

MESATM

Quality Focused, Service Driven.

CATHODIC PROTECTION & INTEGRITY SOLUTIONS

In-Ground Corrosion Coupons

Background and Multiple Uses



Topics

- Coupon Concept
- Coupon History
- Research
- Development
- Uses
- Summary

Coupon Concept

- Pipe-to-Soil potentials are basis for criteria.
- IR-drop produces an error in p/s potentials.

Ohm's Law: Voltage = Current (I) x Resistance (R)

- Interruption is the only practical method for estimating p/s potential free of IR-drop error.

Coupon Concept

- There are application difficulties associated with the interruption method:
 - Simultaneous interruption of all current sources.
 - IR transients (spikes).
 - Second party CP systems.
 - Sacrificial anodes.
 - Long-line currents.
 - Stray currents.
 - Multiple pipelines in the right-of-way.
 - Averaging due to ground level measurement.

Coupon Concept

- Purpose:

- To provide an alternative method of estimating effectiveness of CP.

- Method:

- Bury a coupon near the pipe surface, with the coupon normally shorted.

- Measure the off-potential of coupon through a non-conductive reference tube placed near the coupon by interrupting the coupon.

Coupon Concept

- CP Coupons eliminate or minimize the problems defined in the earlier slide assoc. with interruption:
 - ✓ Simultaneous interruption of all current sources.
 - ✓ IR transients (spikes).
 - ✓ Second party CP systems.
 - ✓ Sacrificial anodes.
 - ✓ Long-line currents.
 - ✓ Stray currents.
 - ✓ Multiple pipelines in the right-of-way.
 - ✓ Averaging due to ground level measurement.

Coupon Purposes

- Can Infer Pipeline Protection Level
- Can Infer Satisfactory Cathodic Protection System Operation
- Can Assess Corrosion Rate for Cathodic Protection Level in a specific Environment
- Can NOT Assess Shielding from Disbonded Coating

History

- Coupons have been used over the past 40 years for monitoring CP systems.
 - Sato K. Kasahara [1979 -80] Papers in Materials Performance: Improved method for Measuring P/S Potential on Cathodically Protected Pipelines.
 - W. Von Baeckmann & W. Schwenk [1982] Wrote about coupon usage in their 'Technology of Measurement' CP Handbook.
- Mentioned in several leading texts
 - Morgan [1960]
 - Peabody [1967]

History

- The majority of the first coupons utilized a flat coated specimen with a holiday.
- Many of these early coupon designs incorporated a permanent reference electrode as part of the design.
 - Kasahara placed a reference electrode very close to the coupon.
 - Baeckmann incorporated a reference electrode in the coupon package.
- Problems included:
 - Long-term reference electrode stability.
 - Reference electrode electrolyte leaching into the soil next to the steel coupon causing contamination.

History

- GERG Study – 1991 Survey of 29 European Companies
 - 48% were using coupons (approx. 8,000 on 100,000 km pipeline).
 - 17% planned to begin using coupons that year
 - One company using coupons for 30 yrs (since 1961) but most using for less than 10 yrs.
 - Many coupon designs; no standard.
 - Sizes ranged from 1 to 300 cm². Flat circles & squares, concave pieces cut pipe, cylindrical shapes.

History

- That same GERG study in 1991 with North American firms revealed coupons used much less in the US.
- In 1992 increased interest in using coupons stimulated by the revision of the criteria in NACE Standard RP 0169-92 which emphasized proving IR-drop for compliance with the -850mV criteria.
- Today used extensively in North America

Research

- Three Phase Program set up by Pipeline Research Committee International (PRCI)
 - Phase I - Proof of Coupon Concept [1992-1998]

Involves test sites in 9 states across US. Evaluated multiple sizes of pipelines and holidays on those lines, coupon size options, multiple environments (wet, dry, hot, cold, low & high resistivity), bare–poorly coated-well coated piping. Basically evaluated every possible installed pipeline scenario to validate the performance of the coupons.
 - Phase II - Use of Coupons for Estimating Off-Potentials [1994-95]
 - Phase III - Relationship Between Coupon and Pipe [1996 -2000]
- On-Going Operational data collection and comparisons.

Research Results

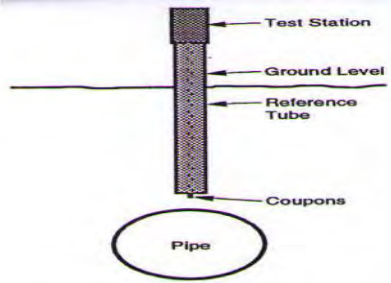
- Focus on measurement method.
 - Is a reference tube necessary? **-YES-**
 - Is measurement through the reference tube only (no interruptions of the coupon) sufficient? **-NO-**
 - Is interruption of the coupon, and not the CP system, sufficient to achieve good measurement of the polarized potential of the coupon? **-YES-**

Research Results

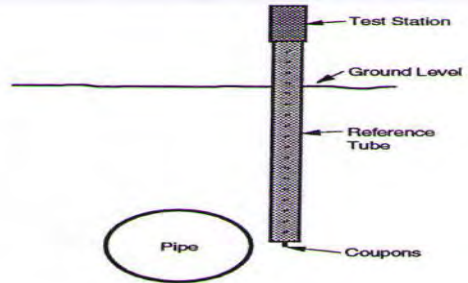
- How does the coupon off-potential compare to the pipe off-potential? Coupon off-potential will occasionally not compare well to the pipe off-potential.
- Problems with comparing coupon and pipe potentials.
 - Coating condition and holiday distribution affect agreement.
 - P/S potentials at any given point are really an average of the potentials of any areas of exposed steel over a fairly wide area. May be affected by local differences in soil type/chemistry, moisture level, oxygen content, as well as influences from long-line currents, sacrificial anodes, etc. The larger the pipe, the greater the chance for these differences to be significant.
 - Coupons are small pieces of metal that are not impacted as much, or at all, by these above factors – thereby yielding more applicable results.

