Cathodic Protection for Pipelines - Electrical Isolation / Interference Issues

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Bio

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Long-Standing, ICorr - Institute of Corrosion Committee Member (Aberdeen Branch – 14yrs).
ICorr Aberdeen Chair for 2016 / 2017 Session and for 2019 / 2020 Session.
ICorr National Vice President 2020-2022 and National President 2022-2024.
SPE Corrosion Conference Co-Chair 2021.
Significant Operator Experience – Amoco / BP / British Gas / ConocoPhillips / Fairfield Energy / INOC / QGPC / Qatar Gas / SNAM / Shell / Talisman Energy / Total Energies.
Mainly Working through – Aberdeen Corrosion Engineers / CAN / Oceaneering.

Abstract

Case Studies

This presentation is intended to raise awareness of **some of the issues** that may arise when applying Cathodic Protection to buried pipelines.

Primary Protection

Applied coatings have traditionally been the primary source of corrosion protection. These have been extensively developed and improved over the last 70 years.

The following **5x** Slides are included courtesy of Susan Jacob, a Senior Pipeline Engineer in Asset Management for One Gas (Natural Gas Distribution, USA).

Coatings History

- **1859** - Use of metallic pipe, mainly Wrought iron, for oil transportation started soon after the drilling of the first commercial oil well by "Colonel" Edwin Drake in Titusville, PA.
- **1920s -** Some operators began to coat the pipe as it was being laid in the ditch, in an attempt to protect it from corrosion. The idea was to place a barrier between the pipe and the corrosive conditions in the soil, hence the term **"the barrier principle"**
- **1943** - **NACE** (now AMPP) was established by 11 corrosion engineers in response to high levels of corrosion failures reported on pipelines.
- **1930s-1950s** - Over-the-ditch application of enamels and asphalts during construction continued up to the 1950s.
- **1950s -** The first plant-applied, extruded polyethylene mainline systems were developed. **ICorr UK founded in 1959.**
- **Late 1950s to Early 1960s - Liquid-based epoxy coatings** (coal tars & asphalts) to polyolefin materials (polyethylene or polypropylene).
- **Fusion Bonded Epoxies** - These powder coatings were used either as standalone' systems or as part of multi-layer system—which really gave birth to the three-layer PP and three-layer PE systems of today.

History and Evolution of Factory Applied and Field Applied Coatings

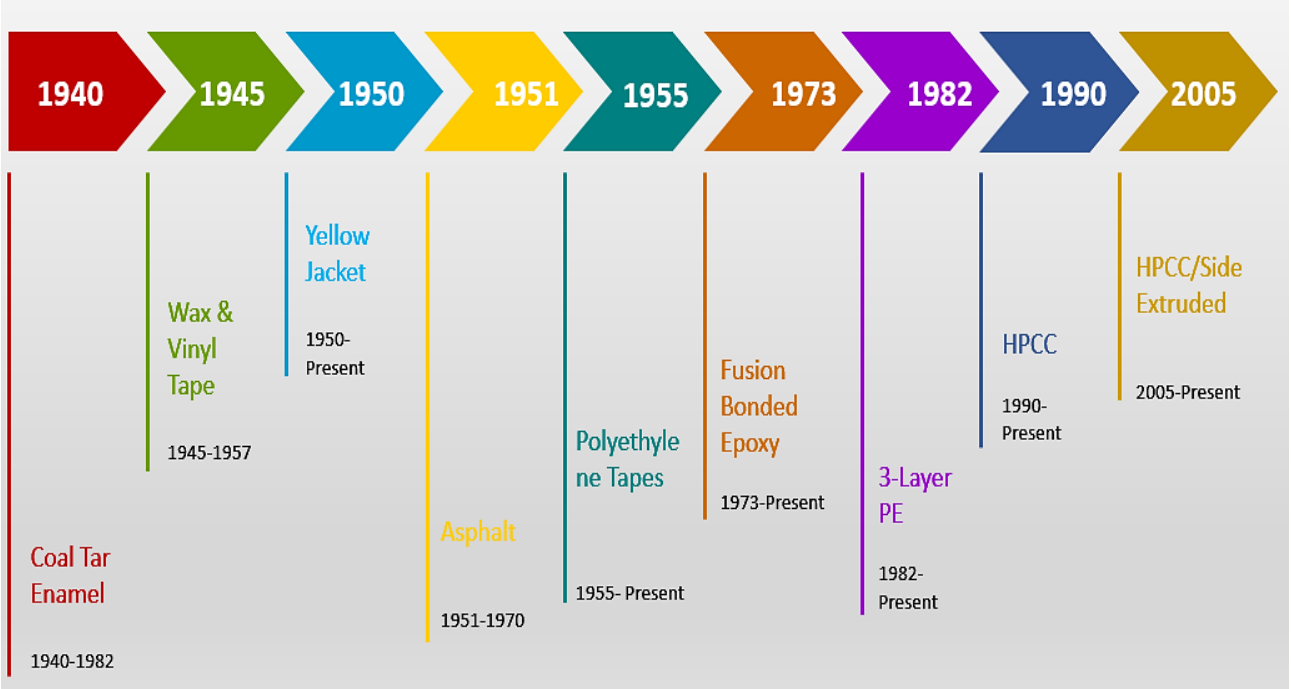
1960s - Saw the birth of mainline coating systems. FBE also provided excellent flexibility properties, this was an answer to the failures of many previous materials due to handling and bending of the pipe spools during pipelay and subsequent cracking of the system

Coatings History

Example of Pipeline Coatings timeline from Shaw's Pipe timeline

(previously Bredero Shaw now Shawcor)

Cited from Pipeline Coatings – Y Frank Cheng and Richard Norsworthy



Coating Defects

Coating Defects can lead to Localised' Corrosion if applied Cathodic Protection (CP) is inadequate.

Field Joints

These are often the weakest points of the pipeline coating system.

