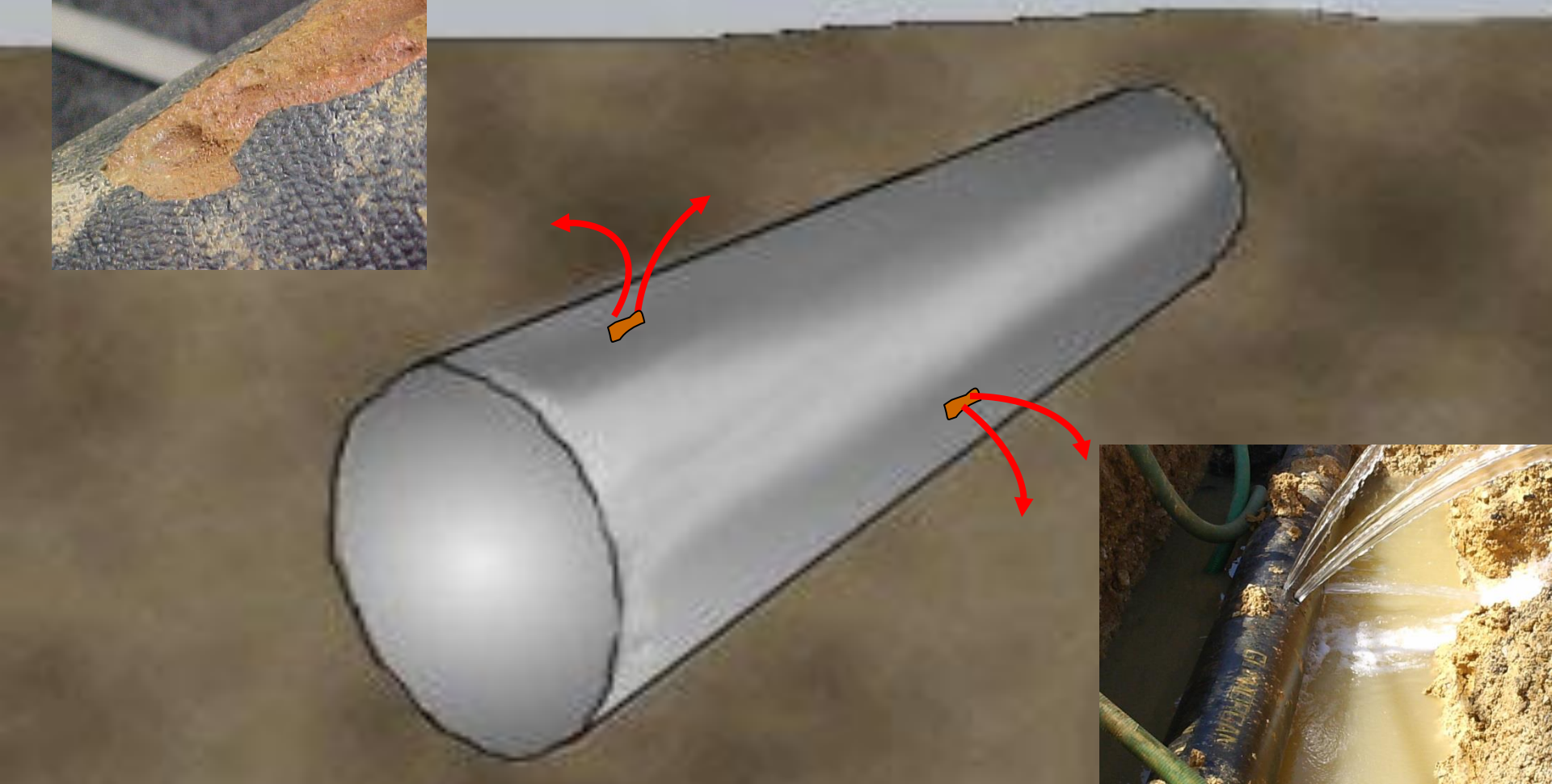


IRON OXIDE

Corrosion Cell on Buried Piping



Corrosion of Metallic Structure



Water
(Electrolyte)

Anodic Area
(Corrodes)

Current
Flow

Metallic Return Path

Cathodic Area
(Protected)

Tank Wall


Hole
Hole

History of Iron Pipe

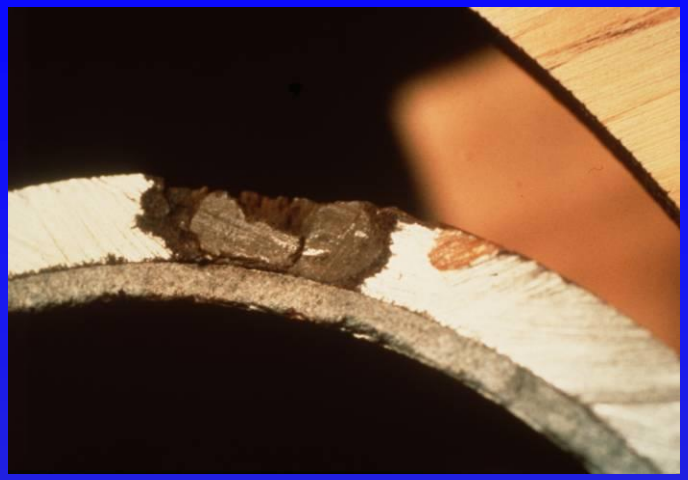
Cast Iron

- Introduced to North America during the 1800's and installed till the 1970's.
- Early on, statically cast process produced a thick walled, heavy pipe.
- No longer produced in North America.

Ductile Iron

- Introduced in 1955 as an improvement to cast iron.
- Centrifugal casting process produces a thinner walled, lighter pipe which is stronger and more ductile than cast iron.

Cast (Grey) Iron Failures



Graphitization leaves pipe brittle and weakened.

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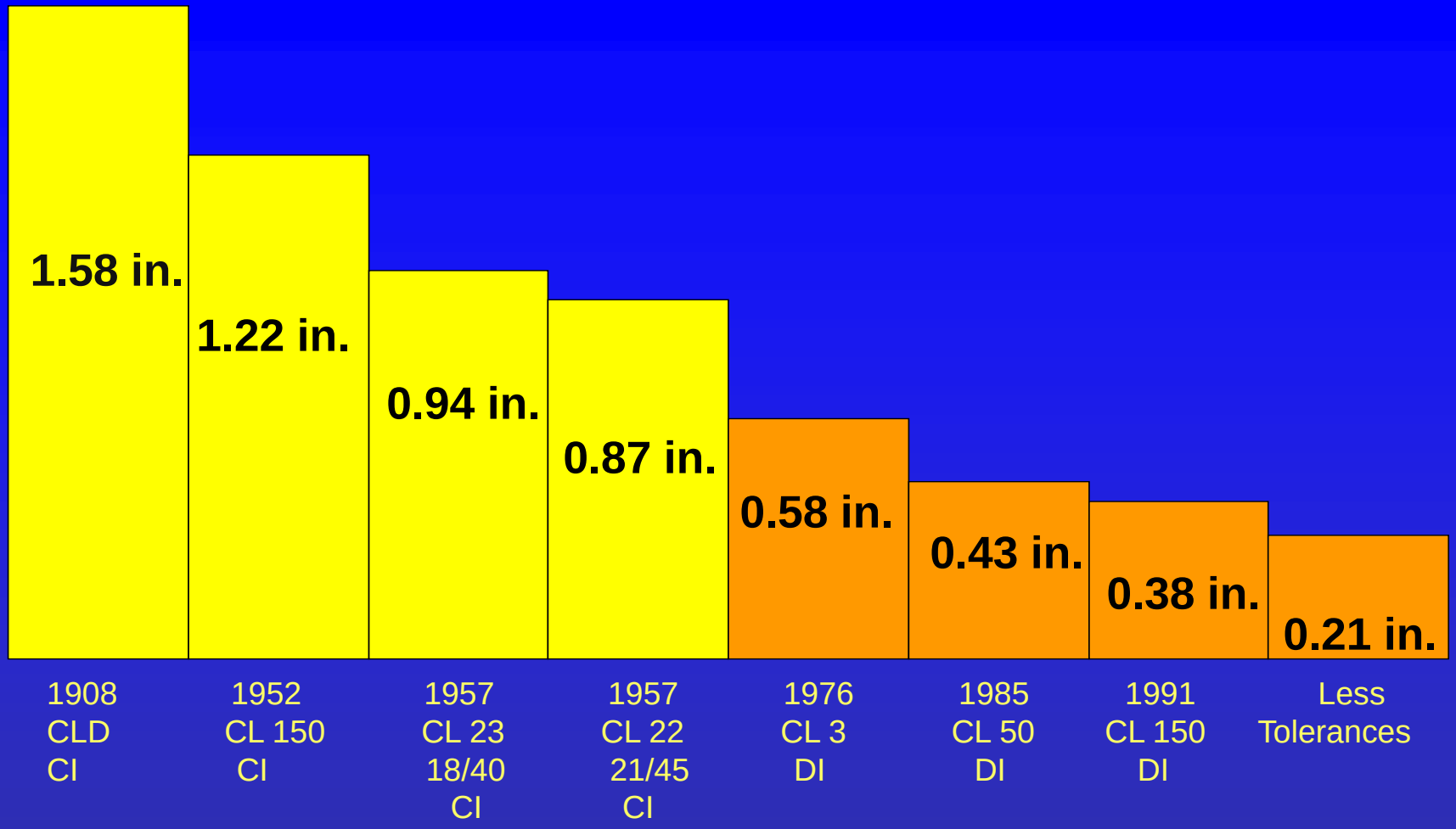


Actual size of AWWA Specification Thickness Reductions for 36-inch Diameter Cast and Ductile Iron Pipe - 1908 to Present (150 PSI Operating pressure)

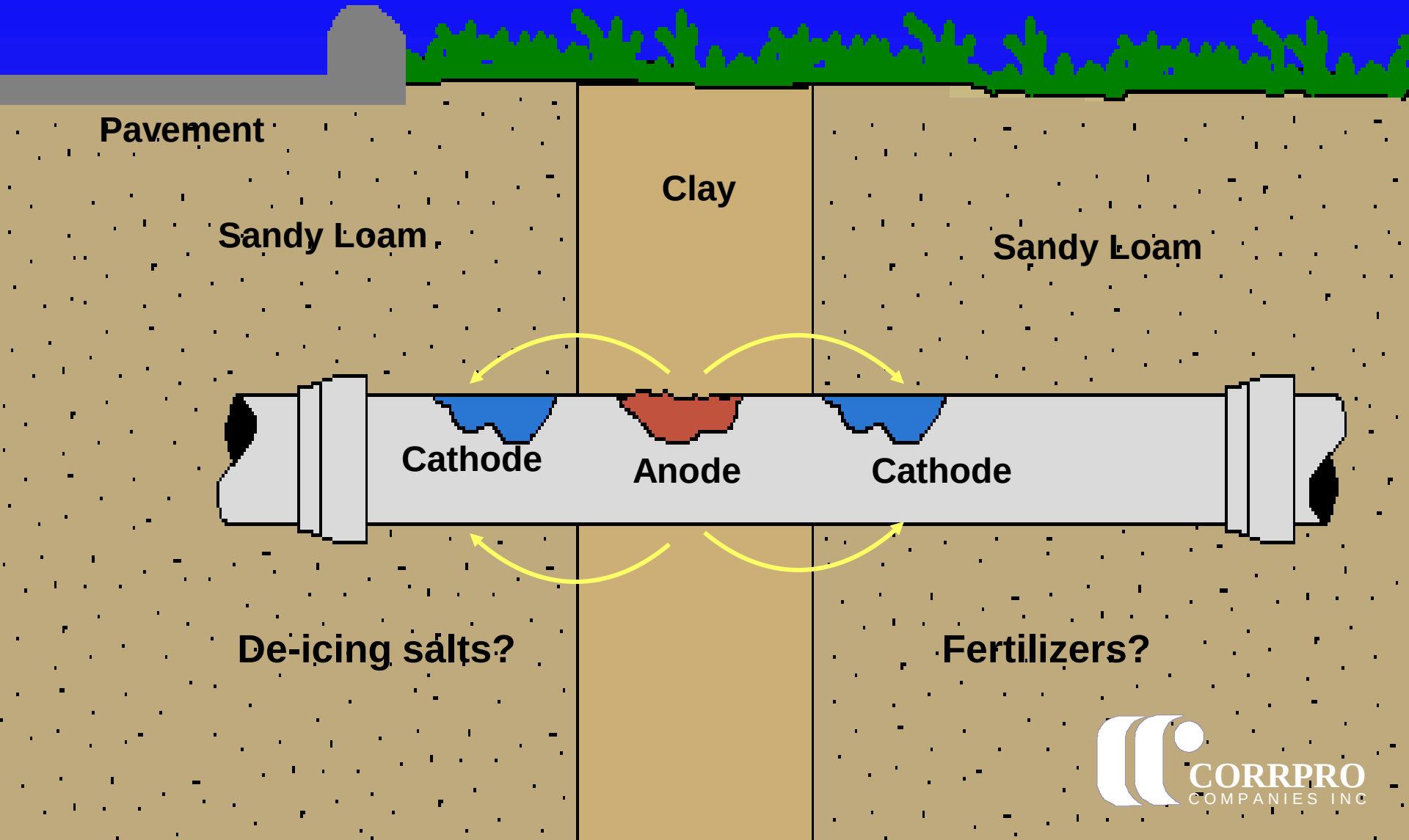
Ductile Iron

Pitting (concentrated) corrosion attack on ductile iron pipe.

Adverse Conditions for Metallic Pipe

- High Chlorides
- Low Soil/Water Resistivity
- High Sulfates
- Acidic Soils
- Wet/Dry Fluctuations
- Bimetallic Couplings
- Stray Current Interference

Dissimilar Soils



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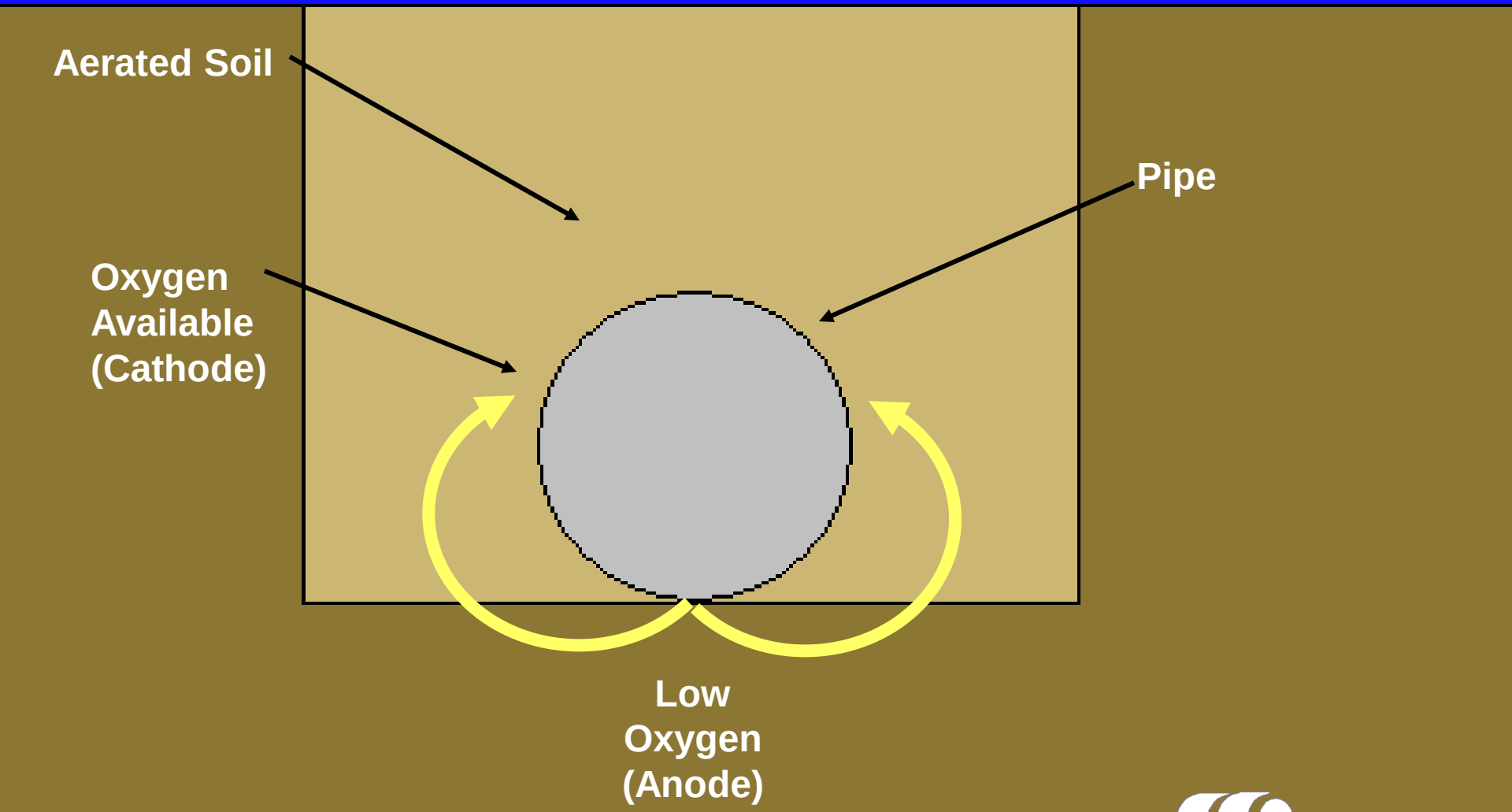
Corrosion Caused by Differential Aeration



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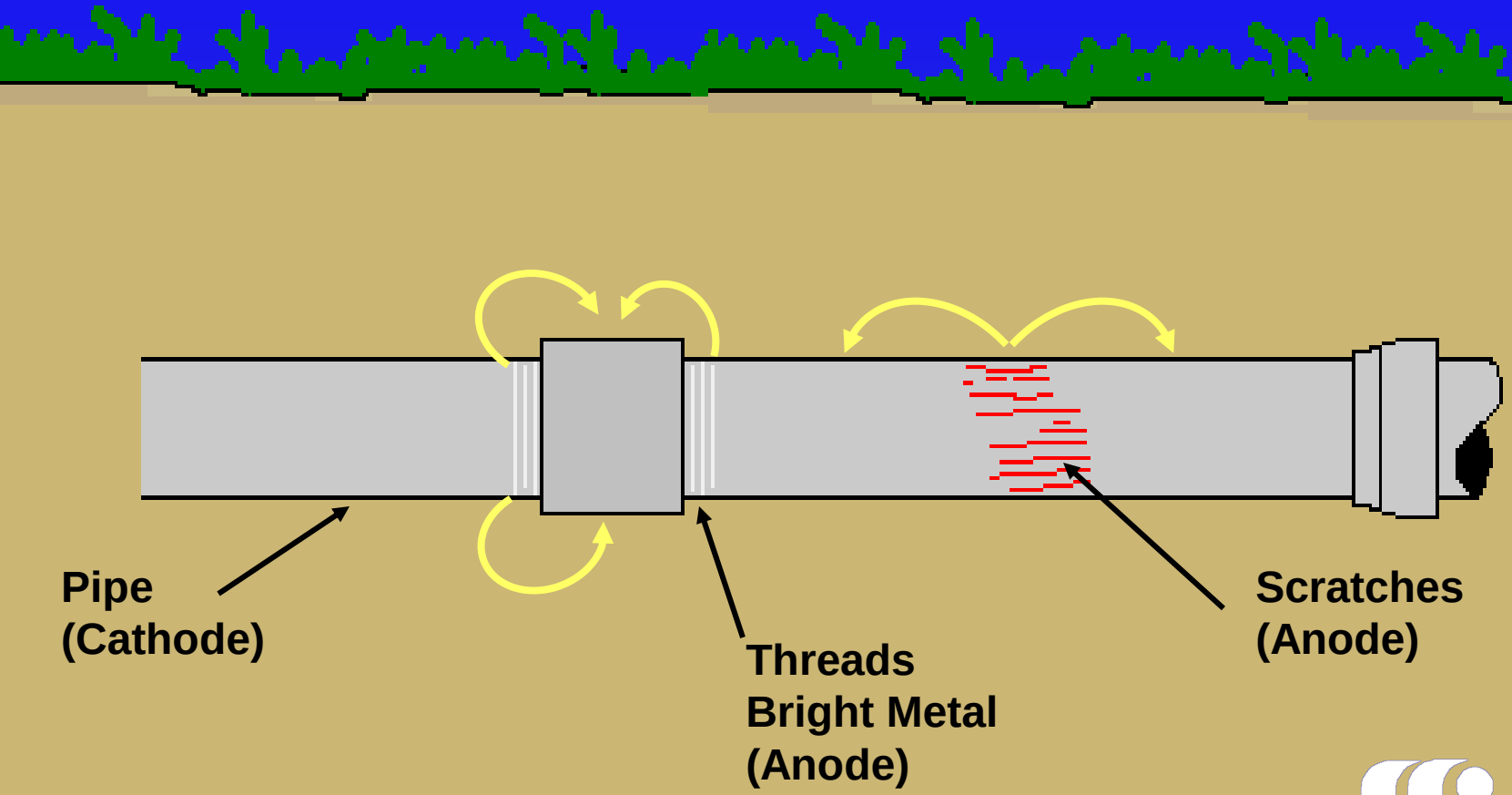
Dissimilar Surface Conditions



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COMPANIES INC

PRACTICAL GALVANIC SERIES

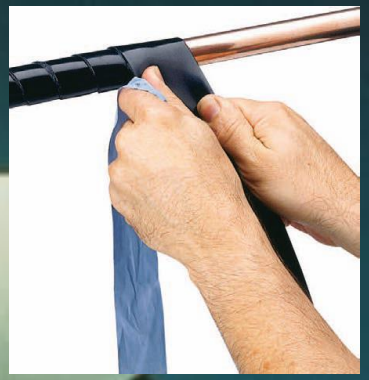
Material	Potential*
Pure Magnesium	-1.75
Zinc	-1.10
Aluminum Alloy	-1.00
Cadmium	-0.80
Mild Steel (New)	-0.70
Mild Steel (Old)	-0.50
Cast/Ductile Iron	-0.50
Stainless Steel	-0.50 to + 0.10
Copper, Brass, Bronze	-0.20
Gold	+0.20
Carbon, Graphite, Coke	+0.30

