Corrosion Control for Metering and Regulating Stations

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Topics to Cover

Corrosion

Identify M&R Corrosion Concerns

Part 192

Coatings

Cathodic Protection

Isolation

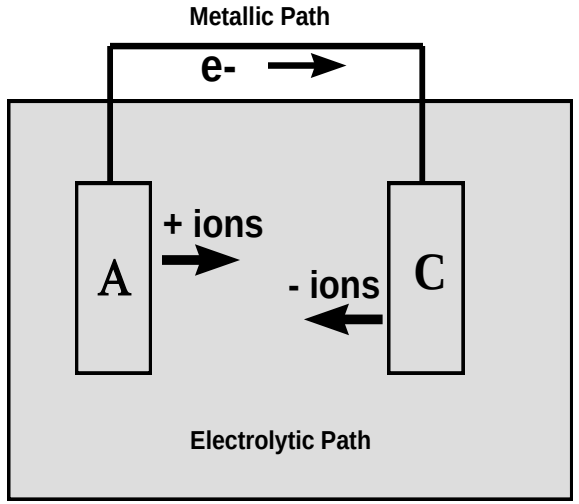
M&R Station Corrosion Control Applications

Definition of Corrosion

“Corrosion is the deterioration of a substance (usually a metal) or its properties because of a reaction with its environment.”

Components of a Corrosion Cell

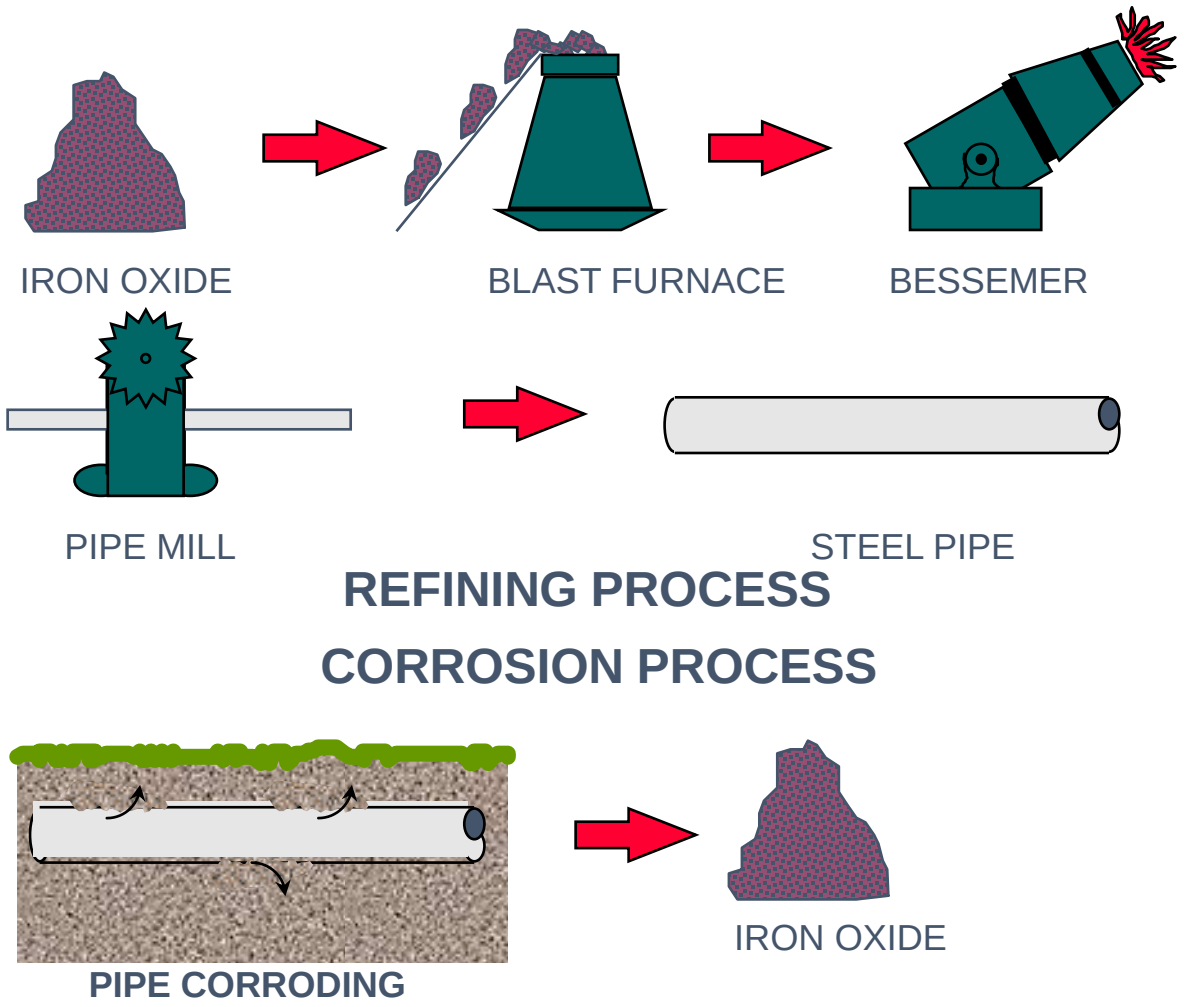
- **Anode (oxidation reaction)**
  - corrosion
- **Cathode (reduction reaction)**
  - no corrosion
- **Electrolyte (cations [+] and anions [-])**
- **External path (usually metallic)**