On rare occasions, pipelines may be buried with some field joints missing.

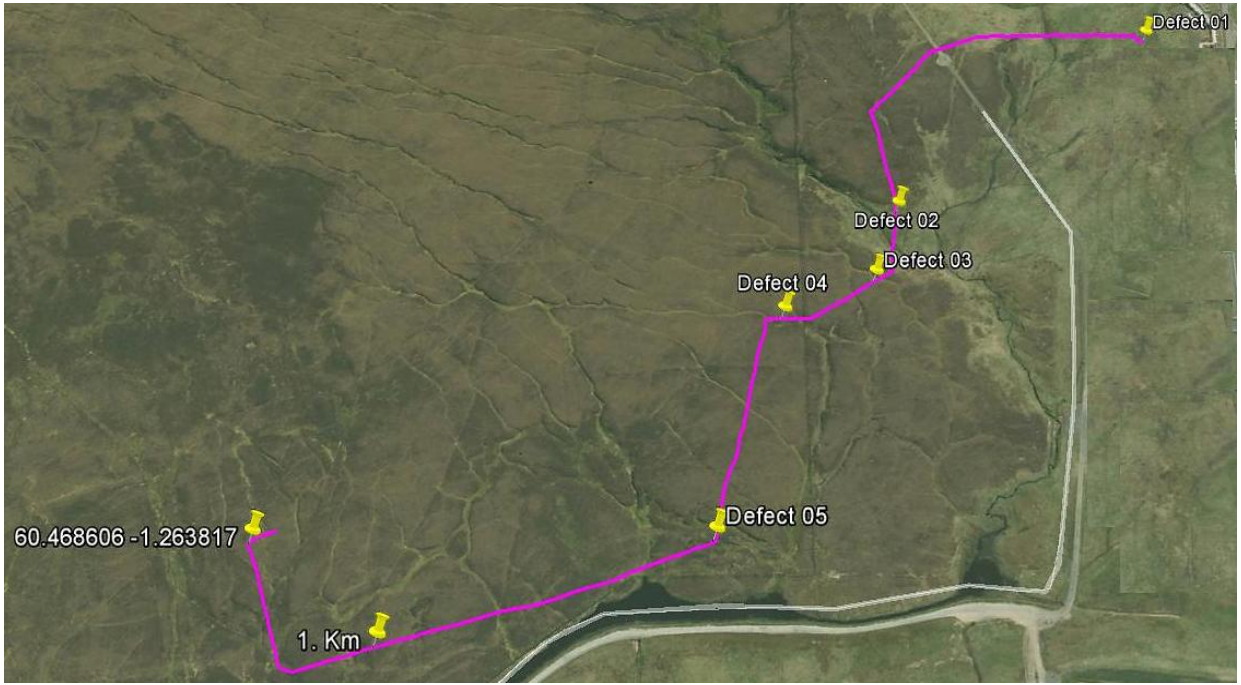
Coating Fault Detection

The Pearson system was one of the **earliest** (but manual) methods of coating fault detection.

More efficient recording' methods such as **C-SCAN** and **DCVG** later followed.

Coating Fault Detection

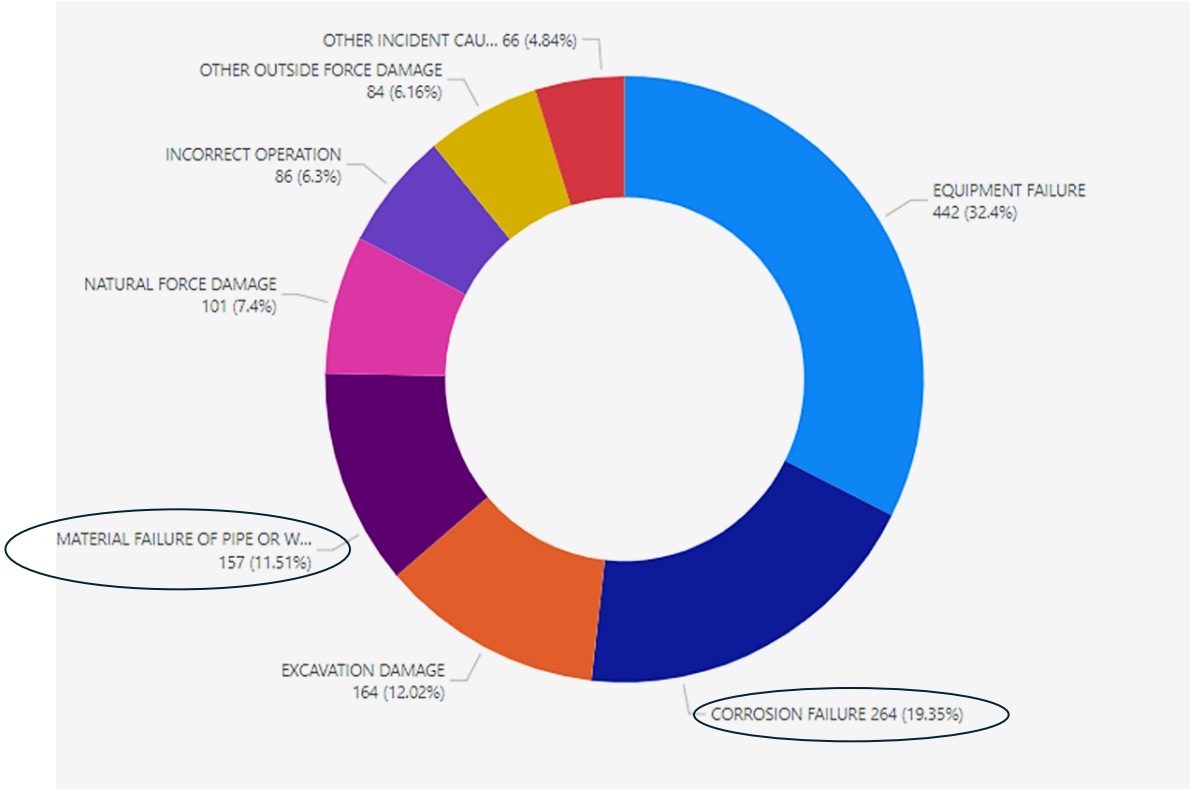
DCVG deploying GPS for accurate' coating fault positioning.



