

IR CONSIDERATIONS IN PIPE-TO-SOIL POTENTIALS

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SAFETY MOMENT



IT'S ALL ABOUT POLARIZATION

- This presentation will discuss ways to measure the most accurate “polarized” potential.
- The first portion of this presentation is about using interruption to consider IR in pipe-to-soil potentials. The second part discusses alternative methods when you can’t interrupt all current sources.
- To effectively measure the polarized potential, it is necessary to eliminate or reduce errors in the measurement, such as:
 - Soil IR (ionic voltage drop due to current flow)
 - Metal IR (metallic voltage drop due to current flow)



DEFINITION OF CATHODIC PROTECTION

- Polarize a structure to a potential that is equal to, or more negative than it's most active anode

Richard Patterson

- Cathodic protection is complete when the corrosion cell cathodes are polarized electro-negatively to the open circuit potential of the most electronegative anode site on the structure

R. B. Mears and R. H. Brown, A theory of cathodic protection, Trans. Electrochem. Soc. 74, 519 (1938)



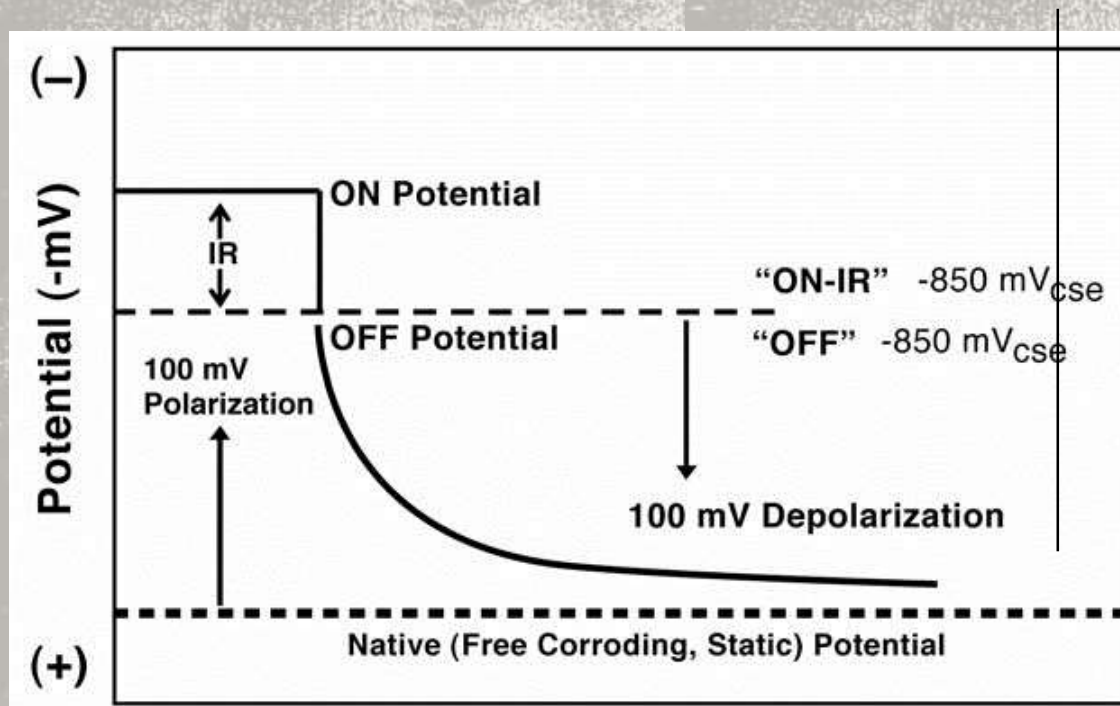
PERTINENT NACE DOCUMENTS RELATING TO IR (VOLTAGE MEASUREMENT ERROR) IN PIPE-TO-SOIL POTENTIALS

- NACE Standard Practice SP0169-2013:
 - Criteria for Cathodically Protected Structures in Electrolyte
 - *“A negative potential of at least 850 mV....with respect to copper/copper sulfate reference electrode.....VOLTAGE DROP (IR)...must be considered for valid interpretation of this voltage measurement.”*
 - *“A minimum of 100 mV of cathodic polarization between the structure surface and a stable reference electrode contacting the electrolyte. The formation or decay of polarization can be measured.”*
- NACE Test Method TM-497
 - Describes consideration of *voltage drops other than across the structure to electrolyte boundary*. Use of coupons to consider soil IR, discusses metal IR and polarization curves.

