

Corrosion Control

Part 192, Subpart I

 **External**

 **Internal**

 **Atmospheric**



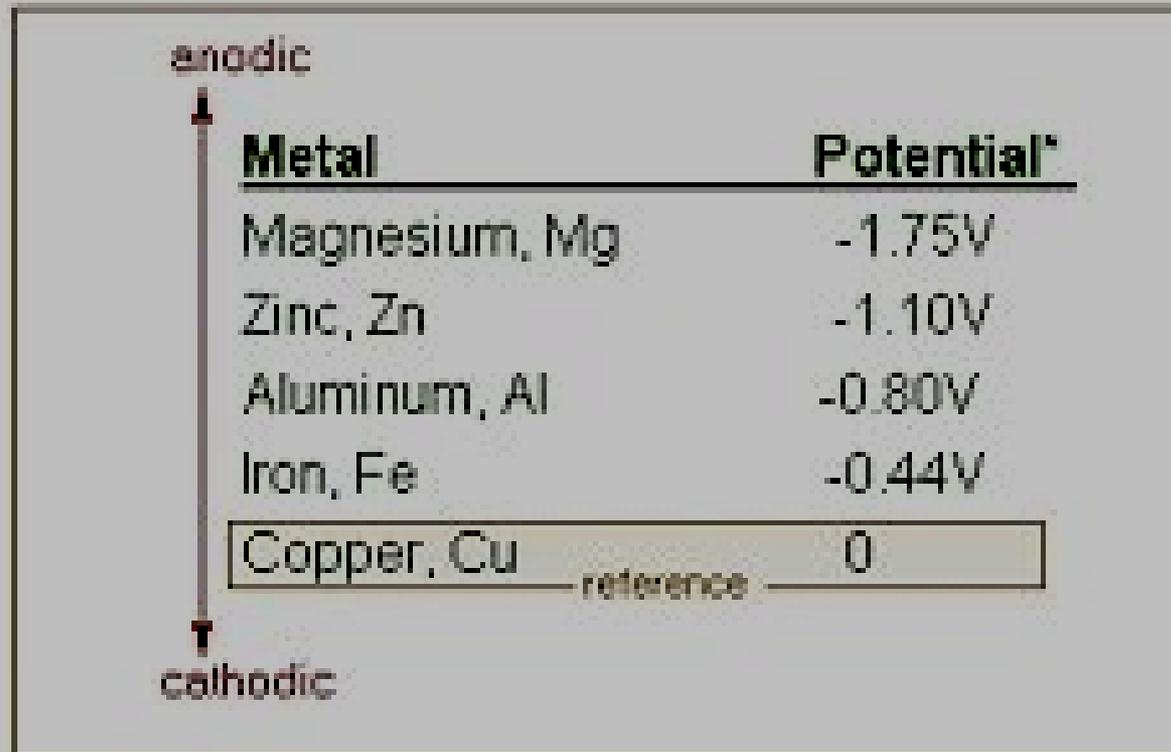
Subpart I Added To Part 192 By Amendment 4, 8/1/71

Definition of Corrosion

-  **The Deterioration of a Material, Usually a Metal, that Results from a Reaction with its Environment.**
-  **Galvanic Corrosion of a Metal Occurs because of an Electrical Contact with a More Noble (Positive) Metal or Non-metallic Conductor in a Corrosive Electrolyte.**

▼ Galvanic Series of Metals

Galvanic Series for Metals in Neutral Soils or Water



The diagram shows a vertical axis with an upward arrow labeled 'anodic' and a downward arrow labeled 'cathodic'. A table lists metals and their potentials relative to a copper-copper sulfate reference electrode. The metals are ordered from most anodic (top) to most cathodic (bottom). The copper-copper sulfate reference electrode is highlighted with a box and labeled 'reference'.

<u>Metal</u>	<u>Potential*</u>
Magnesium, Mg	-1.75V
Zinc, Zn	-1.10V
Aluminum, Al	-0.80V
Iron, Fe	-0.44V
Copper, Cu	0

* Potentials measured in relation to copper-copper sulfate reference electrode.



Basic Corrosion Cell

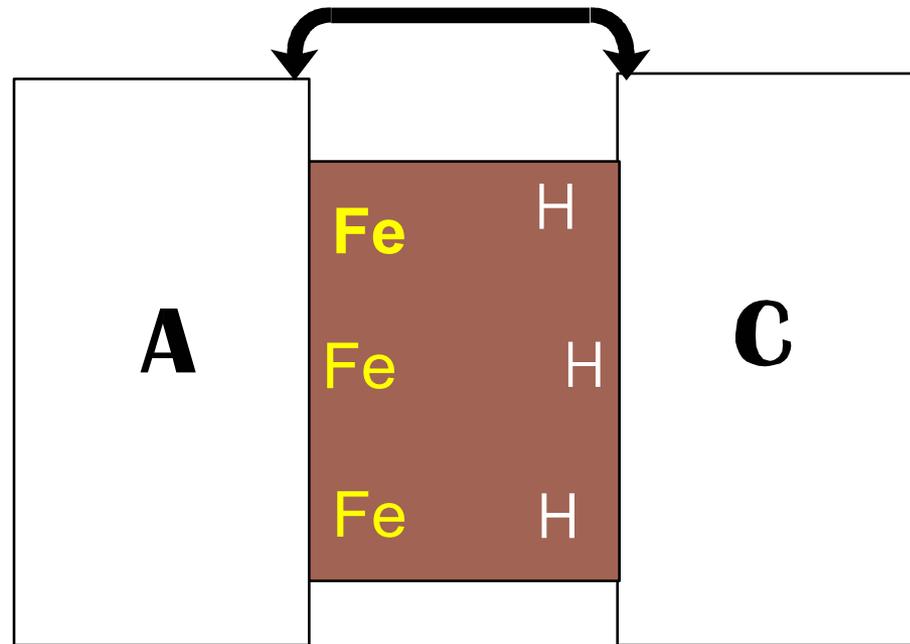
Metallic Path

ANODE

CATHODE

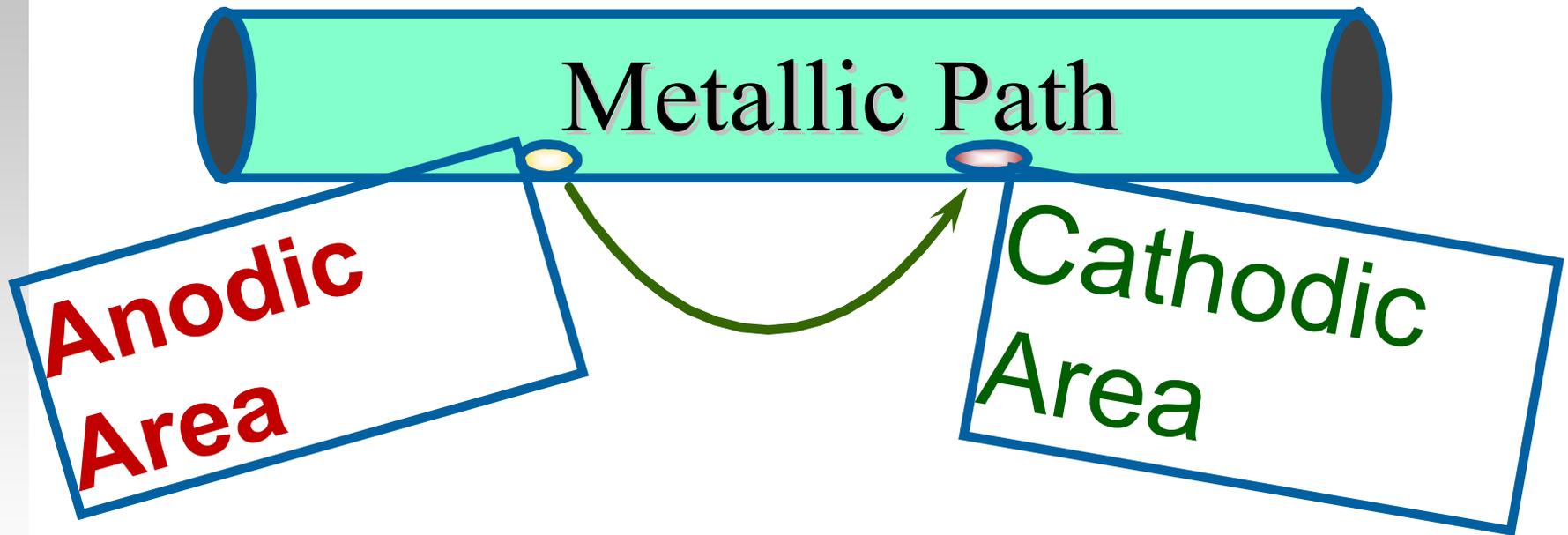
ELECTROLYTE

METALLIC PATH





Pipe Corrosion





Corrosion on Pipelines

✉ **Dissimilar Metals**

✉ **Dissimilar Soils**

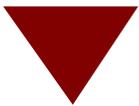
✉ **Differential
Aeration**

✉ **Mill Scale
Corrosion**



▼ Soil Resistivity vs. Corrosivity

Ohm - cm	Description
Below 500	very
500 - 1000	corrosive
1000 - 2000	moderately corrosive
2000 - 10,000	mildly
> 10,000	<< corrosive

