Corrosion Control- New Technologies Applied to Old Testing Techniques

AMPP San Francisco Chapter Meeting

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HISTORY- WHEN DID CATHODIC PROTECTION START?

- Sir Humphrey Davy
  - The first application of **cathodic protection** (CP) can be traced back to 1824, when **Sir Humphry Davy**, in a project financed by the British Navy, succeeded in **protecting** copper sheathing against corrosion from seawater by the use of iron anodes.
- Definition of Cathodic Protection
  - 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)

HISTORY- REGULATIONS COME INTO THE PICTURE

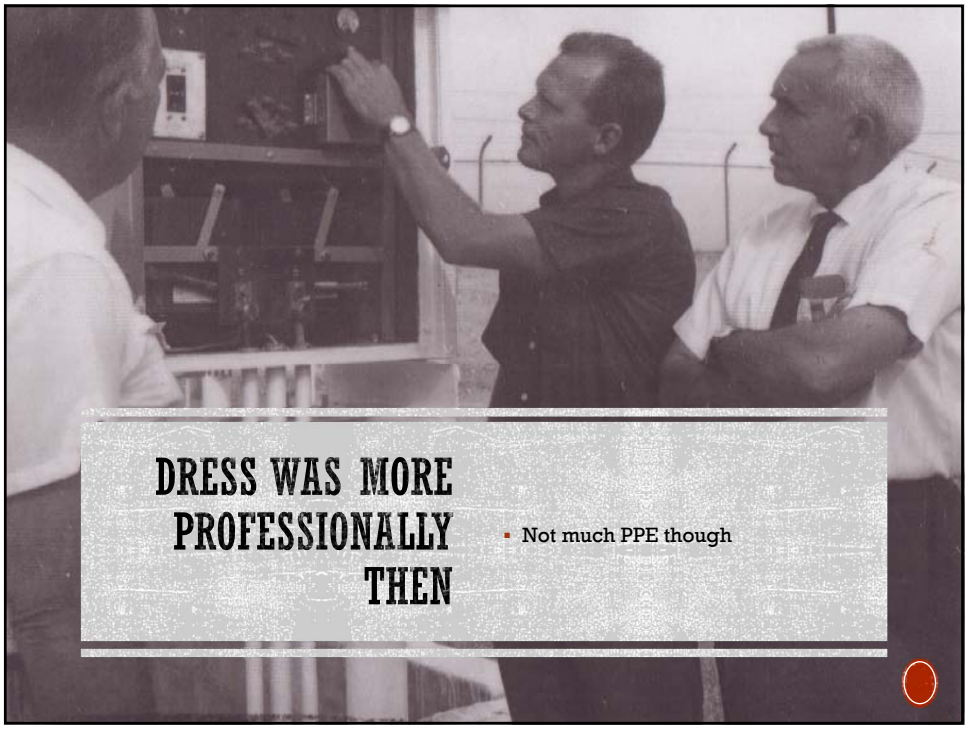
- Possibly the first State statue regulating pipeline safety- State of California Public Utilities Commission- General Order No. 112-A, adopted December 3rd, 1963, and effective January 1st, 1964. Rules Governing Design, Construction, Testing, Maintenance and Operation of California Utility Gas Transmission and Distribution Piping Systems.

- The first Federal statute regulating pipeline safety was the Natural Gas Pipeline Safety Act of 1968, which Congress amended in 1976. Congress added liquid pipelines to the statute in the Pipeline Safety Act of 1979. Subsequent bills included the Pipeline Safety Reauthorization Act of 1988, the Pipeline Safety Act of 1992, the Accountable Pipeline Safety and Partnership Act of 1996, and now the Pipeline Safety Improvement Act of 2002.

HISTORY- EXCERPT FROM GENERAL ORDER NO. 112-A

This is all that was in there about external corrosion control…… It was a start.

841.173 *External Corrosion Criteria.* Suitable investigation shall be made, and if it indicates that protection from external corrosion is needed, steel pipelines or mains shall be protected by any recognized method or combination of methods, such as coating with protective material, application of cathodic protection, and electrical bonding or isolation of sections.