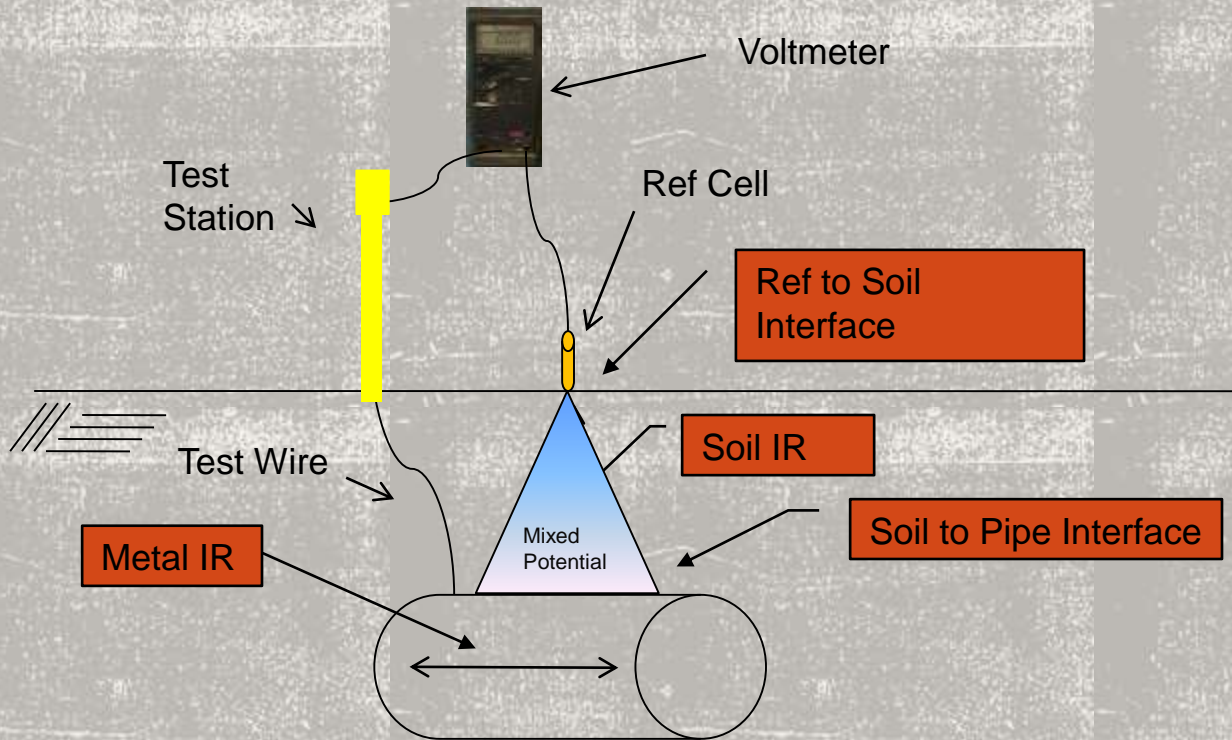


POLARIZATION GRAPH- AND GENERALLY ACCEPTED CP CRITERION

- **-850mV “ON”**
 - With CP applied
 - Knowing which CP systems have influence on this number is helpful
- **-850mV “IRF”**
 - Synchronous current interruption is generally required
 - Knowing and understanding which CP Systems and current sources have an influence on this number is necessary
- **100mV Polarization**



PIPE-TO-SOIL POTENTIAL COMPONENTS



USING CURRENT INTERRUPTION TO REMOVE SOIL AND METAL IR

- Current interrupters:
 - Benefits: Synchronized CP Current interruption to provide instant off potentials reducing effects of soil and metal IR



CONSIDERATION OF METAL IR IN CIS

- Metal IR is the error that occurs in the pipe-to-electrolyte measurement due to current flow in the pipeline or in a cable.
- Metal IR can be measured between test points as the voltage drop between the test points and relates approximately to near ground (NG) and far ground (FG) potentials.
- Metal IR error can either add or subtract from the actual potential, depending upon the resultant current flow between test points



GAS DISTRIBUTION CIS EXAMPLE

- If conducting a CIS on a **2" diameter gas line**, with a rectifier, output **10 amps**, what is the possible metal IR influence?
- **2" pipe** is 79.2 micro-ohms per foot. At the end of a **1000 foot run** going towards or away from the rectifier, then:



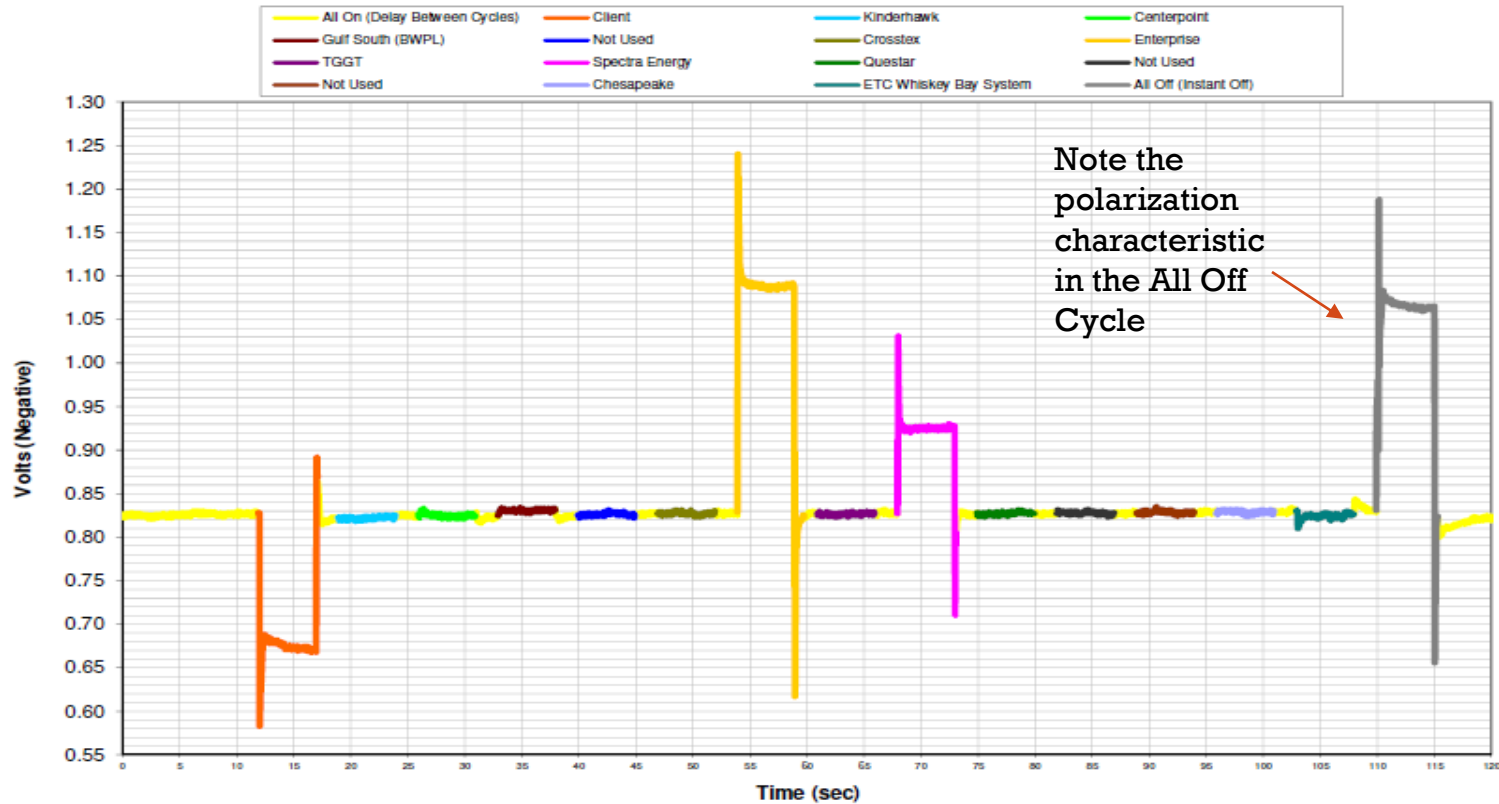
GAS DISTRIBUTION CONTINUED

- $.0000792 \times 1000 = .0792$ ohms $\times 10$ amps = $.792$ volts or 792 mV.
- This means that your “On” P/S could be off by nearly **800mV** in this example!



