

Efficient Use of Coupons and ER Probes for Corrosion Monitoring

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Today's Discussion Topics

- Coupon & ER Probe Background
- CP Coupon Technology
- AC Coupon Technology
- ER – Electrical Resistance Probes Technology
- Test Facilities
- Common Usage of Coupons & ER Probes
- Common Errors & Assumptions
- Wrap Up and Lessons Learned

Coupon Definitions

- A coupon is a representative piece of material or metal subjected to an environment for testing purposes.
- NACE 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.”
- Comment: A CP coupon provides a simple and efficient way to measure a polarized potential without having to interrupt the CP system.

Coupon & ER Probe Background

- Coupons and Electrical Resistance Probes have been around for quite some time
- They have been in service for internal corrosion monitoring and are known as weight loss coupons and ER Probes
- Coupons have also been used for atmospheric corrosion testing and atmospheric coating testing
- So they are not new and most corrosion control folks are comfortable with the concept
- Today we also use them for monitoring and testing buried structures
 - AC Coupons and CP Coupons

Atmospheric Corrosion Testing



How do AC & DC Coupons Work?

- The steel coupon represents a holiday in the coating.
- The coupon is connected to the structure via a test station and becomes part of the electrical circuit.
- The current flow and/or the potential of the coupon is measured.
- The current density is calculated using the coupon size and the current flow.
- An off potential is taken by disconnecting the coupon from the circuit and measuring the instant off potential.
- A static or native potential can be taken if a static/native coupon was also installed.

Assumptions

- The coupon is selected to best represent a “typical” holiday in the coating.
- The coupon size is also selected for ease and consistency of the calculations.
- A separate coupon is needed for AC and CP measurements.
- A soil access “dip” tube is usually installed for taking the portable reference electrode readings.
- A permanent reference electrode is usually installed.
- The coupon material should be of a material similar to the pipeline steel.

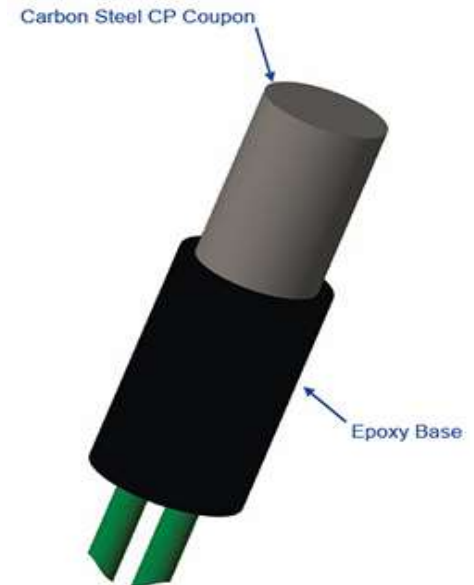
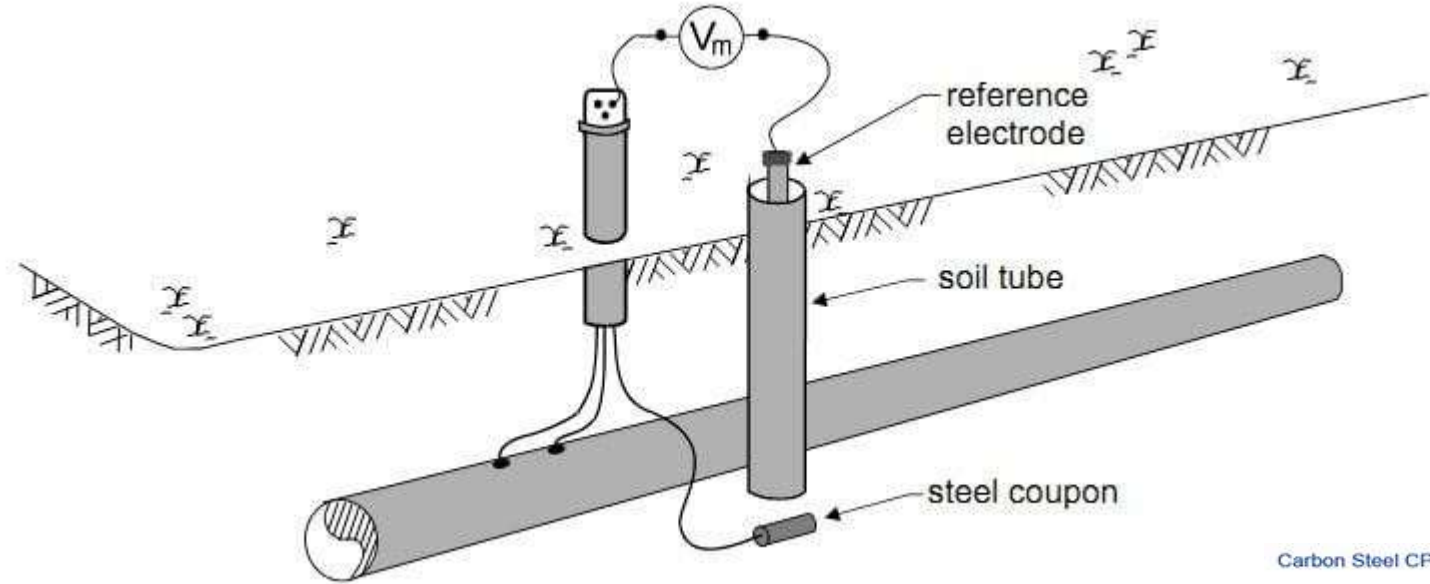
How do ER – Electrical Resistance Probes Work?