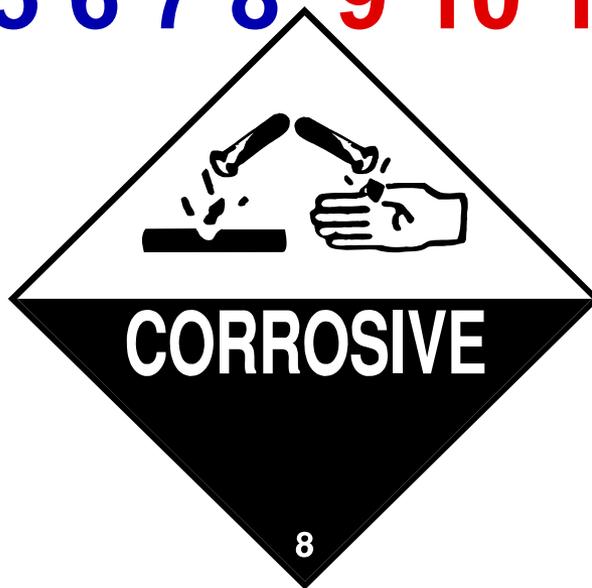


Soil pH

ACIDIC

ALKALINE

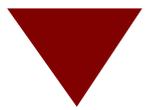
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14



▼ Cathodic Protection

✉ The
Decrease of
Corrosion of
a Metal by
Forcing
Current to
Flow to the
Metal from a
Solution
(Electrolyte).

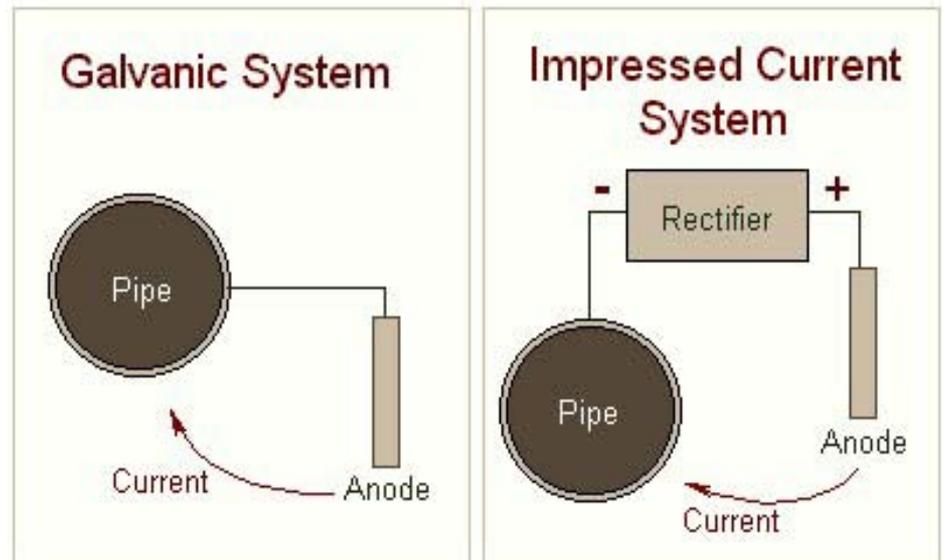




Cathodic Protection

✉ Galvanic Sacrificial Anodes

✉ Impressed Current Systems



* Properly Designed & Installed

▼ Qualified Person §192.453

✉ **Must be carried out by, or under the direction of, a person qualified in pipeline corrosion control methods.**



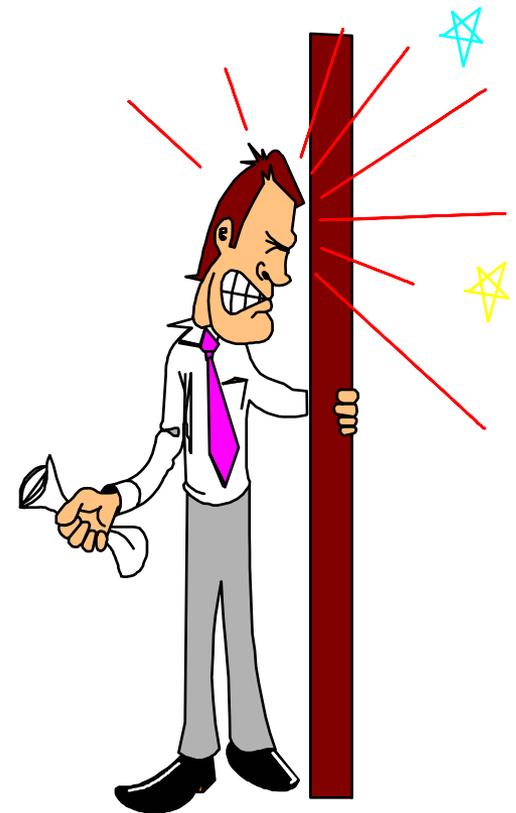
▼ “OQ” Qualified Person

✉ Operator Qualification requires that an unqualified person must be under the direct observation of a qualified person.



▼ Required System Information

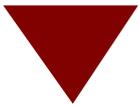
- ✉ **Date of Installation**
- ✉ **Transmission or Distribution**
- ✉ **Coated or Bare**





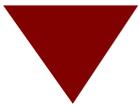
CP Required

-  **Coated Metallic Pipelines Installed after 7/31/71 ~ (§192.455(a))**
-  **Coated Transmission Lines (except station piping) Installed prior to 8/1/71 ~ (§192.457(a))**



CP Required

-  **Areas of Active Corrosion -
Installed < 8/1/71 ~ (§192.457(b))**
 -  **Bare or Ineffectively Coated
Transmission Lines**
 -  **Station Piping (Bare or Coated)**
 -  **Bare or Coated Distribution Lines**



CP Not Required

 **Bare TEMPORARY lines installed after 7/31/71 (§192.455(c)(2)&(d)).**

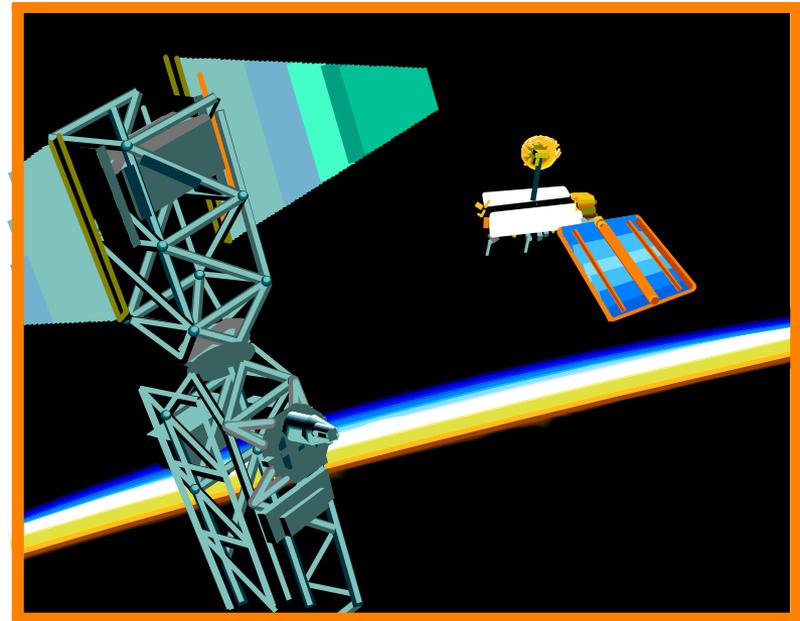
 **Bare or ineffectively coated lines installed prior to 7/31/71 with no evidence of active corrosion ~ (§192.457(b)).**



CP Not Required (cont.)

✉ **Electrically isolated metal alloy fittings in plastic pipeline systems (§192.455(f)).**

✉ **Pipelines in NON-CORROSIVE environments (§192.455(b)).**



▼ Non-Corrosive Environment

Tests Needed to Demonstrate:

- ✉ Soil Resistivity Measurements
- ✉ Corrosion Accelerating Bacteria
- ✉ Leak Frequency
- ✉ Soil Composition
- ✉ pH
- ✉ Bell Hole Examinations
- ✉ Internal Inspections



- ✉ **POST-INSTALLATION TESTS (< 6 MONTHS)**
 - * **Close Interval Potential**
 - * **Soil Resistivity**

▼ Cathodic Protection Criteria

✉ **§192.463 Requires Cathodic Protection to a Level that Complies with Appendix D.**



▼ Cathodic Protection Criteria

✉ **850 mv**

✉ **100 mv Polarization Decay**

✉ **Negative 300 mv Shift**

✉ **Net Protective Current**

✉ **E log I (Gas)**



▼ Components of IR Drop

Resistances

Measuring Lead (+)
Contact Lead (+)/Ref. Cell
Reference Cell
Contact Ref. Cell/Electrolyte
Electrolyte
Polarization
Structure
Contact Test Lead/Structure
Test Lead
Contact Test/Measuring Lead
Measuring Lead (-)
Internal Meter

