AMPP™

DC STRAY CURRENT INTERFERENCE SOURCES AND MITIGATION MEANS

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CONTENTS

Definitions

Galvanic Corrosion, potential difference along a metal or between metals. Corrosion causes a current to flow.

DC Currents flowing through earth onto a structure that is not part of the intended circuit

Electrolytic Corrosion, external sources of direct current, stray current, which leads to corrosion.

When stray currents accumulate on a metallic structure, it can induce electrolytic corrosion of the metal while leaving into its ultimate destination

Faraday's Law

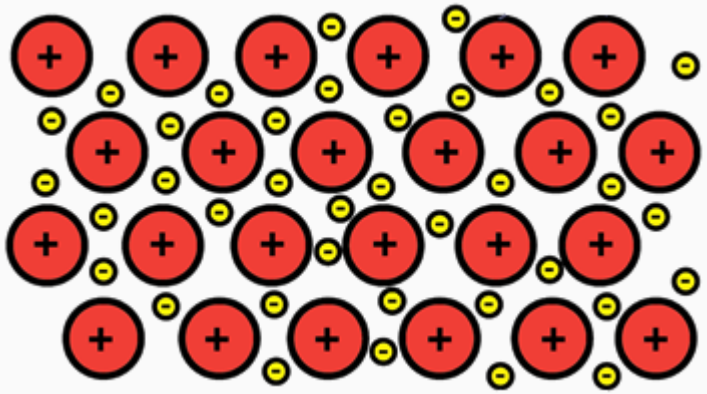
W= K.I.t

W= Weight Loss (kg.)

K= Electrochemical Equivalent (Kg/A-Yr)
(Specific for every type of metal)

I= Current (Amps)

t= Time (Years)



Electrochemical Equivalents

Al = 2.94 kg/amp-year
Cu = 10.38 kg/amp-year
Pb = 33.9 kg/amp-year
Mg = 3.97 kg/amp-year
Fe = 9.13 kg/amp-year
Zn = 10.7 kg/amp-year