Incidents of Corrosion and Material Failures

Recorded Threats by PHMSA 2010-2020.

Similar to HSE, PHMSA is a US federal regulatory body solely dedicated to safety and regulations of pipelines on a national level.



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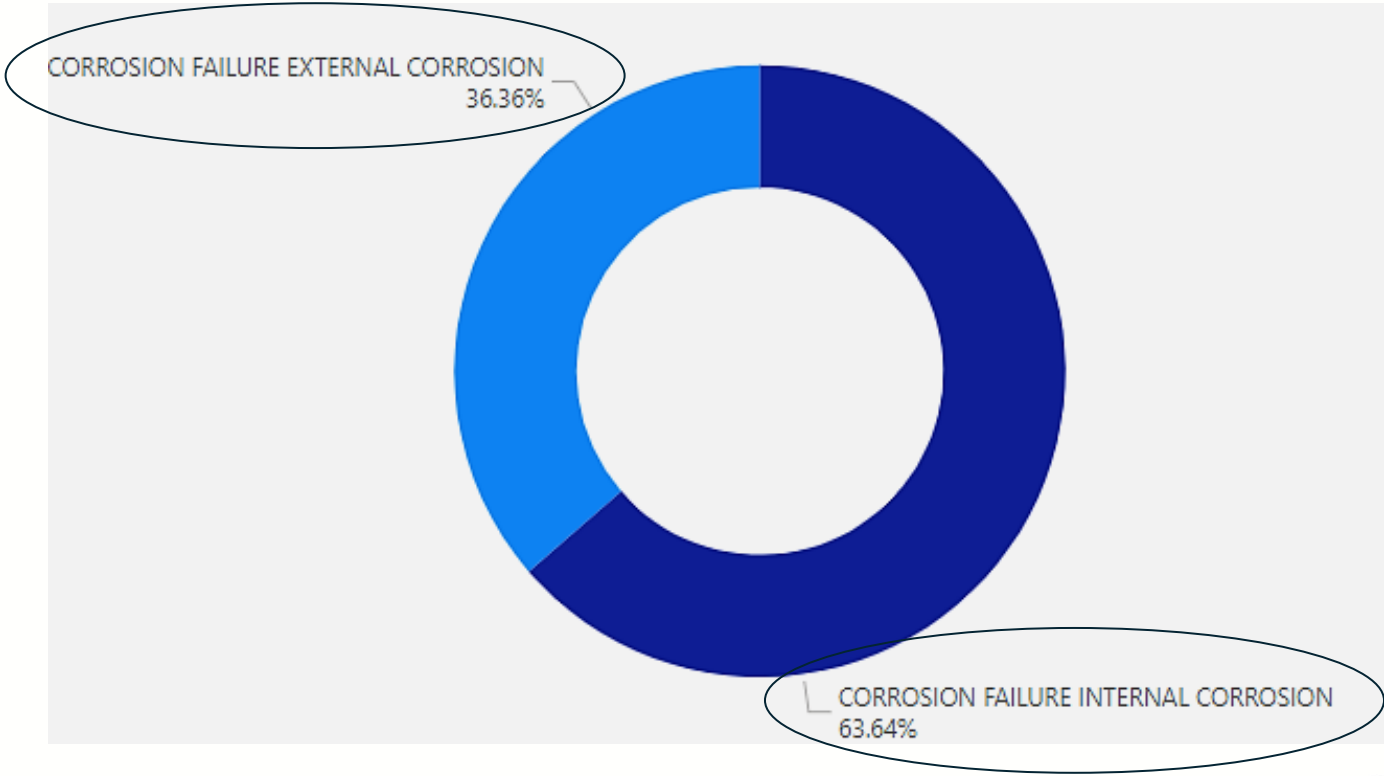
Incidents of Corrosion and Material Failures

Incidents due to corrosion threat 2010-2020.



Secondary Protection

Cathodic Protection
By IP TRU or Sacrificial Anode

Corrosivity

The local ground corrosivity is normally pre-checked early in the **design process** and before a final CP design is produced and the pipeline installed.

Electrical Isolation Issues

Pipelines often run **between** Process Terminals or other Facilities with Insulating' Flanges or Isolating' Joints installed at each end.

Both Impressed Current and Sacrificial (Galvanic Anode) CP Systems can lose their effectiveness if Electrical Isolation of a Pipeline **is lost**.

Insulation Kits

Often used in Plant Pipelines to **separate** Process Areas from buried sections of cathodically protected Pipelines.

Sometimes used to electrically **insulate** between material changes.

Insulation Kit Failure

Cracked Sleeves and Missing Insulating Washers found at site survey.

Insulation Kit Failure

Key Consequences

- Under-protected Sections of Pipeline
- Excessive Impressed Current TRU Outputs (attempting to compensate).
- Increased Electrical Interference to other buried services.

Insulation Joints

Pipelines of longer length, often deploy Impressed Current type CP systems with ‘Monolithic’ Isolation Joints at each end, to separate them electrically from Plant.

Live and Dead Side Connections

Isolation Joint Bypass

A **cladded** Isolation Joint can result in loss of CP / electrical isolation, if ‘metal to metal’ contact is allowed to occur.

Image shows joint with protective surge **divertor**.