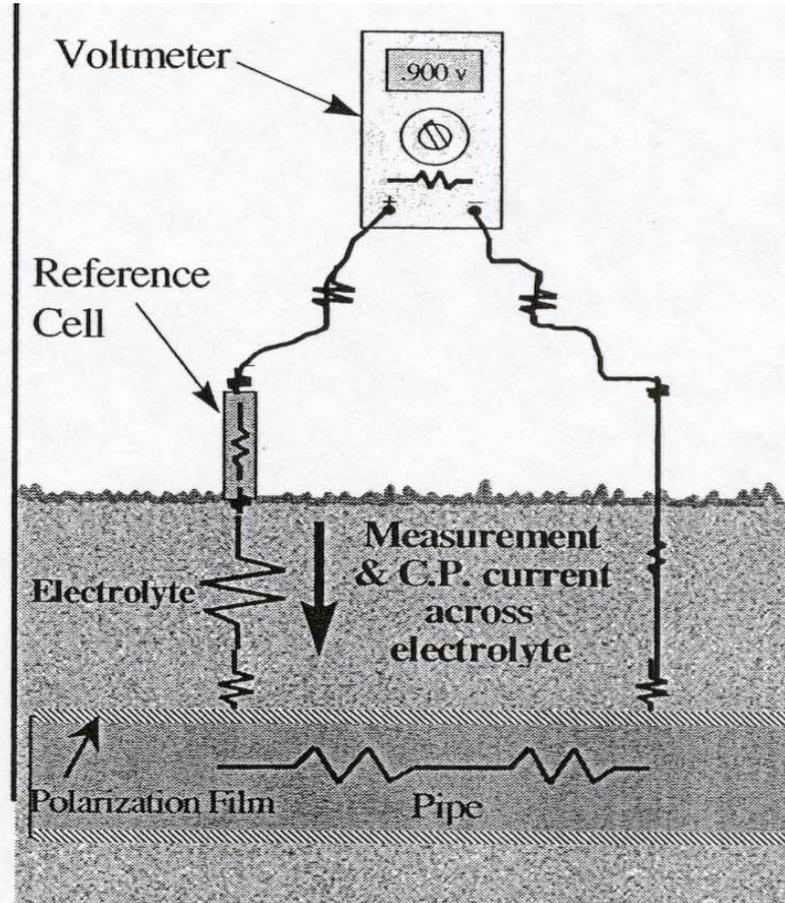


Figure 3.9 Voltage Drops in a Measuring Circuit

▼ IR Drop ~ Major Contributors

✉ **Contact between the reference cell and the soil.**

✉ **Electrolyte (soil)**

✉ **Polarization at the pipe coating / soil interface**



C. P. CRITERIA (850 mV)

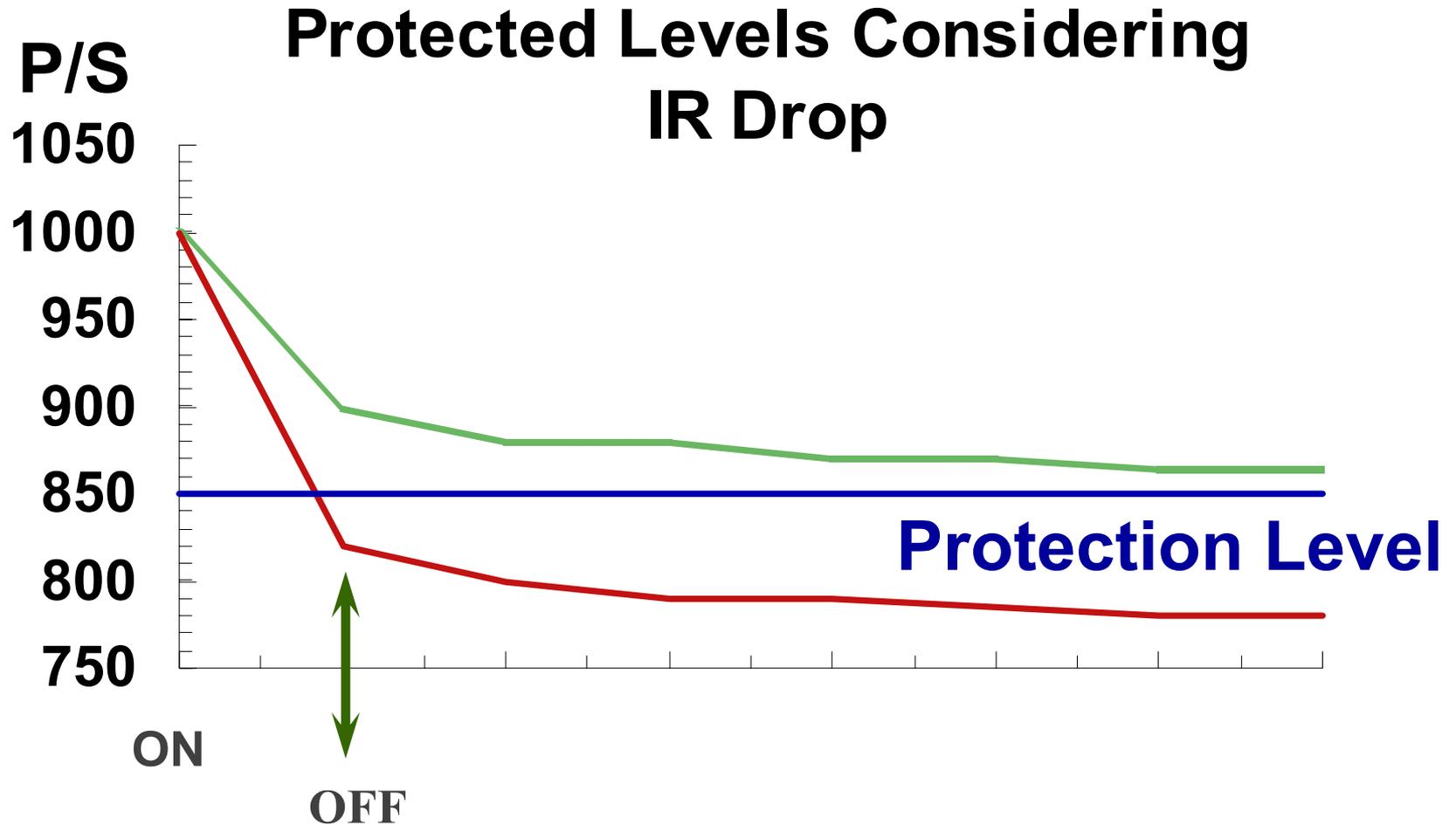
- ✉ 850 mV.
- ✉ Measured with Current Applied
- ✉ Consider IR Drop
- ✉ Cu/CuSO₄ Reference Electrode