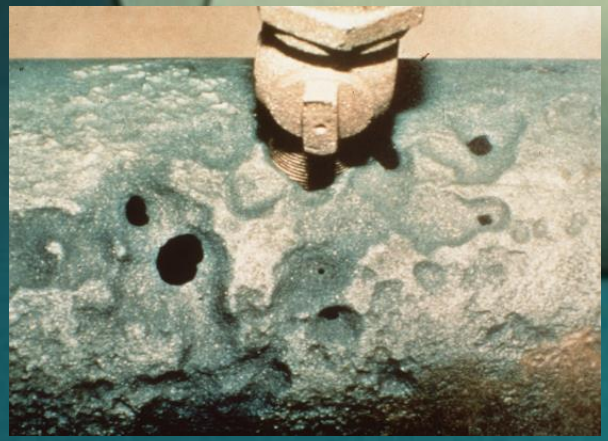
* Potentials With Respect to Saturated Cu-$CuSO_4$ Electrode

Coupling to Dissimilar Metals

Metallic Connection

Copper service (Cathode) - 300mV





Iron pipe (Anode) - 500mV

Proper Handling & Installation of Polyethylene Ductile Iron Pipe

Polyethylene Encasement of Ductile Iron Pipe

-Follow DIPRA installation procedures
-Clean pipe before installing polywrap
-Repair tears or damage to encasement
-Engage an inspector to oversee installation

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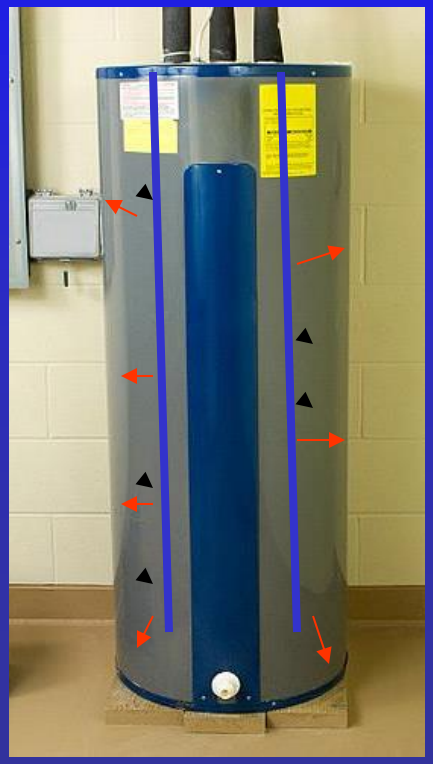
Cathode
(Protected)



Anode

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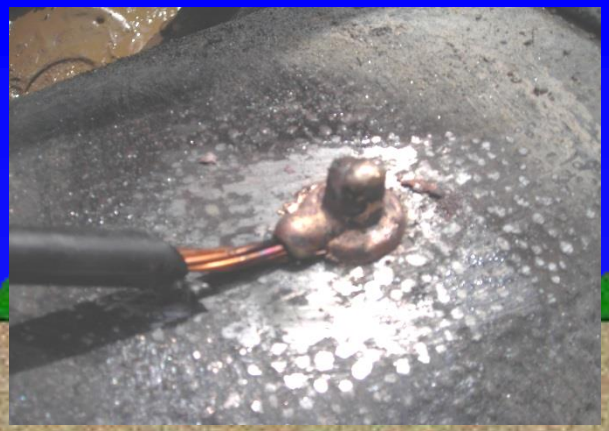
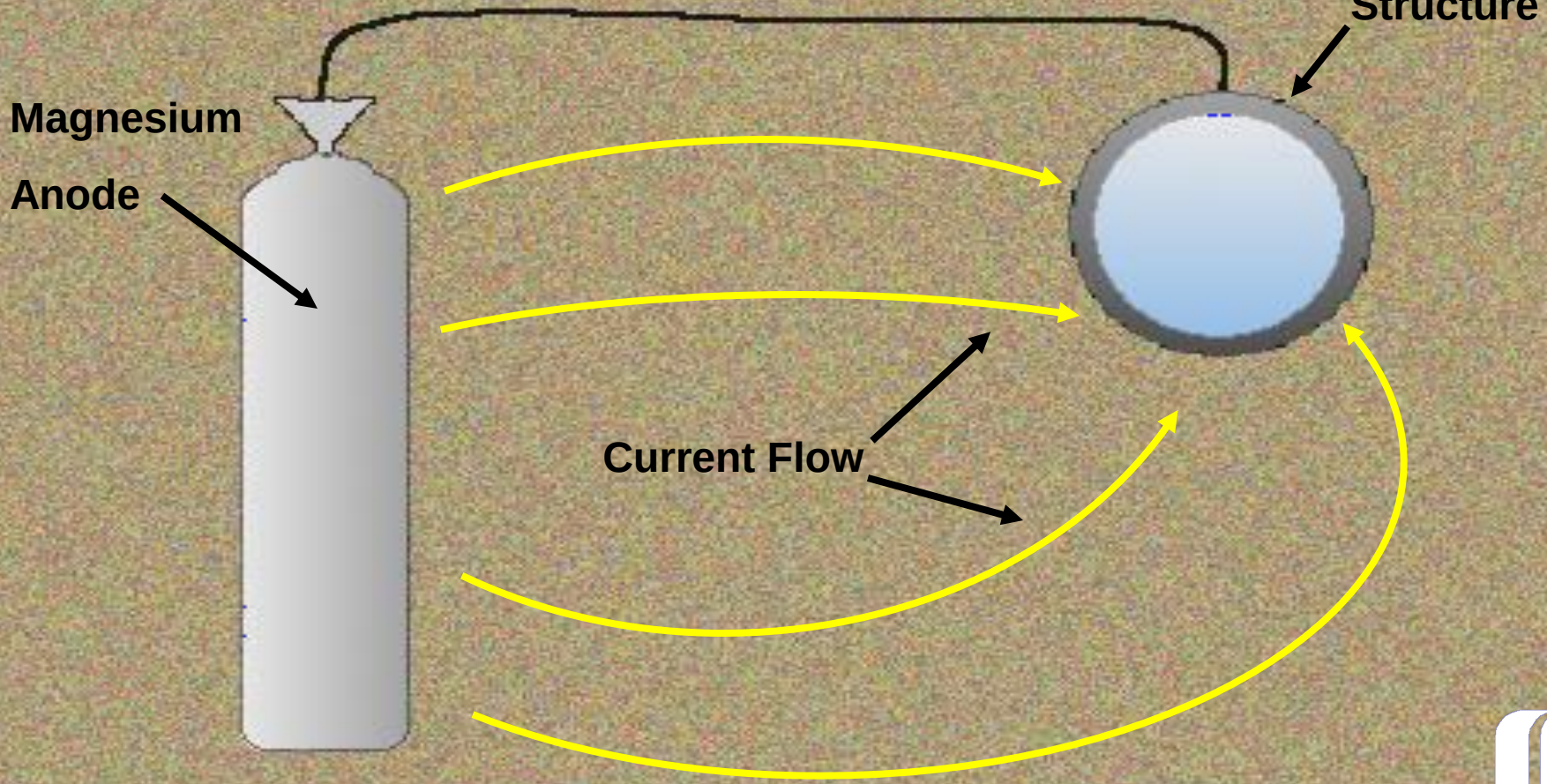
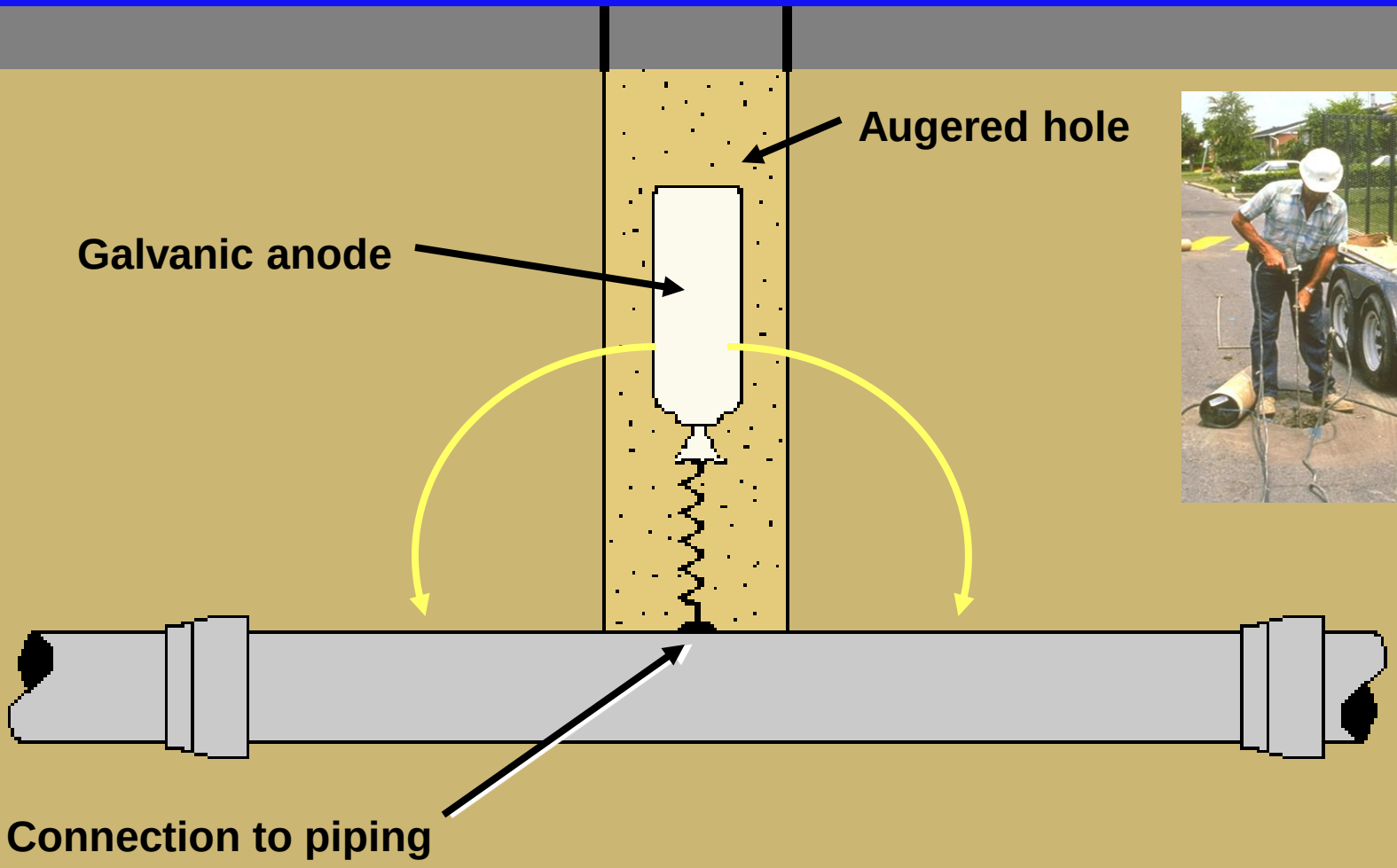
Galvanic Anode

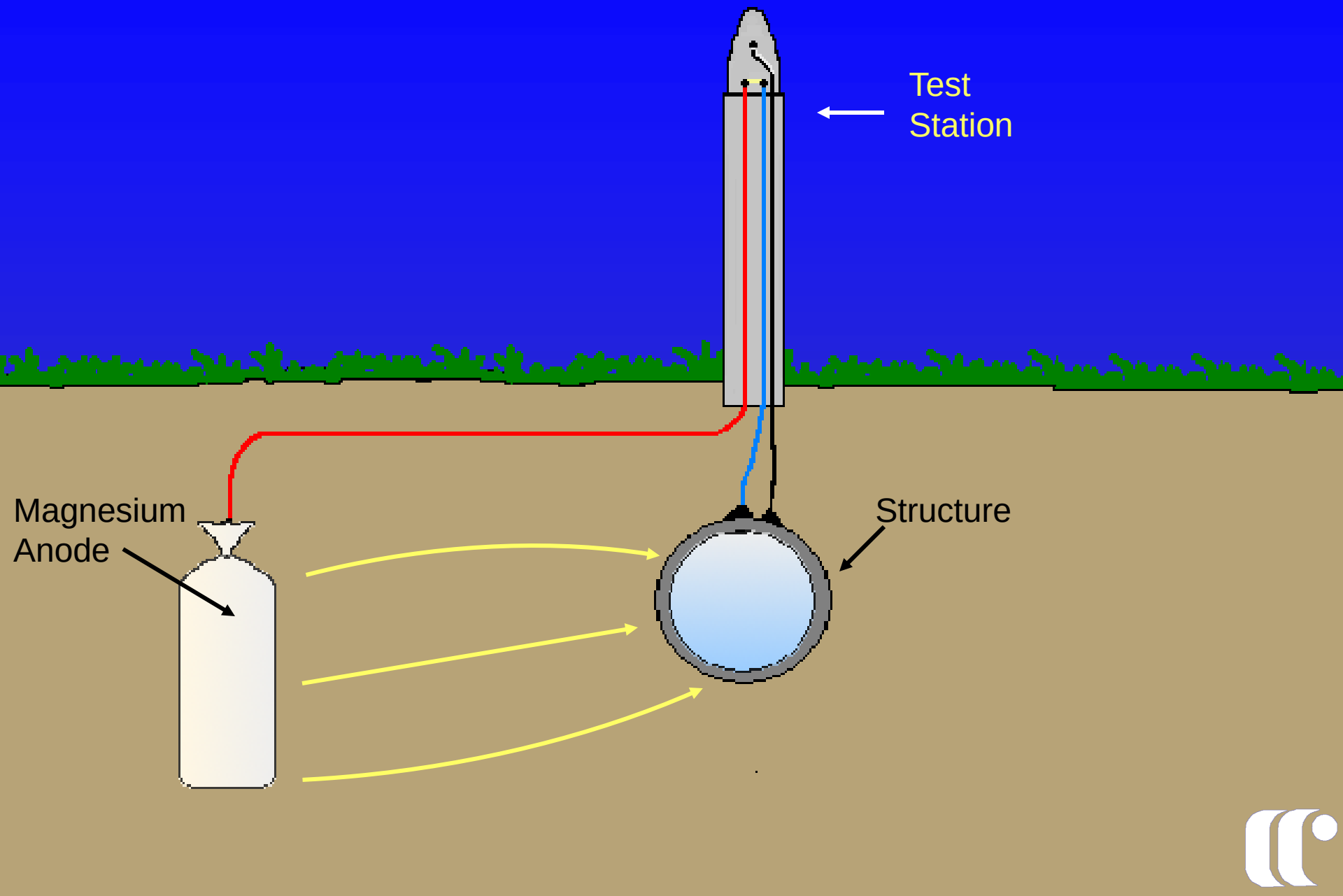


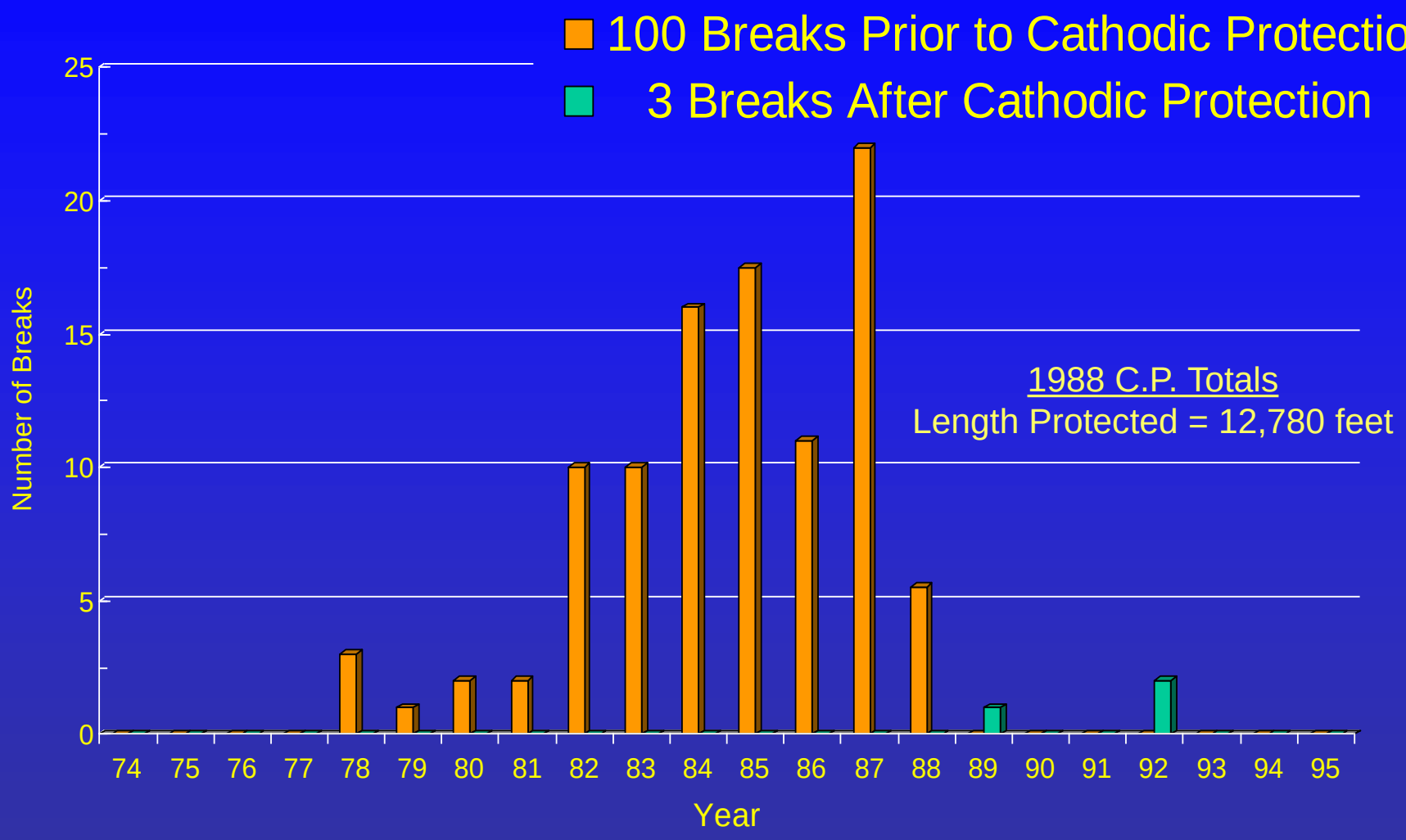


Anode Installation

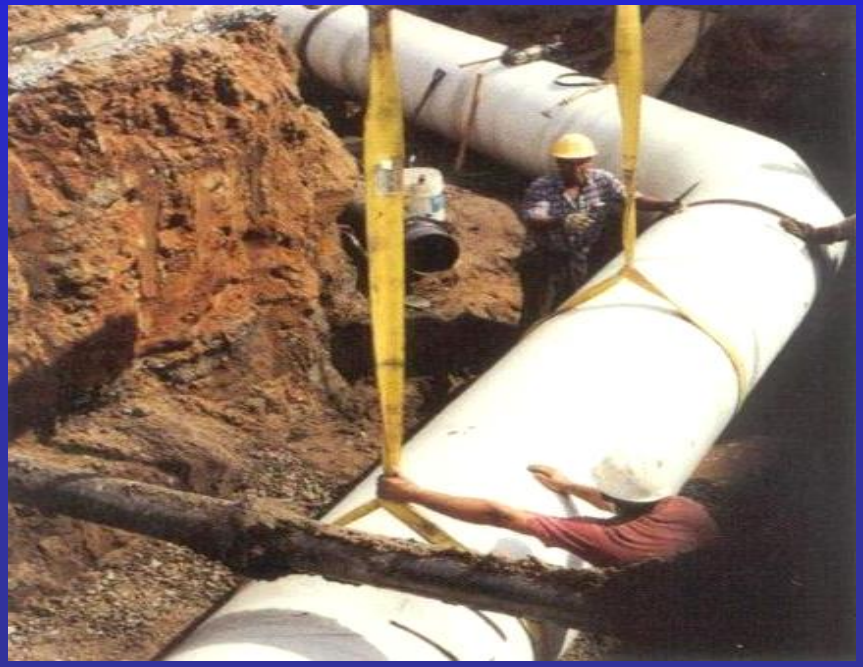


Cathodic Protection Test Station





Break Records for Water Mains Cathodically Protected in 1988



Temporary Fix ?