- The ER probe is installed in the same electrolyte as the structure.
- The probe is connected to the structure and becomes part of the electrical circuit.
- The probe element corrodes and creates a resistance across the probe.
- The probe is plugged into the monitoring instrument and the instrument calculates the corrosion rate of the probe.
- The probe can also be installed without the structure lead connected and it will then give you a corrosion rate and you can calculate the corrosivity of the electrolyte, such as inside a filled pipeline casing.

Assumptions

- Electrical resistance probes are not a new technology as they have been in use since the mid-1950's.
- The probe material should be of a material similar to the pipeline steel.
- You do need a specialized meter or remote monitoring RMU to read the probe.

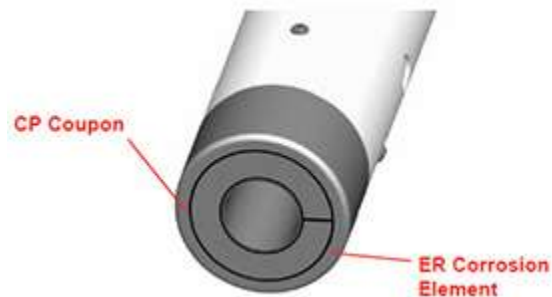
CP Coupon Technology - examples



AC Coupon Technology - examples



ER – Electrical Resistance Probe Technology - examples



Test Facilities for Coupons - examples



The TRITON® is the first coupon test station on the market to offer technically sound AC and DC coupons in an independent package that can be easily installed independent of test station location.

Every feature, from the heavy duty test switch to the bonded zinc anode terminal, is designed to make the TRITON® durable, easy to install, and easy to use.

- Clearly labeled faceplate makes field measurement easy
- Recessed banana plug terminals prevent accidental contact with energized pipeline
- Heavy duty "mil-spec" disconnect switch provides durable connection
- 1 CM² AC coupon is suitable for accurately determining AC current density
- 100 CM² "TEST" coupon is suitable for measuring "ON" and "Instant Off" potentials
- 100 CM² "NATIVE" Coupon suitable for measuring true "Native" potentials
- Custom external markings make identification easy in the field
- Stationary copper/copper sulphate reference electrode incorporated into design to provide measurement of "IR Free" coupon potentials
- Pre-installed #6 AWG THHN primary pipeline connection and bonding strap allows quick connection of zinc anode or other AC current drain
- Pre-installed #10 AWG THHN secondary pipeline connection for testing "ON" pipeline potentials



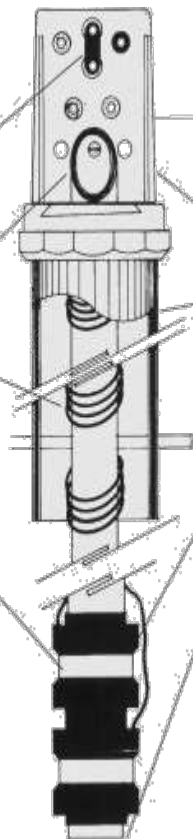
Features:

Bond Plug – Breaks circuit between pipe and coupon for fast, easy instant off potential measurement.