CUI Failure of Test Connections

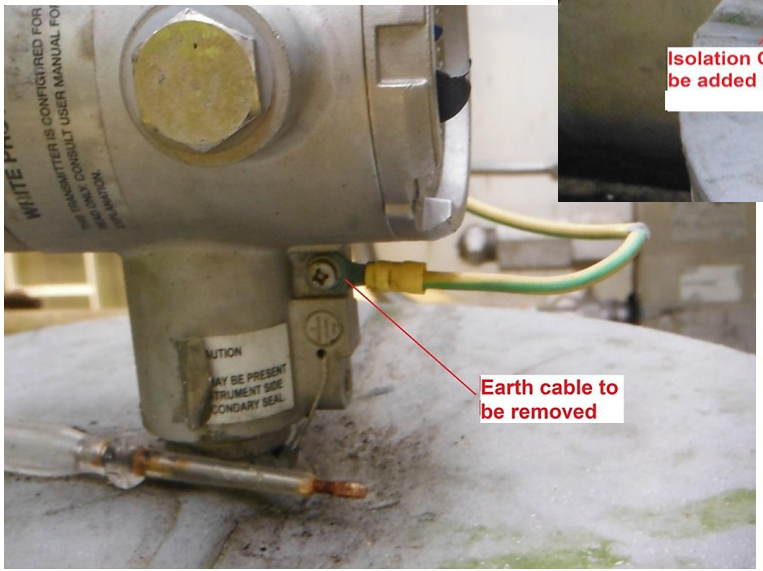
Beneath **cladding** and thermal insulation there are **welded** test cable connection points – ‘tabs’.

Dead and **Live** sides of CP scheme.

Under CUI conditions these will **corrode** and the connections can become unreliable.

Instrument Isolation Bypass

During project **design and build** stage, there may be **insufficient communication** between different disciplines, e.g. Instrument / Piping engineer and CP engineer.

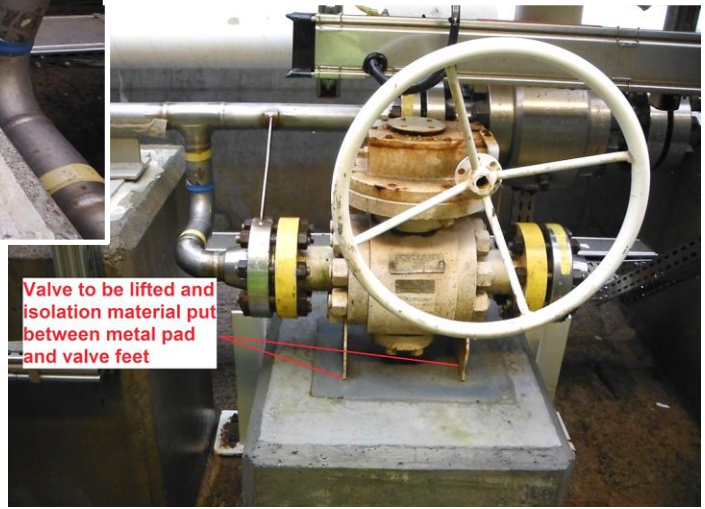


CP solutions by R&R Corrosion

Valve and Pipe Isolation Bypasses

There are **numerous** different possibilities to be aware for loss of CP Isolation via installed plant earths, e.g. Pipe and Valve supports