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Repair of Break Should Include Anode Installation

Incomplete

Complete

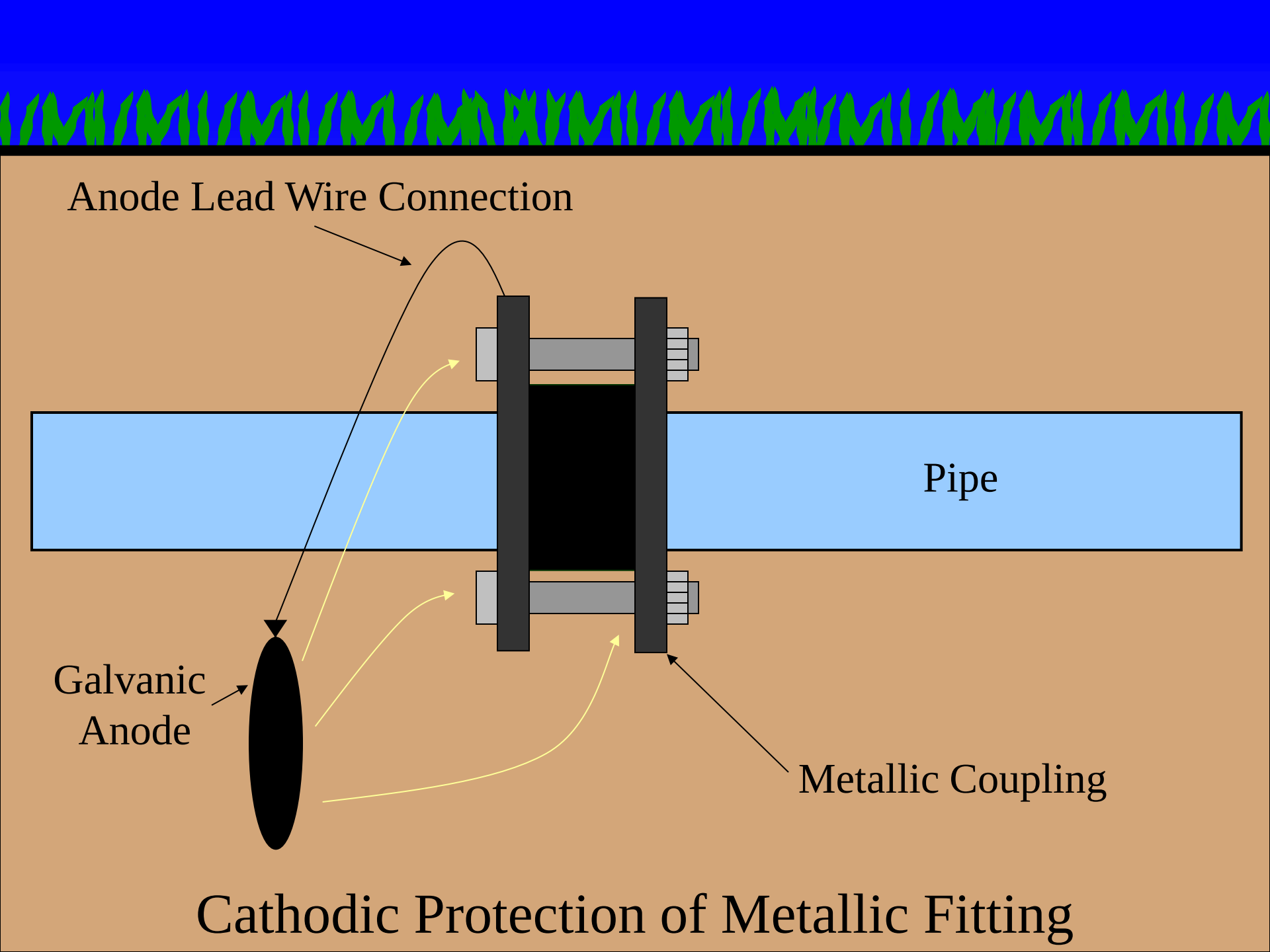
Lower Stress Area
(Cathode)

Pipe

Threaded Bolt
Higher Stress Area
(Anode)

Metallic Coupling

Stress Corrosion



Cathodic Protection of Metallic Fitting

Anode Installed on Metallic Fitting

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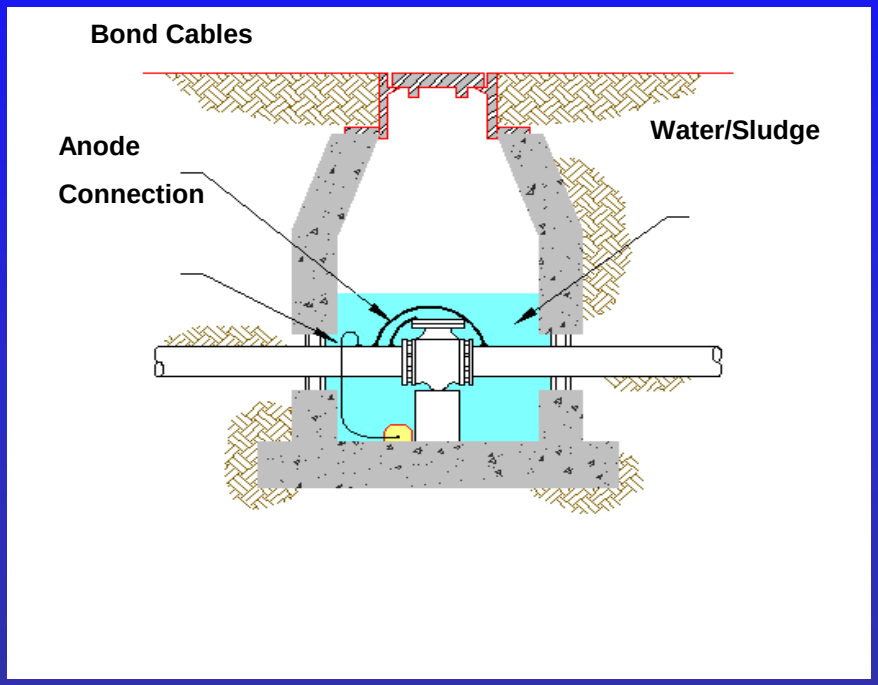
Meter Vault Corrosion

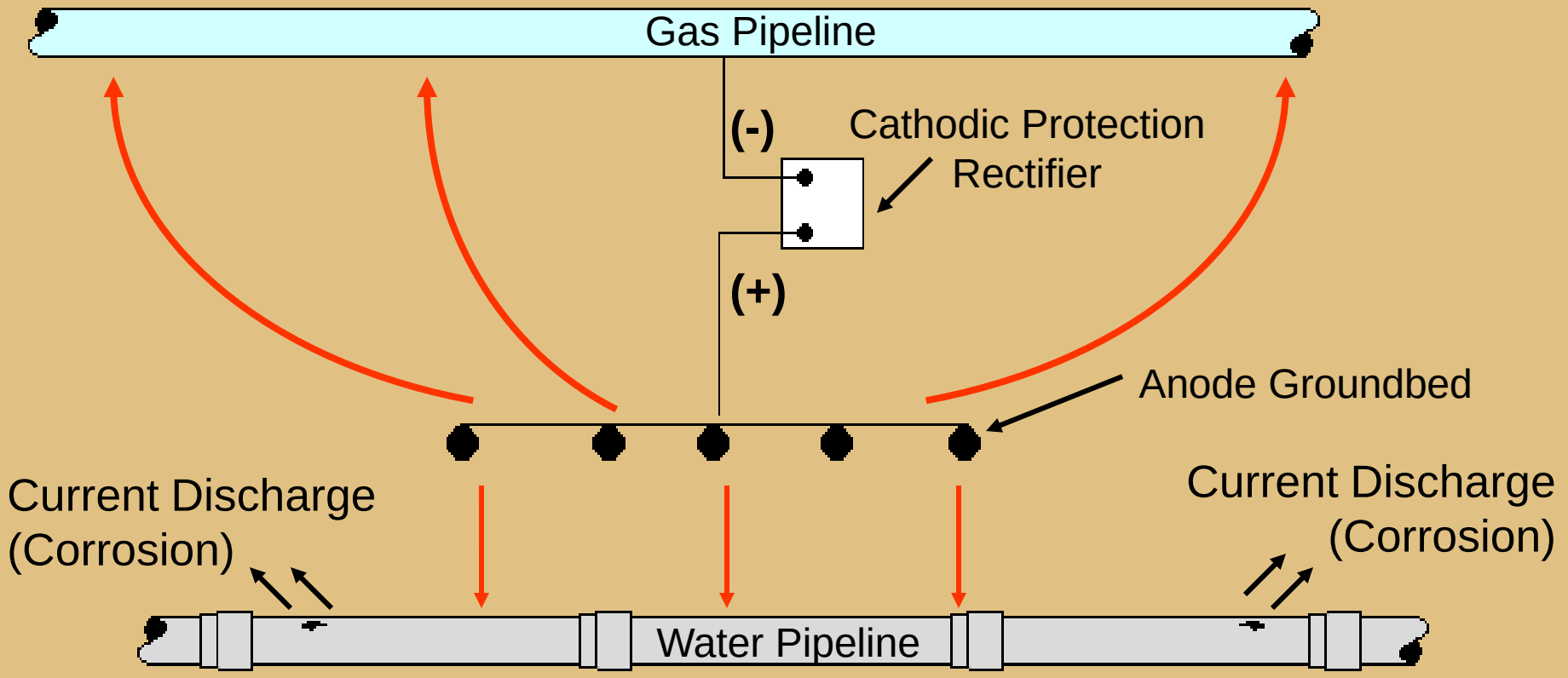


Meter Vault with Anode

Gate Valve Corrosion

Stainless Steel Corrosion

Stray Current



Stray Current Due to Impressed Current Cathodic Protection System

Impressed Current CP System on Oil/Gas Lines can Create Stray Current Problem on Water Lines

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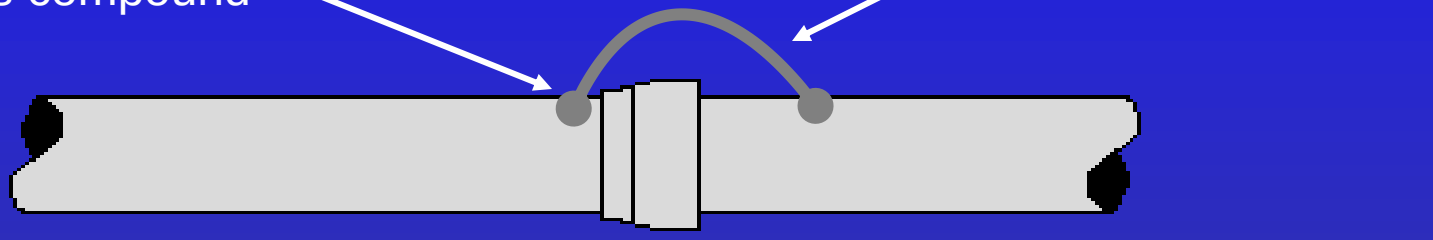
An Aegion™ Company

AC Mitigation

Bonding Across a Bell and Spigot or Slip-joint

Thermite brazed connection coated with bitumous compound

Copper wire with direct burial insulation



Pumping Stations

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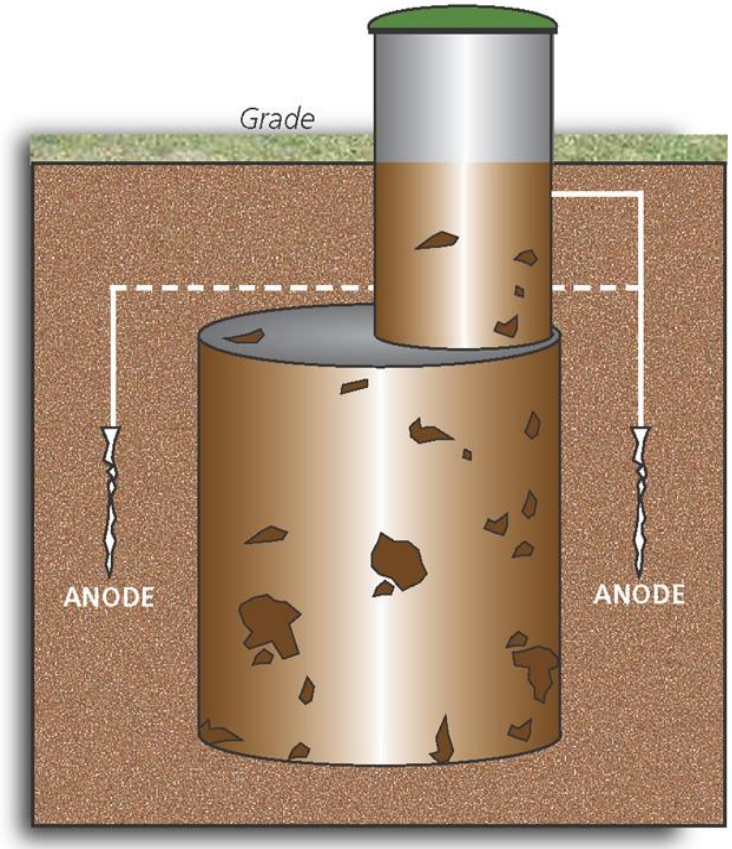
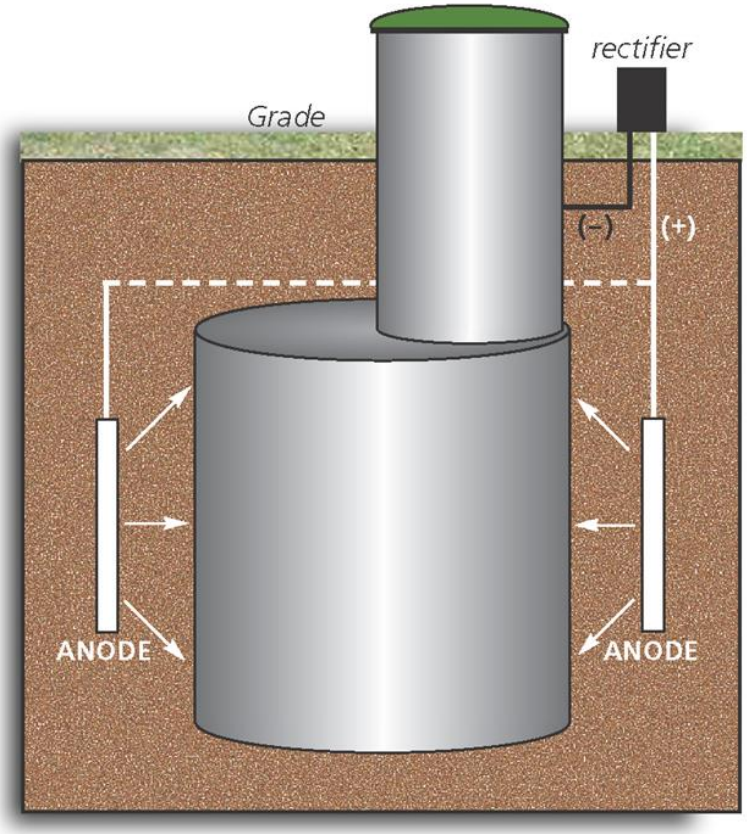
Depleted & Refurbished Cathodic Protection for Lift Stations



Depleted cathodic protection system allows corrosion to occur.



Effective cathodic protection system prevents corrosion and extends life of lift station.

For New or Refurbished Tanks

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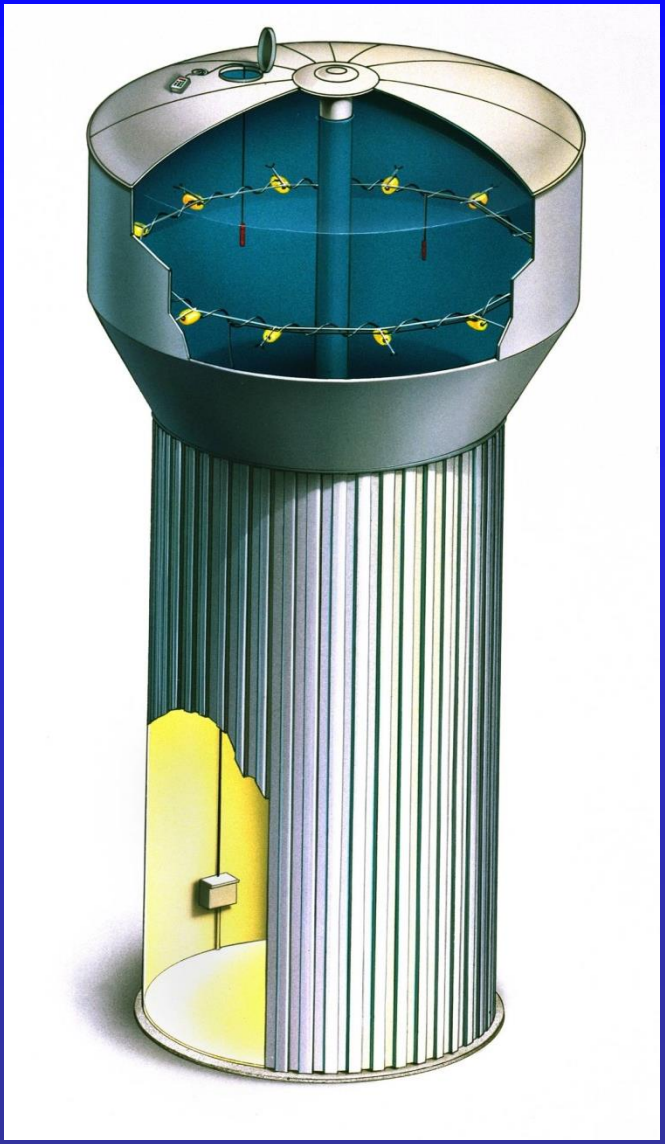
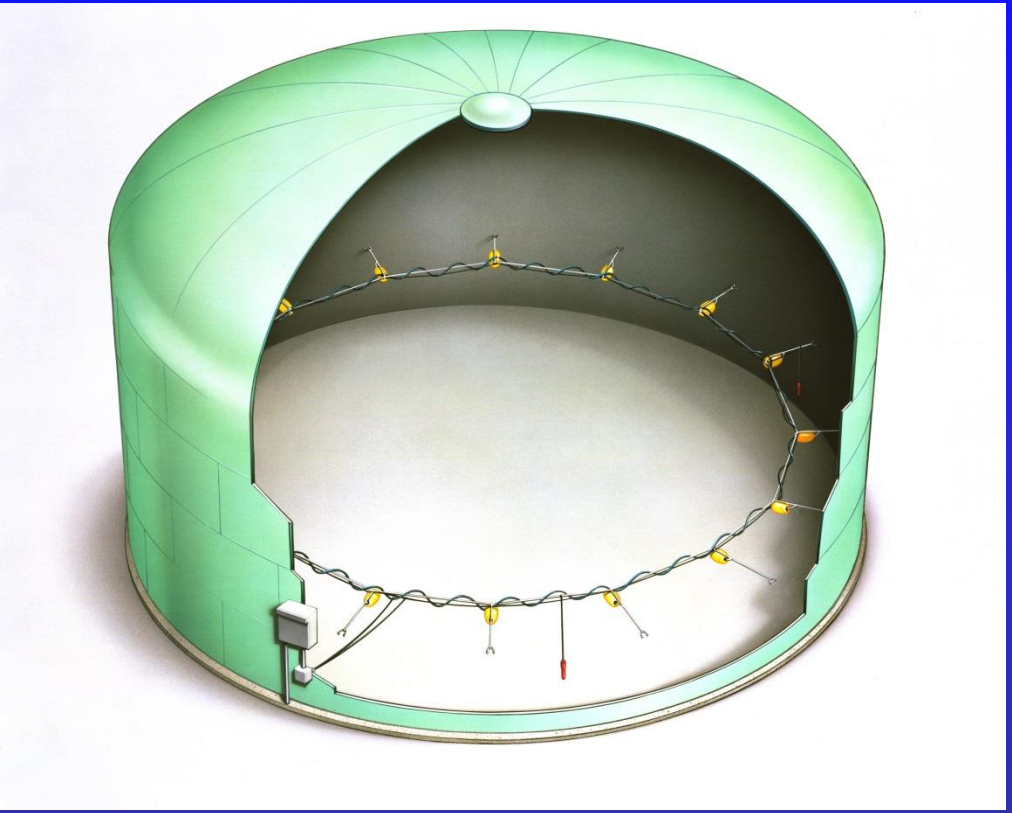
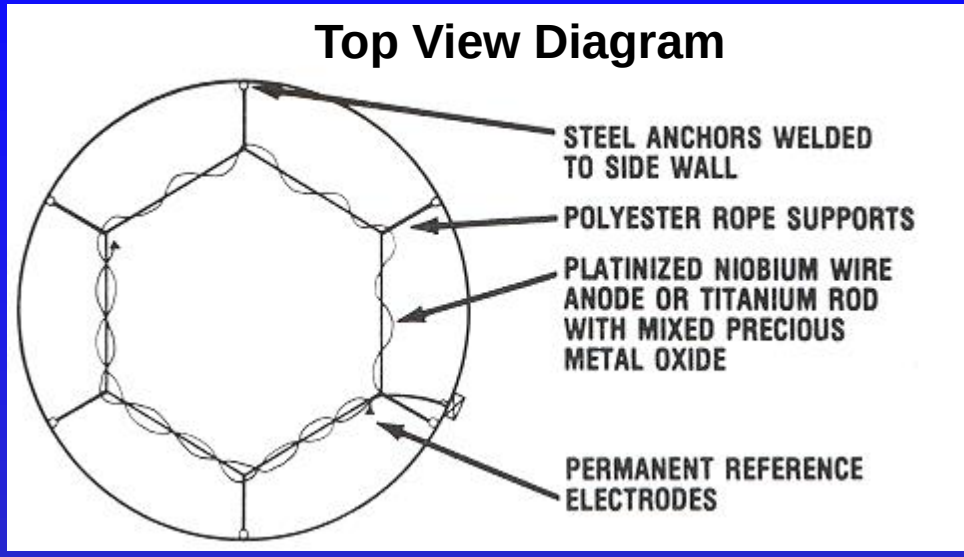
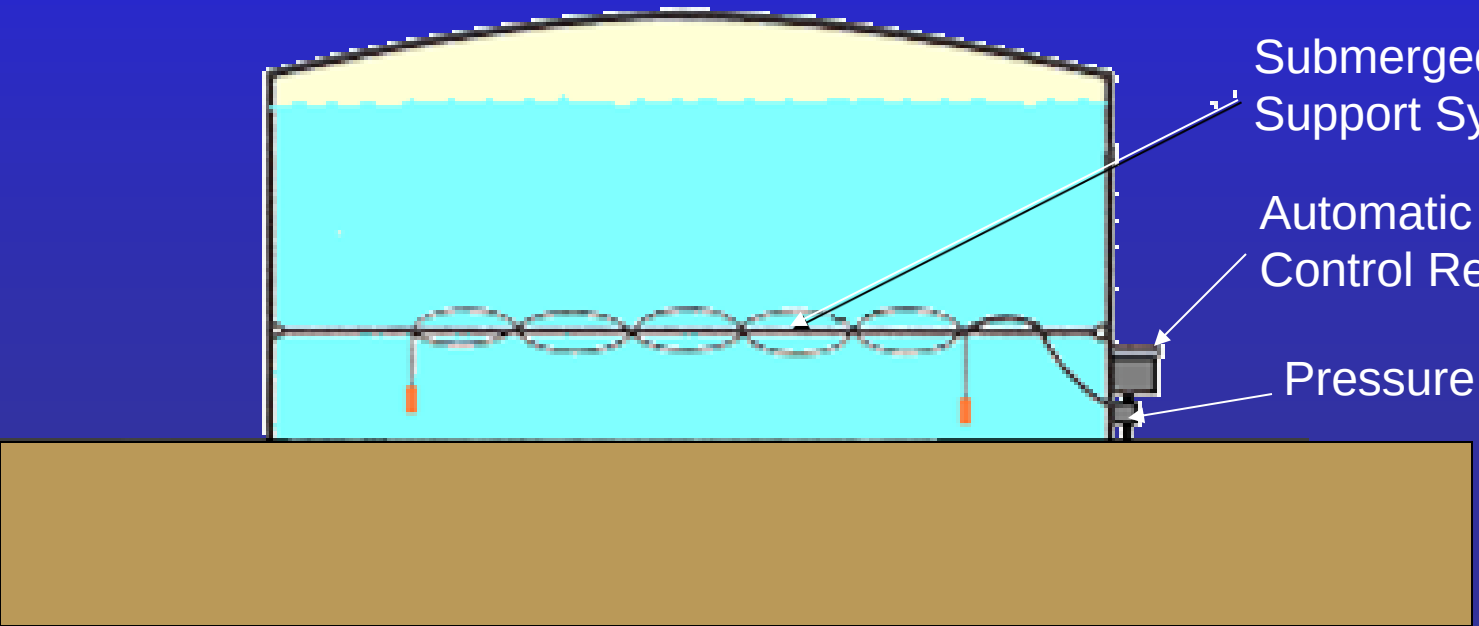




CP Benefits: - Triple life of coating
- Reduce maintenance cost

Suspended Horizontal Anode System





Corrosion of Clarifier Center Well

Annual Maintenance

Internal Corrosion of Force Mains….