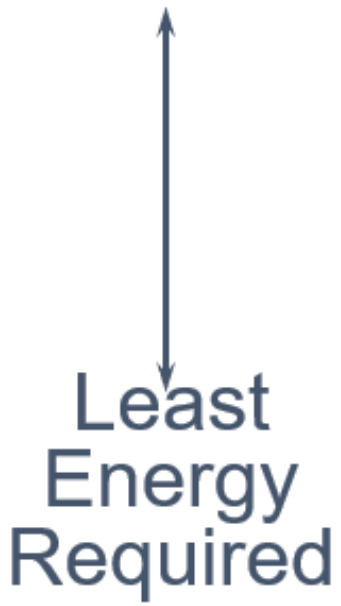
*Electrolytic path could be soil or water

Driving Force For Corrosion

Energy Cycle of Steel



Energy Required to Convert Ore to Metal



Potassium
Magnesium
Beryllium
Aluminum
Zinc
Chromium
Iron
Nickel
Tin
Copper
Silver
Platinum
Gold

Faraday’s First Law

- The weight of any material deposited on the cathode (or liberated from the anode) is directly proportional to the quantity of electric charge passing through the circuit.

Electrochemical Equivalents

Metal	Kg/A-Yr	Lb/A-Yr
Carbon	1.3	2.86
Aluminum	3.0	6.5
Magnesium	4.0	8.8
Iron/Steel	9.1	20.1
Silicon/Chromium/Iron	0.5	1.0
Nickel	9.6	21.2
Copper (monovalent)	20.8	45.8
Zinc	10.7	23.6
Tin	19.4	42.8
Lead	33.9	74.7

Anode/Cathode Ratio

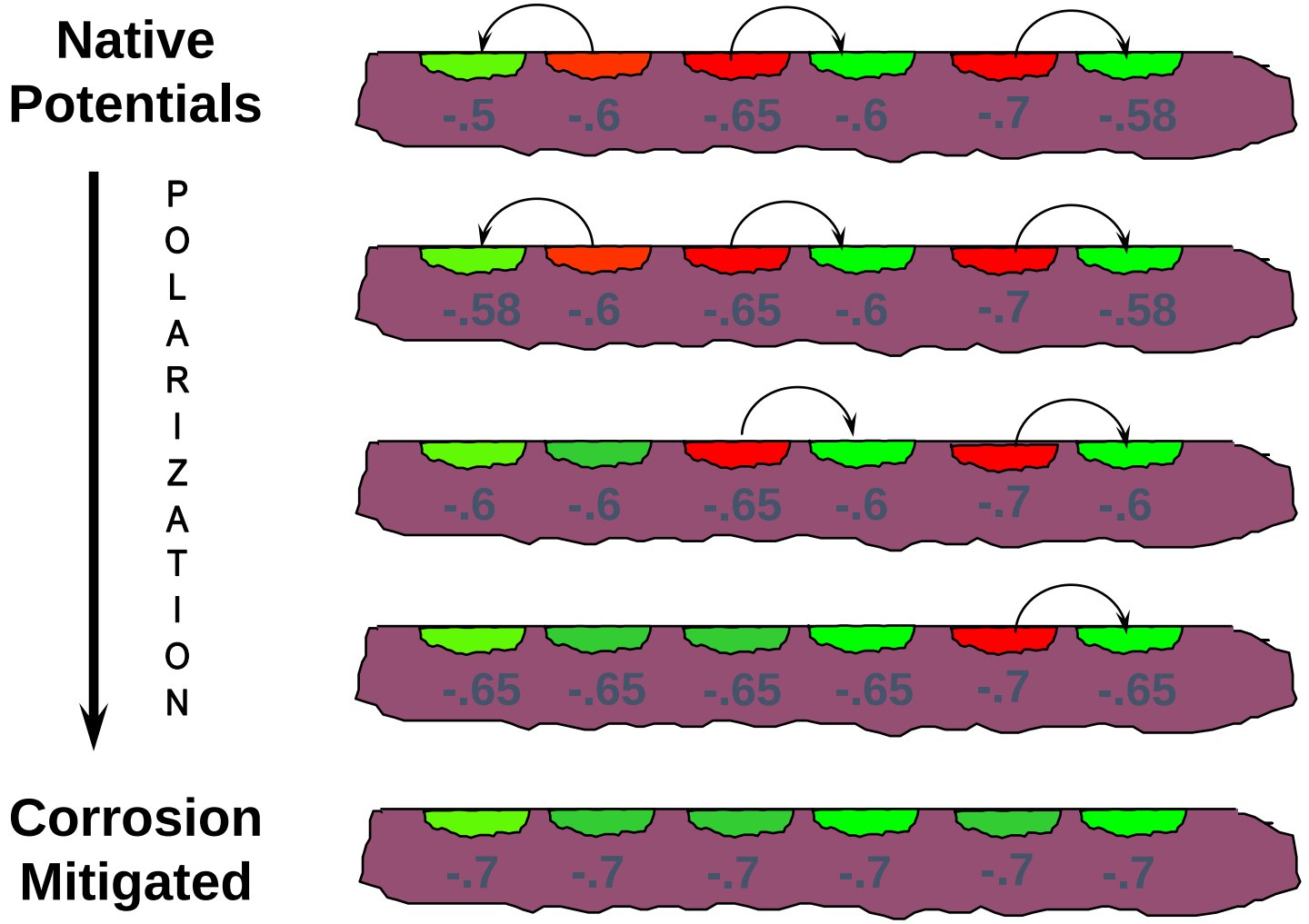
- The effect of current concentrated on a small area will be greater than the effect of the same amount of current on a larger area.