FOCUS ON TESTING TECHNIQUES

- Close Interval Survey
  - Pipe Location
  - Chainage
  - Rectifier Interruption- GPS Synchronized and RMU's
  - Data Logging
  - Data Management
- Interference Testing
  - Rectifier Flip Test
  - Timed Interruption (Rectifier Influence Testing)
- Soil Resistivity
  - Deep Soil Resistivity Equipment
- Short Locating
  - Short Locating Equipment

RECTIFIER CURRENT INTERRUPTION- THEN

RECTIFIER INTERRUPTION- NOW

- GPS Synchronized Current Interruption
  - Prior to GPS, synchronized current interruption was performed by synchronizing slave units to a master, using a cable. They would stay in sync for up to a day, but could drift if temperatures were different in various locations.
- Remote Monitoring Units (RMU's)
  - GPS and improved electronics have allowed the development of RMU's which use cellular or satellite communication. These are of great benefit to enhancing monitoring, DC interference testing and rapid alerting when rectifiers are down.

DATA LOGGING- THEN

MCM strip chart recorder with gear box. MCM Sincorder data logger.

DATA LOGGING- NOW

Some newer portable and stationary data loggers

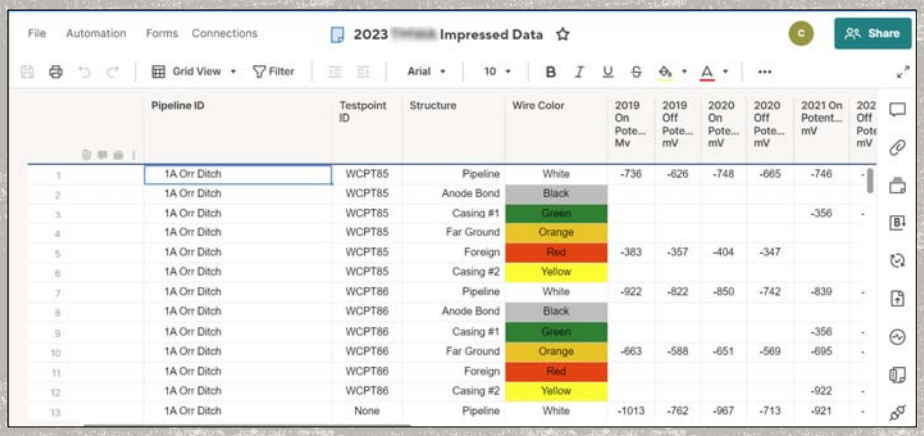
DATA MANAGEMENT THEN AND NOW

In the past, data was collected on paper and type written or hand entered into computers.

Newer hardware/software allows real-time data collection with upload to cloud based systems. ESRI and others have products that allow data collection on your phone. Features include photo uploads and driving directions to a test location.

Database improvements allow improved data presentation and trending. These features continue to rapidly improve.

NEWER DATA COLLECTION AND MANAGEMENT



	Pipeline ID	Testpoint ID	Structure	Wire Color	2019 On Pote... Mv	2019 Off Pote... mV	2020 On Pote... mV	2020 Off Pote... mV	2021 On Potent... mV	202 Off Pote mV
1	1A Orr Ditch	WCPT85	Pipeline	White	-736	-626	-748	-665	-746	-
2	1A Orr Ditch	WCPT85	Anode Bond	Black						
3	1A Orr Ditch	WCPT85	Casing #1	Green					-356	-
4	1A Orr Ditch	WCPT85	Far Ground	Orange						
5	1A Orr Ditch	WCPT85	Foreign	Red	-383	-357	-404	-347		
6	1A Orr Ditch	WCPT85	Casing #2	Yellow						
7	1A Orr Ditch	WCPT86	Pipeline	White	-922	-822	-850	-742	-839	-
8	1A Orr Ditch	WCPT86	Anode Bond	Black						
9	1A Orr Ditch	WCPT86	Casing #1	Green					-356	-
10	1A Orr Ditch	WCPT86	Far Ground	Orange	-663	-588	-651	-569	-695	-
11	1A Orr Ditch	WCPT86	Foreign	Red						
12	1A Orr Ditch	WCPT86	Casing #2	Yellow					-922	-
13	1A Orr Ditch	None	Pipeline	White	-1013	-762	-967	-713	-921	-