Force Main Inspections

36” Above Ground Crossing

- Failure of force main at above ground crossing
- Crown of pipe attacked by hydrogen sulfide gas

24” Ductile Iron Force Main

- Internal failure following loss of internal mortar lining
- Failure was along top of pipe due to formation of hydrogen sulfide gas

Dual 26” Force Mains

- Internal failures at bottom of pipe
- Failure following loss of internal mortar lining
- Failures concentrated at low areas (dips) in pipeline alignment
- Cause is corrosion under accumulated solids

Rehabilitation Options

Investigative Structure (Existing)

Corrosion Assessment

- Review of General Characteristics of Water System
  - Age
  - Material Type
  - Wall Thickness
  - Construction Practices
- Review Break / Leak History
- Field Survey
  - Soil Conditions (Resistivity, Moisture Content, Chemical Analysis)
  - Electrical Test
- Data Analysis & Risk Management
- Priority Index (Identification of Opportunities to Reduce Replacement / Repair Costs)

New Piping

PHASE I

- Obtain drawings of proposed route
- Conduct independent field investigation:
  a) Soil resistivity study
  b) Identify foreign pipeline crossing
  d) Identify AC potential influence
  e) Collect soil samples (moisture content, chlorides, pH, sulfate ions concentration, conductivity)
- Stray current investigation

Corrosion Protection Design
Phase II

Prepare Bid Quality Specifications for:

- Coatings or Polyethylene Encasement
- Test Stations (Monitor Corrosion Rates)
- Bonded Joints
- Stray DC/AC Mitigation
- Cathodic Protection
- Combination of Multiple Items

- Review Submittals/Onsite Periodic Inspection

Summary

- Reducing corrosion rates on existing water distribution piping will result in a reduction of the number of breaks and also extend the operational life.

- Corrosion control measures should be considered during the design stage for any new metallic piping ans storage tank installations.


Traffic Disruptions
Water Loss
Fire Protection
Damages
Legal & Environmental Claims

QUESTIONS ?

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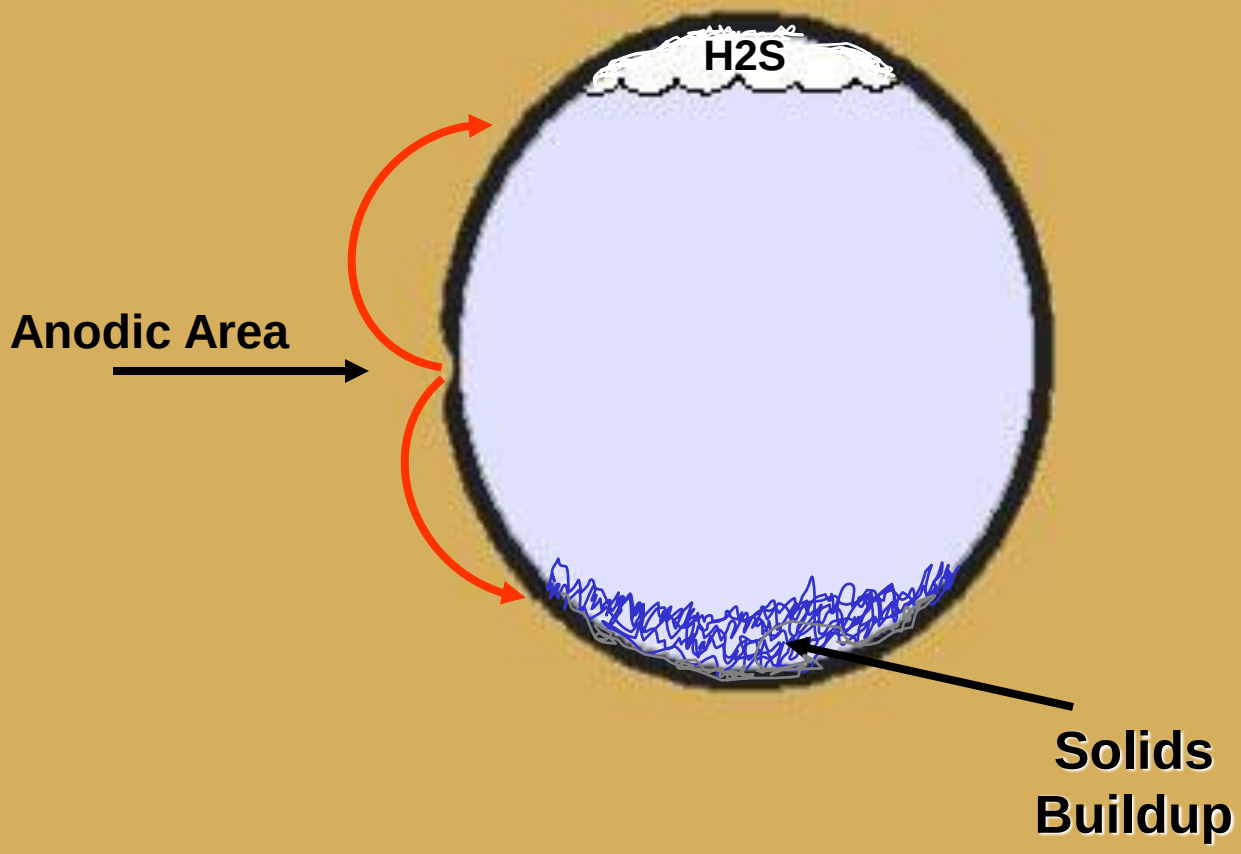
Impressed Current CP System on Oil/Gas Lines can Create Stray Current Problem on Water Lines


27 10:32AM


Transformer Rectifier

Internal & External Corrosion of Force Mains….



36” Above Ground Crossing

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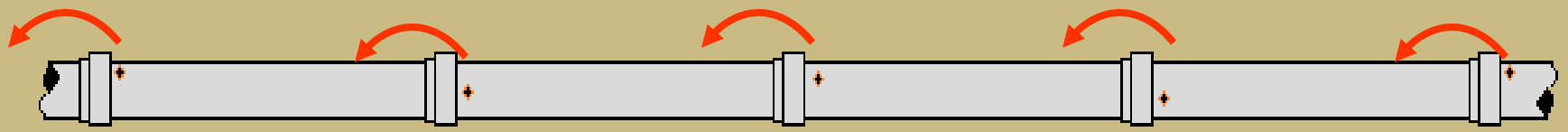
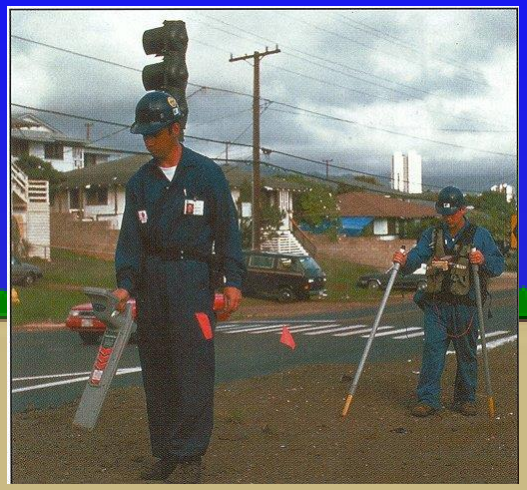
Stray Current



Computerized Potential Logging Survey



Test Station

Backpack Computer Unit

Chainer/Wire Dispenser & Counter

Reference Cells

Bonded Joints

Polywrap

Pipeline

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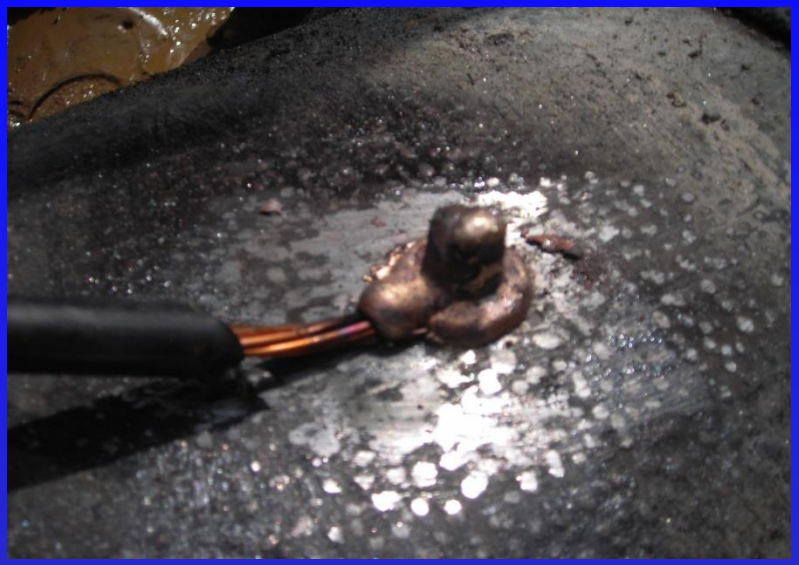
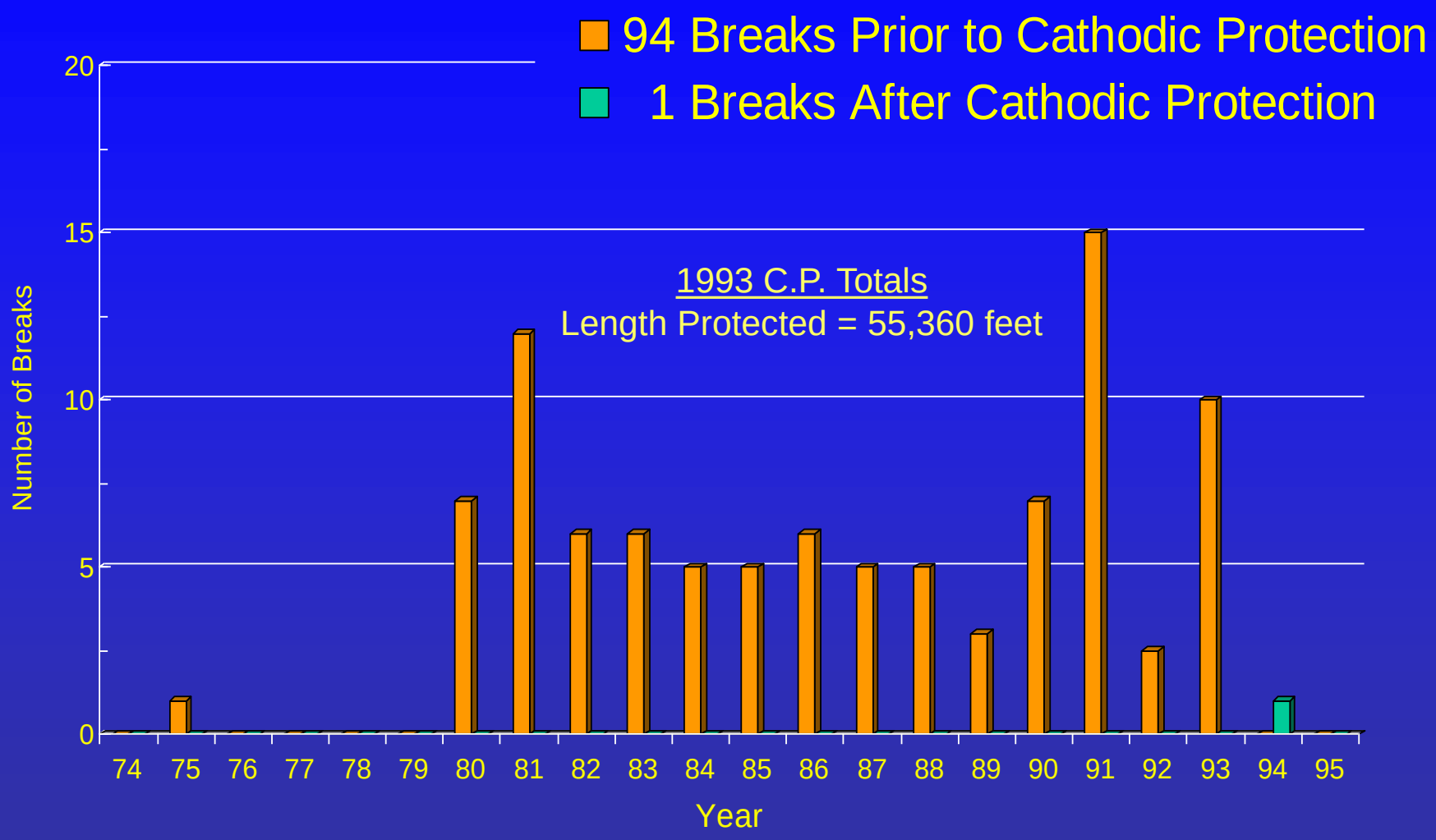
Thermit Weld to Pipe



Access to Pipe



Break Records for Water Mains Cathodically Protected in 1993

Water Leak Repair Kit

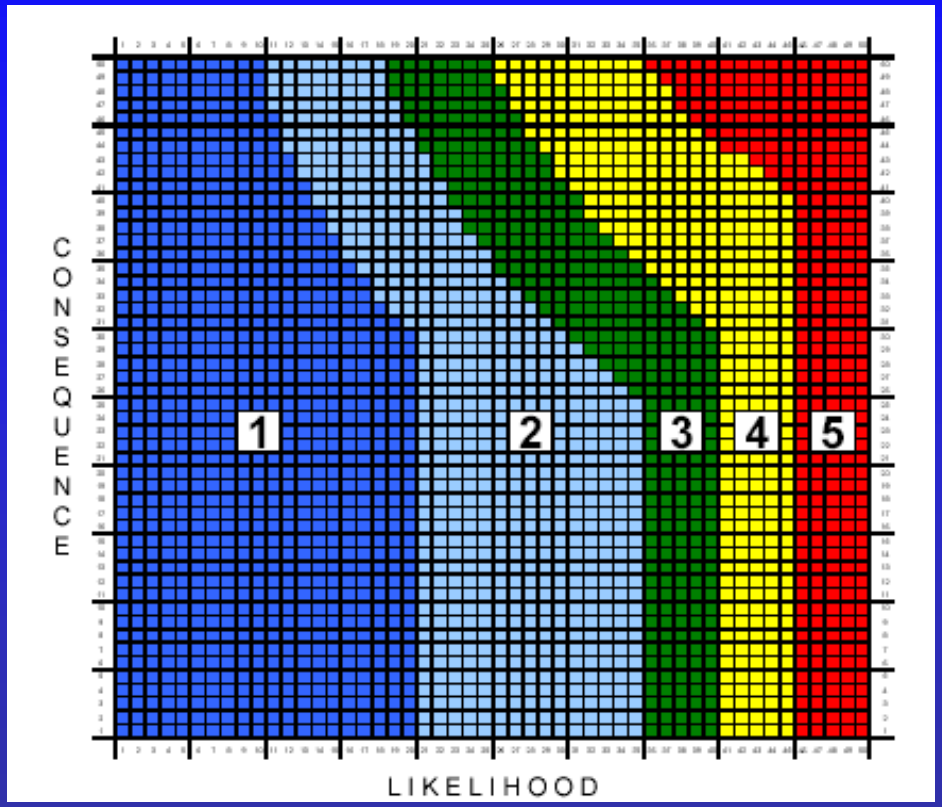
Includes:

Installation instructions.

One day onsite technical assistance.

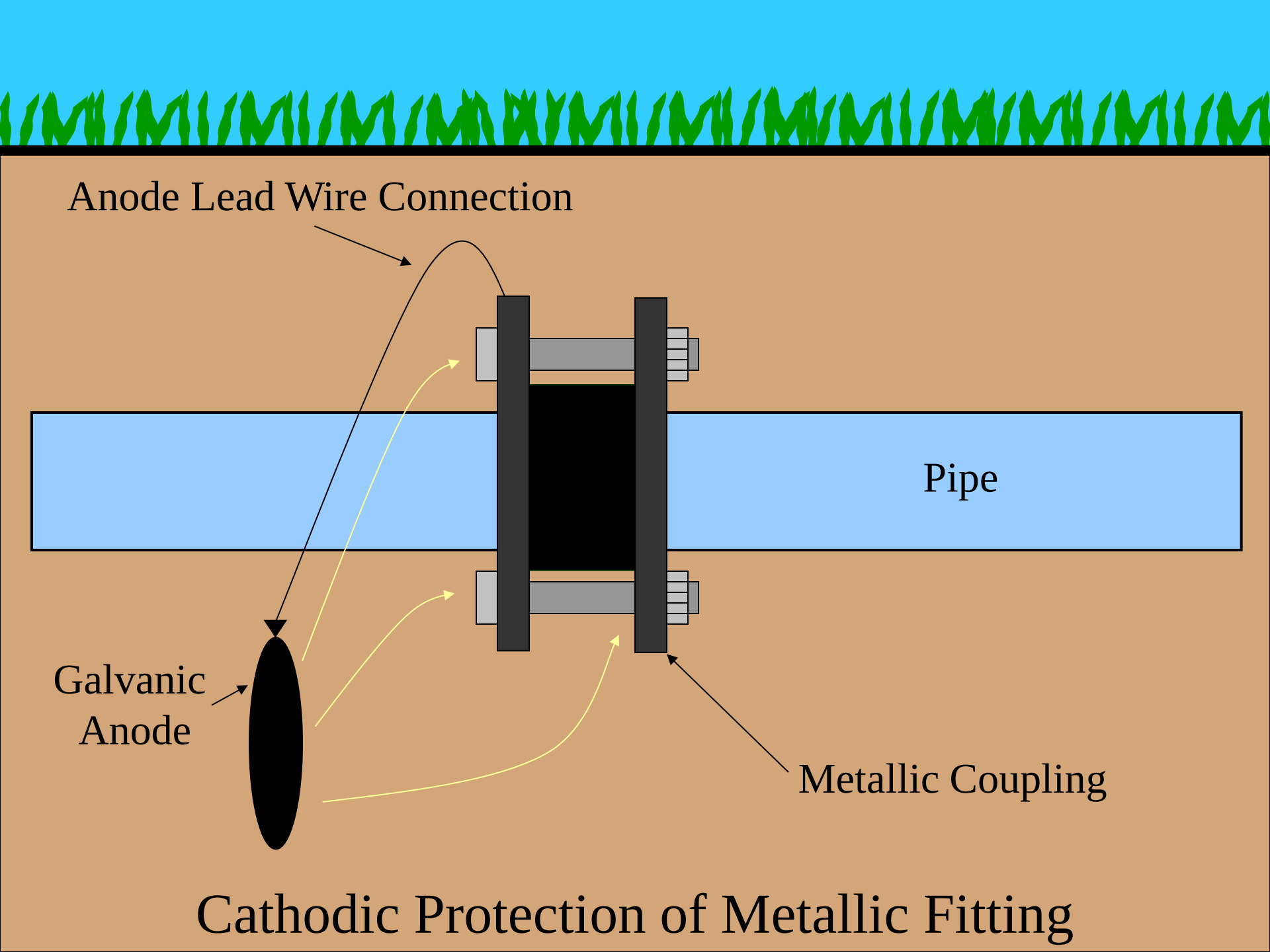
Cathodic protection components/connection materials suitable for 10 repairs.