SOIL-IR AFFECT TO THE "ON" POTENTIAL AT A CROSSING

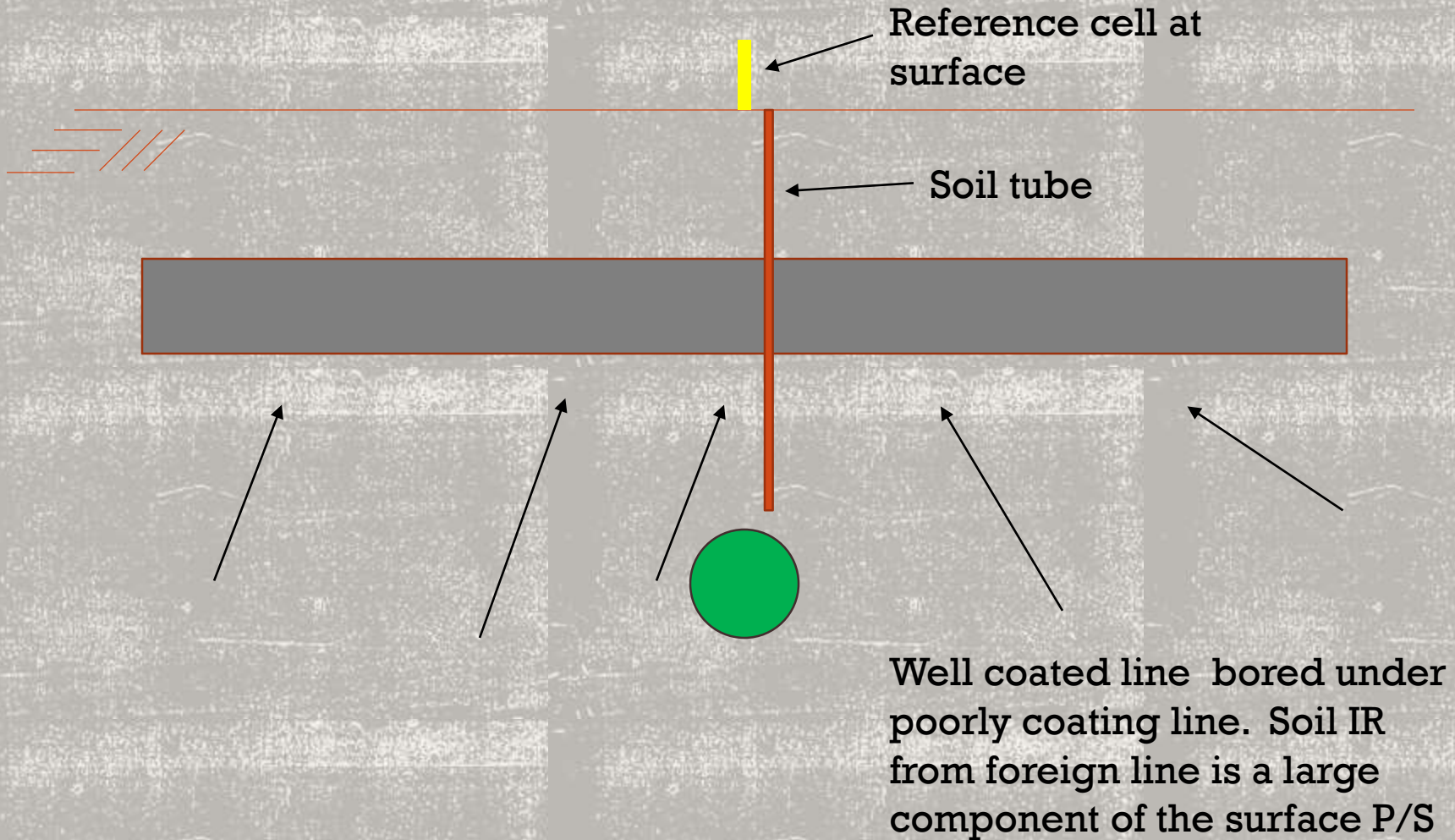
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Note the polarization characteristic in the All Off Cycle