Access Tube – for quick, unobstructed placement of reference electrode close to the coupon.

CP Wire – for underground service and color coded for easy lead identification.

Steel Ring Coupon – certified API 5L with 0.01 ft² standard exposed area for easy calculations. Coupon surface is clean and protected from contamination. Coupon weight certified and recorded (optional). Single coupon standard. (Double coupon optional.)



Big Fink CP Test Station – proven convenience and durability.

COTTShunt (optional) – to measure current direction and magnitude.

COTT Pipe PC – support and access tube made from high strength polycarbonate (same as Big Fink) which ensures that the electrode access stays open. Cott Pipe PC available in all colors and lengths from 4' to 40'.

PE Shrink Fittings – isolate coupon and eliminate "edge effects". All annular spaces epoxy sealed.

Porous Ceramic Alloy Plug – prevents contamination of the "salt bridge" – keeps sensing port 1" from the coupon.



Custom “Homemade” Test Facilities



Common Usage of Coupons & ER Probes

- CP Coupons are used to monitor potentials and to provide a simple method of obtaining a polarized potential without having to interrupt the current sources.
- Can be used where you have directly connected galvanic anodes.
- CP Coupons are also used at interference locations to provide a true polarized potential of the structure(s).
- CP Coupons are also used to measure the DC Current density in DC & AC monitoring locations.
- AC Coupons are used as a monitoring tool to determine the AC Current Density in areas of high AC current and potentials.
- ER Probes are used to measure the corrosion rate and the corrosivity in various situations.

How Does it Work?

The voltmeter is connected to the test lead and to the reference electrode.

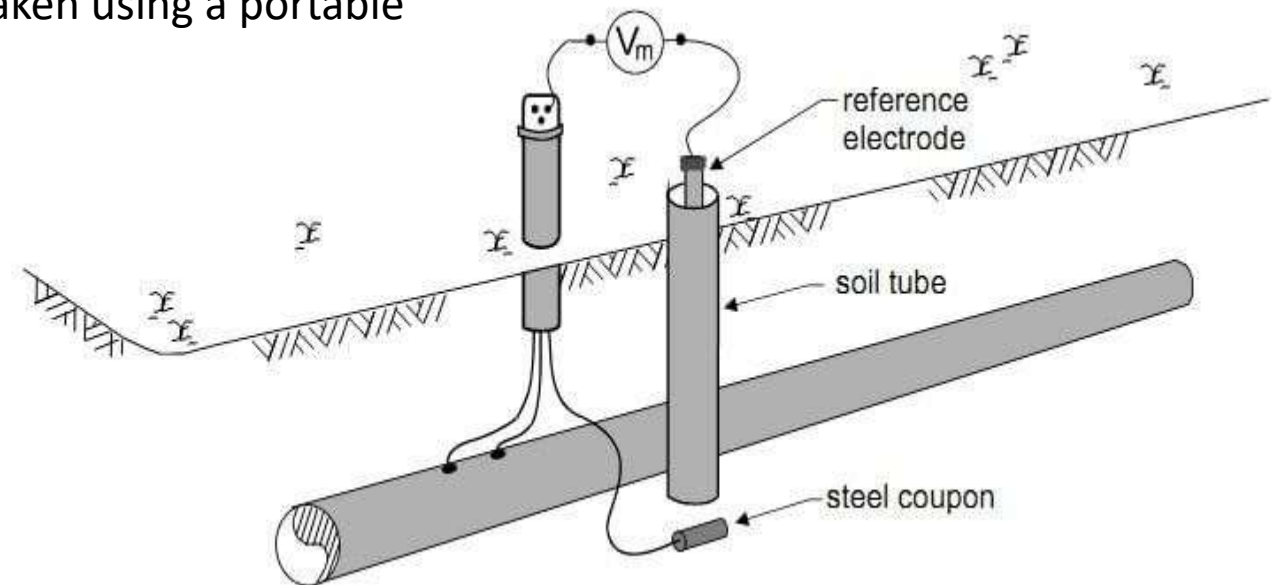
A pipe to soil potential is taken.