- ✉ 800 mV. Ag/Ag Cl for sea water



C. P. CRITERIA (850 mV)

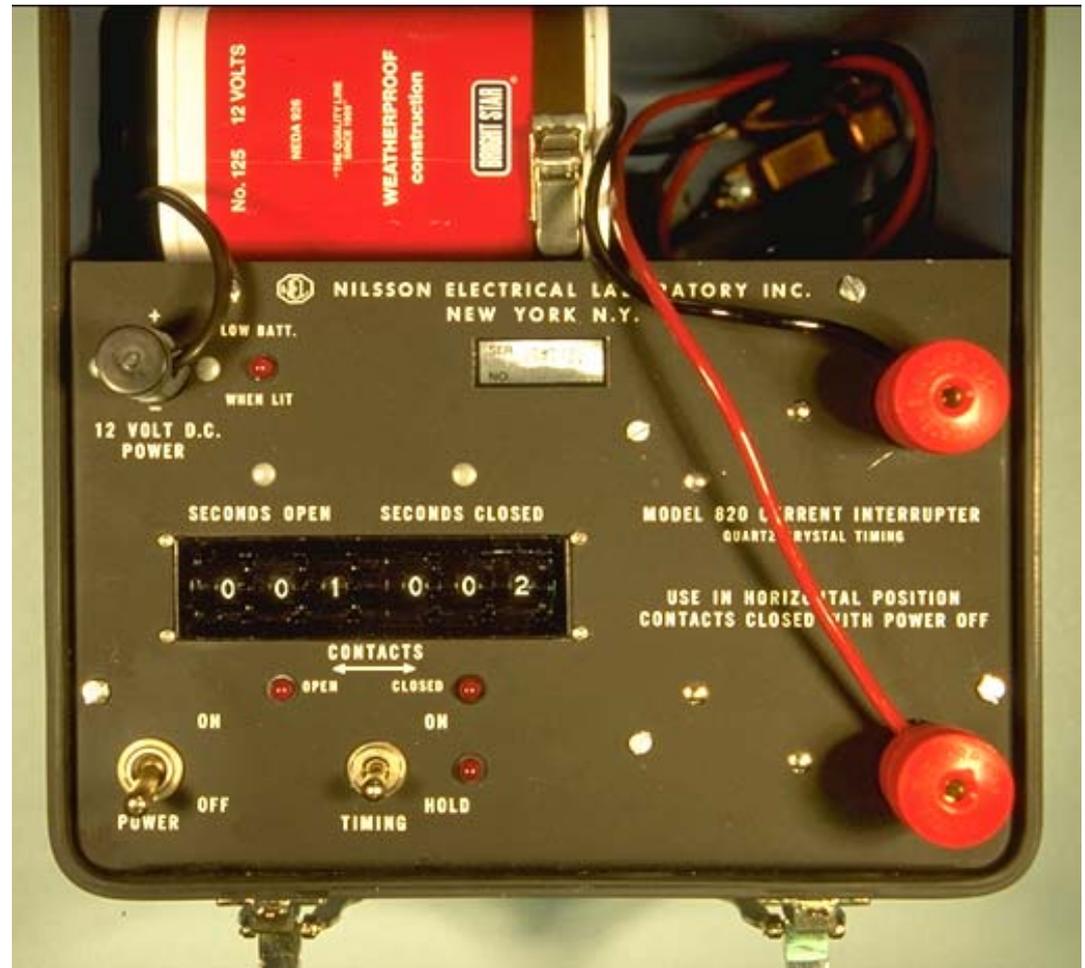


▼ Cathodic Protection Criteria

100 mv. Polarization Decay

✉ Current Interruption

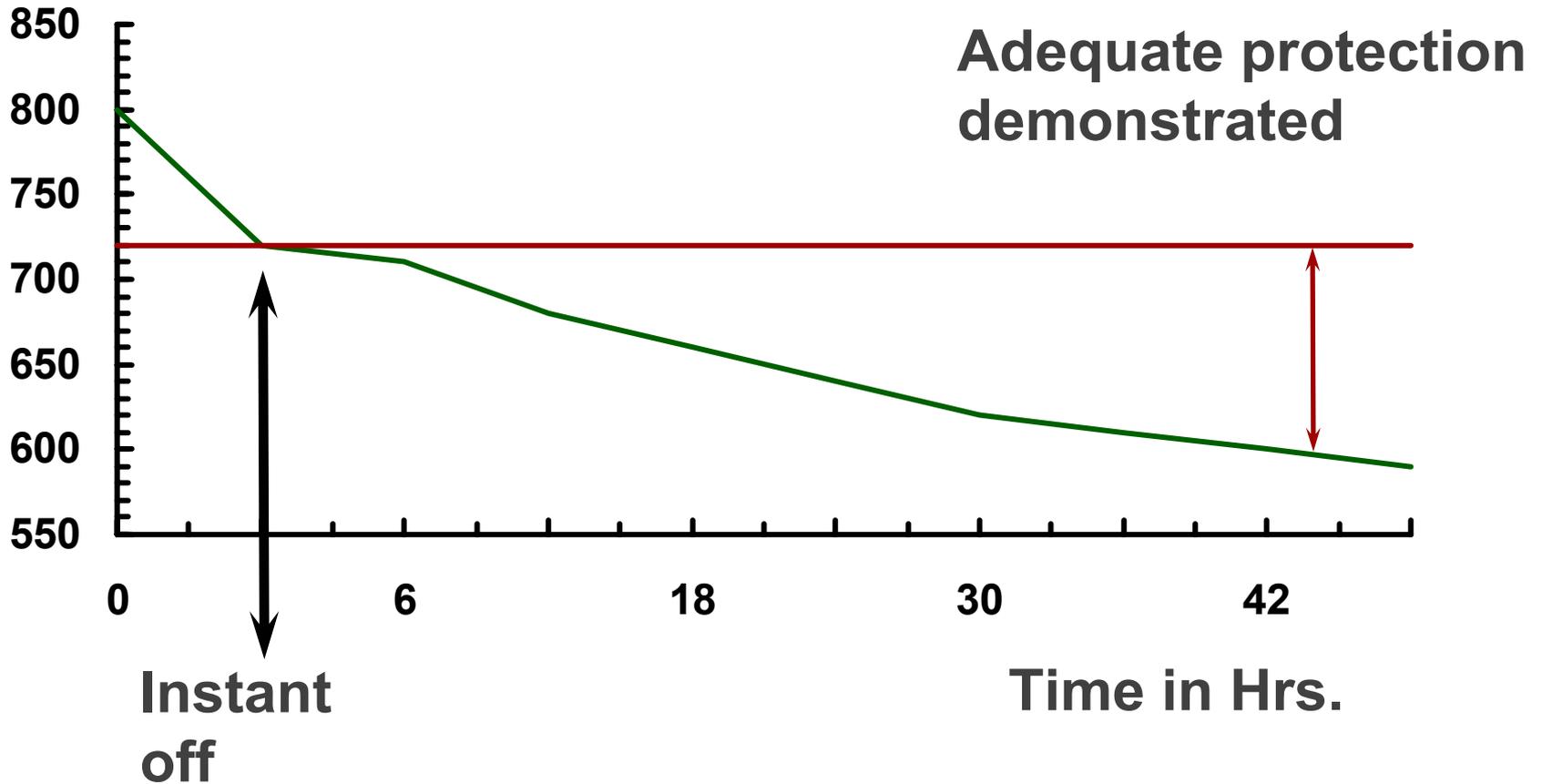
✉ Cu/CuSO₄ Reference





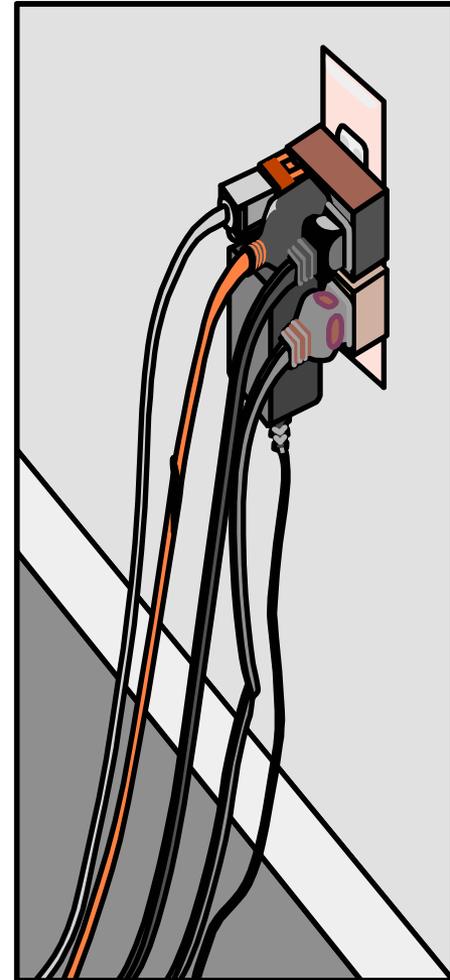
100 MV Polarization Decay

P/S



▼ C. P. Criteria (-300 mV Shift)

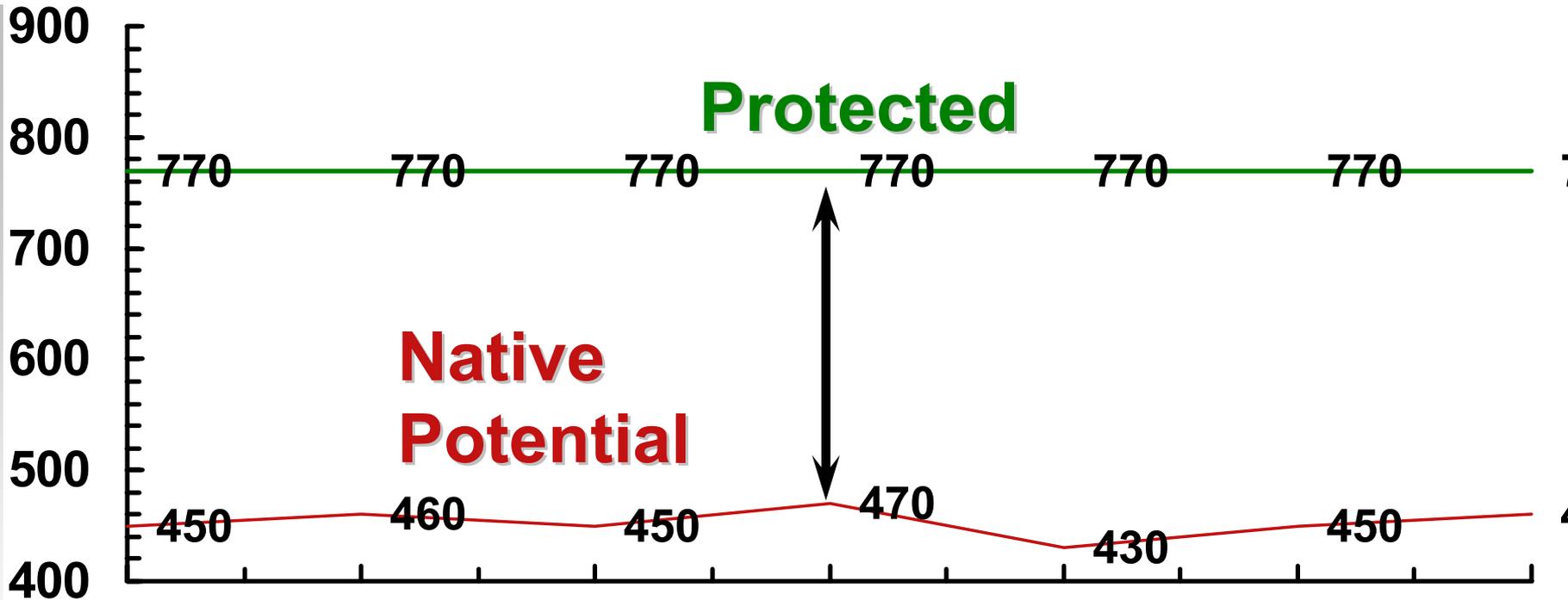
- ✉ **Measured with
Current Applied**
- ✉ **Consider IR Drop**
- ✉ **Cu/CuSO₄ Reference**
- ✉ **Does NOT Apply to
Structures with
Different Anodic
Potentials**