Polarization

The change from the open-circuit potential because of current across electrode/electrolyte interface.

As polarization increases corrosion rate decreases.

Polarization of a Structure

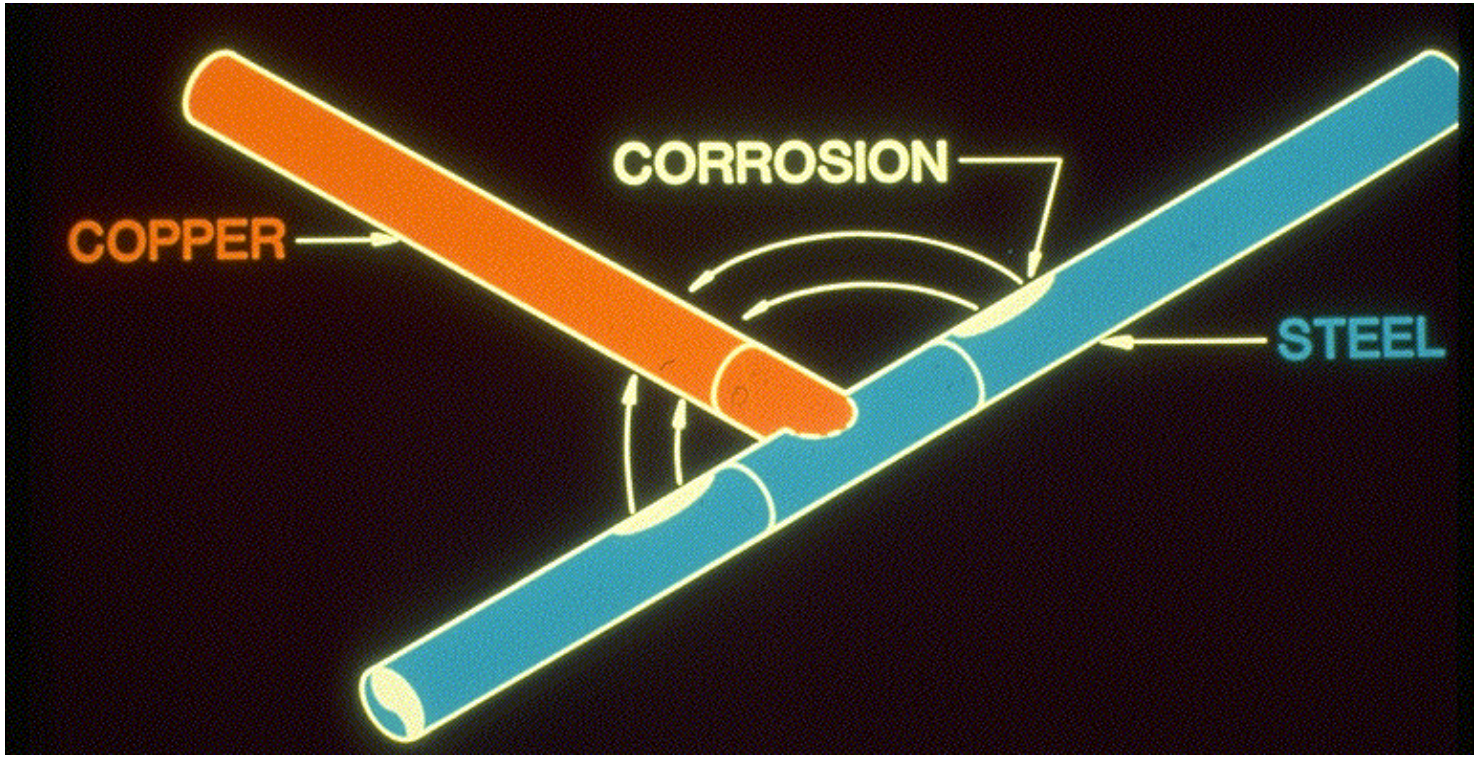


Practical Galvanic Series

Material	Potential (V)*
High Potential Magnesium	-1.75
Magnesium Alloy	-1.60
Zinc	-1.10
Aluminum Alloy	-1.05
Clean Carbon Steel	-0.50 to -0.80
Rusted Carbon Steel	-0.20 to -0.50
Cast/Ductile Iron	-0.50
Lead	-0.50
Steel in Concrete	-0.20
Copper	-0.20
High Silicon Iron	-0.20
Carbon, Graphite	+0.30

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

Dissimilar Metals Corrosion



Two types of corrosion at M&R stations

Atmospheric

- Environments
- Coating
- Re-coating
- Transitions

Soil side

- Steel Pipeline with CP
- Steel Pipeline without CP
- Poly Pipeline – Steel Riser

What does 192 say?

§ 192.455 External corrosion control: Buried or submerged pipelines installed after July 31, 1971.

(a) Except as provided in paragraphs (b), (c), (f), and (g) of this section, each buried or submerged pipeline installed after July 31, 1971, must be protected against external corrosion, including the following:

(1) It must have an external protective coating meeting the requirements of § 192.461.

(2) It must have a cathodic protection system designed to protect the pipeline in accordance with this subpart, installed and placed in operation within 1 year after completion of construction.

What does 192 say?

§ 192.481 Atmospheric corrosion control: Monitoring.