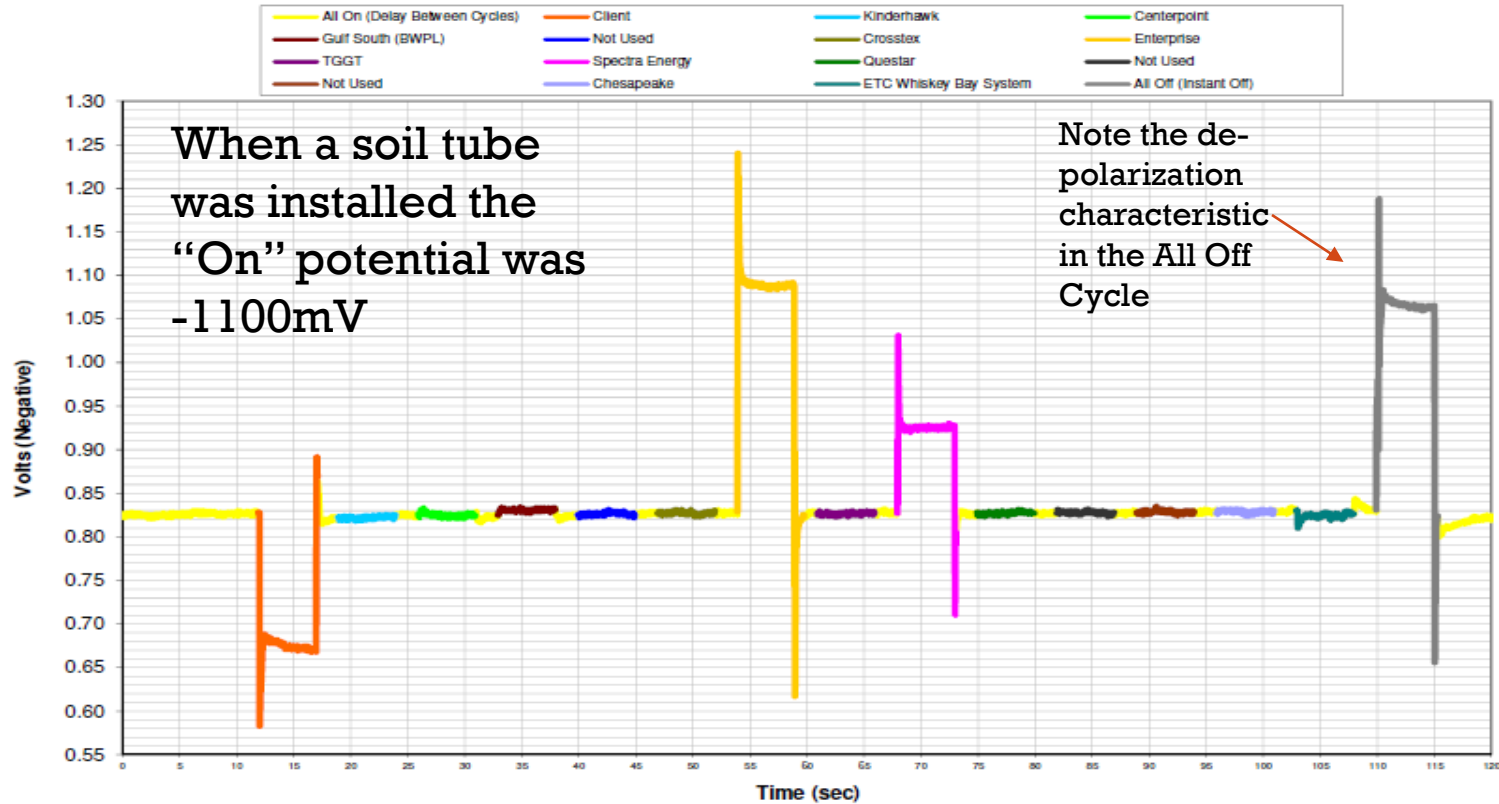


PIPELINE CONFIGURATION AT CROSSING

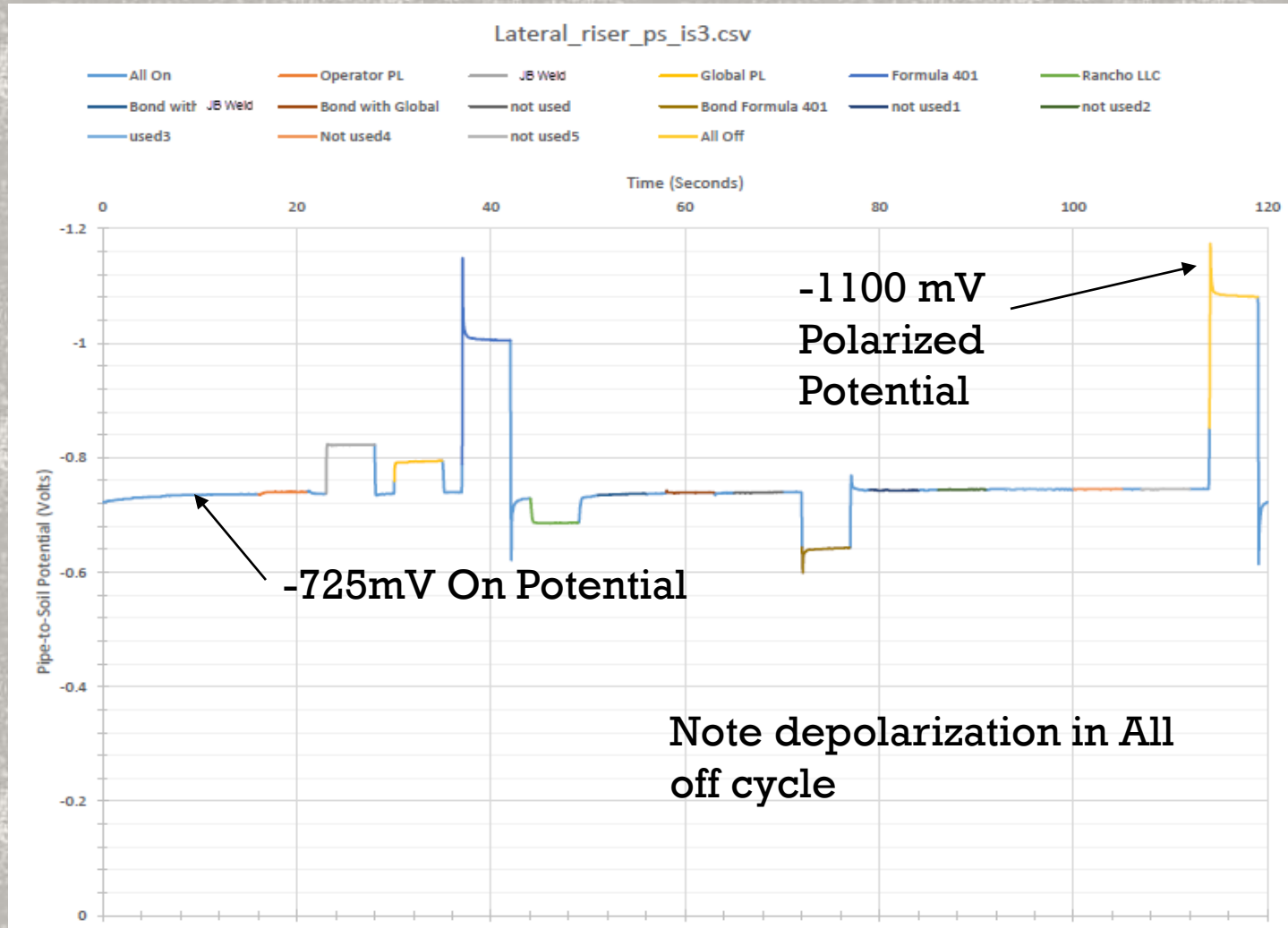


CONCLUSION- THE "ON" POTENTIAL IS JUST INFLUENCED IN THE POSITIVE DIRECTION BY THE SOIL IR)