300 mv Shift

P/S



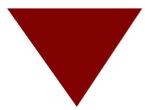
▼ Cathodic Protection Criteria

Net Protective Current

✉ **Current Flow from Electrolyte to Structure**



✉ **At Predetermined Anodic Areas**

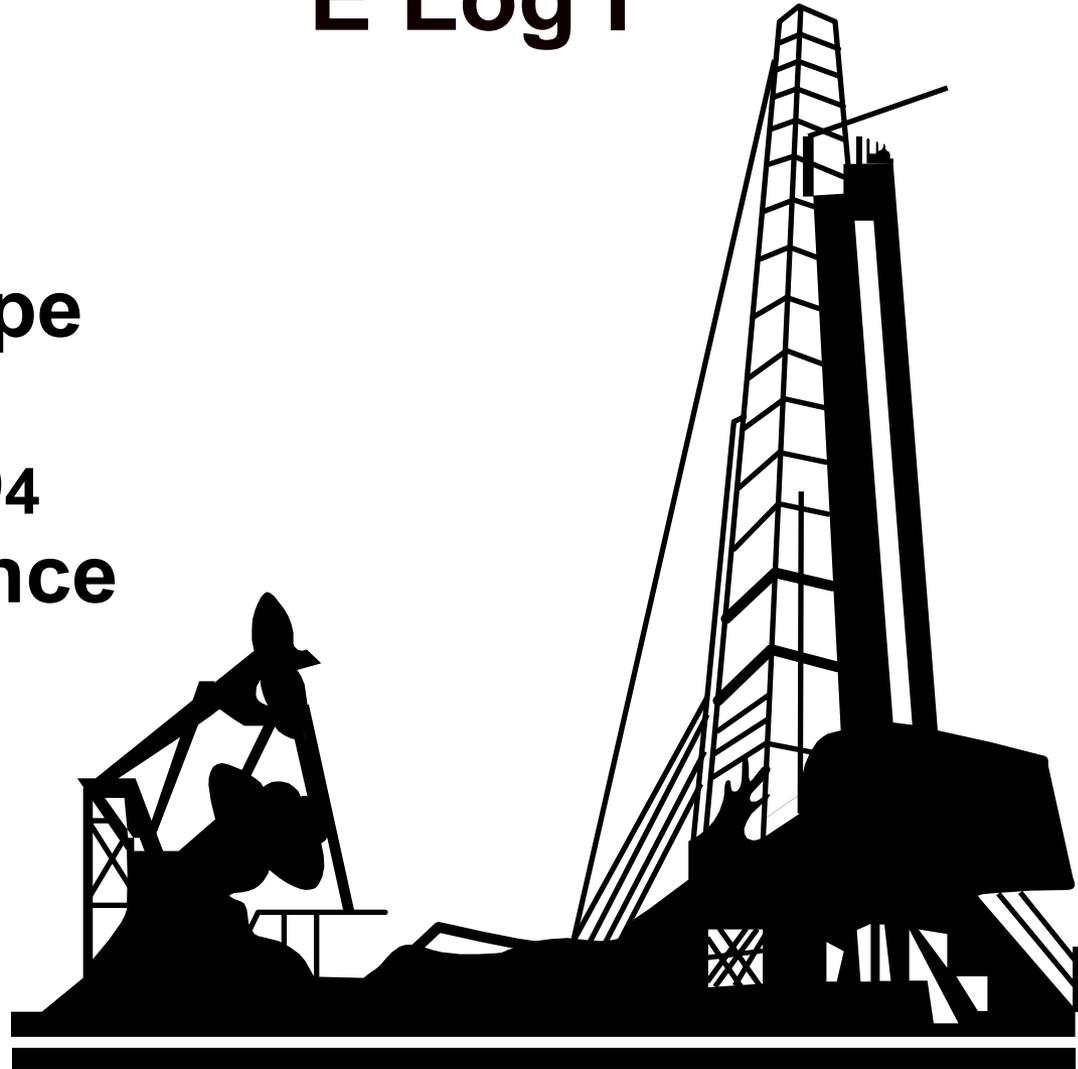


Cathodic Protection Criteria

E Log I

 **Tafel Slope**

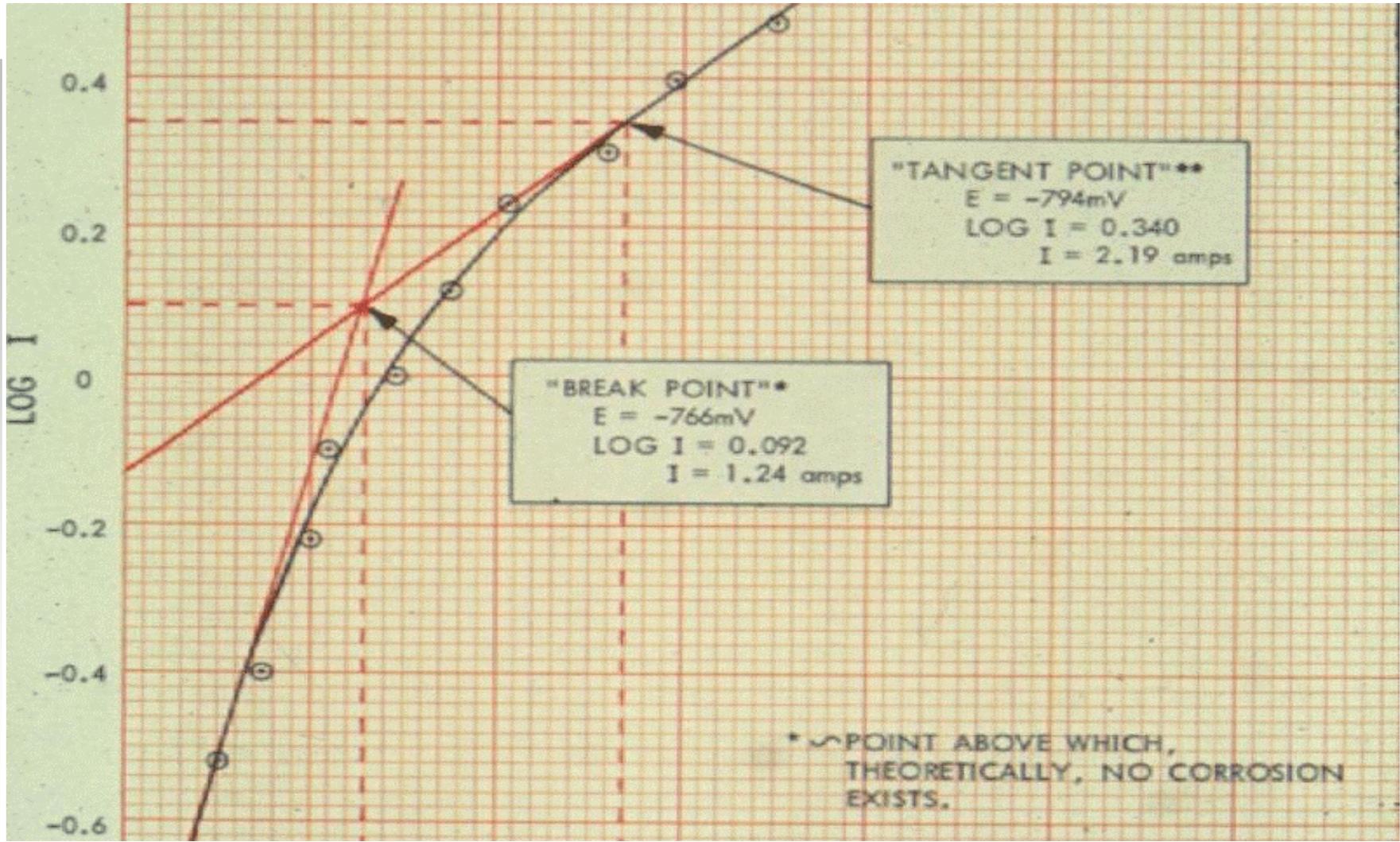
 **Cu/CuSO₄
Reference**





Cathodic Protection Criteria

E Log I



▼ Monitoring ~ §192.465(a)&(c)

✉ **Cathodically Protected Zones**

✉ **Isolated Sections
< 100 ft. (Gas Mains
or Transmission)
10% Sampling Per Yr.**

✉ **Non-Critical Bonds**



Each Calendar Year Not Exceeding 15 Months

▼ Monitoring ~ §192.465(b)&(c)