The voltmeter lead is moved to the coupon lead and a coupon to soil reading is taken with the coupon attached to the pipe.

The coupon is then disconnected from the pipe and still connected to the voltmeter and an instant off potential taken on the coupon.

The static/native potential may also be taken by leaving the meter connected to the coupon and the reference electrode and letting the coupon depolarize.

Note the soil tube that allows the potentials to be taken using a portable reference electrode at grade.



How Does it Work?

- Measure Current Coming From Coupon
- Calculate Current Density
- Common Unit of Measure is A/m²
- Amperes Per Square Meter

Watch Your Units!!!!!!

- Real current measurements can be mA or μ A
- Clamp-On Ammeters Cannot Read This
- Coupons are measured in cm²
- For a 1 cm² AC coupon: 100A/m² = 10mA/cm²
- For a 100 cm² DC coupon: 100 A/m² = 1A/cm²

How Do You Read Coupons?

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.

Why it May Not Work!

- Buried Reference Electrodes Fail!
- Coupons can upset CP-Pipeline circuit.
- Well coated pipeline – coupon is large holiday
- To many coupons on a well coated pipeline
- Coupon can become part of interference circuit
- Wires Break
- Don't Forget to Flip the Switch (On or Off)
- Lightning & Surge Damage to Coupon, RMU or Circuit Card

Why Current Density is Important

Expected DC Current Densities for CP in:

- Acidic Solutions: 350 - 500 A/m²
- Saline Solutions: 0.3 – 10 A/m²
- Sea Water: 0.05 – 0.15 A/m²
- Saline Mud: 0.025 – 0.05 A/m²

Expected AC Corrosion Damage for Given AC Current Densities on Adequately Cathodically Protected Pipelines

- $d < 30$ A/m²: No AC Induced Corrosion Expected
- 30 A/m² $< d < 100$ A/m²: Unpredictable
- 100 A/m²: Expected

Why Current Density is Important

AC Corrosion Rates

- Are highest at holidays having a surface area of 1 – 3 cm²
- Increase in chloride containing or deaerated environments
- Increase with decreasing AC frequency below 100 Hz
- Increase with increasing CP current density
- Decrease with time
- **$i_{ac} = 8V_{ac}/\rho\pi d$**
- 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

Common Errors & Assumptions

- A coupon represents a typical holiday on the pipe and not an actual holiday.
- The coupon size is also selected to make the calculations for current density easier.
- One coupon test station is not enough. You need quite a few in various locations and scenarios to get a good picture of your system.
- ER Probes work very well in showing whether you have the corrosion under control. These probes work well in locations where you are unsure of the structures status.

Guidance

- Company Procedures, Standards & SOPs – Standard Operating Procedures
- NACE SP0169 – Latest Edition – “Control of External Corrosion on Underground or Submerged Metallic Piping Systems”
- NACE SP0104 – Latest Edition – “The Use of Coupons for Cathodic Protection Monitoring Applications”
- NACE SP21424 - Latest Edition - “Alternating Current Corrosion on Cathodically Protected Pipelines; Risk Assessment, Mitigation and Monitoring”
- Manufacturers, Vendors and Suppliers – Materials and Individual Equipment Instruction and Guidance

Wrap Up and Lessons Learned

- Coupons are just one tool in the corrosion professionals tool kit.
- They provide a reliable and accurate method to measure DC and AC potentials and current densities.
- They are one method for accounting for voltage drop – aka IR Drop.
- ER Probes are another tool in the tool kit.
- They can show that your CP is working by keeping the corrosion rate less than 1 mpy on the probe when connected to your structure.

Questions – Comments – Concerns!

Thank You



AC Corrosion

AC current can cause corrosion of the steel pipe