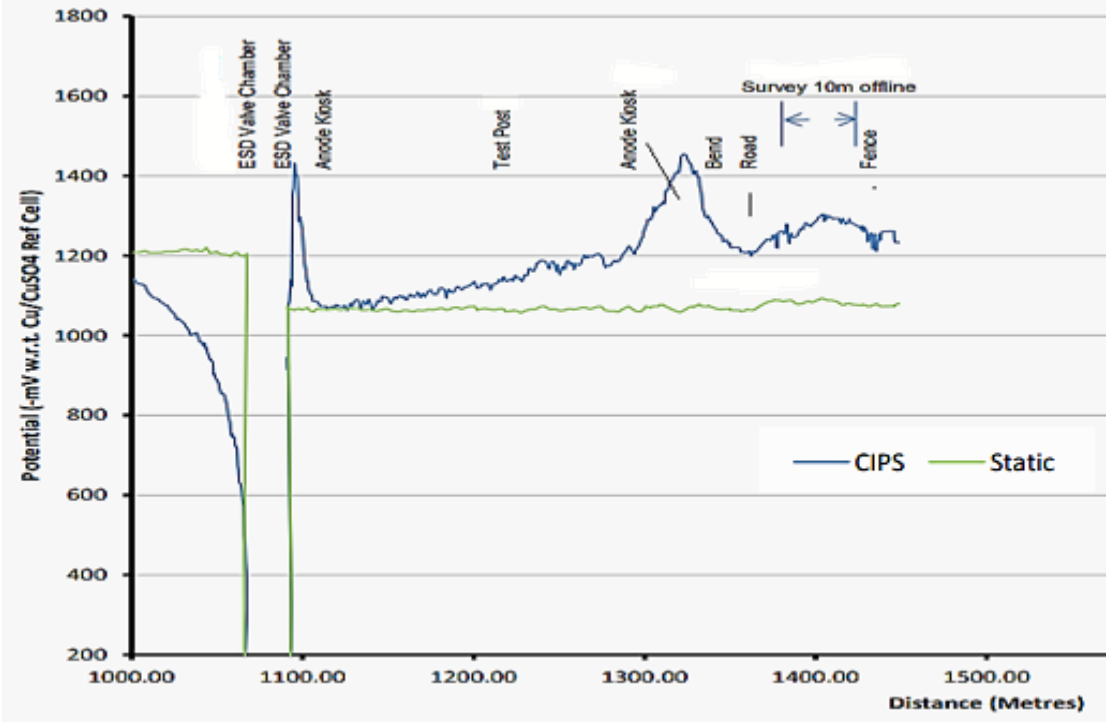
CP solutions by R&R Corrosion



(CIPS) Detected Faults – Galvanic System

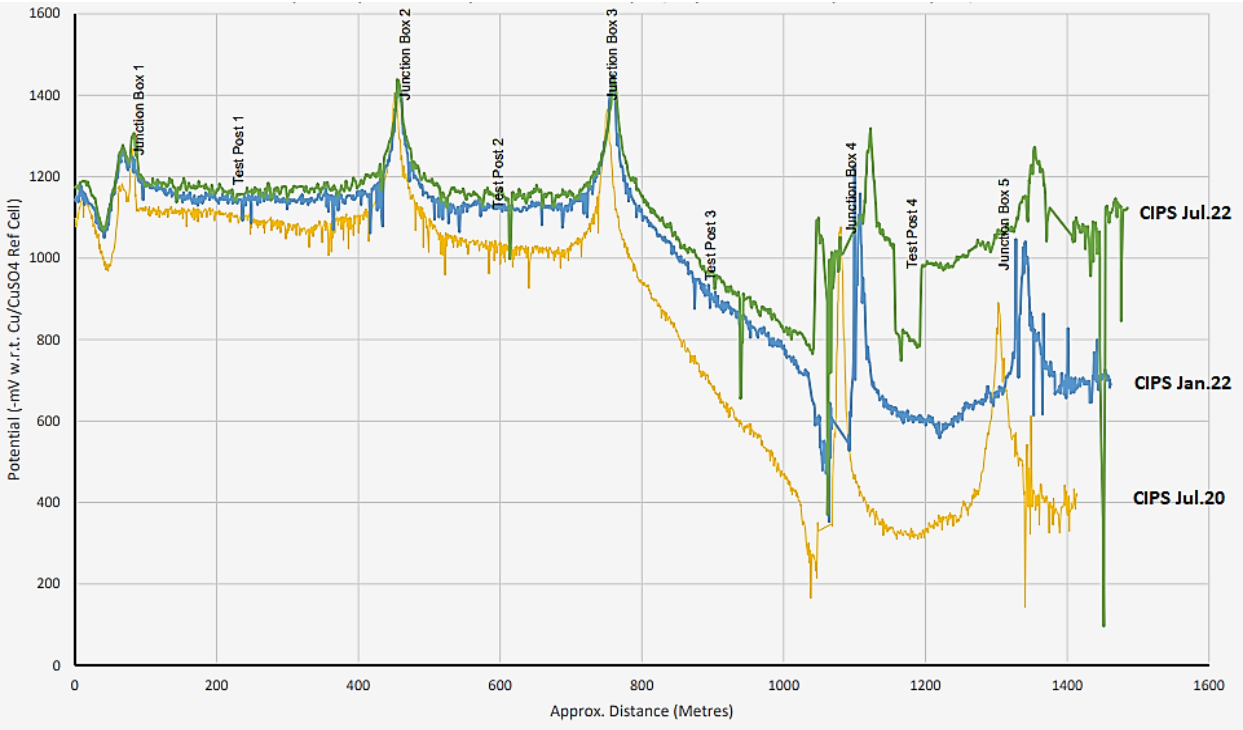
This survey identifies a significant fault on a Sacrificial Anode CP Scheme at the Emergency Shutdown Valve (ESD).

Due in this instance to direct bonding of Pipeline via Valve controls to Copper Safety Earthing (Grounding).



(CIPS) Rectified Faults – Galvanic System

Over a period **of 4 yrs** 2020-2024 it was possible to perform a range of remedial works at the Emergency Shutdown Valve (ESD). Pit and provide alternative earthing and isolation solutions, that reduced **significantly** the impacts and improving Cathodic Protection levels over the Pipeline.



Checking CP Effectiveness

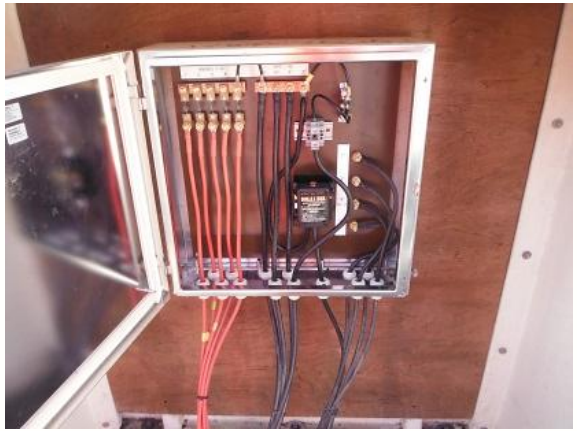
It is essential to confirm the CP protection is being provided **to all areas** of the pipeline in accordance with the latest published CP standards.

Manual CP Monitoring

Manual CP System Monitoring (on Land) deploys a **Cu/CuSO4** Reference Electrode connected to a High Impedance Multi-meter.