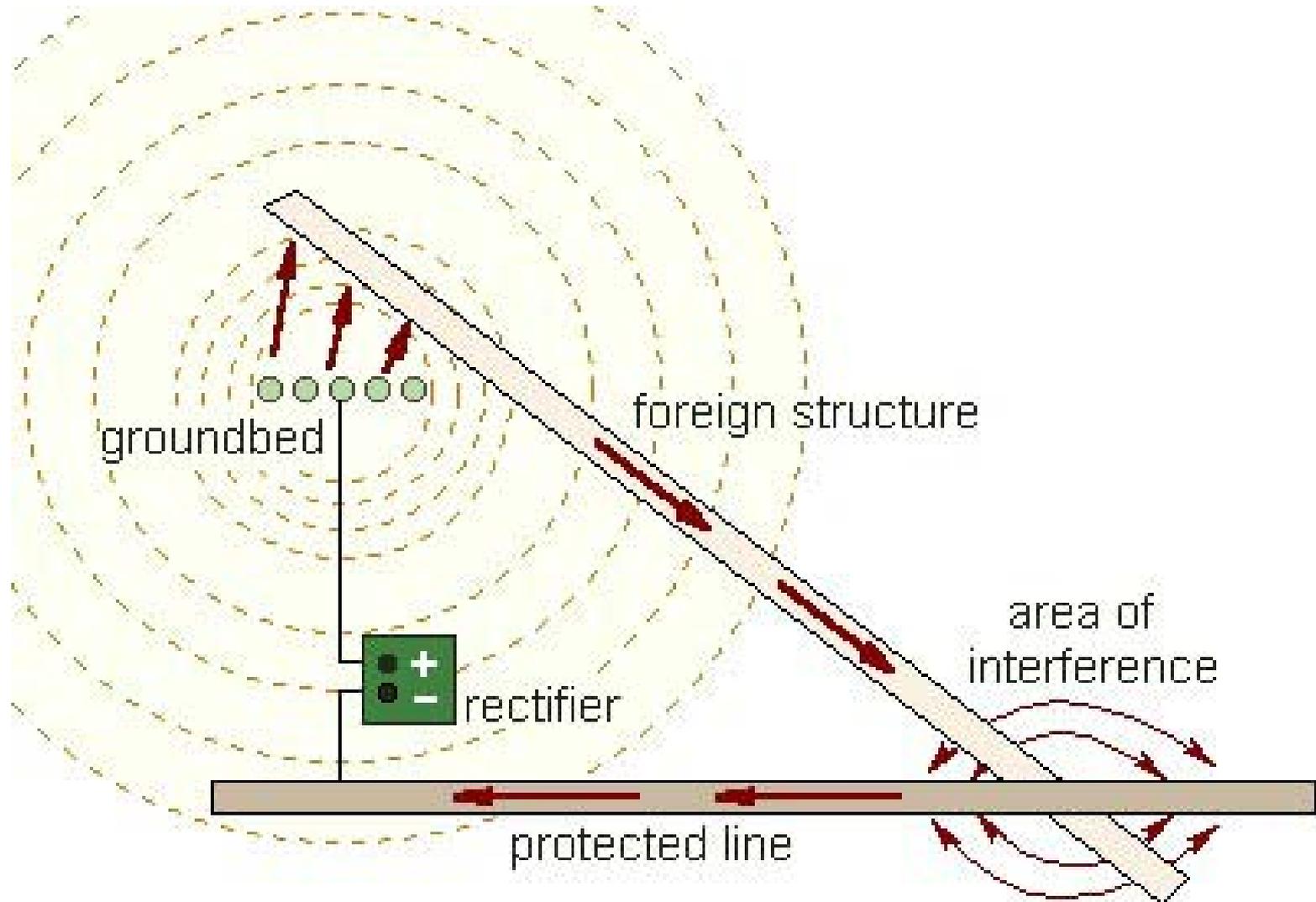
- ✉ **Rectifiers**
- ✉ **Critical Bonds**
- ✉ **Reverse Current Switches**
- ✉ **Diodes**

***6 x year - Intervals
Not Exceeding
2 1/2 Months***

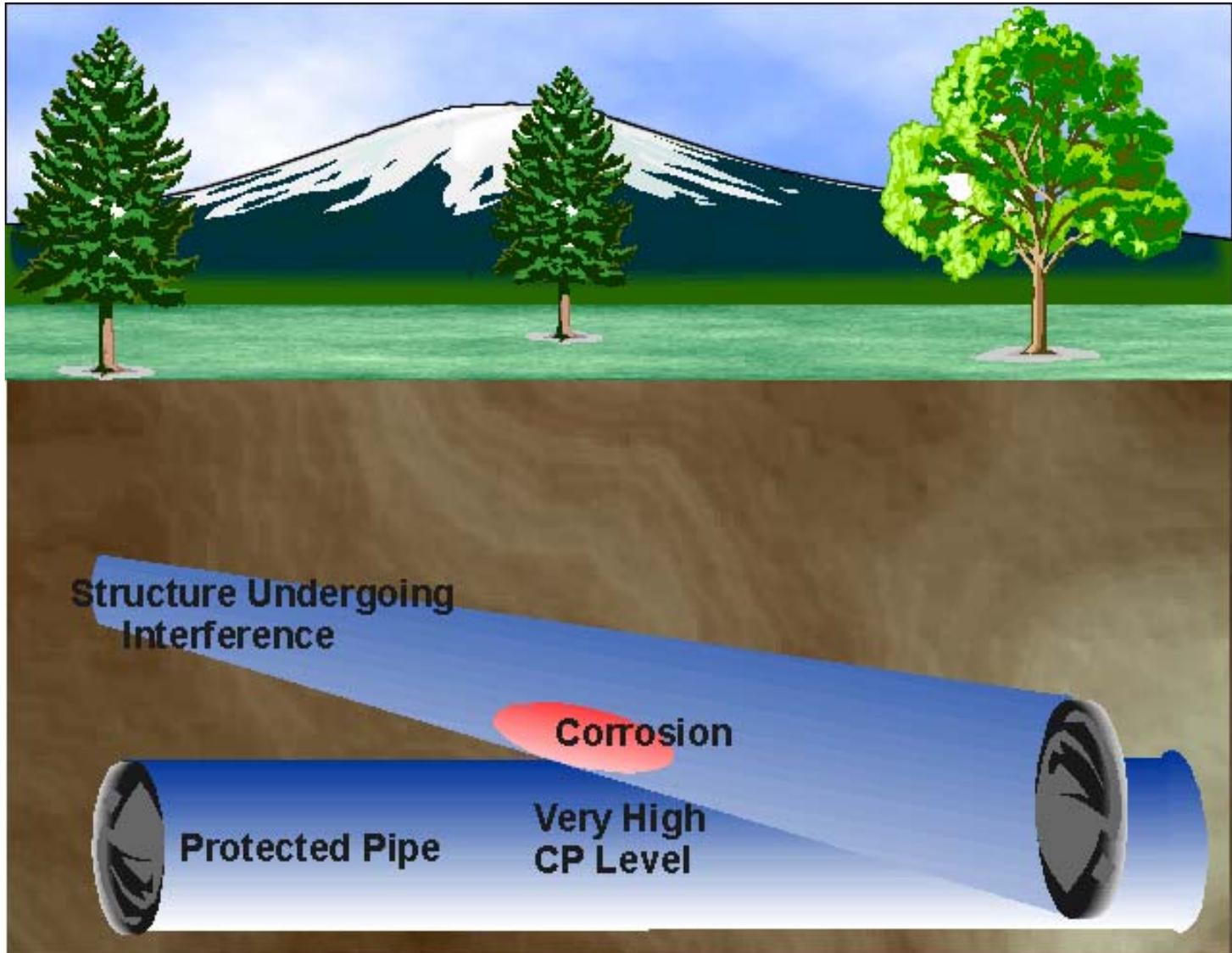




Monitoring ~ §192.465(e)



▼ Monitoring ~ §192.465(e)



Monitoring ~ §192.465(e)

- ✉ **Reevaluation of Unprotected Lines**
 - ✉ **Every 3 Years not to exceed 39 Months**

- ✉ **Determine Areas of Active Corrosion**
 - ✉ **Electrical Survey (Where Practical)**
 - ✉ **Corrosion and Leak History**
 - ✉ **Leak Survey**
 - ✉ **Exposed Pipe Inspection Records**
 - ✉ **Pipeline Environment**



Active Corrosion

✉ Continuing corrosion which, unless controlled, could result in a condition that is **DETRIMENTAL to PUBLIC SAFETY** --
§192.465(e)(1) [was 457(c)]