Research Results

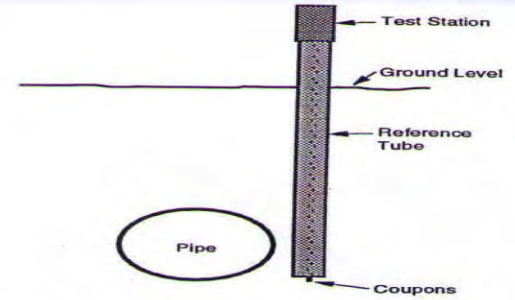
- Coupons respond to changes in the CP level in a similar manner as the pipe.
- The size of the coupon in a range of 1.4 in² (9cm²) to 7.75 in² (50cm²) had a small effect on the coupon off-potential. Outside these ranges are not recommended.
- The position of the coupon circumferentially around the pipe had only a slight effect on the coupon off-potential. (See next slide)



a. Coupon at Top of pipe



b. Coupon at Side of Pipe



c. Coupon at Bottom of Pipe

Research Results

- Polarization behavior of the coupon did in fact represent that of a holiday of similar size on the pipe.
- Application of the criteria for protection.
 - Existing criteria can be applied:
 - -0.850 V
 - 100 mV Depolarization
 - The standard CS3100 CTS includes a second coupon that is not connected into the CP system (freely corroding) for measuring the native potential.
 - Current density pick-up and discharge to the CP coupon can be measured. This allows the use of Linear Polarization Resistance measurement which can tell you the rate of ongoing corrosion.

Development

- PRCI Design

- Reference tube is placed directly over the coupon so outside influences are minimized or eliminated.
- Coupons should be placed within 6"- 10" of the pipe.
- Compact soil around coupons – reduces oxygen intrusion.
- The reference tube is filled with soil from the excavation up to grade level.
 - Maintain soil conditions as close to original as possible.
- Installation can be accomplished without major excavations.
 - Auguring only a hole the size of the reference tube.
 - Minimizes soil disturbance.

Development

- PCRI Design (Con't)

- No permanent reference cell is required; portable reference is placed inside the tube in contact with the soil.
- Cylindrical bare coupon made of Grade 10/18 steel (same as most pipe) provides for optimum current distribution and minimizes disturbance of the voltage field around the pipe.
- Condition coupon by allowing it to corrode until a stable free corrosion potential is reached.
 - May take only a few days in low resistivity soil or up to 3 months in high resistivity environment.

Note: to be safe a dateable tag is attached to each new CTS requesting pipe coupon be left in off position for 3 months minimum.

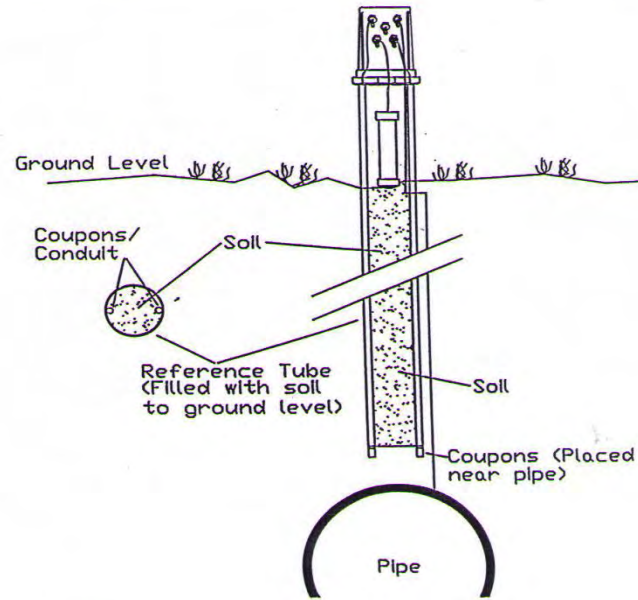


Figure 2.1 Coupon and Reference Tube Configuration

Summary

- There can be problems associated with conventional CP monitoring (i.e. ability to get “true” instant –off measurements)
- CP Coupons have been used for many years to ‘troubleshoot’ problem areas (i.e. stray current, direct connect anodes.... etc.)
- Coupons represent a holiday of similar size located on a pipeline.
 - Respond to changes in the CP level.
 - Coupon polarization behavior is similar to pipeline.
- Coupons provide an effective means of evaluating the performance of a CP system.
- Coupon research is ongoing.

NACE SPO 104-2004

- Recommended Practice on “Use of Coupons for Cathodic Protection Monitoring Applications”
 - Gives guidance on installation, conditioning, commissioning and use of coupons
 - Incorporates all the learning's from the PRCI report
 - You should have this if you use coupons

QUESTIONS?