(a) Each operator must inspect and evaluate each pipeline or portion of the pipeline that is exposed to the atmosphere for evidence of atmospheric corrosion, as follows:

Expand Table

Pipeline type:	Then the frequency of inspection is:
(1) Onshore other than a Service Line	At least once every 3 calendar years, but with intervals not exceeding 39 months.
(2) Onshore Service Line	At least once every 5 calendar years, but with intervals not exceeding 63 months, except as provided in paragraph (d) of this section.
(3) Offshore	At least once each calendar year, but with intervals not exceeding 15 months.

(b) During inspections the operator must give particular attention to pipe at soil-to-air interfaces, under thermal insulation, under disbonded coatings, at pipe supports, in splash zones, at deck penetrations, and in spans over water.

(c) If atmospheric corrosion is found during an inspection, the operator must provide protection against the corrosion as required by § 192.479.

What does 192 say?

Appendix D to Part 192—Criteria for Cathodic Protection and Determination of Measurements

I. *Criteria for cathodic protection—*

A. *Steel, cast iron, and ductile iron structures.*

(1) A negative (cathodic) voltage of at least 0.85 volt, with reference to a saturated copper-copper sulfate half cell. Determination of this voltage must be made with the protective current applied, and in accordance with sections II and IV of this appendix.

(2) A negative (cathodic) voltage shift of at least 300 millivolts. Determination of this voltage shift must be made with the protective current applied, and in accordance with sections II and IV of this appendix. This criterion of voltage shift applies to structures not in contact with metals of different anodic potentials.

(3) A minimum negative (cathodic) polarization voltage shift of 100 millivolts. This polarization voltage shift must be determined in accordance with sections III and IV of this appendix.

How do you stop corrosion?

Coatings AND Cathodic Protection

- Coatings are the first line of defense in underground and submerged applications.
- Coatings are the only defense in atmospheric applications.

Atmospheric Applications

Common coating types for M&R station piping

- Paint
  - Zinc rich primers
- Epoxy
  - Macropoxy
  - FBE
  - Denso
  - Usually are not UV resistant to sunlight
- Tape
  - RD-6
  - Wax Tape

Transitions

Transitions are areas of pipe transition from below grade to above grade.

Challenging to protect

Splash zones

Erosion

Physical damage

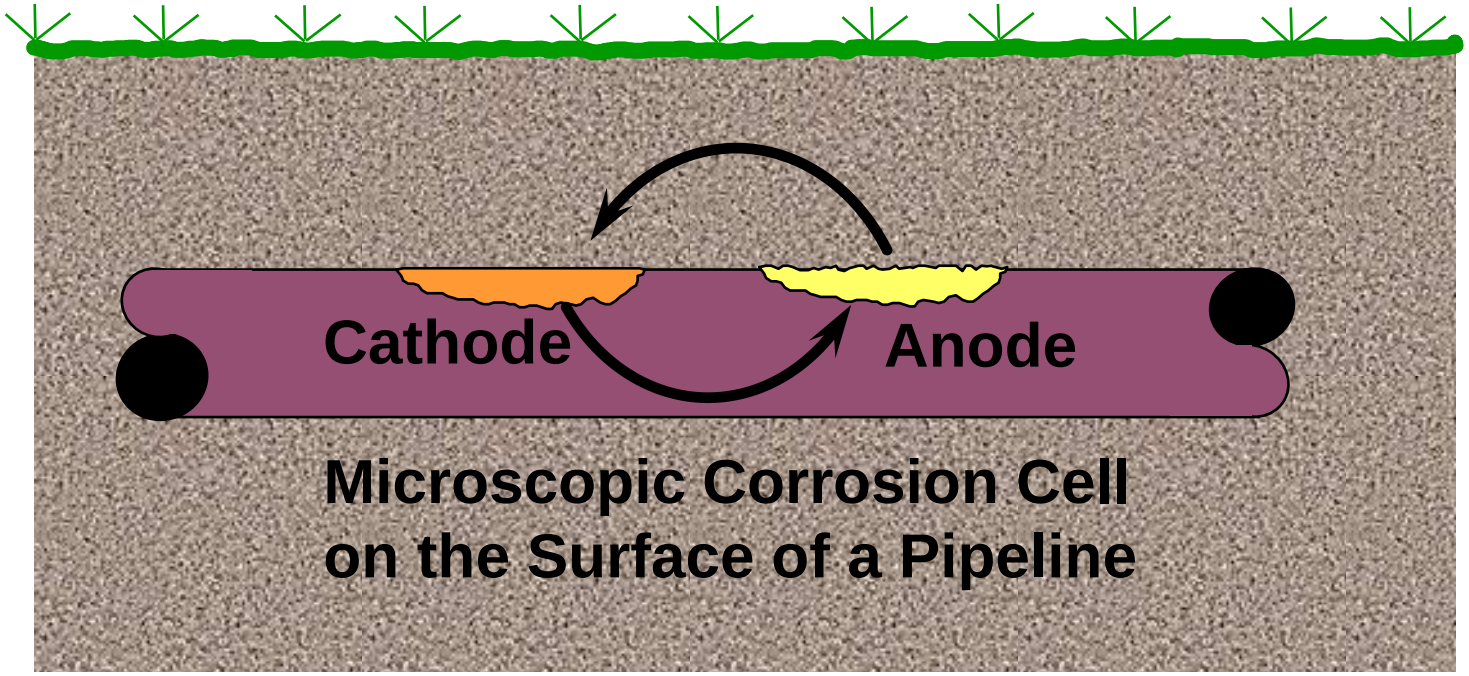
Direction of wrap – always wrap up – shingle effect