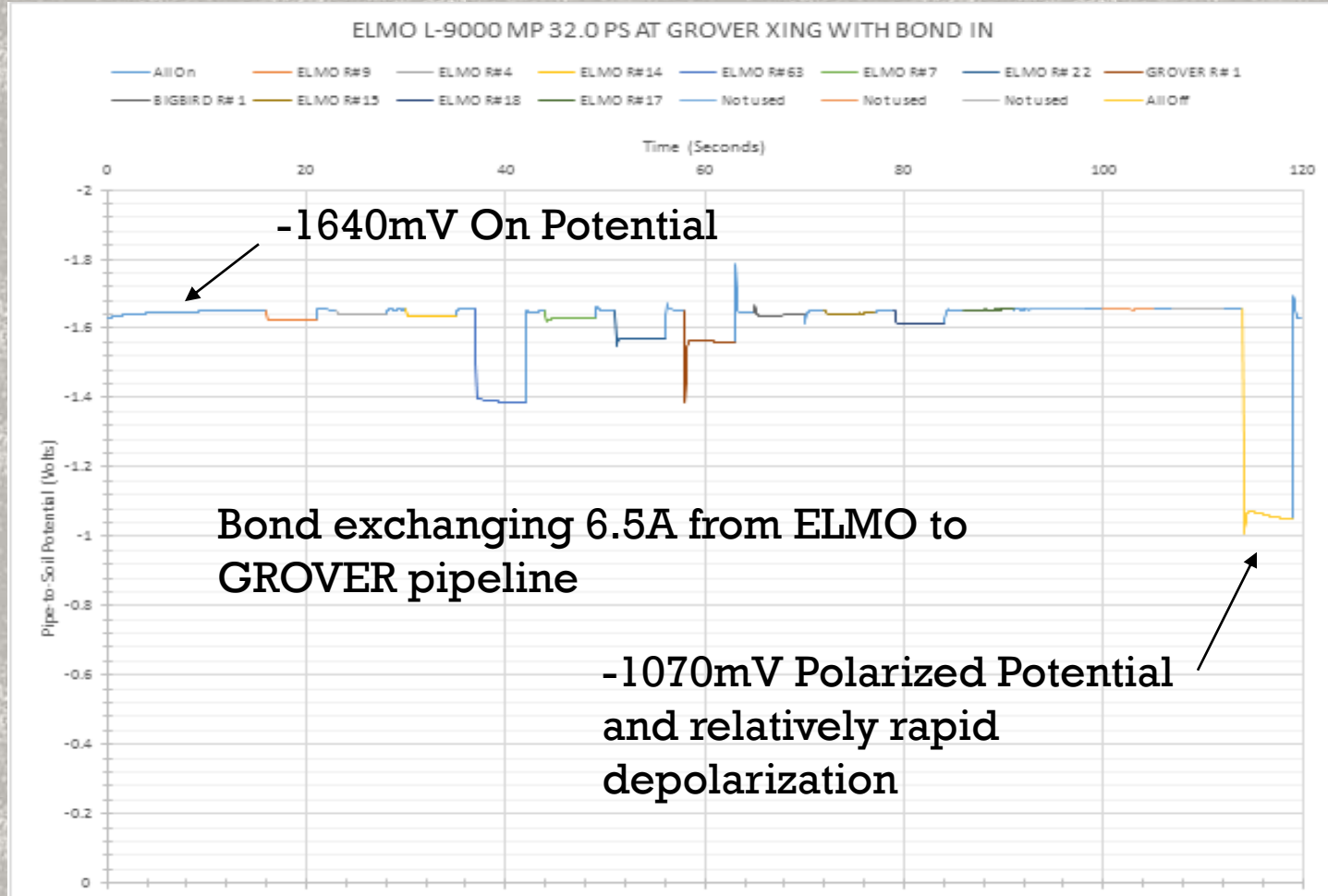
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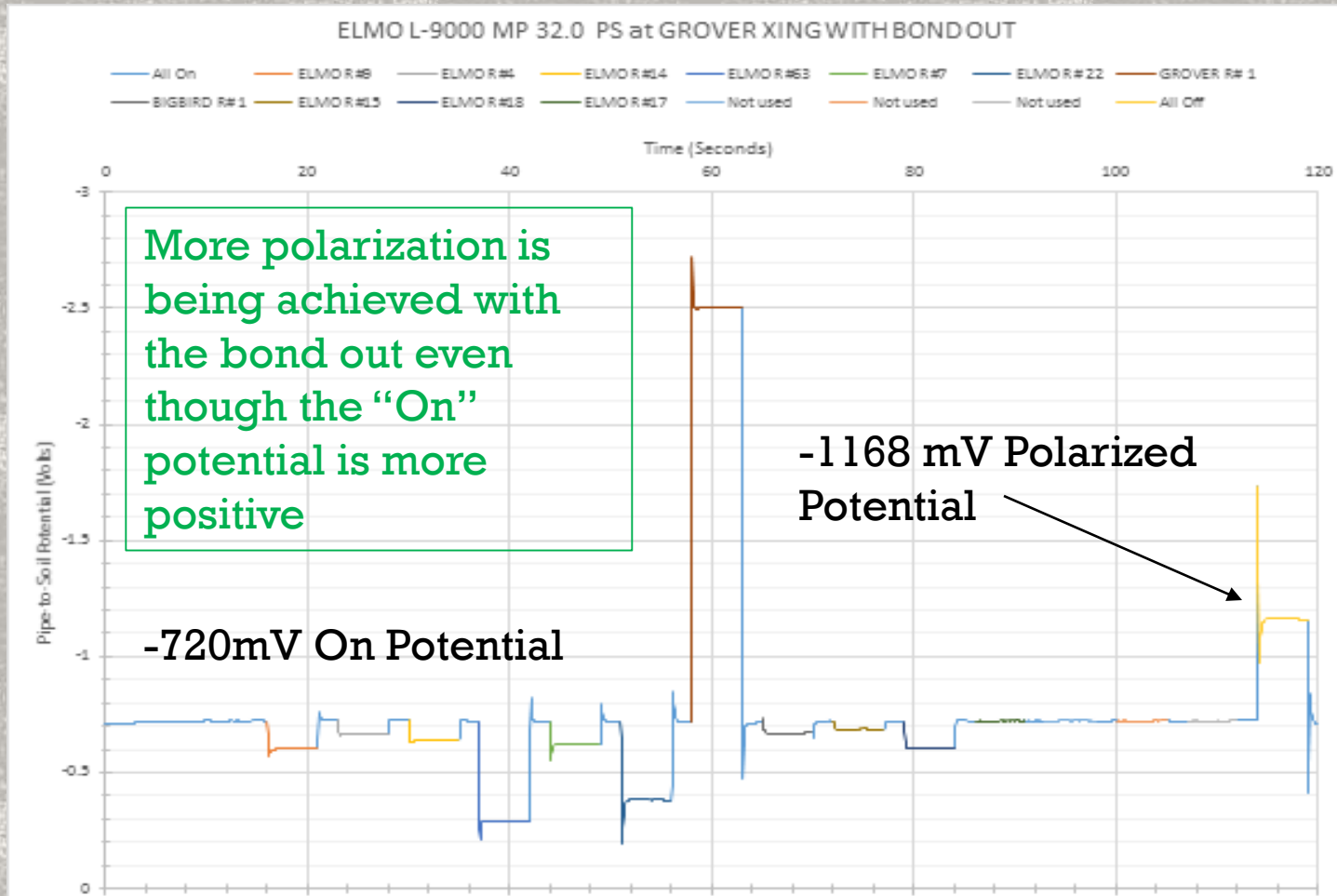
P/S WAVEFORM AT RISER IN STATION- INVALID "ON" POTENTIAL. NO INTERFERENCE AND MEETS NACE CRITERIA