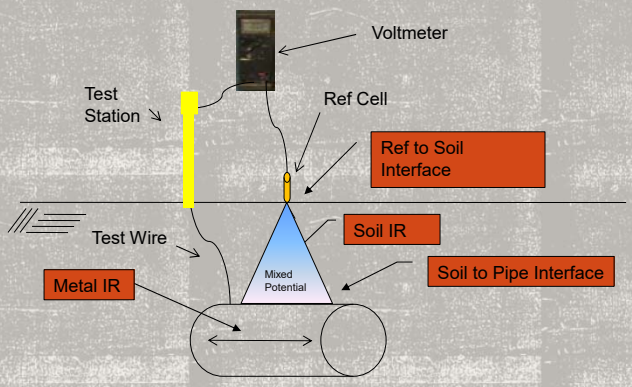
INTERFERENCE TESTING- THEORY

There are 4 parts that make up the voltage displayed on your meter.

1. The pipe and the soil interface
2. The reference to soil interface
3. The soil IR (voltage drop due to any current flow in the soil. Not only your company's current flow. Any current flow)
4. The metal IR (if not at the pipe connection)

INTERFERENCE TESTING- THEORY

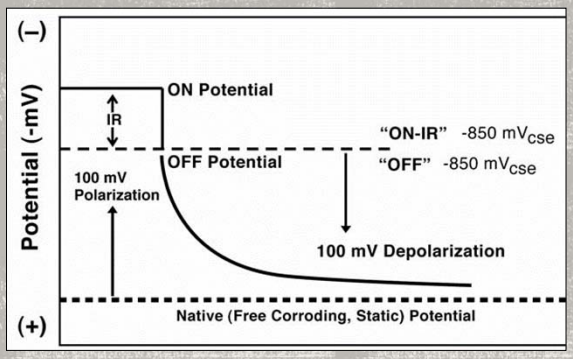
Pipe to Soil Potential Components



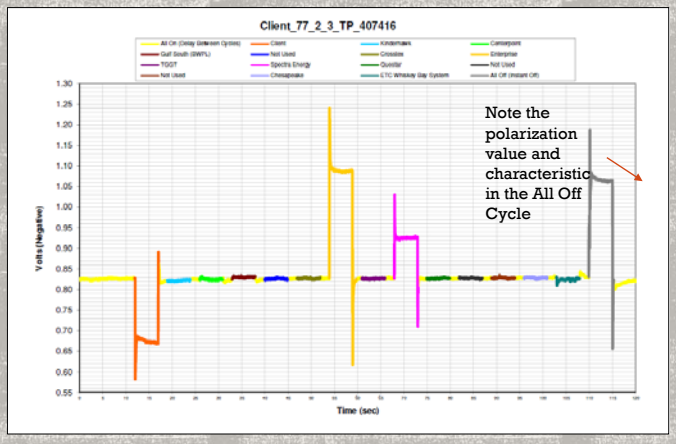
INTERFERENCE TESTING- THEORY

Polarization Graph and Generally Accepted and Applied CP Criteria

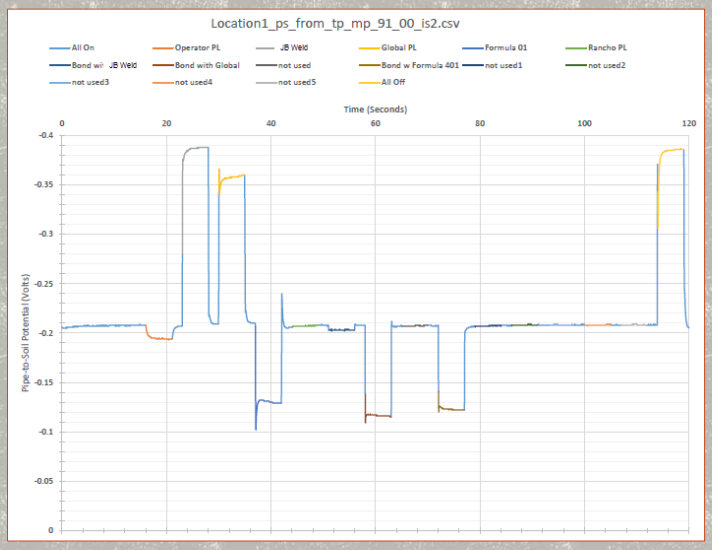
- **-850mV "ON"**
  - With CP applied
  - Knowing which CP systems have influence on this number is helpful
- **-850mV "IRF"**
  - Synchronous current interruption is generally required
  - Knowing and understanding which CP Systems and current sources have an influence on this number **is necessary**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