Cathodic Protection

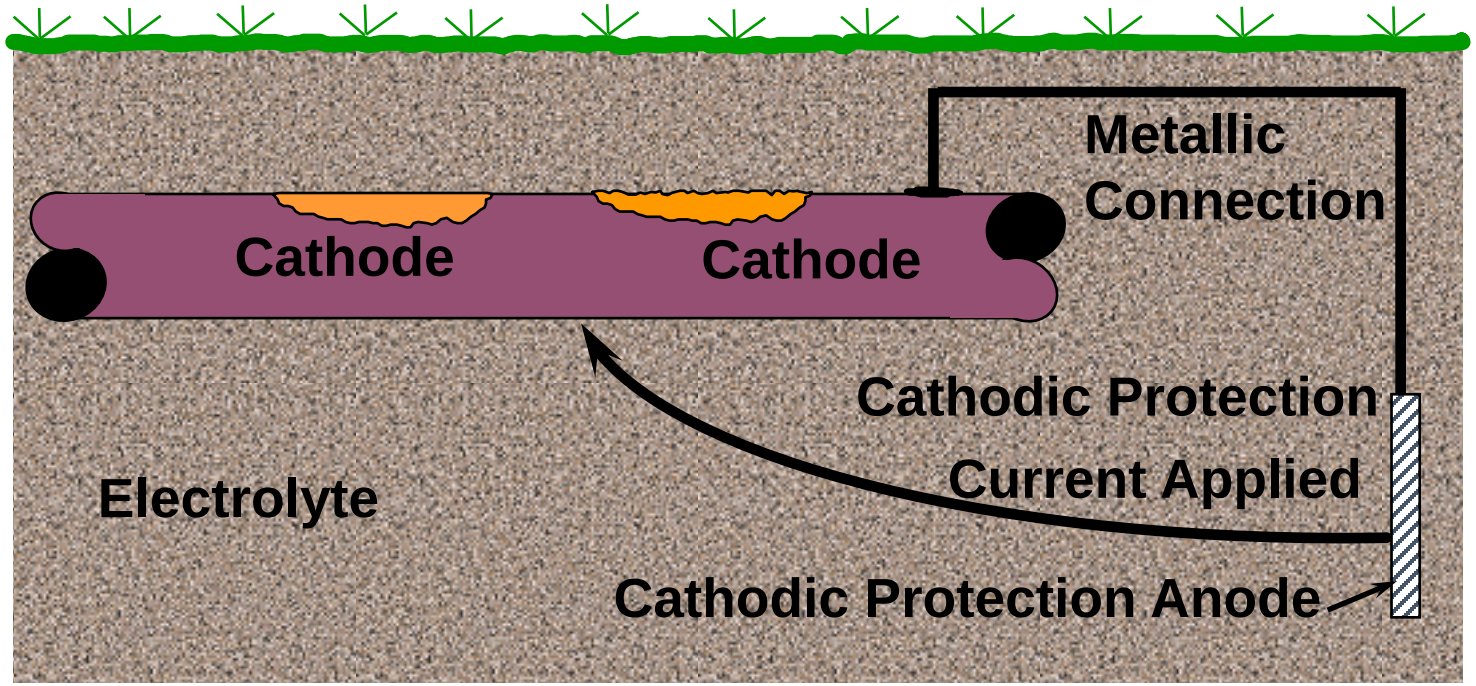
Cathodic Protection - is the polarization of all noble potential areas (cathodes) to the most active potential on the metal surface.

Cathodic protection is achieved by making the structure the cathode of a direct current circuit.

Microscopic View of a Corrosion Cell



Cathodic Protection on a Structure (Macroscopic view)