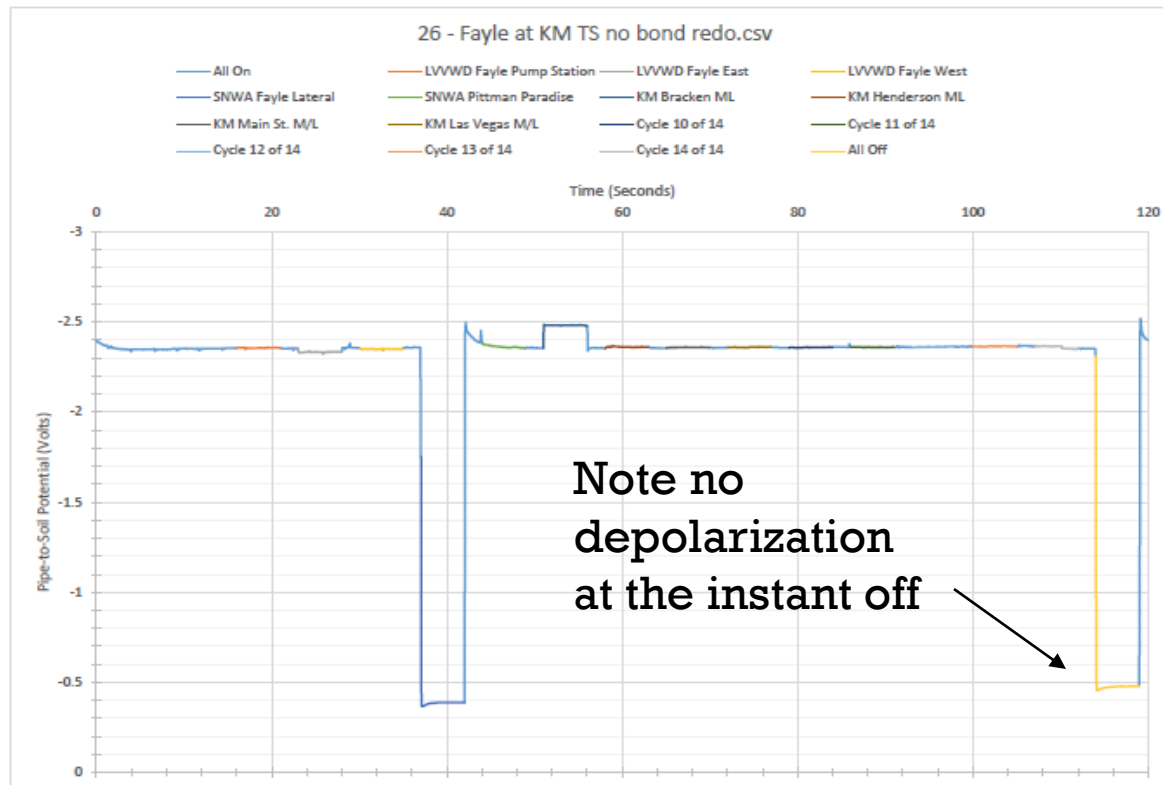
P/S WAVEFORM AT CROSSING WITH BOND IN PLACE (AS FOUND)



P/S AT THE SAME LOCATION WITH BOND REMOVED (AS LEFT)



EXAMPLE OF A VERY NEGATIVE "ON" POTENTIAL BUT ZERO POLARIZATION BEING ACHIEVED



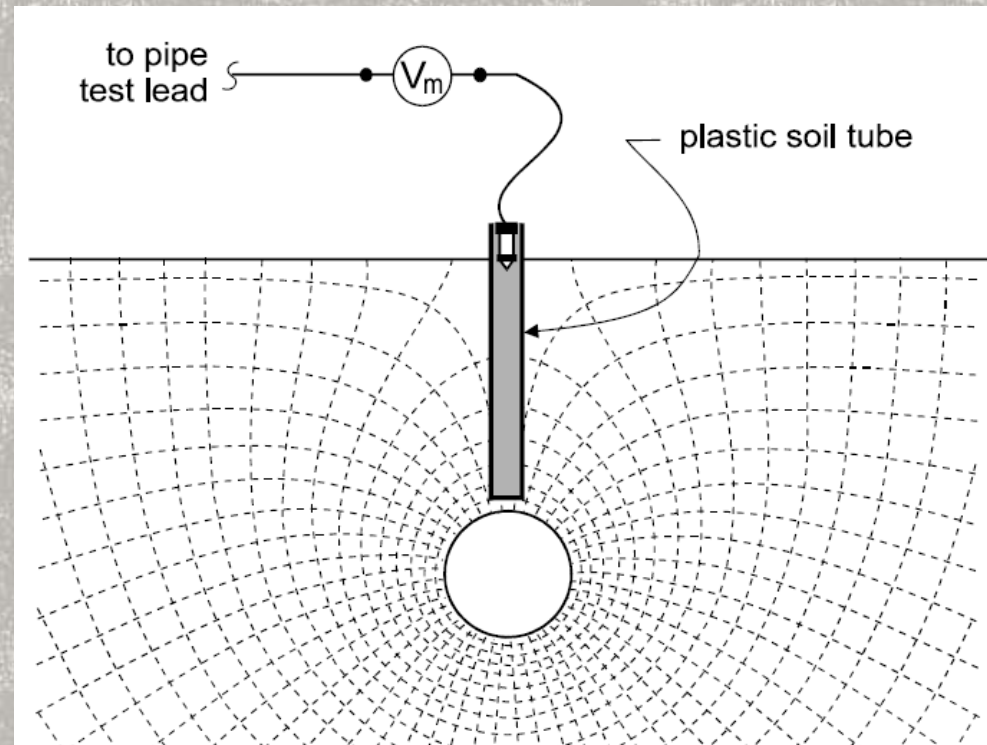
ALTERNATIVE METHODS TO CONSIDER SOIL IR

- Soil Tubes-
- Coupon Test Stations-



METHODS OF REDUCING IR

- Soil Access Tubes
 - Benefits: Reference Cell potentials near the surface of the structure reducing effects of soil IR