Design Decision Model



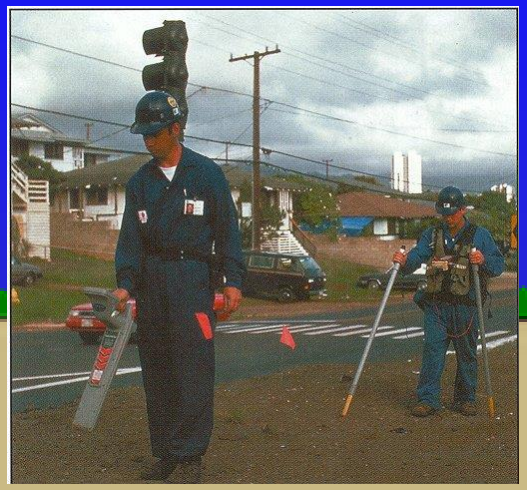
For Ductile Iron Pipe

Insituform



Cathodic Protection of Metallic Fitting

Computerized Potential Logging Survey



Test Station

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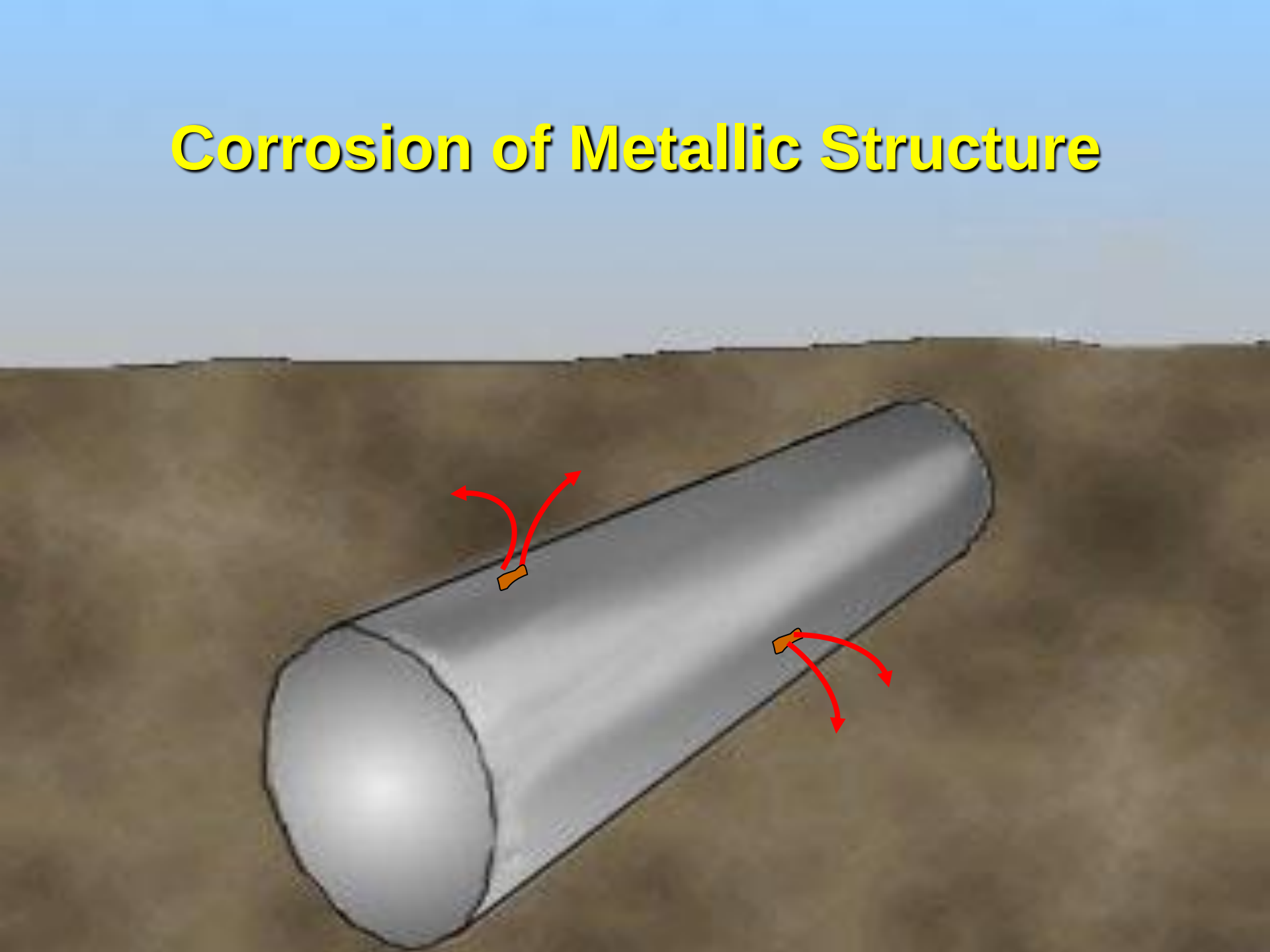
Chainer/Wire Dispenser & Counter

Reference Cells

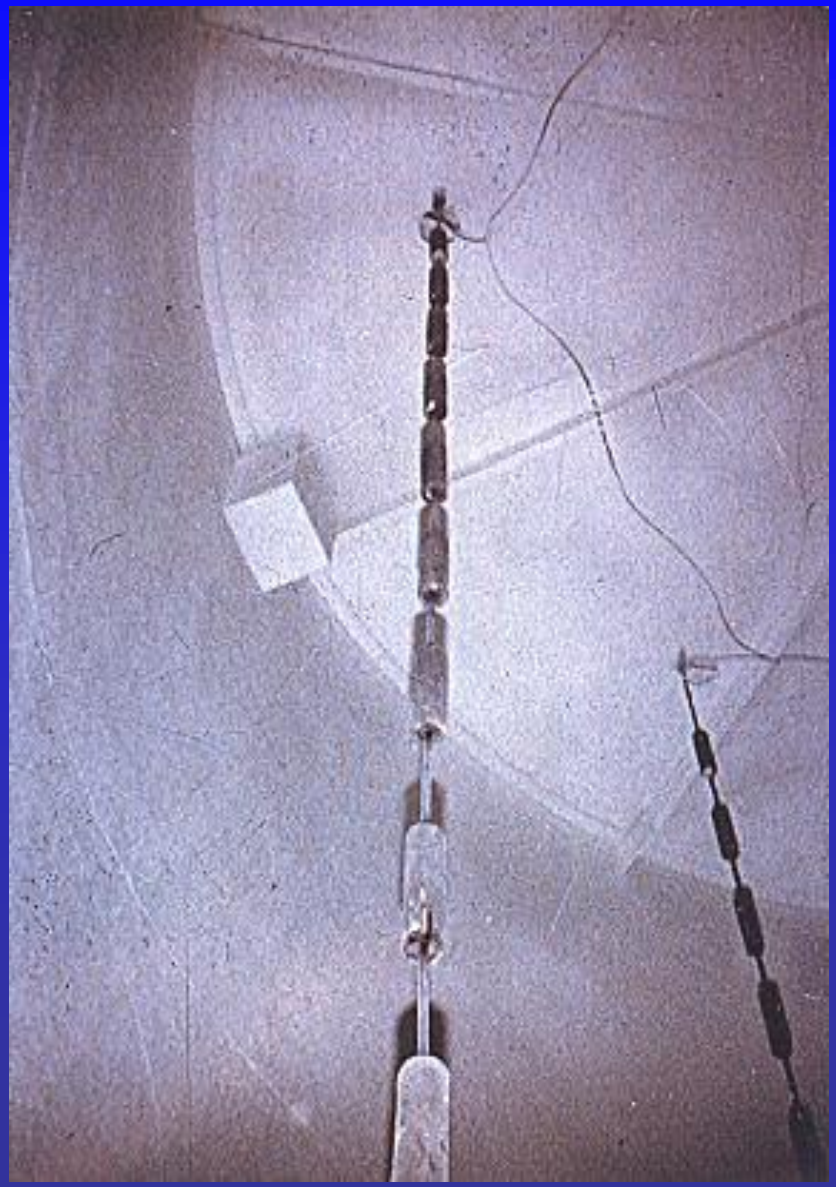
Bonded Joints

Pipeline

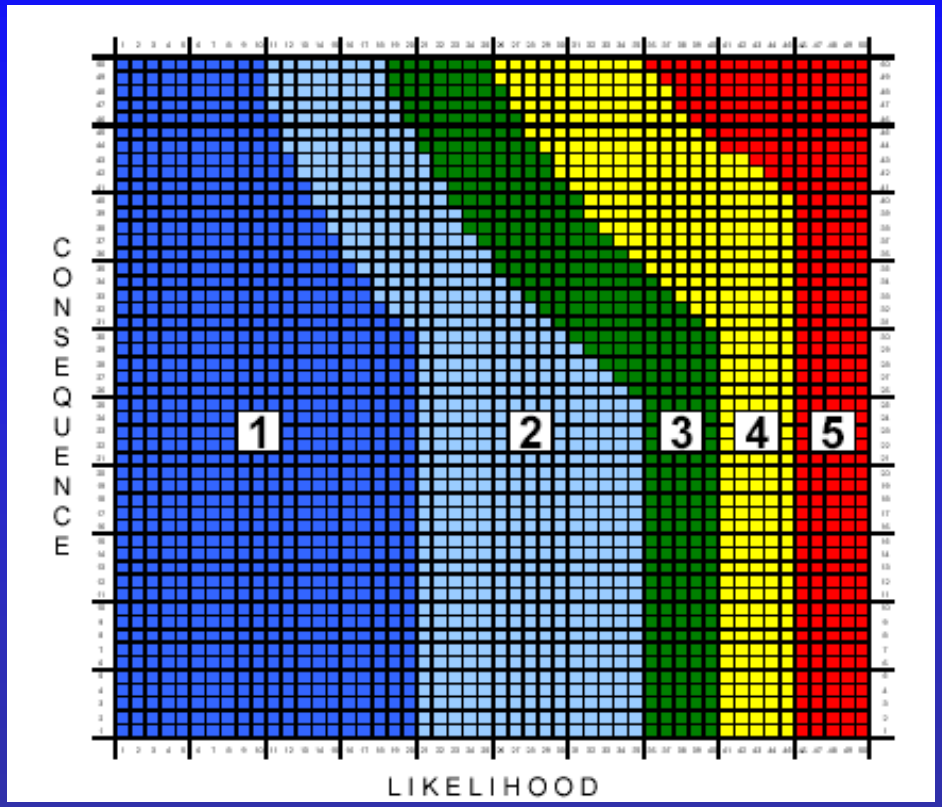
Corrosion of Metallic Structure



Vertically Suspended High Silicon Cast Iron Anode String



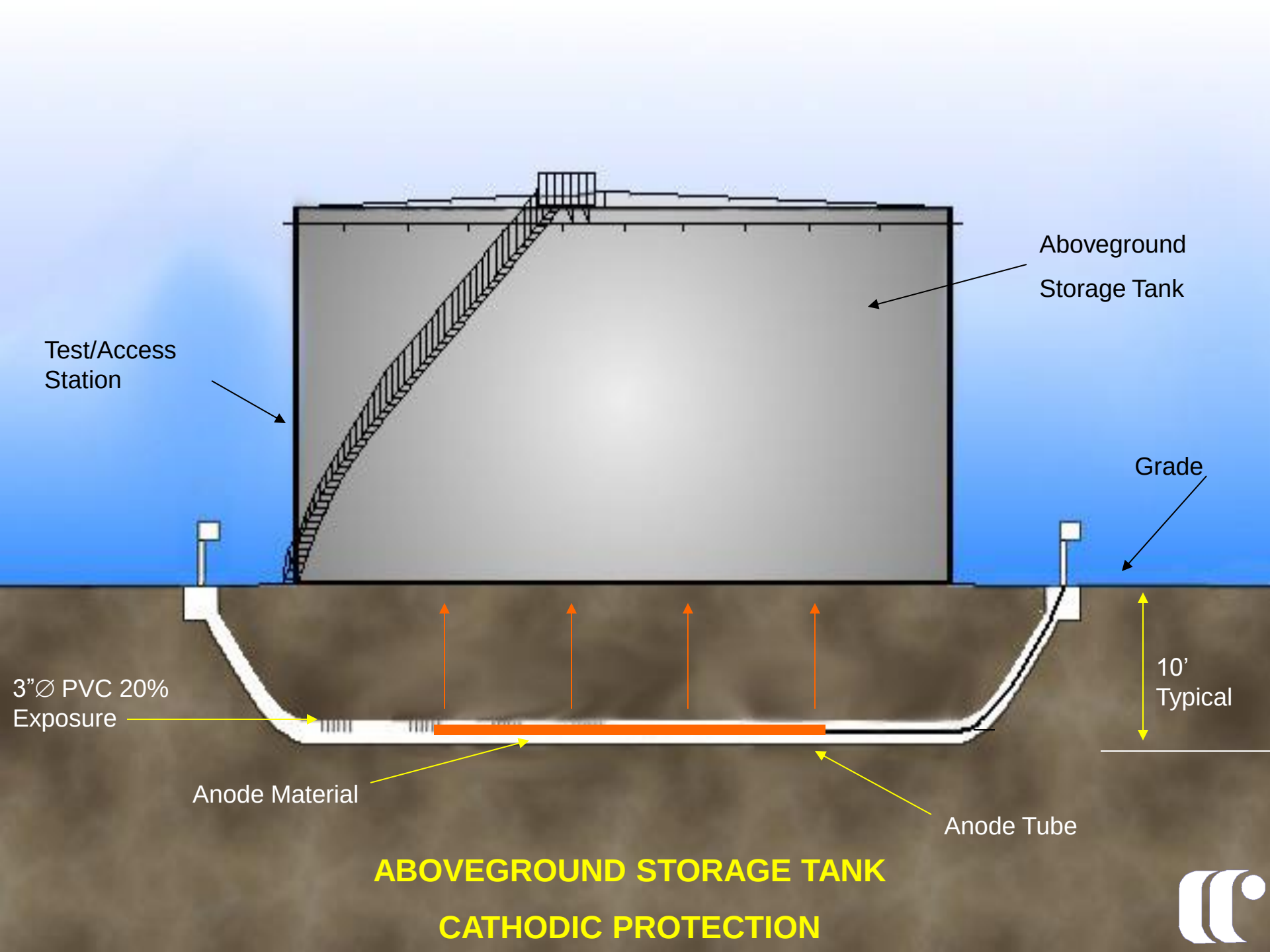
Design Decision Model



For Ductile Iron Pipe


27 10:23AM

Horizontally Submerged Cathodic Protection System in Water Storage Tank



ABOVEGROUND STORAGE TANK

CATHODIC PROTECTION

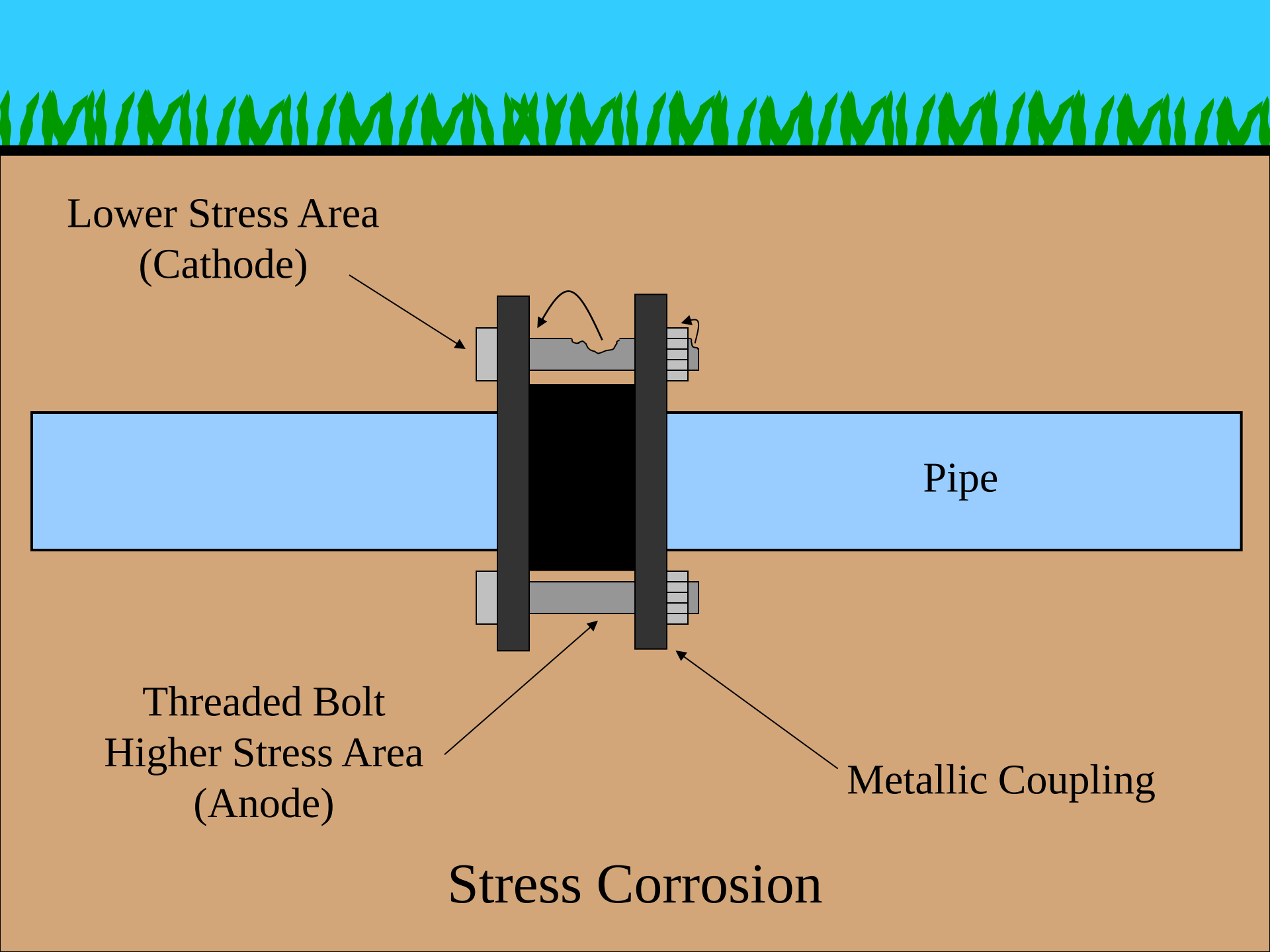
The estimated annual cost to repair water piping breaks in North America alone is estimated to be*:

$1.5 Billion

& based on 250,000 breaks at a repair cost of $5,875.00 U.S.D. each

Budget Estimate for Complete Cathodic Protection System for 1MMG Water Tank

$12,000



Stress Corrosion

Insituform

Corrosion Can be Defined as Either:

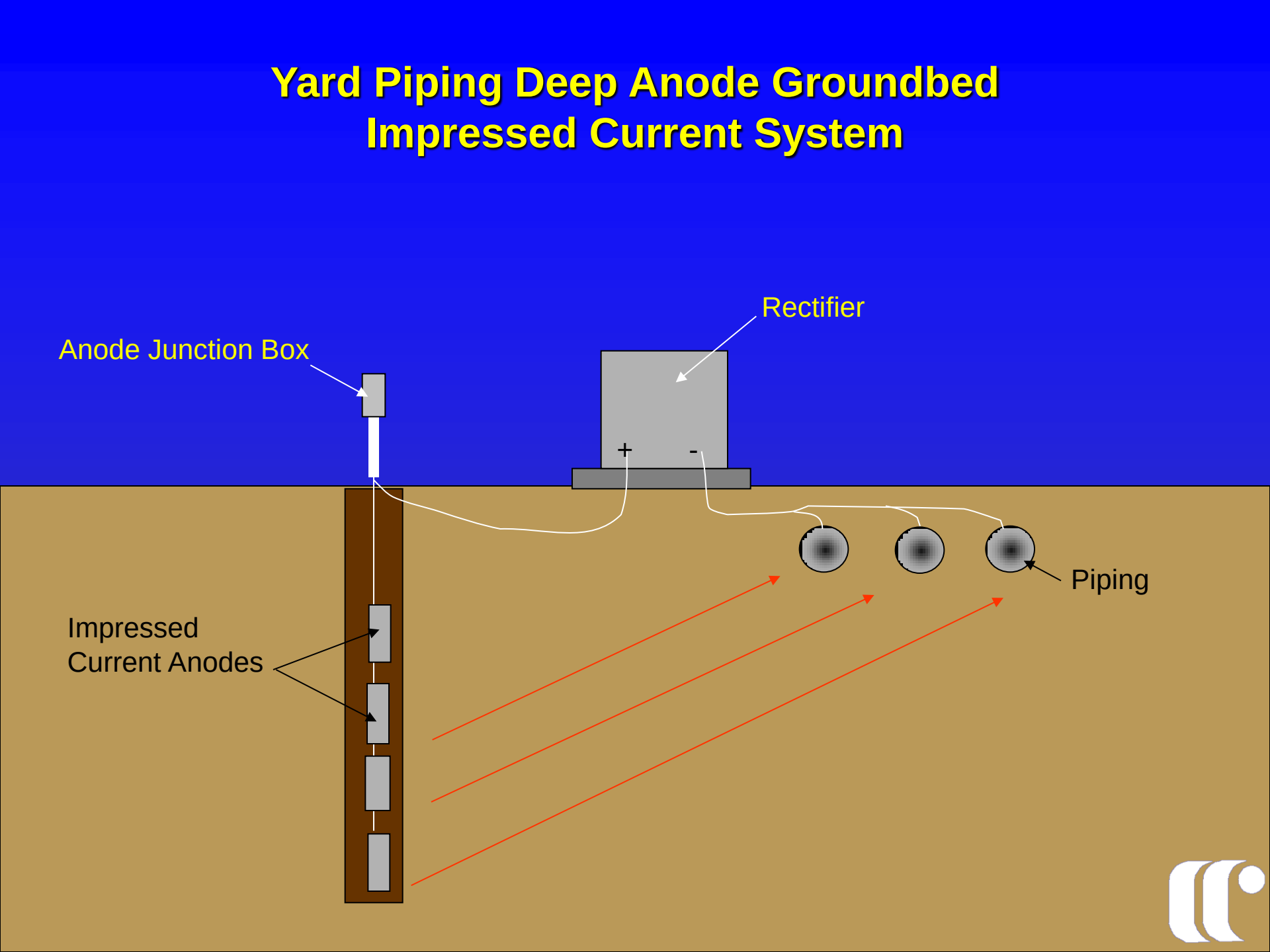
- Practical

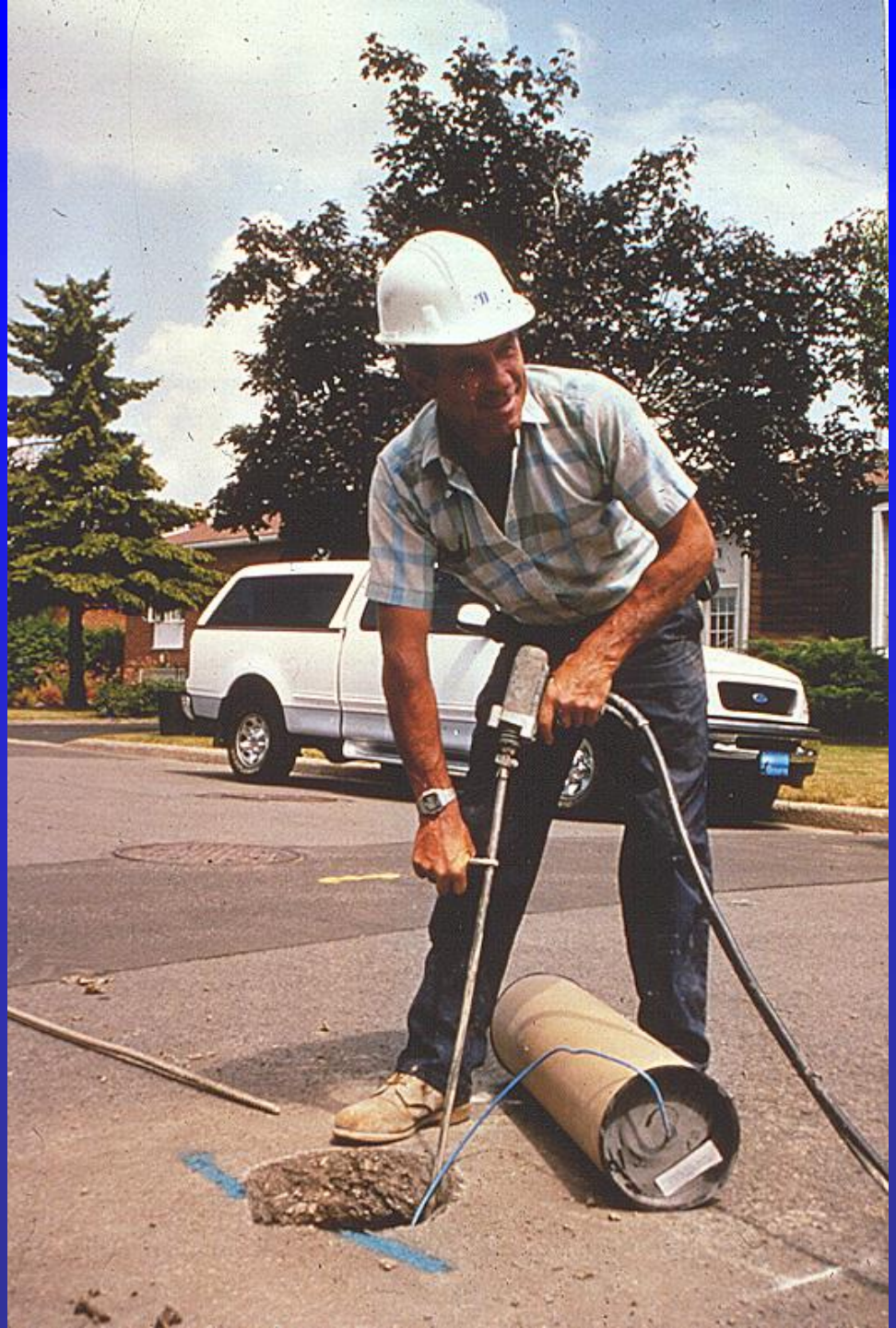
  Tendency of a Metal to Revert to its Native State