Cathodic Protection Systems

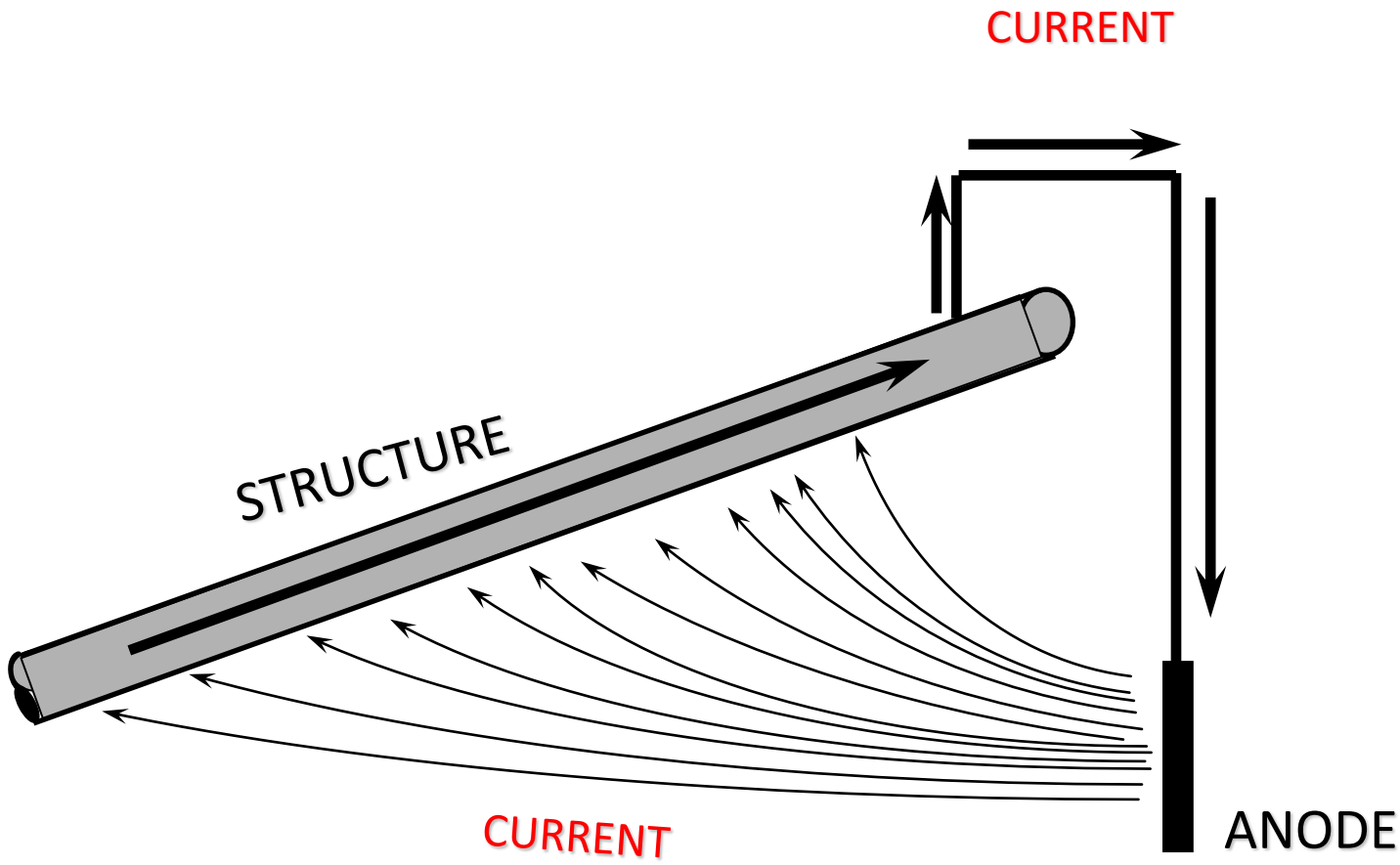
Galvanic or Sacrificial

- Dissimilar metals

Impressed Current

- Forced current flow

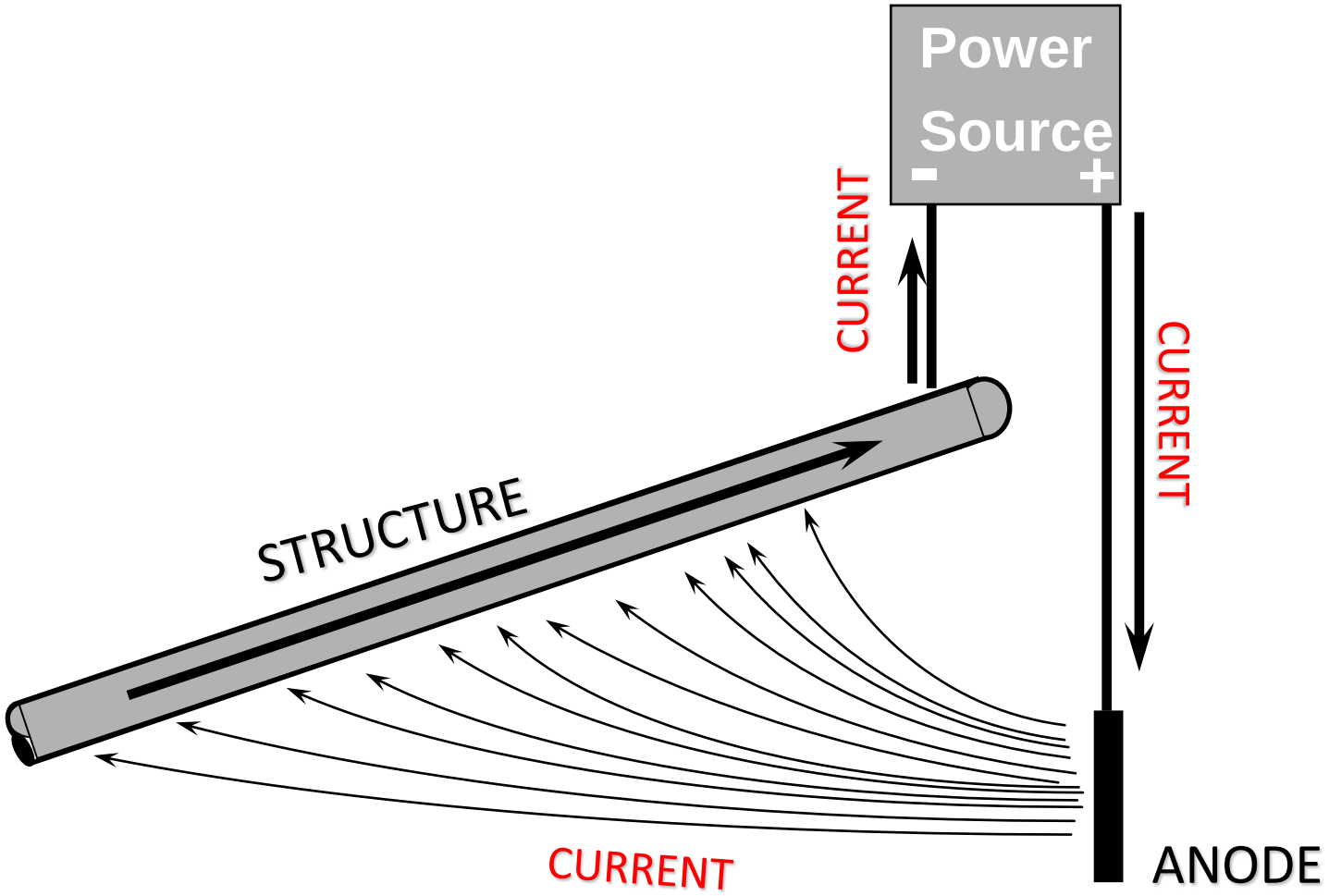
Galvanic Anode Cathodic Protection System