- Figure from NACE International



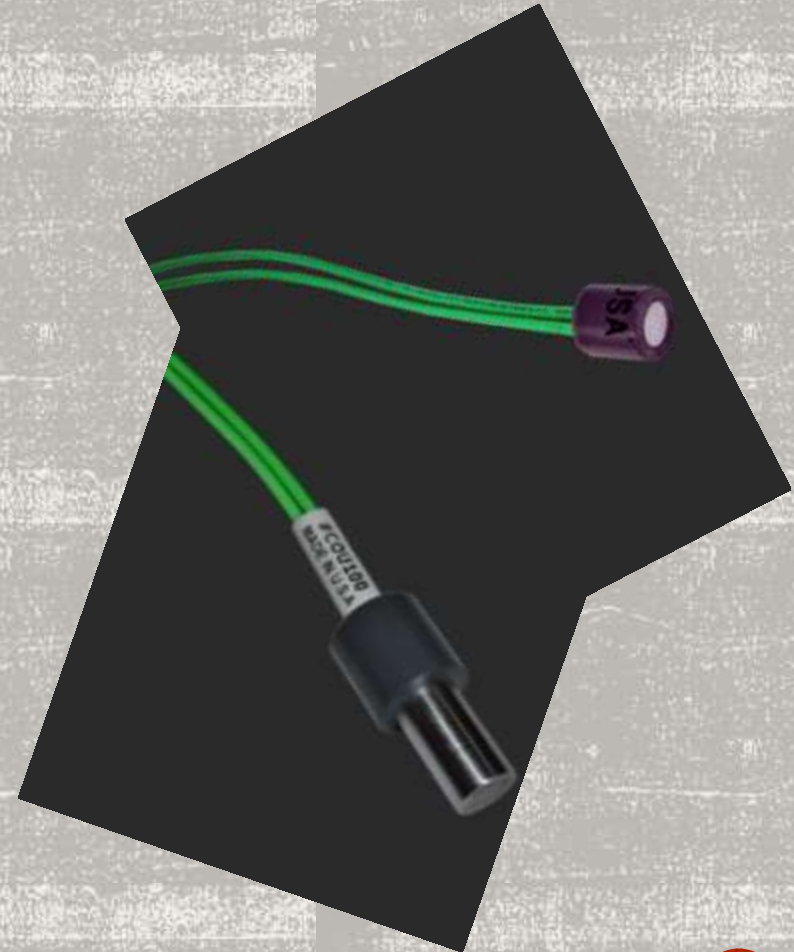
METHODS OF REDUCING IR

- Corrosion Coupons:
 - NACE Standard Practice SP0104-2014:
 - Title: The Use of Coupons for Cathodic Protection Monitoring Applications
 - Outlines the use of coupons as a means to consider IR drop in potential measurements when determining the level of CP.
 - NACE Test Method TM0497-2012: Appendix C
 - Title: Measurement Techniques Related to Criteria for CP on Underground or Submerged Metallic Piping Systems
 - Using Coupons to Determine Adequacy of Cathodic Protection



METHODS OF REDUCING IR

- Use of Coupons at Test Stations
 - **Benefits:** Simulated coating deficiency under known conditions with breakable bond to the CP system to provide instant off potentials reducing effects of metal IR. If coupled with a soil access tube, reduction to soil IR can also be achieved.