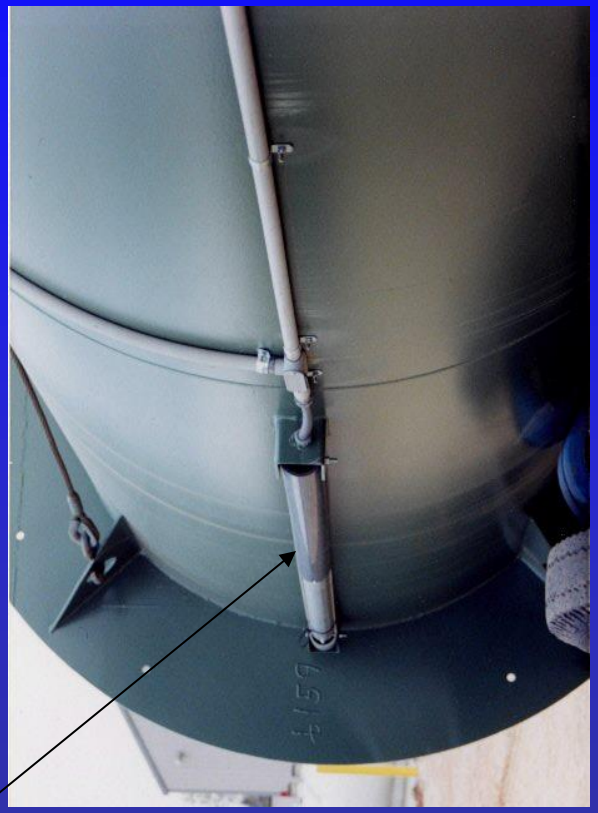
- Scientific

  Electrochemical Degradation of Metal as a Result of a Reaction with its Environment

Yard Piping Deep Anode Groundbed
Impressed Current System







Factory Installed Cathodic Protection Systems

Bi-Metallic Corrosion Between Carbon Steel Tank & Stainless Steel Ladder

Corrosion Control for Water System Piping Results in Reduction of Water Loss

Presented By:

James T Lary
Corrpro Companies, Inc
1090 Enterprise Dr.
Medina, OH 44256
Tel. 330-723-5082 (x1215)
email: jlary@corrpro.com
http://www.corrpro.com

Repair of Break Should Include Anode Installation

Incomplete

Complete

Annual Cathodic Protection Survey

Corrosion Control for Water & Wastewater Systems

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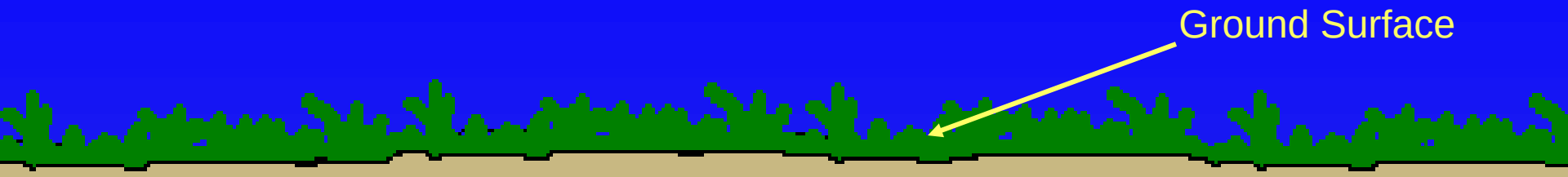
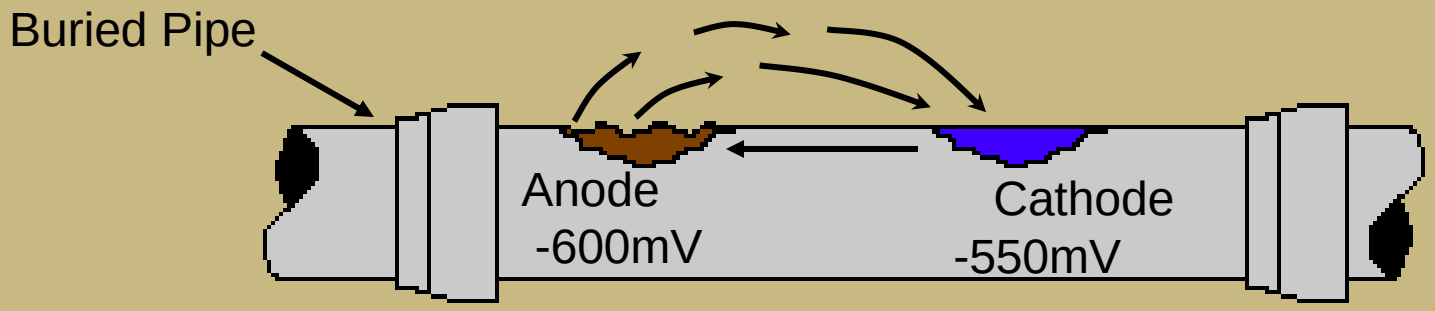
Corrosion is the leading contributor to cast and ductile iron water system breaks!

Bolt & Nut Corrosion

Inspection of CP System

Basic Corrosion Cell





1) **Anode**
2) **Cathode**
3) **Electrolyte**
4) **Electrical Connection**

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Structures

- *Piping (Distribution/Transmission)*
- *Metallic Fittings*
- *Water Storage Tanks*
- *Clarifier Units*
- *Lift Stations*

Corrosion Can be Defined as Either:

- Practical

  Tendency of a Metal to Revert to its Native State

- Scientific

  Electrochemical Degradation of Metal as a Result of a Reaction with its Environment

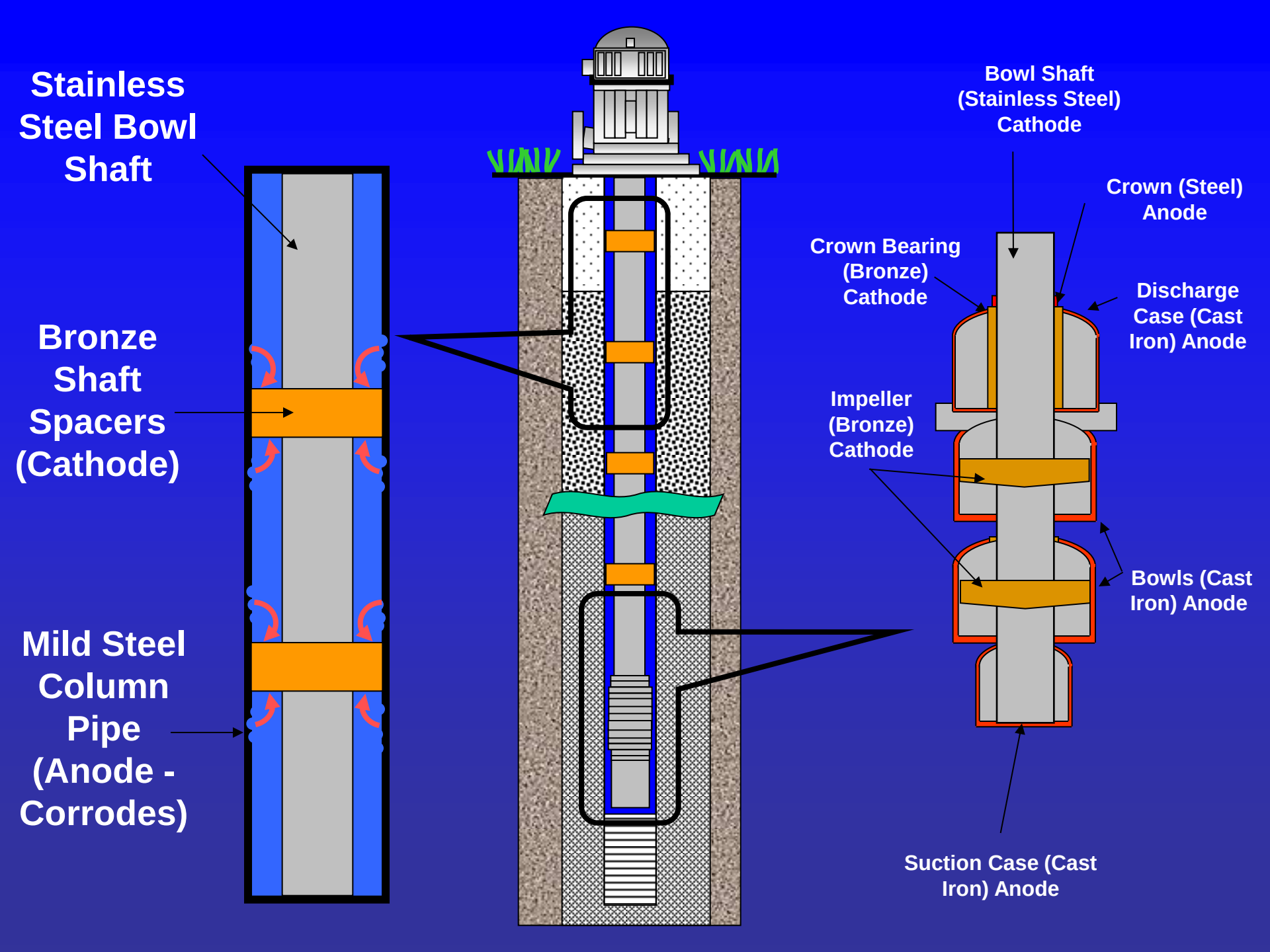
Copper Service Connections

Anode Installation Prevents Corrosion on Copper Service Line

Non metallic or Polyethylene Encased Ductile Iron Main

Anode Connection to Line

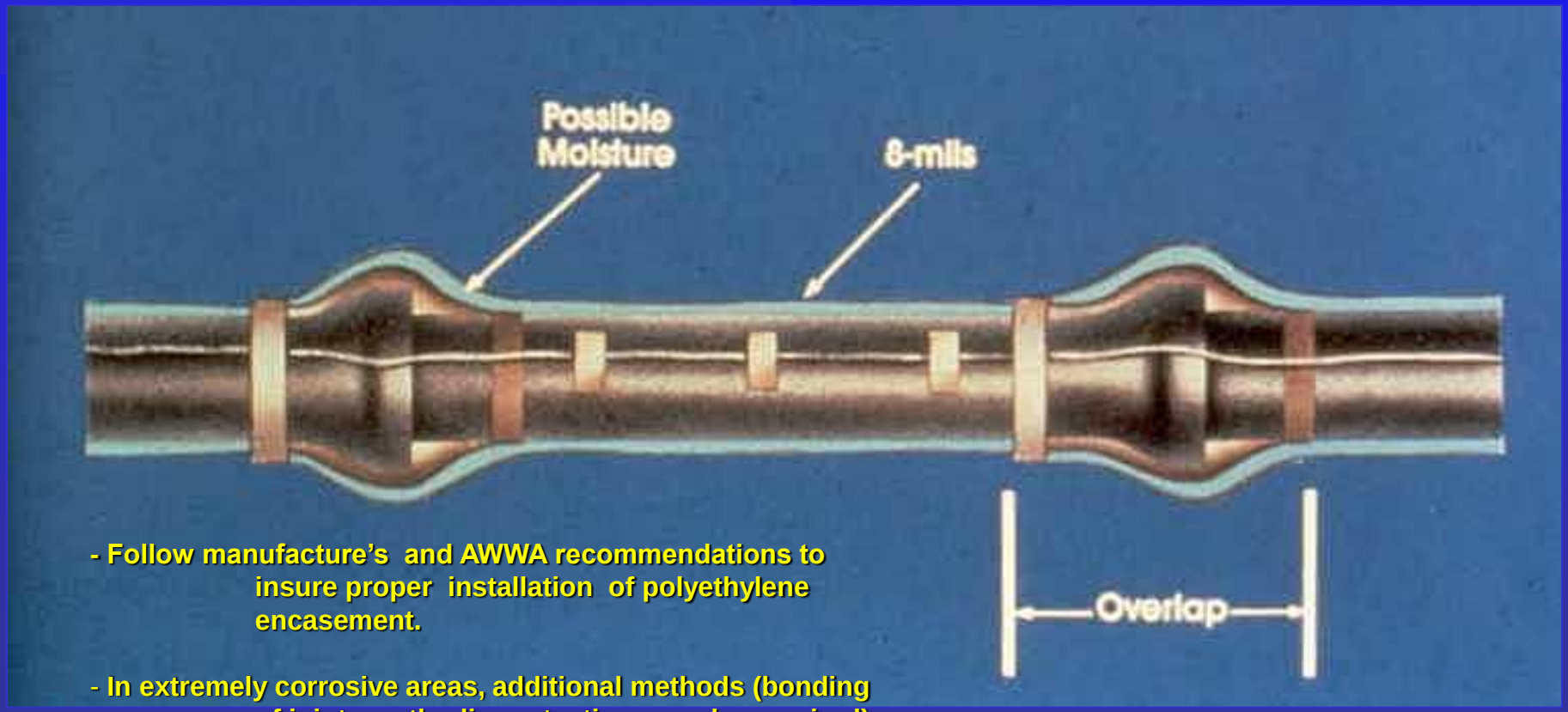
Anode


Stainless Steel Bowl Shaft
Bronze Shaft Spacers (Cathode)
Mild Steel Column Pipe (Anode - Corrodes)
Bowl Shaft (Stainless Steel) Cathode
Crown (Steel) Anode
Crown Bearing (Bronze) Cathode
Discharge Case (Cast Iron) Anode
Impeller (Bronze) Cathode
Bowls (Cast Iron) Anode
Suction Case (Cast Iron) Anode

Water Wells

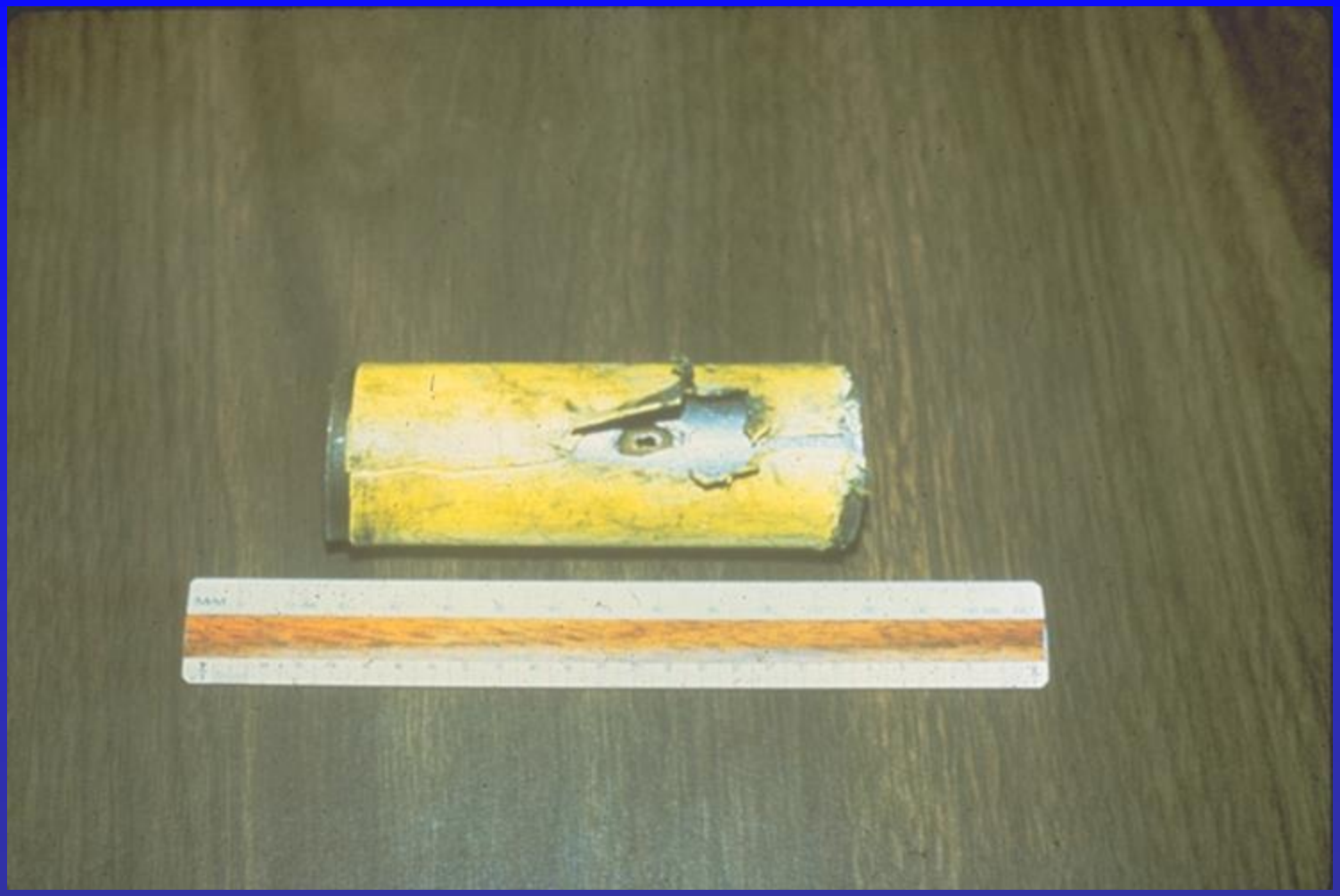
Stainless Steel Corrosion

Polyethylene Encasement



- Follow manufacture's and AWWA recommendations to insure proper installation of polyethylene encasement.

- In extremely corrosive areas, additional methods (bonding of joints, cathodic protection, may be required).