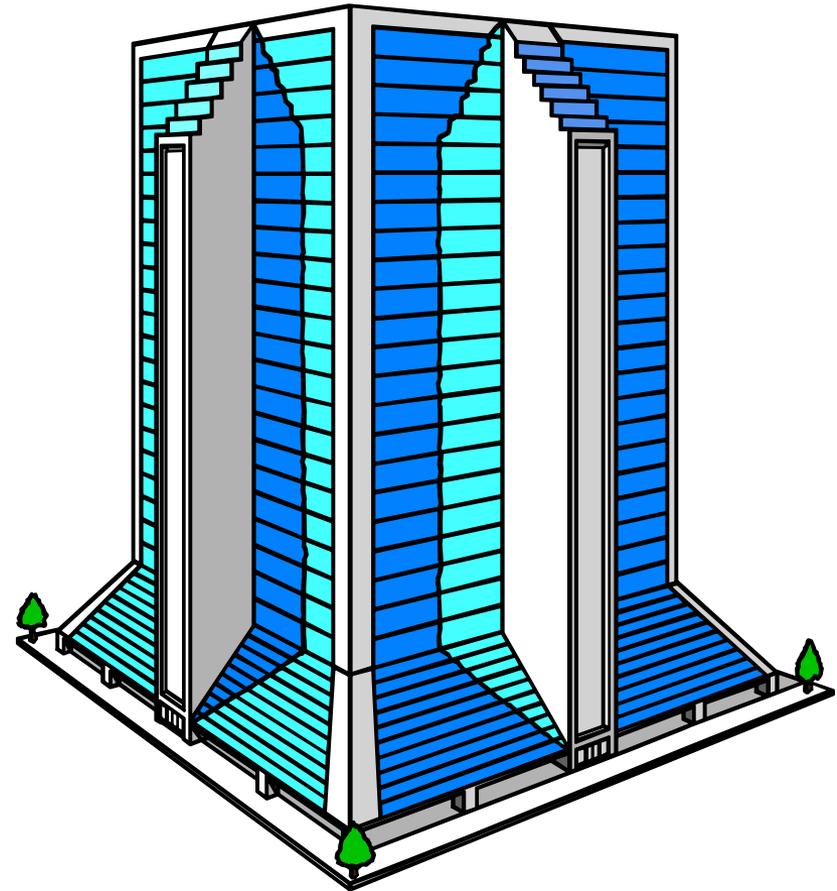
Detrimental to Public Safety

Considerations

- ✉ **Pipeline Location**
Population Density
Road Crossings

- ✉ **Pressures**

- ✉ **Corrosion Rate**
(3 Year Intervals)





Electrical Survey

 **Definition ~ (Per §192.465 (e)(2))**

...A series of closely-spaced pipe-to-soil readings over a pipeline that are subsequently analyzed to identify locations where a corrosive current is leaving the pipeline



Electrical Surveys

What's Impractical

-  **Wall to Wall Paving**
-  **Common Trench**
-  **"Stray Current" Areas**
-  **Pipeline Cover In and Out of Paving**



Pipeline Environment

-  **Soil Resistivity (High or Low)**
-  **Soil Moisture (Wet or Dry)**
-  **Soil Contaminants**
-  **Other Known Conditions**

▼ Monitoring ~ §192.459

✉ Examination of Pipelines When Exposed for Any Reason --

✉ Check
Condition of
Coating and
Pipe





Exposed Pipelines

- ✉ Investigate to determine whether corrosion or coating deterioration exists
- ✉ If corrosion found, investigate beyond exposed area (visual or other means)
- ✉ Repair any problems
- ✉ Keep records





Remedial Actions

§192.465(d)

 **“Within Monitoring Period”**

 **“Prompt”**

Consider:

-  **Population Density**
-  **Environmental Concerns**
-  **Rate of Corrosion**
-  **Climatic Conditions**
-  **Availability of Materials**

▼ Electrical Isolation ~ §192.467

✉ From Other Underground Structures

✉ From Casings

✉ Effective Insulation

✉ Protection From Arcing





Shorted Casings

✉ P/S reading **ESSENTIALLY**
the Same as Casing
reading

**Other Tests May
be Necessary
to Demonstrate
Isolation**





Shorted Casings

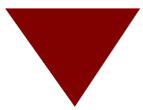
Remedial Measures

 1) Clear the Short

 2) Fill Annular Space with Dielectric

 3) If 1 or 2 Impractical, Monitor with Gas Detection Equipment at Intervals Specified in .705 & .721, or Smart Pig





Test Stations/Test Leads

§192.469 & 471

- ✉ Must Have **SUFFICIENT** Test Stations or Other Contact Points to Determine the Adequacy of Protection.



▼ Test Leads ~ §192.471

- ✉ **Attach to Minimize Stresses on Pipe**
- ✉ **Coat the Bared Wire/Pipe Connection**
- ✉ **Maintain Mechanically Secure & Electrically Conductive**



▼ Test Leads ~ §192.471

- ✉ **Attach to Minimize Stresses on Pipe**
- ✉ **Coat the Bared Wire/Pipe Connection**
- ✉ **Maintain Mechanically Secure & Electrically Conductive**



Internal Corrosion Control

§192.475

-  **Corrosive Product Transported**
 -  **Test to Determine Effect on Pipeline**
 -  **Take Steps to Minimize Effect**

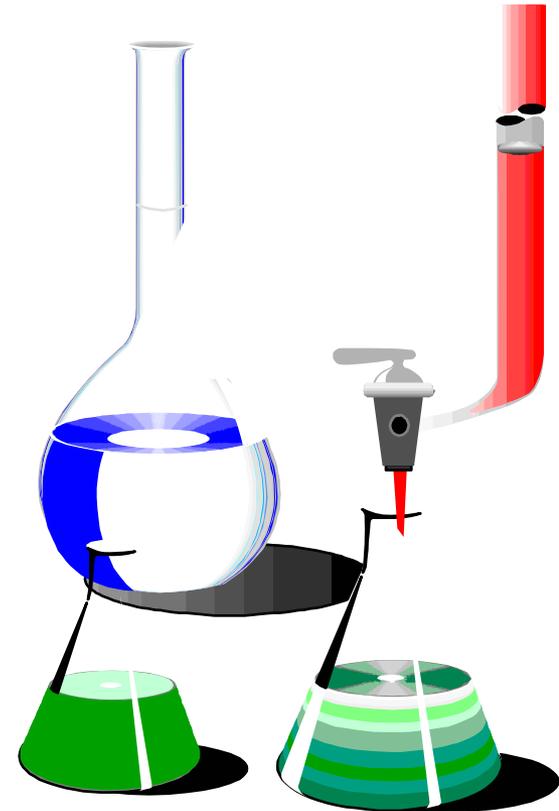
-  **Whenever a Segment is Removed**
 -  **Inspect Internal Surfaces**
 -  **Replace if Required By Remedial Measures**

Internal Corrosion Control Monitoring ~ \$192.477

✉ When Corrosive Product is Transported

- ✉ Must Be Monitored
For I.C.
- ✉ 2x Calendar Year
N.T.E. 7 ½ mos.

Coupons
Water Analysis
Microbiological Analysis
Inhibitors



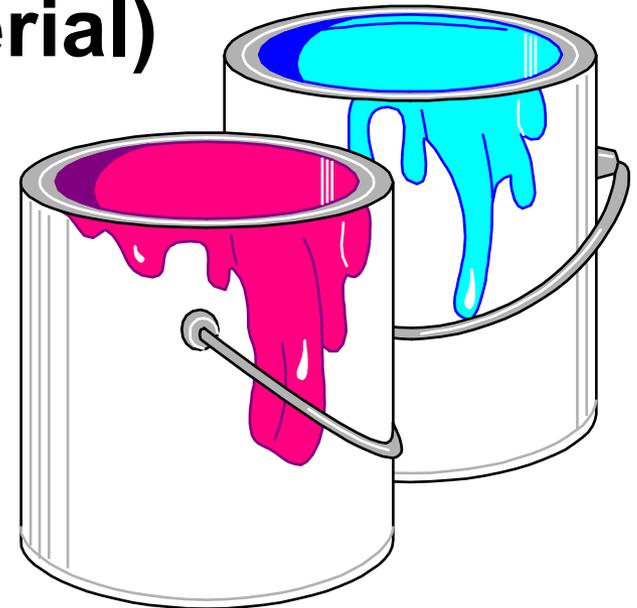


Atmospheric Corrosion Control

§192.479

- ✉ Pipeline Exposed to Atmosphere
 - ✉ Cleaned
 - ✉ Coated (Suitable Material)

**Unless Non-Corrosive
Environment or Only
Light Surface Oxide**



▼ Atmospheric Corrosion Control

§192.479

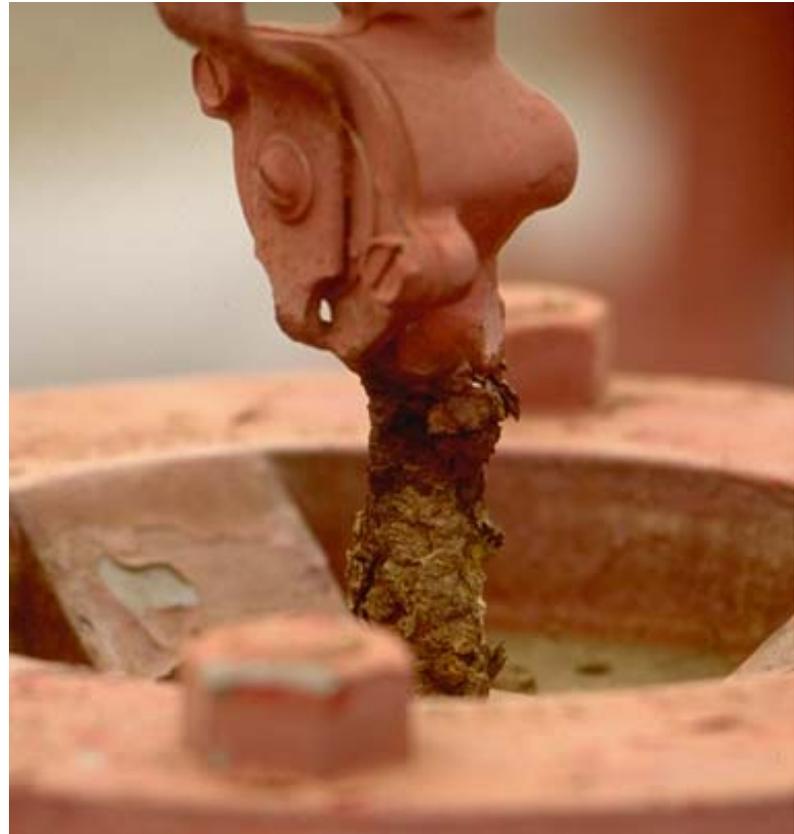
- ✉ **Non-Corrosive Environment not applicable to Offshore Splash Zones or Soil-to-Air Interfaces**