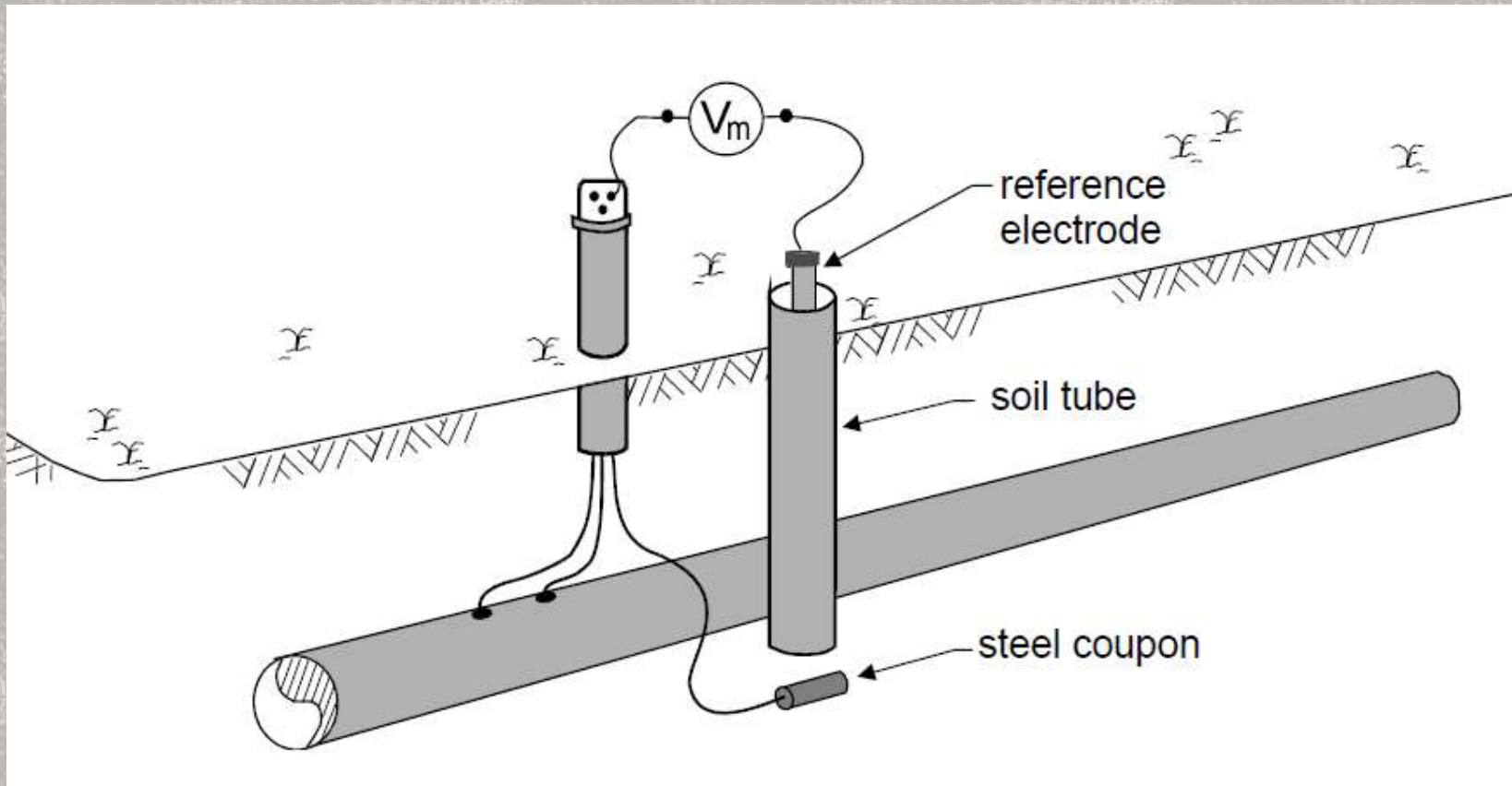


CP COUPONS

- Test Method – 0497-2012L Appendix C
- **Selected Test Site Considerations:**
 - Nominally of the same material and surface condition of structure
 - Small enough to avoid excessive current drain for the CP System
 - Placed at pipe depth in the same backfill
 - Surface prepared with all mill scale & foreign materials removed
 - Placed at a know location of suspected coating defect
 - Bonded to CP System through test leads brought up above surface



CP COUPONS



- Figure from NACE International



CP COUPONS

- Coupons Test Stations

- Widely Commercially available for install.

- Two Types:

- Integrated Coupon Test Station

- Coupon(s) mounted at the end of PVC soil tube and wired to a switch or bus bar to trigger instant off potential readings.

- Vertical IR Drop Coupon Test Station

- Coupon embedded into the face of test station with vertical porous plug slot centered in the coupon. With this configuration, no IR drop exist between the reference and coupon and therefore no disconnect is necessary.



INTEGRATED COUPON TEST STATION

▪ Farwest Coupon Test Station

Features:

Bond Plug – Brakes 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.)

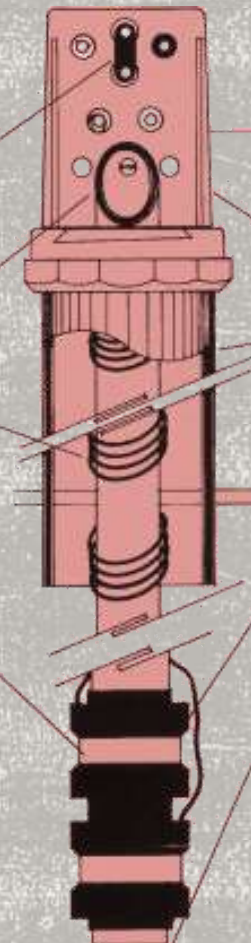
Big Fink CP Test Station – proven convenience and durability.

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

COTTPipe 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.

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



INTEGRATED COUPON TEST STATION

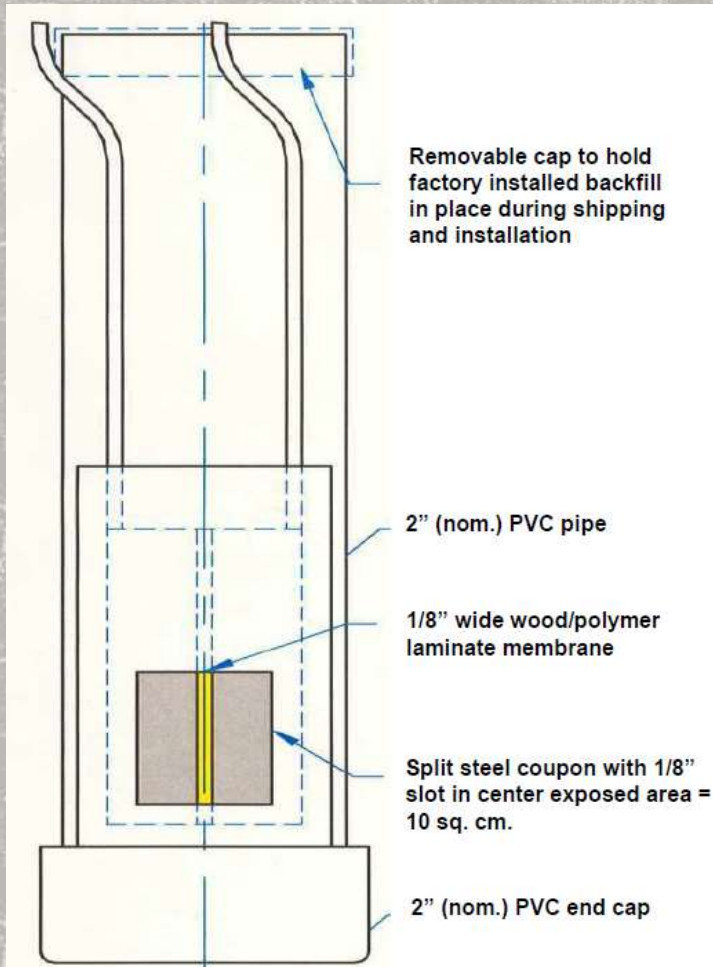
- American Innovations Fink



- ACCI ALL In One Test Box



VERTICAL IR DROP COUPON TEST STATION



TAKE AWAY INFORMATION

- If you are not interrupting all current sources you may not be measuring an accurate polarized potential. Polarization is the achievement of cathodic protection.
- Most Operators only interrupt their own rectifiers while performing annual surveys and while conducting Close Interval Surveys. Foreign soil IR may be influencing in this situation.
- When performing interference testing, all influencing current sources should be included in the testing to measure the “polarized” potential. A suppression caused from a foreign operator is not necessarily interference. The “On” potential may just be influenced by soil gradient. All “IR” should be considered.
- Soil tubes and coupons are a great alternative to consider IR in pipe-to-soil potentials when not all current sources can be interrupted.