INTERFERENCE TESTING USING GPS TIMED INTERRUPTION- EXAMPLE INFLUENCE ONLY



INTERFERENCE TESTING USING GPS TIMED INTERRUPTION- EXAMPLE OF INTERFERENCE



SOIL RESISTIVITY THEN AND NOW

- Older soil resistivity instruments such as the Associated Research Vibro-ground and Nilsson-400 meter will measure soil resistivity to a depth of about 20-feet. Newer more powerful instruments (such as the ABEM Terrameter and AMEC model 4630, allow measurement to greater depths, up to 500-feet or more.
- The older and newer resistance meters are both 4-pin instruments, C1, P1, C2, P2 and typically utilized to apply the Wenner or Schlumberger test methods.
- Often for deep soil resistivity testing the Barnes Layer Analysis is applied. I applied this incorrectly for years.

ASSOCIATED RESEARCH VIBROGROUND®

NEWER 4-PIN RESISTANCE METERS

EXAMPLE OF BARNES LAYER ANALYSIS

Applied correctly, it should not produce negative values, unless the geological layers are sloping. Use the technique of moving all 4-pins from a center point.

Spacing in (feet)	Resistance Measured R_T (Ohms)	Soil Resistivity to Surface	Conductance $1/R_T$ (Siemens)	Layer Change in Conductance* (Siemens)	Soil Layer Depth Location (feet)	Layer Footage	Layer Resistance (Ohms)	Layer Resistivity** (Ohms-cm)
25	0.88	4213	1.14	1.14	0-25	25.0	0.9	4213
50	0.60	5745	1.67	0.53	25-50	25.0	1.9	9028
75	0.49	7038	2.04	0.37	50-75	25.0	2.7	12796
100	0.40	7660	2.50	0.46	75-100	25.0	2.2	10426
125	0.32	7660	3.13	0.63	100-125	25.0	1.6	7660
150	0.27	7756	3.70	0.58	125-150	25.0	1.7	8273
175	0.23	7708	4.35	0.64	150-175	25.0	1.6	7433
200	0.19	7277	5.26	0.92	175-200	25.0	1.1	5230
225	0.17	7325	5.88	0.62	200-225	25.0	1.6	7732
250	0.14	6703	7.14	1.26	225-250	25.0	0.8	3798
275	0.13	6846	7.69	0.55	250-275	25.0	1.8	8713
300	0.12	6894	8.33	0.64	275-300	25.0	1.6	7468

PIPE AND SHORT LOCATING THEN

Ray Czepowski begins tracking down the culprit, corrosion, in a Phoenix alley. Somewhere under the surface there's a pipe being destroyed, and Czepowski has to find it, using this electronic pipe-finder.

PIPE LOCATING NOW

Today's locators collect survey grade GPS and can be used for precise distance measurements- chainage for CIS surveys

Key Features

- Fully-integrated RTK GNSS
- One-hand locating and mapping
- Cloud-based data management
- Survey-grade GNSS Accuracy
- Simplistic locating modes
- Reduces multiple field equipment

SHORT LOCATING NOW

Todays short locaters supplant the need in most cases for current spans or other methods to locate shorts

CHAT GPT- FUTURE TOOL? EH ONE DAY

Asked Chat GPT "how to take a pipe-to-soil potential?"

- Fill the reference electrode with the appropriate electrolyte solution (copper sulfate or saturated potassium chloride). Ensure the electrode is wet but not dripping.
- Attach wire and connectors to the reference electrode to connect it to the meter.
- **Access the Pipeline:**
- Use a shovel or probe to carefully expose the pipeline at the selected measurement points. Be cautious not to damage the pipeline.
- **Connect the Reference Electrode**:
- Place the reference electrode in direct contact with the exposed pipeline. Ensure good electrical contact.
- Connect the wire from the reference electrode to the "negative" or "reference" terminal of the cathodic protection pipe-to-soil potential meter.
- **Set Up the Meter:**
- Turn on the pipe-to-soil potential meter and set it to the appropriate measurement range (typically millivolts, mV).
- **Measurement:**
- With the reference electrode connected to the pipeline, insert the probe of the meter into the soil a short distance away from the pipeline.
- Record the potential reading displayed on the meter. This reading represents the pipe-to-soil potential difference at that specific point.
- **Repeat Measurements:**