History of Iron Pipe

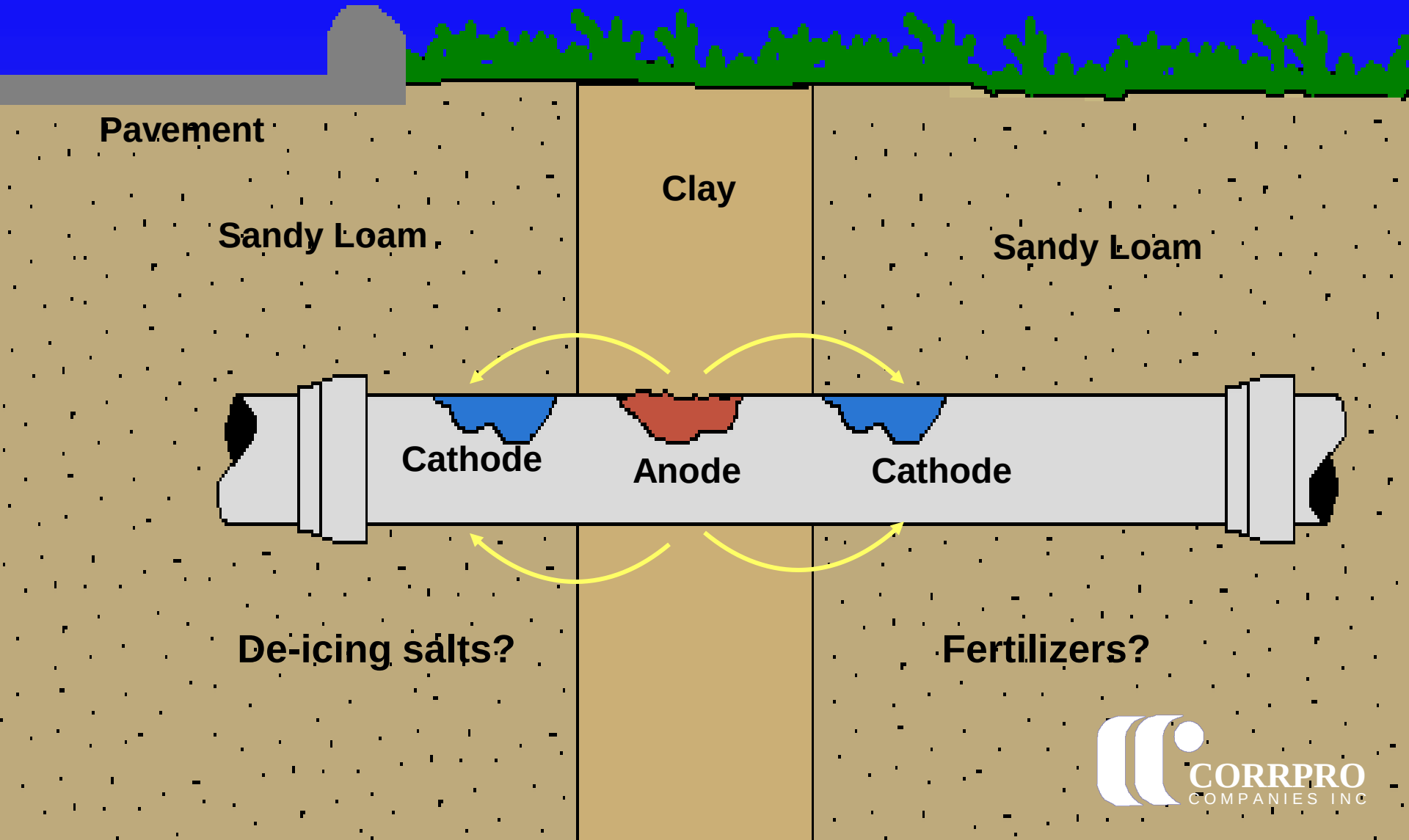
Cast Iron

- Introduced to North America during the 1800's and installed till the 1970's.
- Early on, statically cast process produced a thick walled, heavy pipe.
- No longer produced in North America.

Ductile Iron

- Introduced in 1955 as an improvement to cast iron.
- Centrifugal casting process produces a thinner walled, lighter pipe which is stronger and more ductile than cast iron.

Dissimilar Soils



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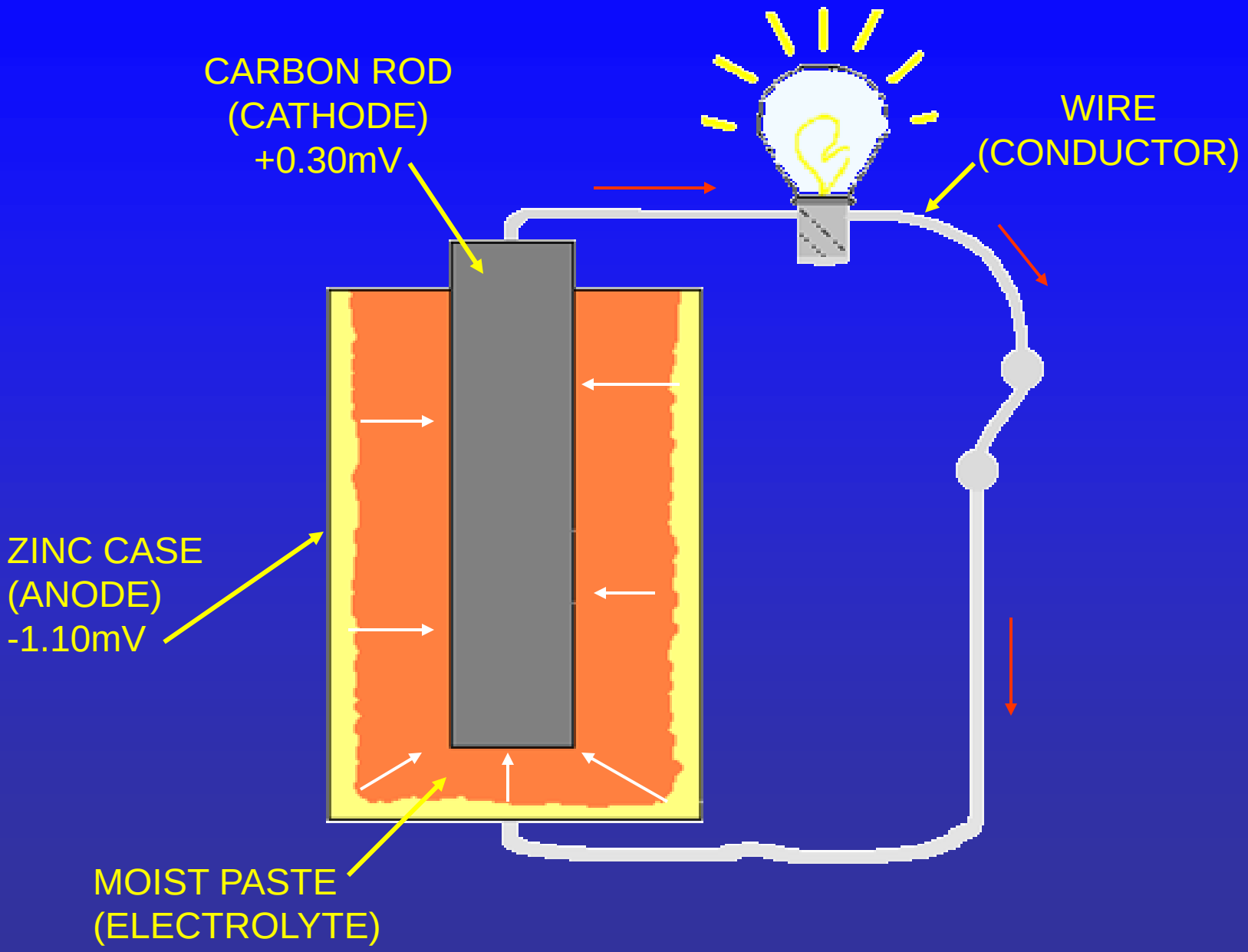
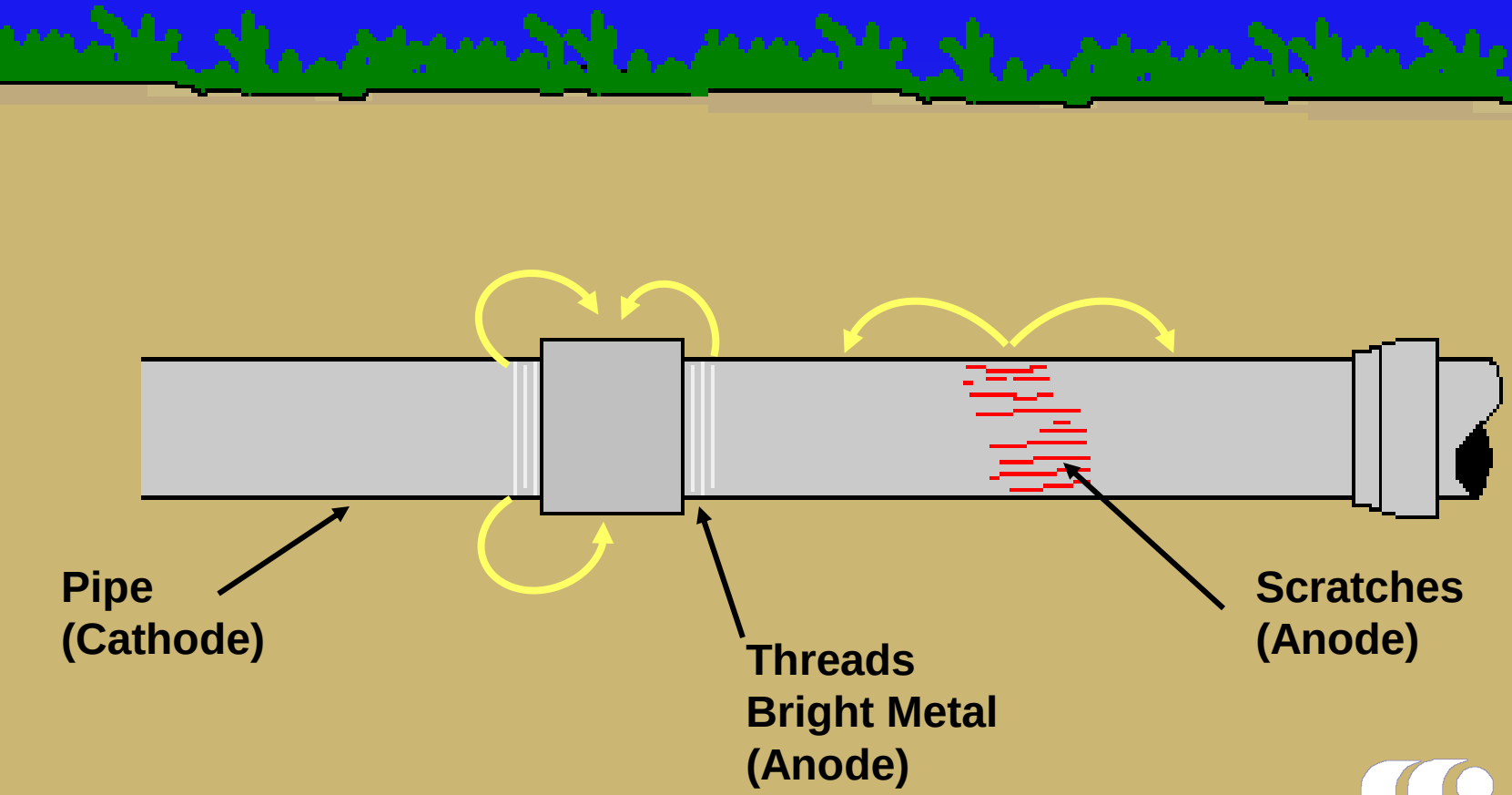

CARBON ROD
(CATHODE)
+0.30mV
WIRE
(CONDUCTOR)
ZINC CASE
(ANODE)
-1.10mV
MOIST PASTE
(ELECTROLYTE)

Corrosion of iron when coupled to copper service line.

Corrosion Pitting

Dissimilar Surface Conditions



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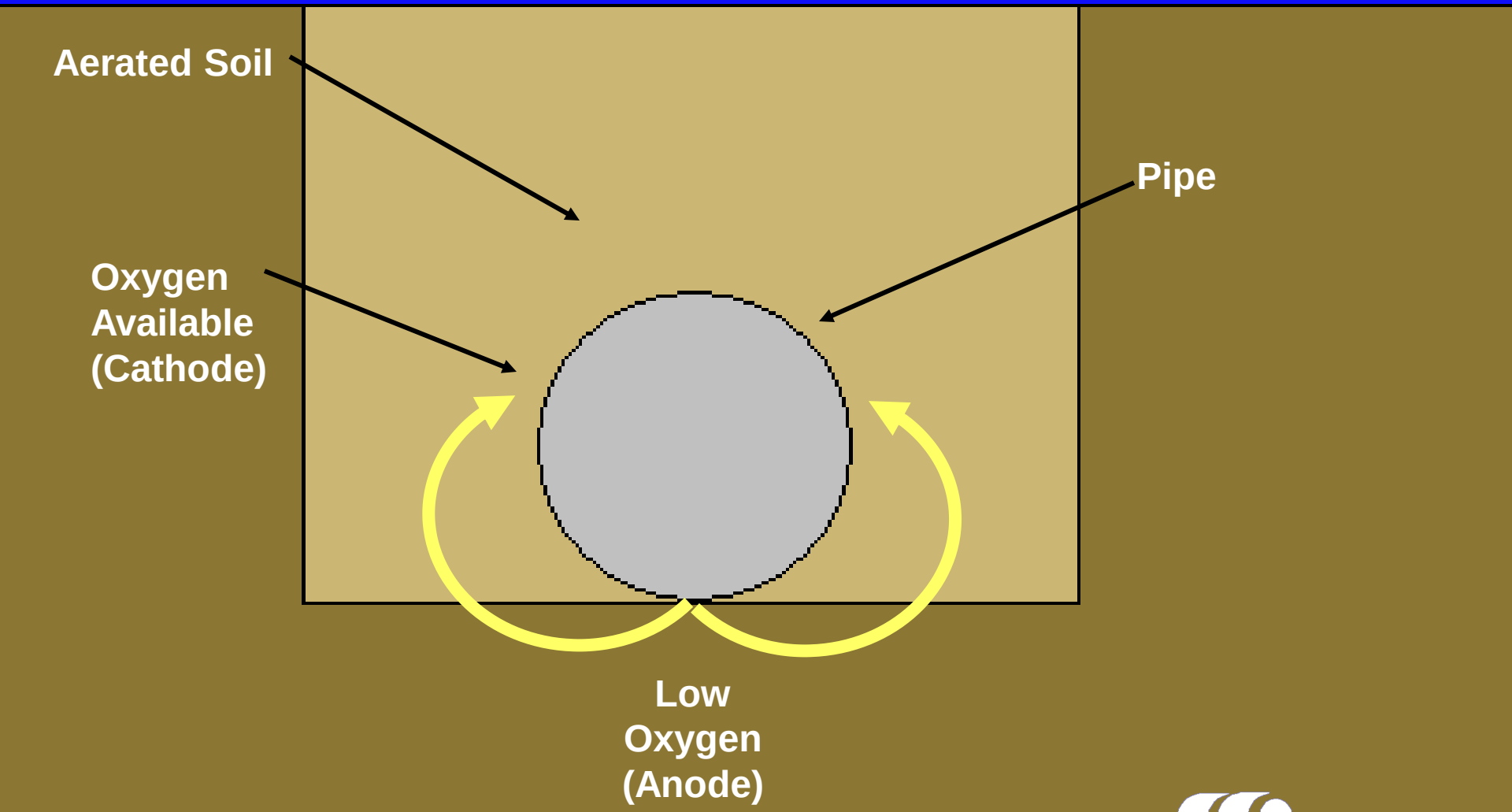
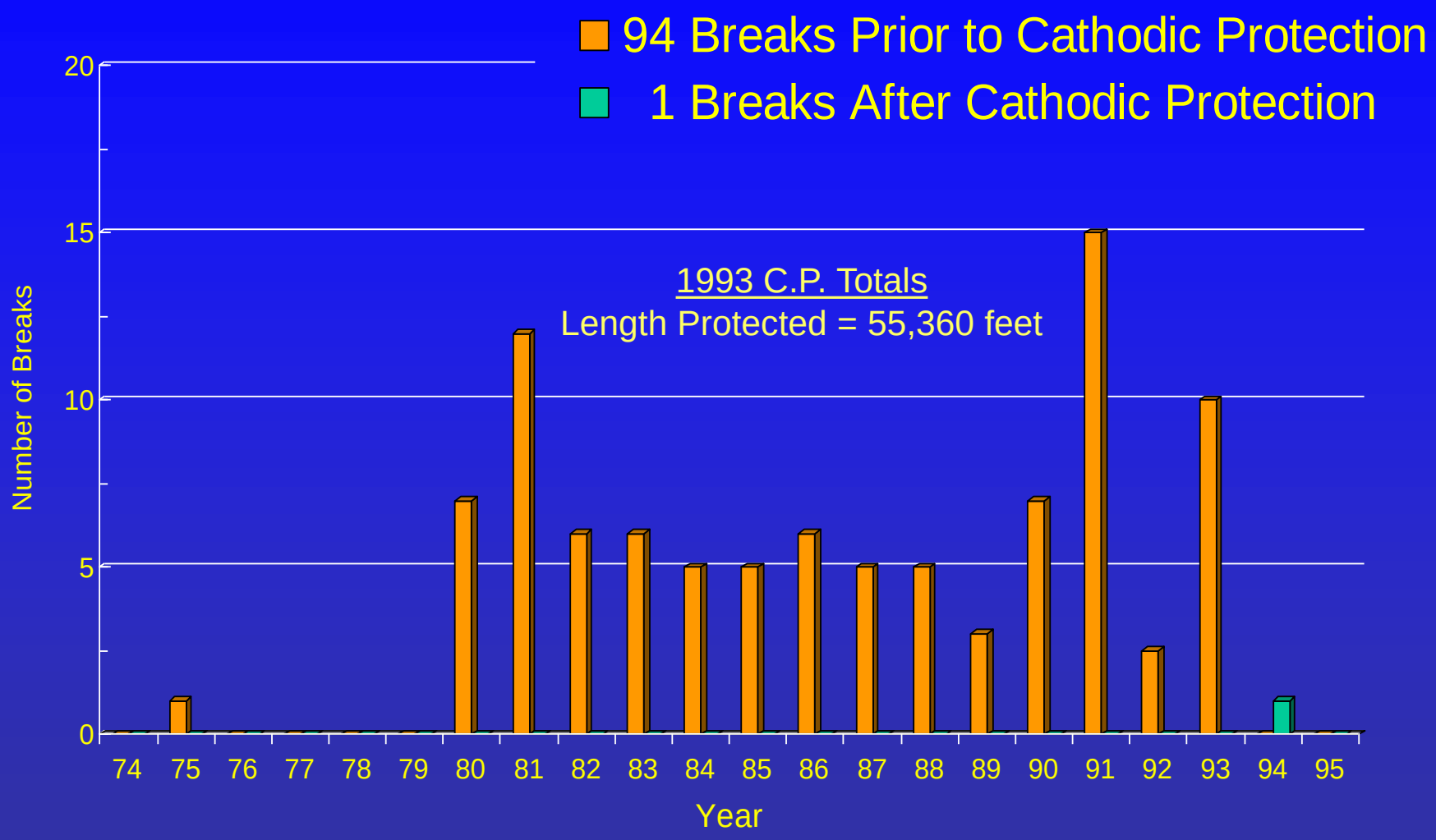
Corrosion Caused by Differential Aeration



CORRPRO COMPANIES INC



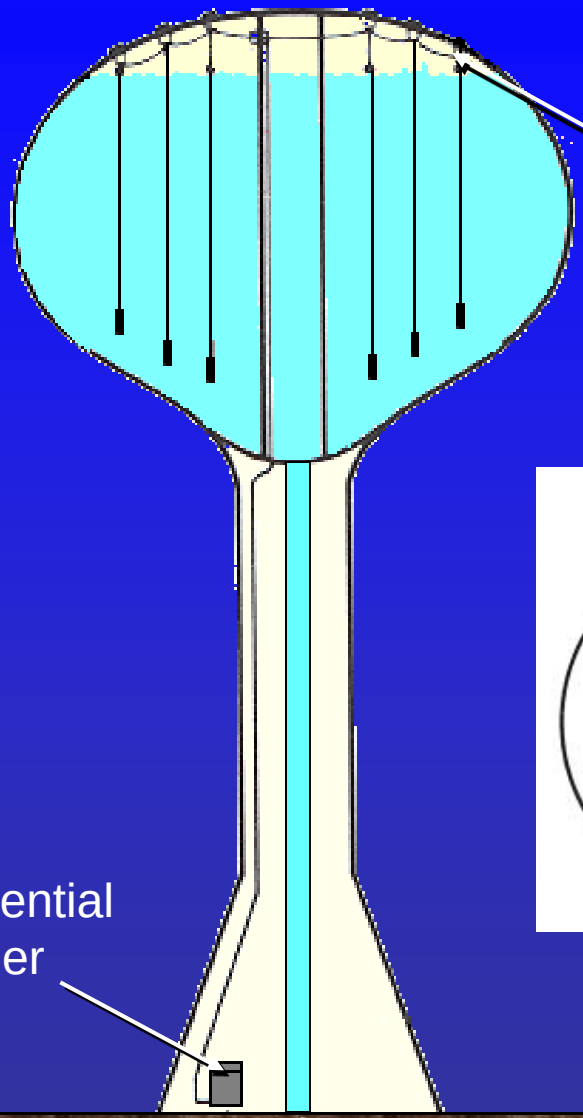
Break Records for Water Mains Cathodically Protected in 1993


Traffic Disruptions
Water Loss
Fire Protection
Damages
Legal & Environmental Claims

Corrosion on damaged polyethylene encased pipe.

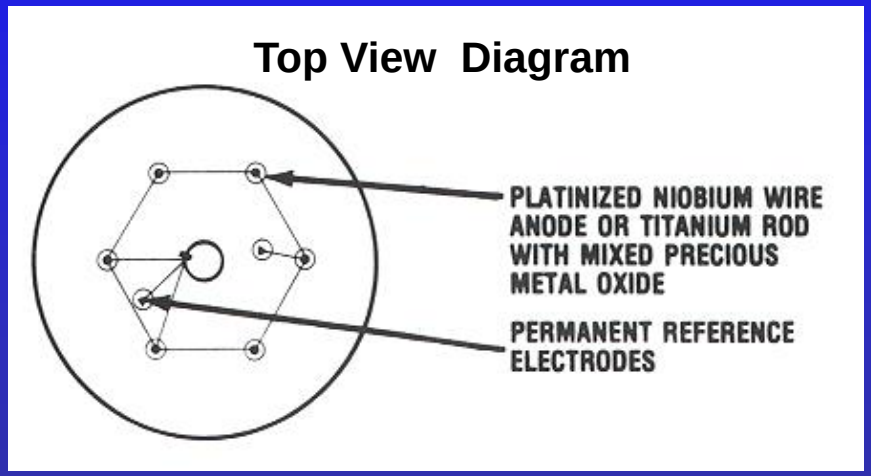
Corrosion of pre-stressed concrete cylinder pipe (P.C.C.P.).