Applications for Galvanic Anodes

- When relatively small increments of current are required and/or a low resistivity electrolyte exists
- Local cathodic protection to provide current to a specific area on a structure
- Additional current is needed at problem areas
- Located at point of stray current discharge
- Provide protection to structures in congested areas
- Shorted casings
- Shielded areas
- Interior surfaces of vessels
- Offshore structures
- Poorly coated or bare valves

Impressed Current System



Applications of Impressed Current Systems

- Large current requirement
- Depleted galvanic anodes
- Large heat exchangers
- Water tank interiors
- Large pipelines
- Foundation & sheet piling
- Ship hulls
- Any electrolyte resistivity
- Overcome stray current
- AST bottoms
- Underground storage tanks
- Offshore structures

Electrical Isolation for Corrosion Control

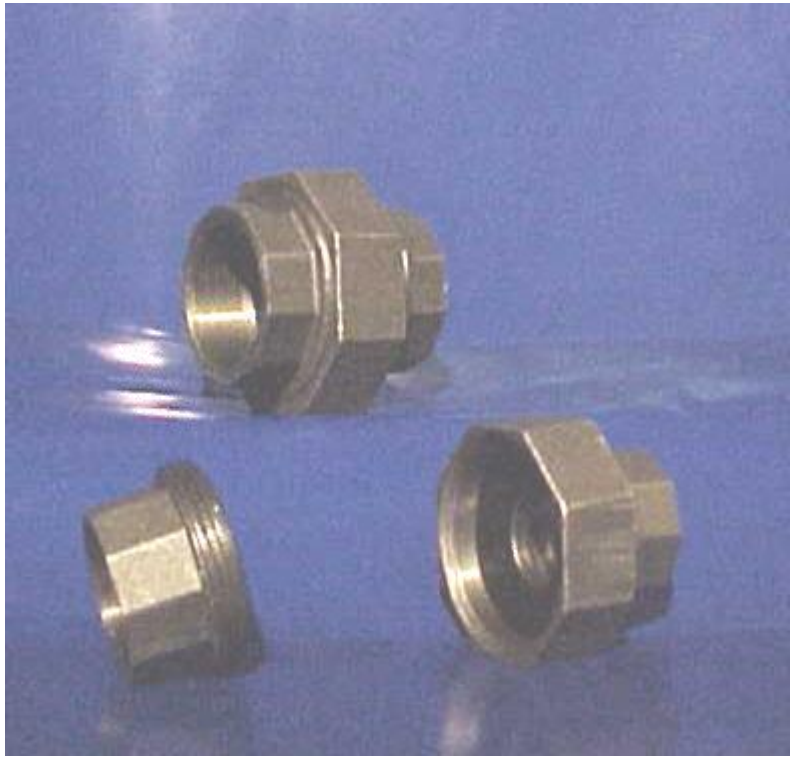
Separate dissimilar metals

Use with cathodic protection

Why is Isolation so Important?

- Current Requirement
- Shock Hazard
- Meter Interference
- Current Pickup – AC grounding

FLANGE INSULATION KIT



INSULATING UNIONS (DIELECTRIC UNIONS)

Soil Side Corrosion

1

Transition zones

2

Underground upstream and downstream piping

3

Station piping

Risers at M&R Stations

- Steel pipeline with CP
- Steel pipeline without CP
- Poly Pipeline – Steel Riser
- Anodeless Risers – small diameter