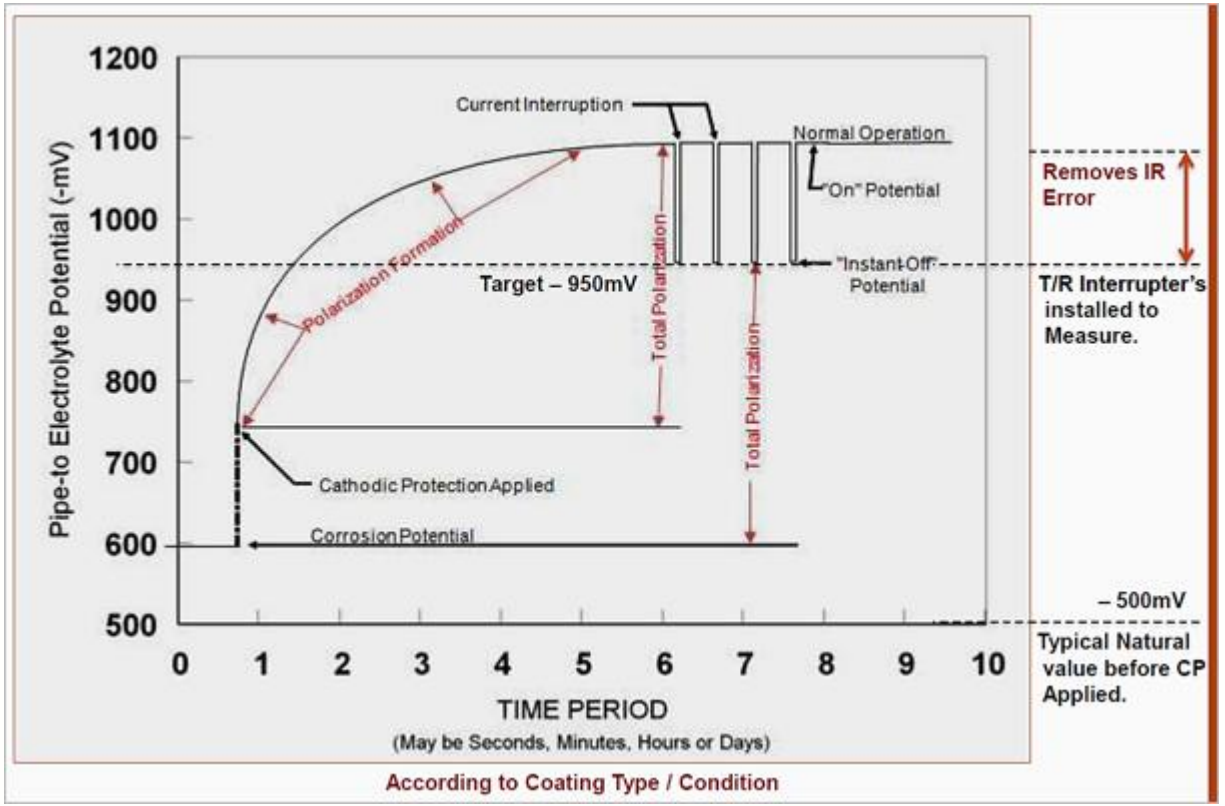
An Anode Connection Box is also shown (Anode Cable Tails **in Red**).

Other Reference Electrodes may be deployed according to the Pipeline Environment. e.g. **Ag/AgCl** for Marine conditions.



(CIPS) Measurement – Impressed System

With Impressed currents systems, **GPS** timing devices are installed at all Pipeline current sources to allow **simultaneous switching** and accurate measurements to be taken.



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Close Interval Potential Surveys (CIPS)

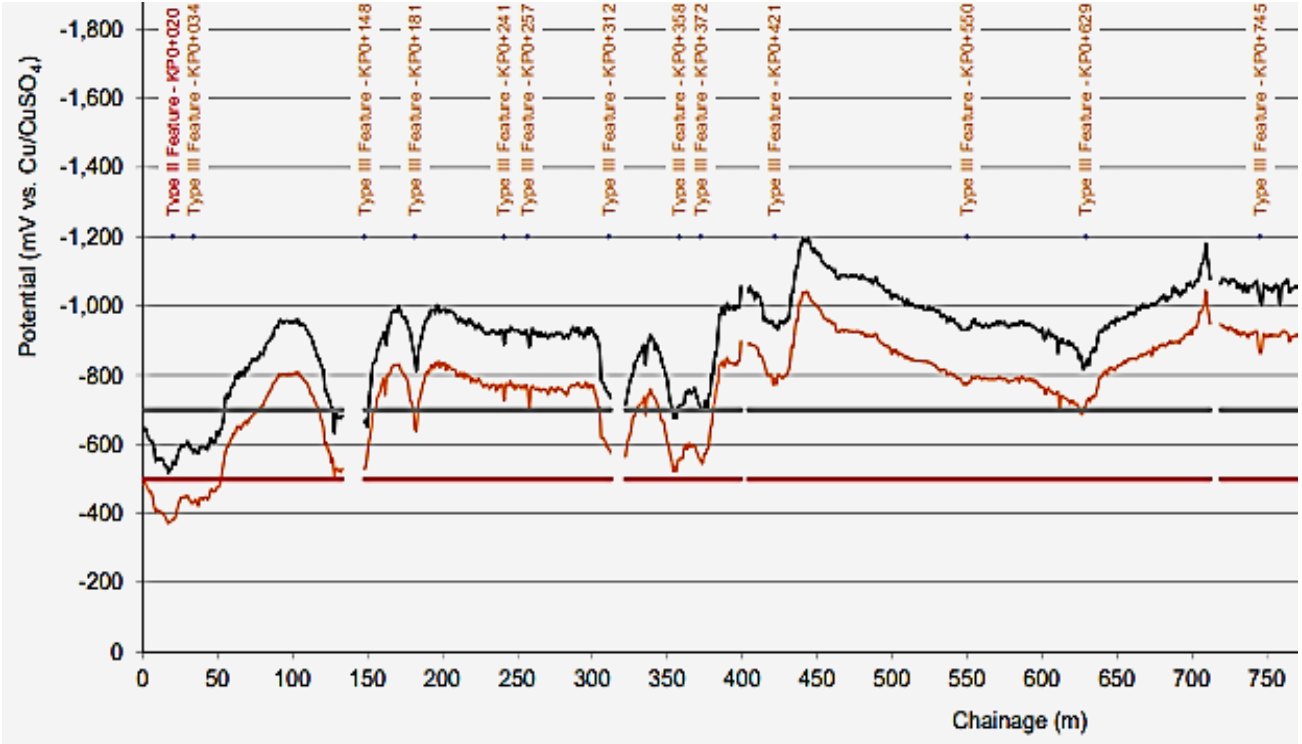
Verification of CP performance is very important and is normally done via **CIPS** with measurements taken ~ I metre Intervals.

The leading surveyor is using a Pipeline locator to **stay on course** over Pipe centreline.

(CIPS) Detected Faults – Impressed System

This survey shows an **Impressed current** CP System switching On/Off and the resulting CIPS and DCVG (Direct Current Voltage Gradient) recording (as Slide 10 above).