Suspended Vertical Anode System



Support System Bolted to Roof for Bowl Anodes and Reference Electrodes

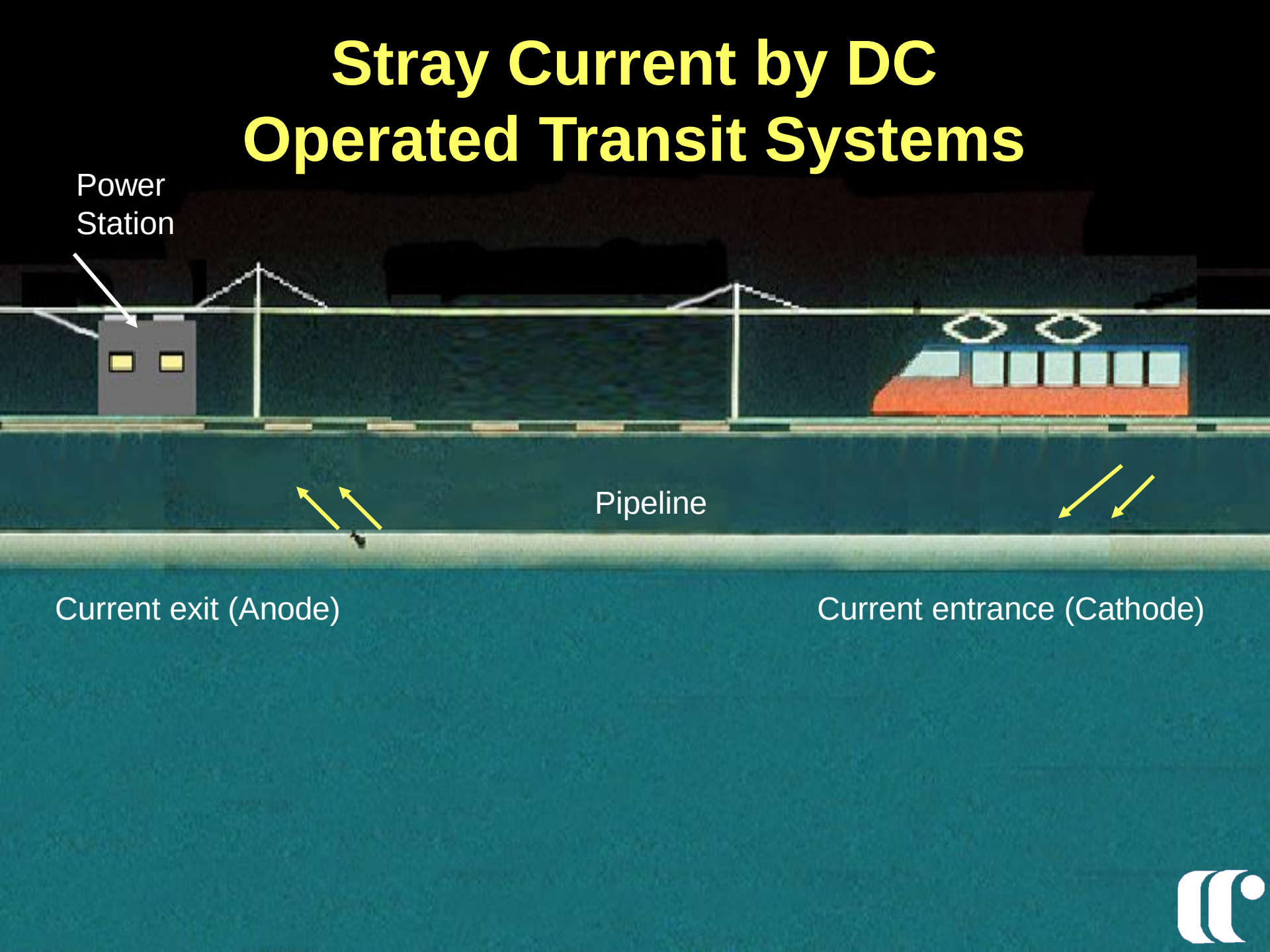
Automatic Potential Control Rectifier



Corrosion

PCCP Failure

Stray Current by DC Operated Transit Systems



Pre-stressed Concrete Cylinder Pipe (PCCP)

Give Me a Break
Fundamentals of Pipeline Corrosion

Presented By:
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corrpro®

Corrosion Control & Cathodic Protection of Water & Wastewater Systems

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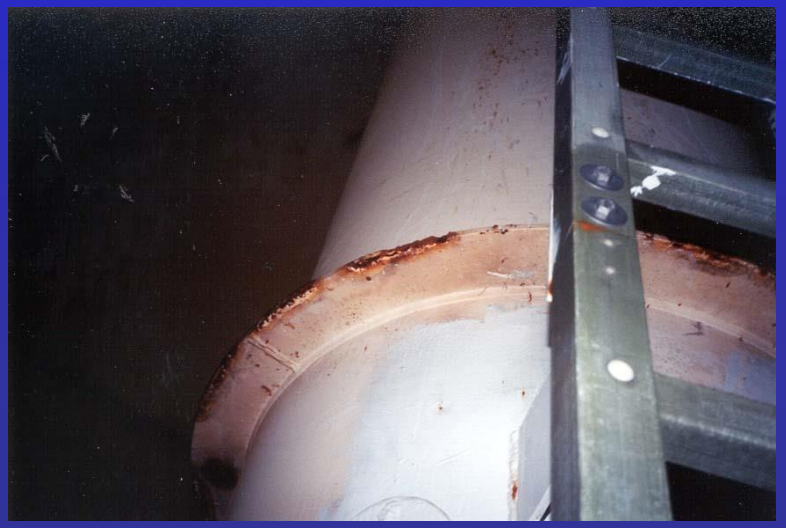
Coating Flaws (Holidays)



Pipeline Inspection Report

Inspector name_____ Date____ Address of pipeline inspection _____ Leak? Yes____ No____ File Number:_____

1) Type of Pipe: cast iron_____ ductile iron____ carbon steel___ copper_____ carbon steel_____ non metallic_____ other____

2) Diameter of pipe _____" Pipeline Name_____ Service Type: Water____ Wastewater____ Estimated date of pipe installation_____ Depth of pipe_____'

3) Type of Pipe: Distribution____ Transmission____ Service_____ Hydrant _____ Mechanical joint_____ Fasteners_____ Other____ Unknown____

4) Type of Coating: Polyethylene Encased____ Shop applied coating___ No Coating____ Tape Wrap____ Unable to determine____

5) External Pipe Condition: Very Good____ Good____ Poor____ comments:_____

_____

6) Is corrosion pitting evident? ____ Yes ____ No Number of Pits_____ Typical Size of Pits_____ Quantity of pits:_____

7) Is graphitization evident (longitudinal or circumferential breaks) ____Yes ____ No

8) Is the pipe installed in (check off appropriate items): Industrial area____ Residential area____ Rural area____ Near street or road ____
Near creek or waterway ____ In reclaimed land___ Near oil or gas pipelines____ Near high voltage lines ____.

8) Describe soil conditions where inspection occurred: wet____ dry____ clay soil ____ rocky soil____ cinders ____ other_____

9) Where soil samples obtained, sealed and analyzed for chlorides, moisture content, pH, sulfides, resistivity? If yes results were: _____

10) Were previous repairs made on the pipeline (leak clamps, etc) Yes____ No ____. Was new pipe installed____ Yes ____ No.

11) Was a repair clamp installed on the pipe during inspection ___ Yes ___ No

12) Was a galvanic anode installed as part of the inspection process? ___ Yes ___ No, if yes size and quantity

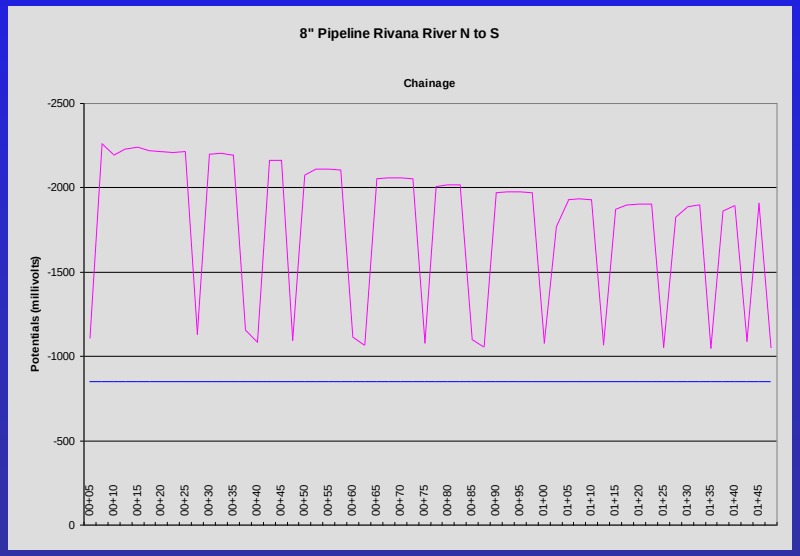
13) Please relay additional comments:

_____

14) Plan of Action_____

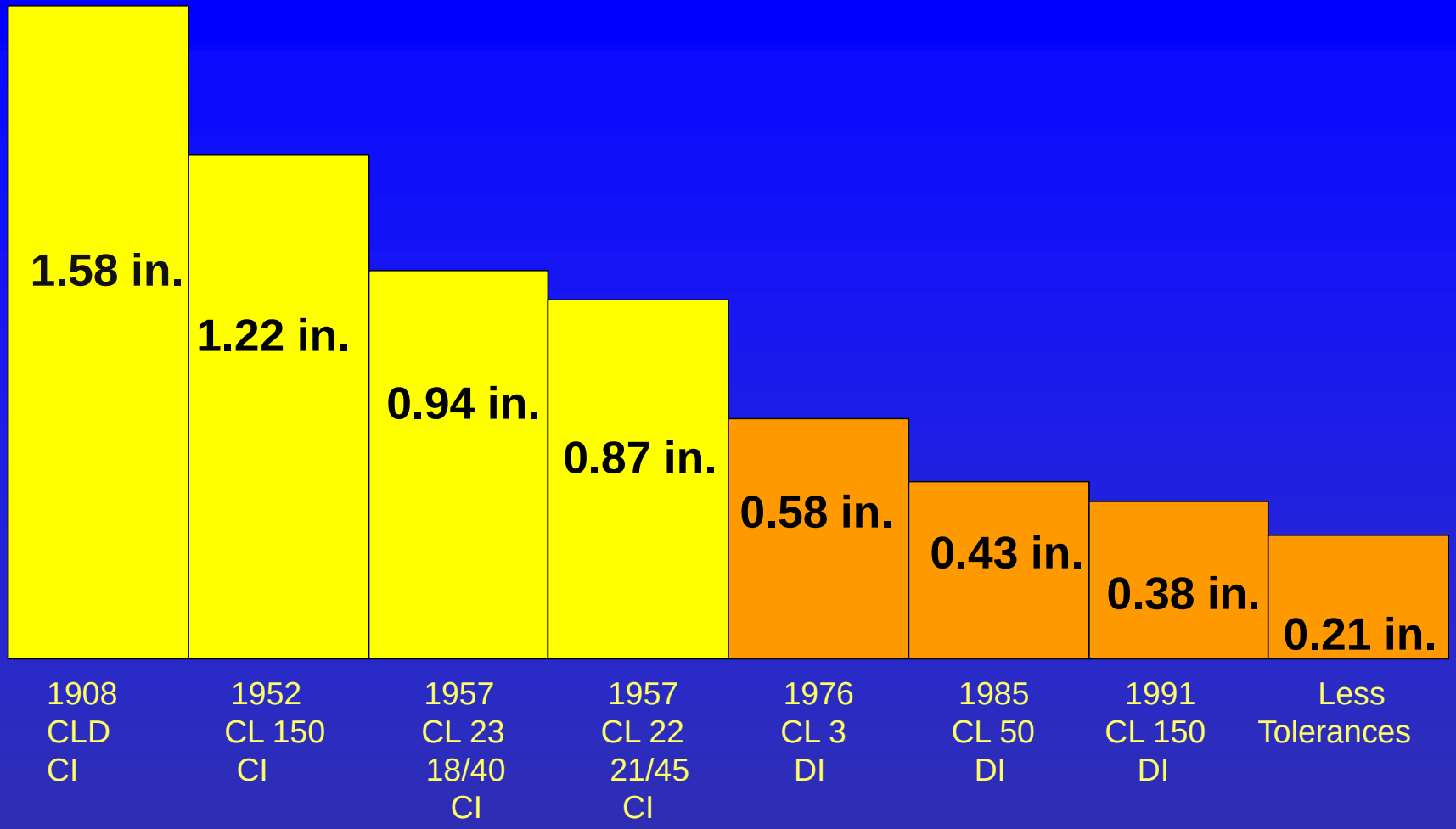
15) Insert digital photos below:

CIS Survey



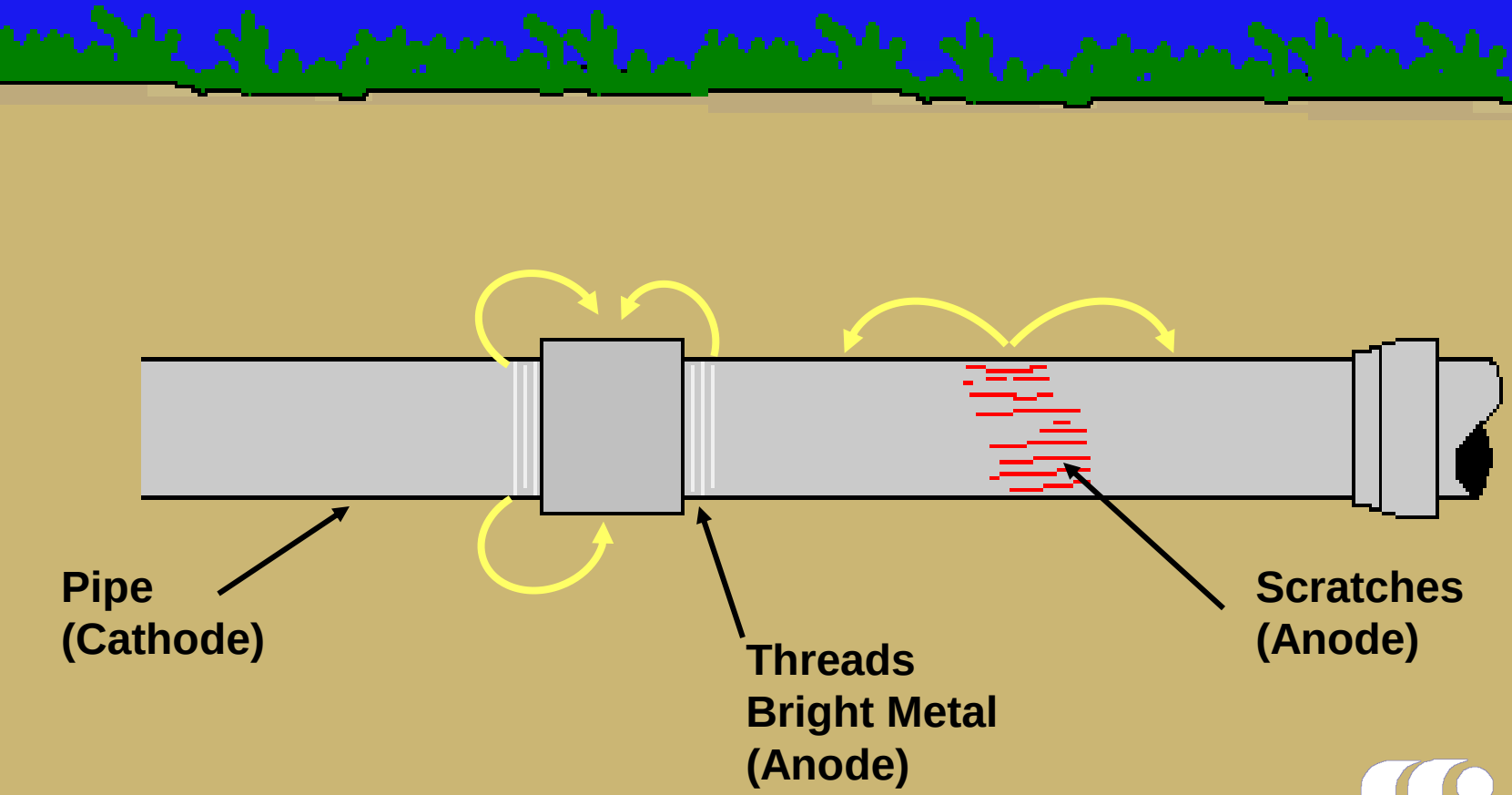
Close Interval Data
Interrupted Survey

Close Interval Data
PG/WFA Survey



Actual size of AWWA Specification Thickness Reductions for 36-inch Diameter Cast and Ductile Iron Pipe - 1908 to Present (150 PSI Operating pressure)

Dissimilar Surface Conditions



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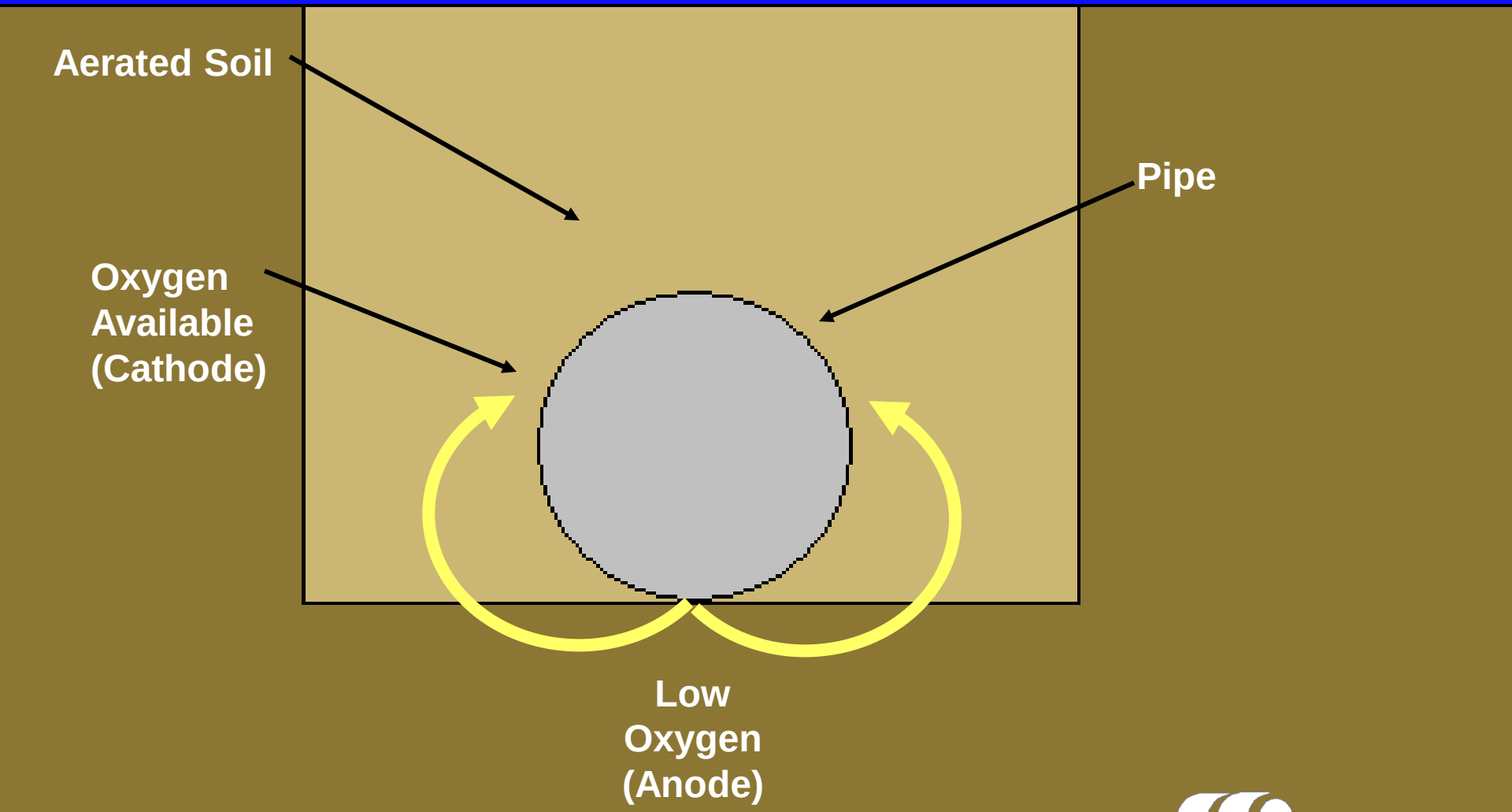
Corrosion Caused by Differential Aeration



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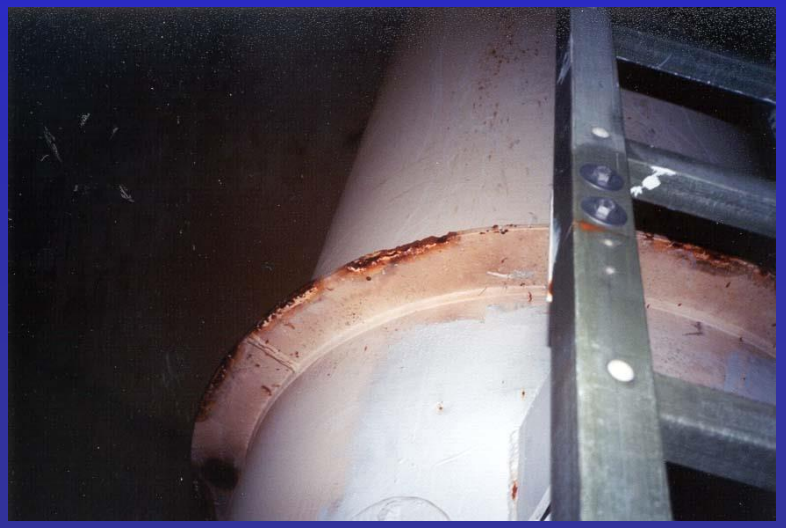
Coating Flaws (Holidays)



Meter Vaults

(Keep dry if possible)

Water Wells

Galvanic Anode on Polyethylene Encased Ductile Iron Pipe