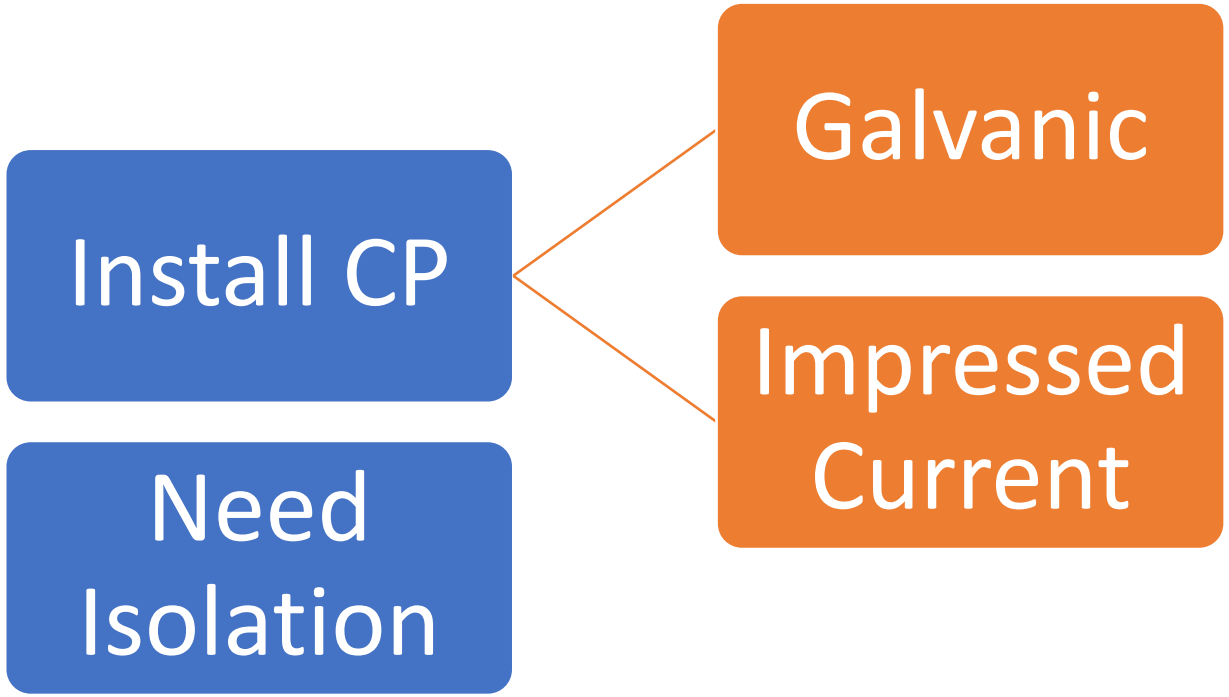
Steel Pipeline with CP

Verify Isolation

Install test station – save your paint

If in concrete building – Install permanent reference cell

Steel pipeline without CP



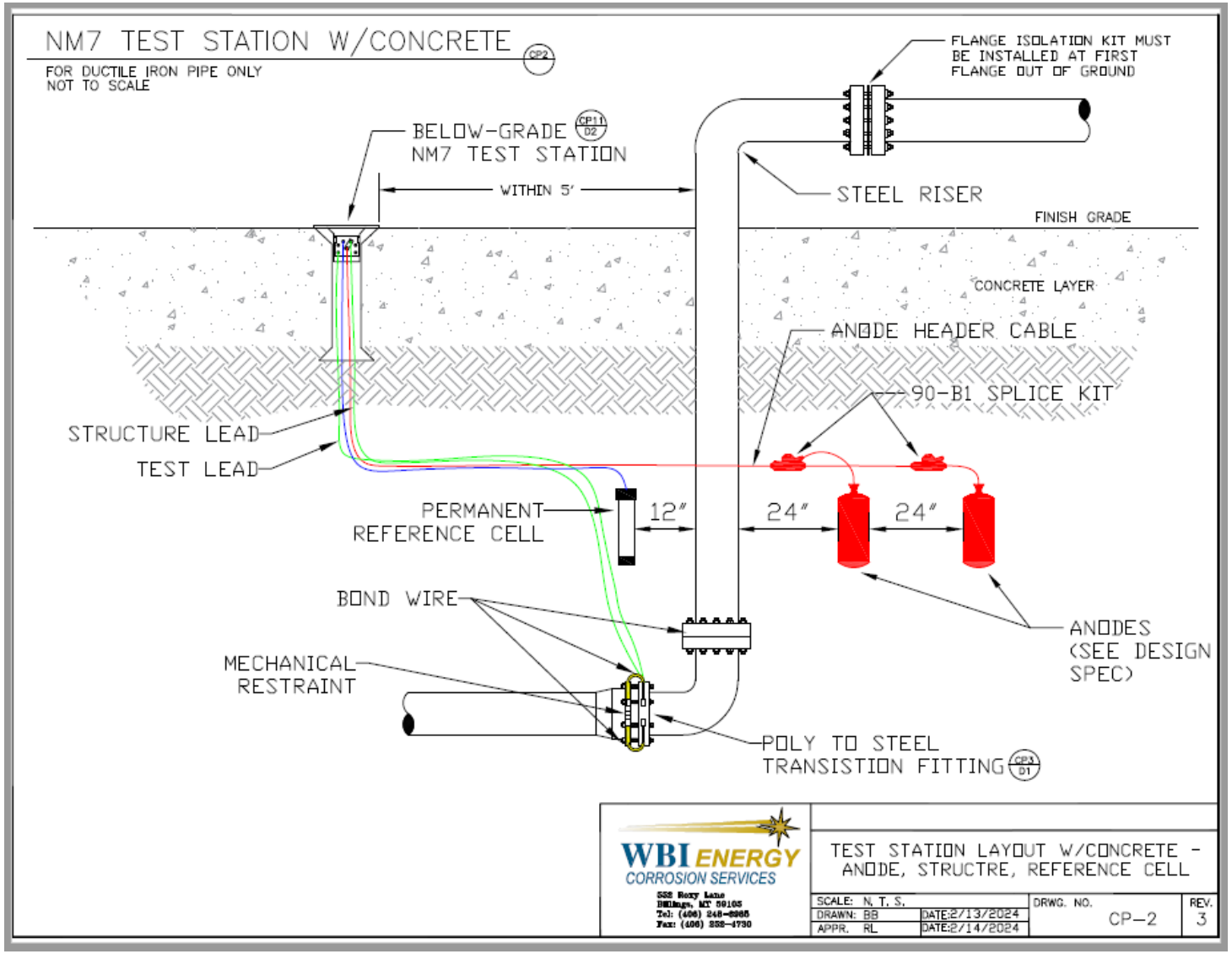
Poly pipeline with a Steel Riser

Galvanic Cathodic Protection

Isolation is required

Anode and test station

Concrete Floor



Anode Installation

Test Station Terminations

Test Station

Anodeless Risers

- No CP Required
- No isolation concerns
- Pay attention to tracer wire shorting

Summary

- Coatings and Cathodic Protection
  - Everything above grade should have a coating on it.
  - Everything below grade should have both a coating and cathodic protection on it.

Questions?

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