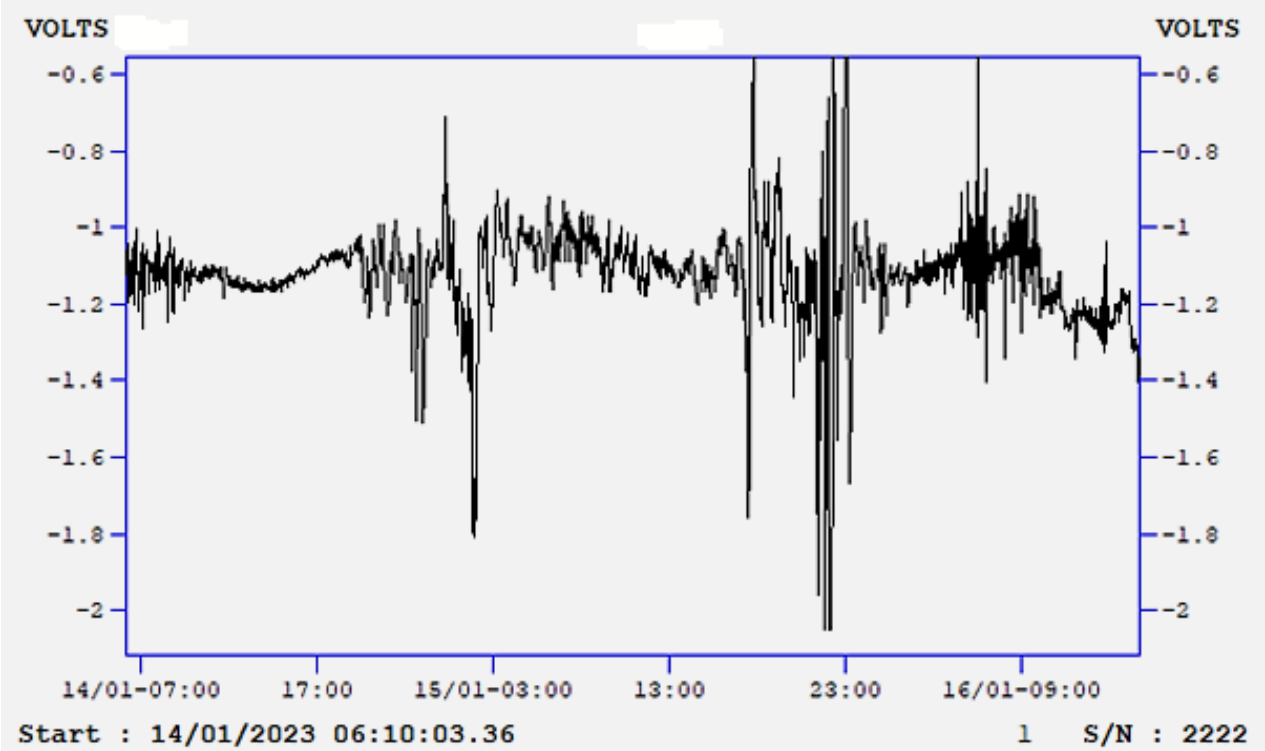
Areas of **Under/Overprotection** are highlighted from these initial surveys along with Coating Defects.



External Interference Issues.

External Interference to CP systems can result from many different **AC and DC** sources, e.g. Geomagnetic, Plant Equipment or Tidal changes.

In such circumstances, Long-Term **logging** is normally utilised.

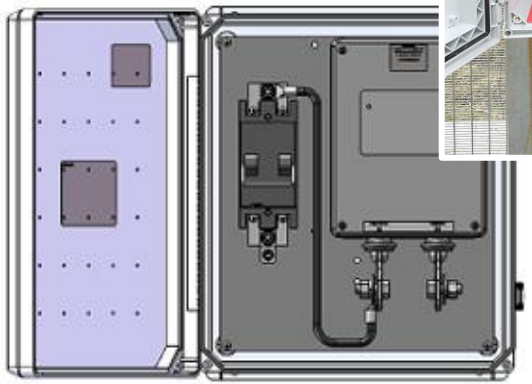


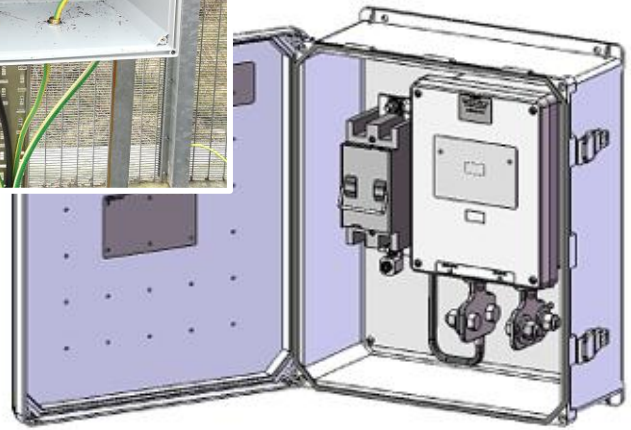
Security Fence Crossing Pt.

Plant Security Fences may cross Incoming/Outgoing Pipelines at **multiple points**, sometimes at several points on the same pipeline.

These can cause significant **Interference** Issues if left unresolved.

CP solutions by Corrpro





Ordering Instructions
- SWX-100-ENCL
- Any PCR-3.7KA, PCR-5KA or PCR-10KA
- MTL Conductor Kit, Optional
- BCL-2 Shorting Cable

NOTE: HOLE REQUIRED FOR CONDUIT - FIELD INSTALLED.