▼ Atmospheric Corrosion Control

Monitoring ~ §192.481

✉ Onshore

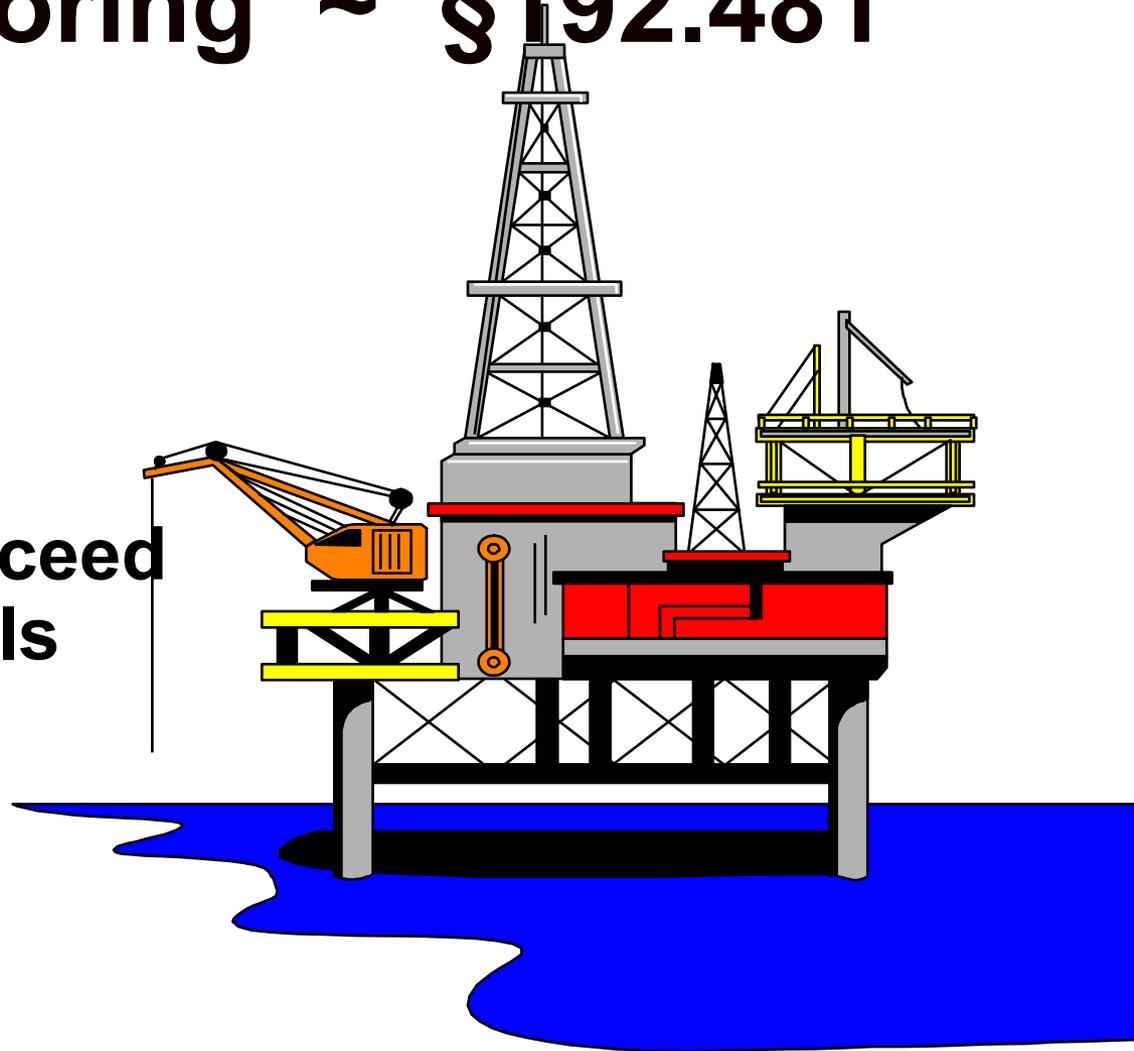
**Every 3
Calendar
Years at
Intervals not
exceeding 39
Months**



▼ Atmospheric Corrosion Control Monitoring ~ \$192.481

✉ Offshore

Every Calendar
Year Not To Exceed
15 mos. Intervals



Atmospheric Corrosion Control

Monitoring ~ \$192.481

Inspections Must Include Pipe:

-  **At Soil-to-Air Interfaces**
-  **Under Thermal Insulation**
-  **Under Disbonded Coatings**
-  **At Pipe Supports**
-  **In Splash Zones**
-  **At Deck Penetrations**
-  **In Spans Over Water**

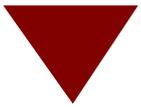
▼ Remedial Measures ~ General

§192.483

✉ Pipe that Replaces Pipe because of External Corrosion

Cleaned
Coated
Cathodically
Protected





Remedial Measures

Transmission §192.485

 **General Corrosion**

 **Replace**

 **Lower
MAOP/MOP**

 **Repair**

 **Localized
Corrosion**

 **Replace**

 **Repair**

 **Reduce Operating Pressure**





Remedial Measures

Transmission §192.485



General Corrosion



**Closely Grouped Pitting Affecting
Overall Strength of the Pipe**



Localized Corrosion Pitting

Guides: GPTC & RSTRENG



Remedial Measures

Gas Distribution (exc. CI & DI) ~ §192.487

 **General Corrosion or W.T. <30%
Remaining**

 **Replace**

 **Repair**

 **Localized
Corrosion**

 **Repair**

 **Replace**





Remedial Measures (Gas)

Cast & Ductile Iron ~ \$192.489



Graphitization General



If Fracture May Result -
Replace



Localized-If Leakage Might Result



Repair



Replace



Seal Internally



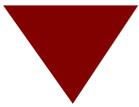
Corrosion Control Records

§192.491(a)

✉ Records or Maps

- ✉ Location of Protected Piping
- ✉ Cathodic Protection Facilities
- ✉ Galvanic Anodes
- ✉ Bonds to Other Structures



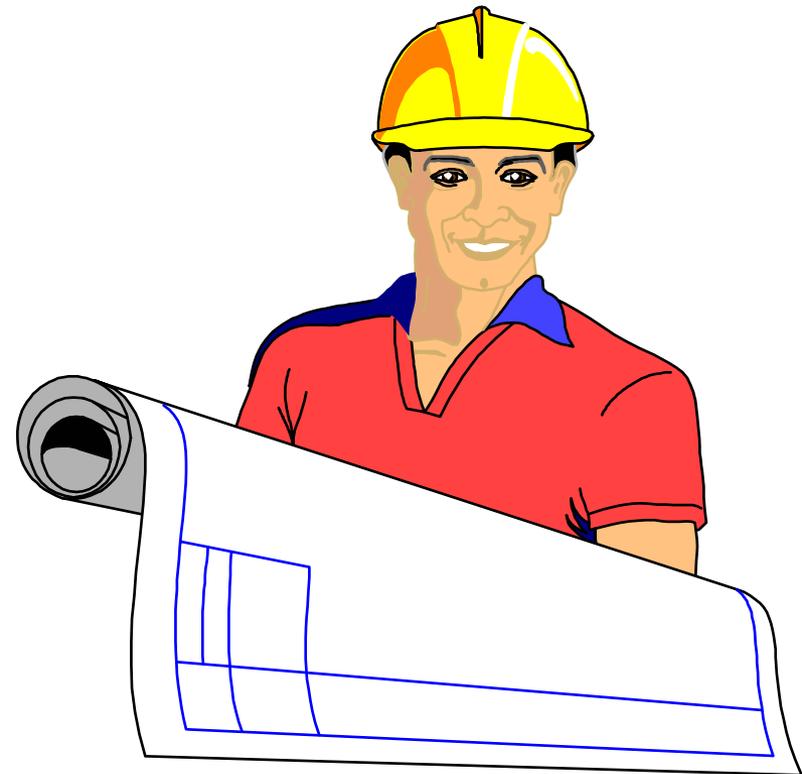


Corrosion Control Records

§192.491(b)



 **Retain for Service
Life of System**





Corrosion Control Records

§192.491(c)

Tests, Surveys, or Inspections

-  Required by Subpart I
-  Retain for at least 5 Years
-  Specified Exceptions
-  Check with Attorneys



Corrosion Control Records

§192.491(c)

- ✉ **Exceptions/Retain for Service Life**
 - ✉ **Annual P/S Surveys ~ 465(a)**
 - ✉ **3-Year Reevaluations ~ 465(e)**
 - ✉ **Inspections for Internal Corrosion ~ 475(b)**

