DC and AC Coupon Technology

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DC & AC Coupon Technology

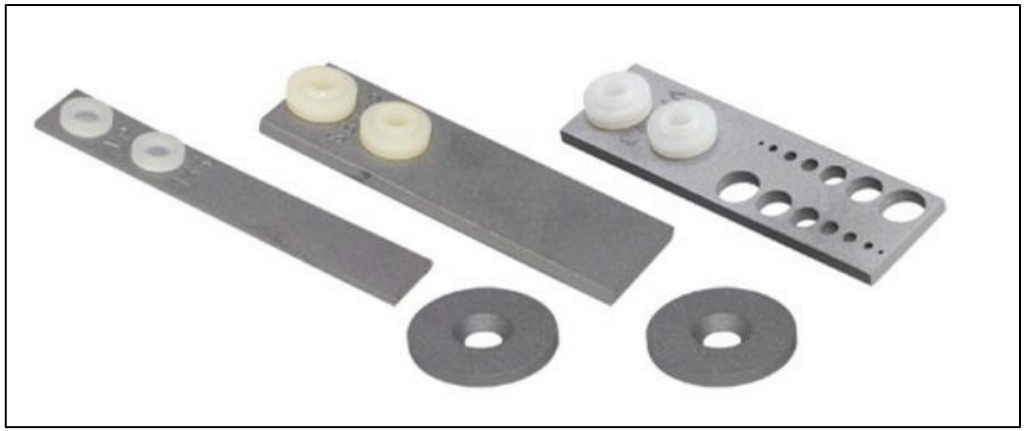
- What are they?
- What do they look like?
- How do you install them?
- What is the Data From A Coupon Good For?
- How Do You Read Them?

DC & AC Coupon Technology

- This is a coupon:

Coupon History

- Traditionally Coupons Were for Internal Corrosion and Atmospheric Corrosion Monitoring and Testing



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Coupon History

- Internal Corrosion Coupons Were Placed Inside the Pipeline To Monitor the Corrosive Effects of What the Pipeline Carried.
- Liquids or Gas

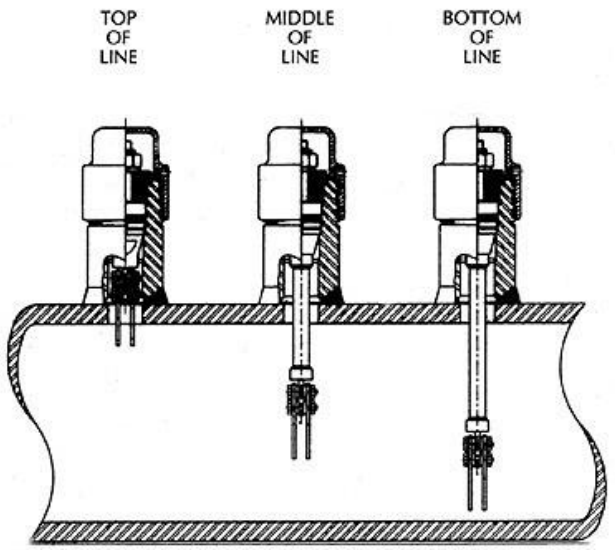
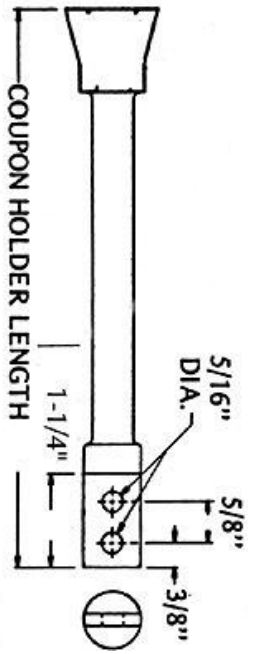


FIG. 1
Coupons shown rotated 90° from normal position.



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Coupon History

- Atmospheric Coupons Either Tested Multiple Metals or Multiple Coatings to a Corrosive Atmosphere

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Coupon Definition

- A coupon is a representative piece of material or metal subjected to an environment for testing purposes.
- SP0104-2014: *"Cathodic Protection Coupon – a coupon that is connected to the external surface of, and immersed in the electrolyte adjacent to, the structure being protected by cathodic protection."*

Pipeline Coupon Examples

- Basic
  - Simple Single Coupon
  - Two Wire

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Pipeline Coupon Examples

- More Advanced
  - Multiple Coupons
    - 1 cm^2 for AC
    - 2- 100 cm^2 for DC
  - Reference Electrodes
  - Test Station Switching