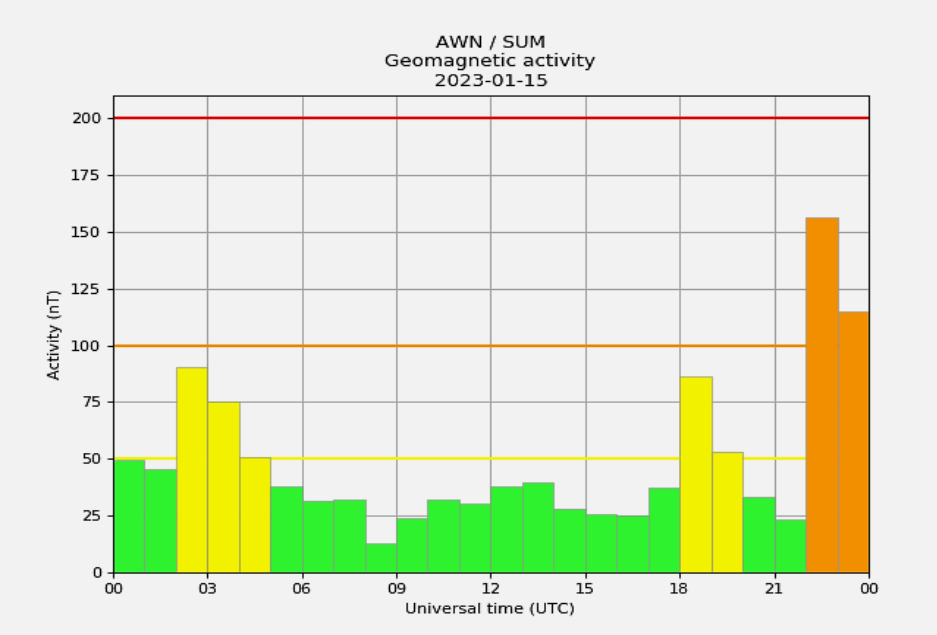
Telluric Interference

Pipelines are subjected to telluric current activity due to the modulation of the earth's magnetic field by solar particles. This changing magnetic field produces an electric field that causes charges to flow in the earth and in metallic networks located on the earth such as pipelines, electric powerlines, and communication cables. This electrical disturbance is observed on pipelines as potential and current fluctuations that can vary with time due to the earth's rotation, tidal cycles, the sun's rotation, eleven-year solar cycles, and solar storms.

The magnitude and location of these disturbances depend on the pipeline's proximity to the earth's magnetic poles, on its length, on its orientation, on changes in direction, on the coating resistance, on electrical continuity along its length, on soil resistivity and the presence of abrupt changes in earth conductivity, and proximity to the coast.

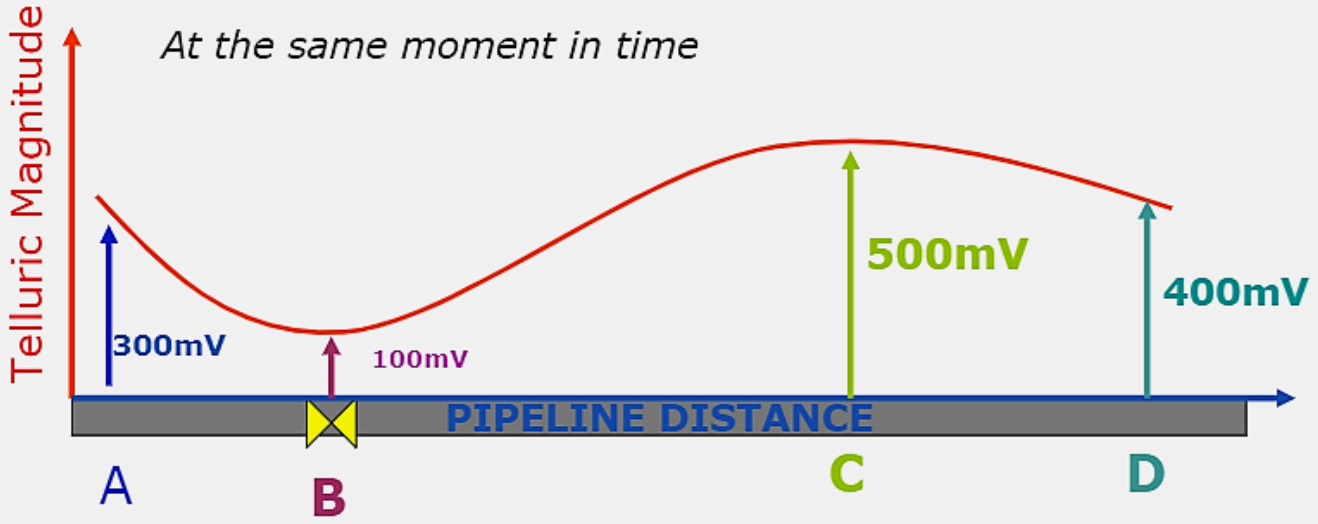
Telluric current interference may be especially pronounced at locations where a pipeline parallels an AC powerline, because both structures are subject to induced voltages.

Ref: Pipeline Research Council International - PRCI Contract PR-262-0030 Telluric & Ocean Current Effects on Buried Pipelines & their Cathodic Protection Systems Final Report – January 2002.



There are various forecasting services, probably the best known is BGS – British Geological Survey. In the UK BGS run three magnetic observatories that constantly monitor the changes in the Earth's magnetic field.
LINK Current geomagnetic activity in the UK and across the globe

Voltage Effects



Regional Effects on pipeline structures on telluric variation:
Valves, bends, rectifiers, anodes, insulating flanges

Summary

- Pipeline CP Projects are often designed by **3rd Parties**, not within the main Project Team.
- They can be prone to **Inter-Disciplinary** Communication breakdowns, leading to CP System Faults and **inappropriate** Pipeline material choices.
- Post-Installation Remedials may be required to **restore** full system operation if isolation is lost.
- Operational requirements may **delay** Rectifications.

Cathodic Protection for Pipelines - Electrical Isolation / Interference Issues

Thank you for your attention.
Any Questions?

Advancing Corrosion Science & Engineering

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Aberdeen CAD Event - 2025