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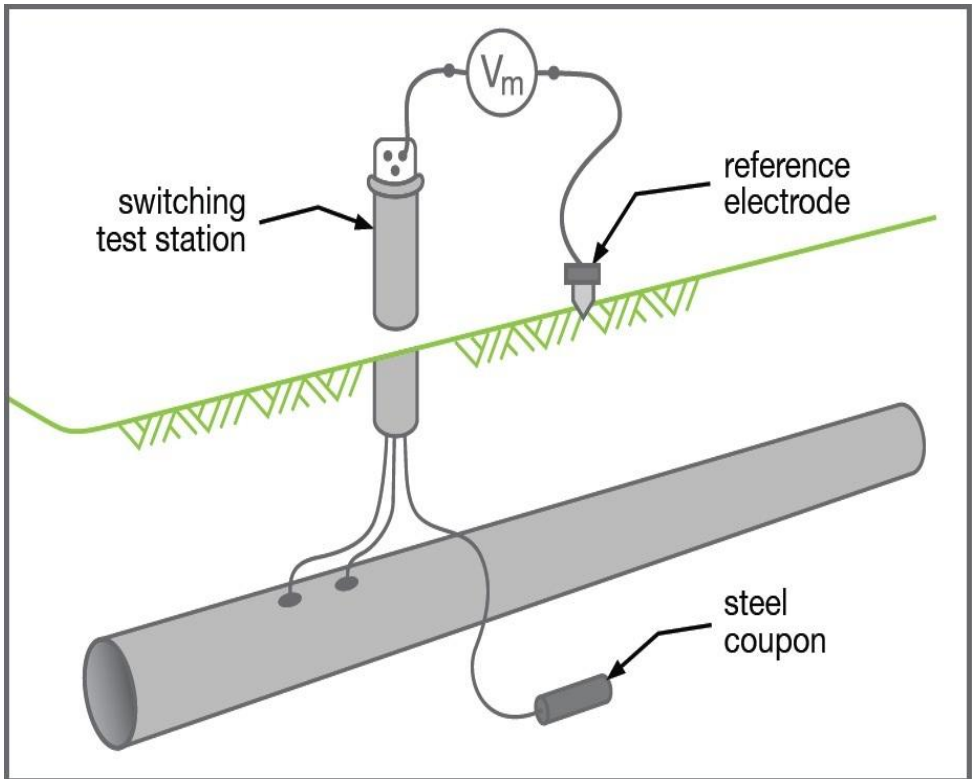
Coupon 101 – Install

- Coupon is placed in the ground next to the pipe – IN THE SAME ELECTROLYTE
- Cpn is connected to pipeline in test station
- Ref Cell is used to read pipe or cpn potentials



Testing for Polarized Potential with Coupon

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Coupon 101 – How to Read

- Regular Ref Cell Placement
- Coupon Still Hooked Up to Pipe – Read Both
- Break Coupon Lead Wire – Read Just Coupon
- Sounds Simple – Right?
- Well It Is – Sort Of

Coupon 201

- Buried Reference Electrodes Fail!
- Coupons can upset CP-Pipeline circuit.
  - Well coated pipeline – coupon is large holiday
  - Too many coupons on a well coated pipeline
  - Coupon can become part of interference circuit
- Wires Break
- Forget to Flip the Switch (On or Off)
- Lightning Damage to Coupon or Circuit Card

Data from a Coupon - DC

- Native Potentials – This Coupon is never hooked to pipeline
- ON Potentials – Read with the Pipeline
- I-Off Potentials – Disconnect Coupon and read the Coupon Instant Off
  - Do not Have to Interrupt Multiple Rectifiers
  - Direct Connect Sacrificial Anodes
  - Interference Studies
  - Multiple Pipelines in single ROW

Data from Coupon – DC & AC

- Measure Current Coming From Coupon
- Calculate Current Density
- Common Unit of Measure is A/m^2
  - Amperes Per Square Meter
  - **Watch Your Units!!!!!!**
    - Real current measurements can be mA or μA
      - Clamp-On Ammeters Cannot Read This.
    - Coupons are measured in cm^2.
    - For a 1 cm^2 AC coupon: $100A/m^2 = 10mA/cm^2$
    - For a 100 cm^2 DC coupon: $100\ A/m^2 = 1A/cm^2$

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Why Is Current Density Important?

- *"Cathodic Protection"* by PE Francis
  - Expected DC Current Densities for CP in:
    - Acidic Solutions: 350 - 500 A/m^2
    - Saline Solutions: 0.3 – 10 A/m^2
    - Sea Water: 0.05 – 0.15 A/m^2
    - Saline Mud: 0.025 – 0.05 A/m^2
- *"AC Corrosion-A New Challenge To Pipeline Integrity"* by Gummow/Wakelin/Segall
  - Expected AC Corrosion Damage for Given AC Current Densities on Adequately Cathodically Protected Pipelines
    - $d < 20$ A/m^2: No AC Induced Corrosion Expected
    - 20 $A/m^2 < d < 100$ A/m^2: Unpredictable
    - 100 A/m^2: Expected

Why Current Density is Important?

- *"AC Corrosion – Case Histories, Test Procedures & Mitigation"* by Gummow/Wakelin/Segall
- AC Corrosion Rates
  - Are highest at holidays having a surface area of 1 – 3 cm^2
  - Increase in chloride containing or deaerated environments
  - Increase with decreasing AC frequency below 100 Hz
  - Decrease with increasing CP current density
  - Decrease with time
- $\boldsymbol{i_{ac} = \frac{8V_{ac}}{\rho \pi d}}$
  - i_{ac} = AC current density
  - V_{ac} = AC voltage of pipeline to remote earth
  - ρ = soil resistivity
  - d = diameter of a circular holiday having an area equal to that of the actual holiday

How do you read them?

- Directly – Voltmeter for Potential Measurements
- Directly – Ammeter for Coupon Current Measurements
  - Very Low Scale Such as Milliamps or even Microamps
  - Careful – Breaking the circuit to hook up the ammeter in series causes depolarization
- Remote Monitoring – Reads It For You
  - Remote Access
  - Constant Monitoring
  - Records History
- CAUTION: Every Meter Has Errors.
  - Since you are reading very small numbers, a small error can sway data.

Guidance

- Company SOPs
- NACE SP0169-Latest Edition for Magnitudes – *"Control of External Corrosion on Underground or Submerged Metallic Piping Systems"*
- NACE SP0104-Latest Edition for How To – *"The Use of Coupons for Cathodic Protection Monitoring Applications"*
- Vendors and Suppliers – Materials and Individual Equipment Instruction