Sources of Stray Current

Static

- Foreign ICCP Systems
  - Anodic
  - Cathodic

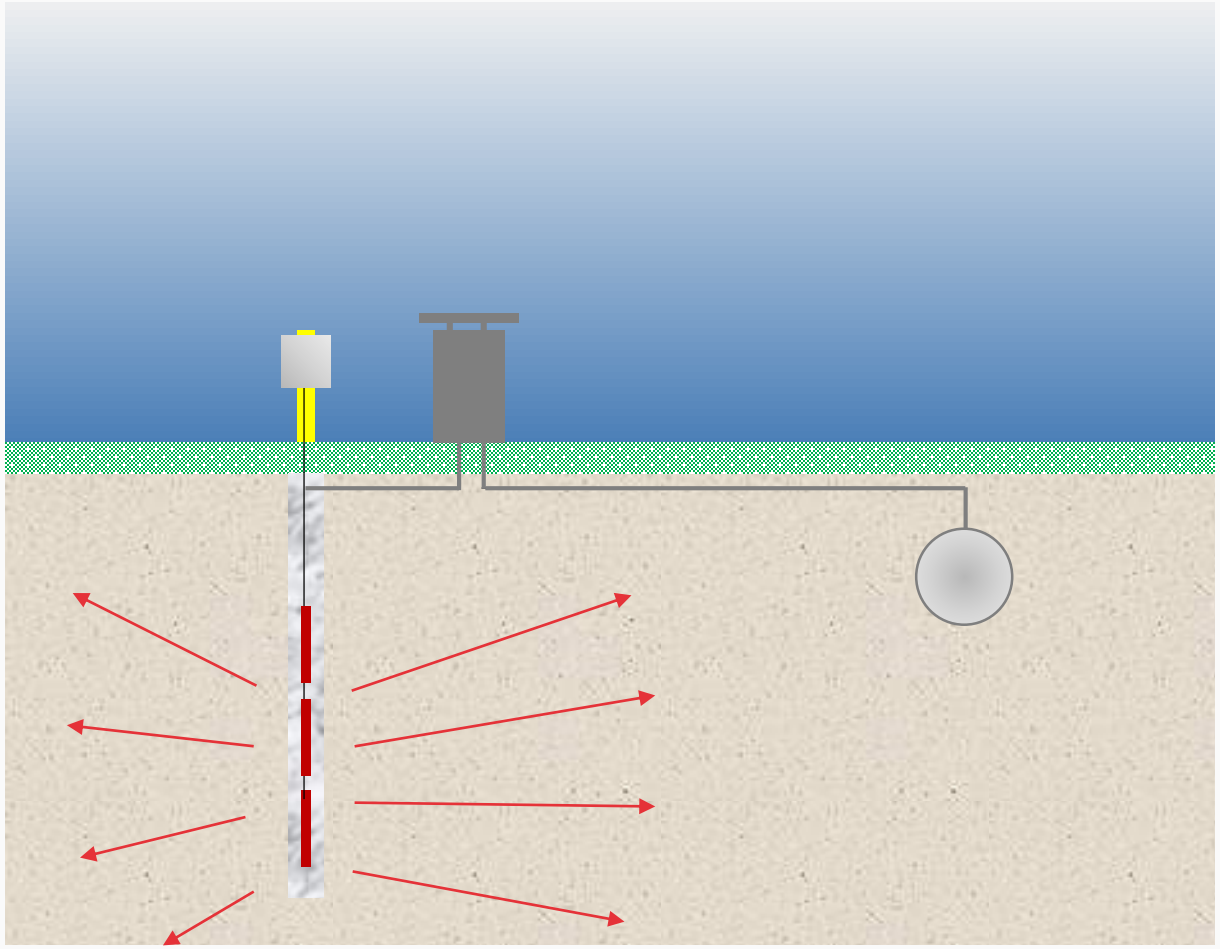
Dynamic

- DC Transit Systems
- HVDC
- Geomagnetic earth current (Telluric)
- Grounding Systems
- Welding with improper ground

Static Stray Current

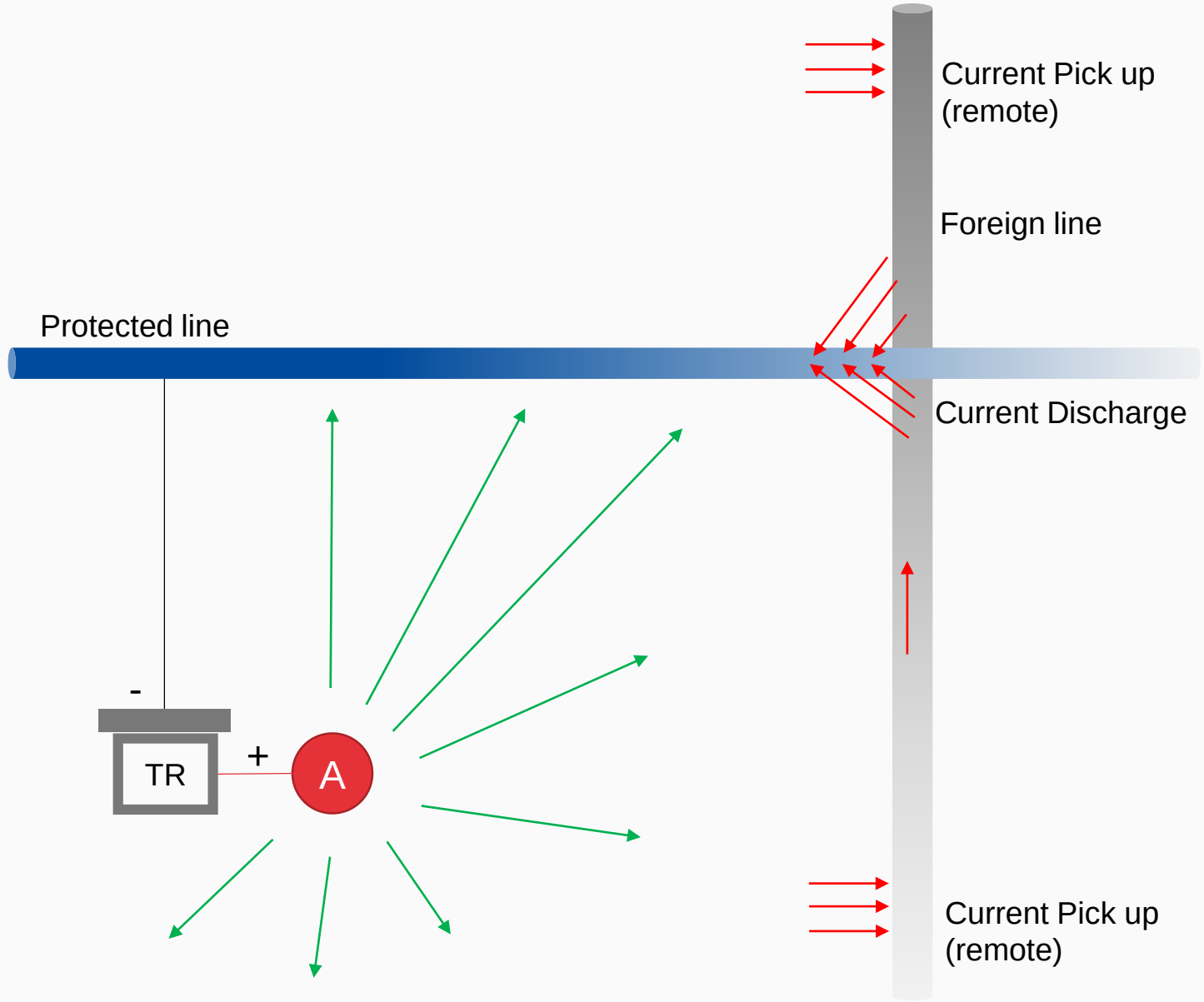
Steady State, where stray currents maintain constant magnitude and electric path in the ground

Foreign impressed current CP system is a major example of static stray current



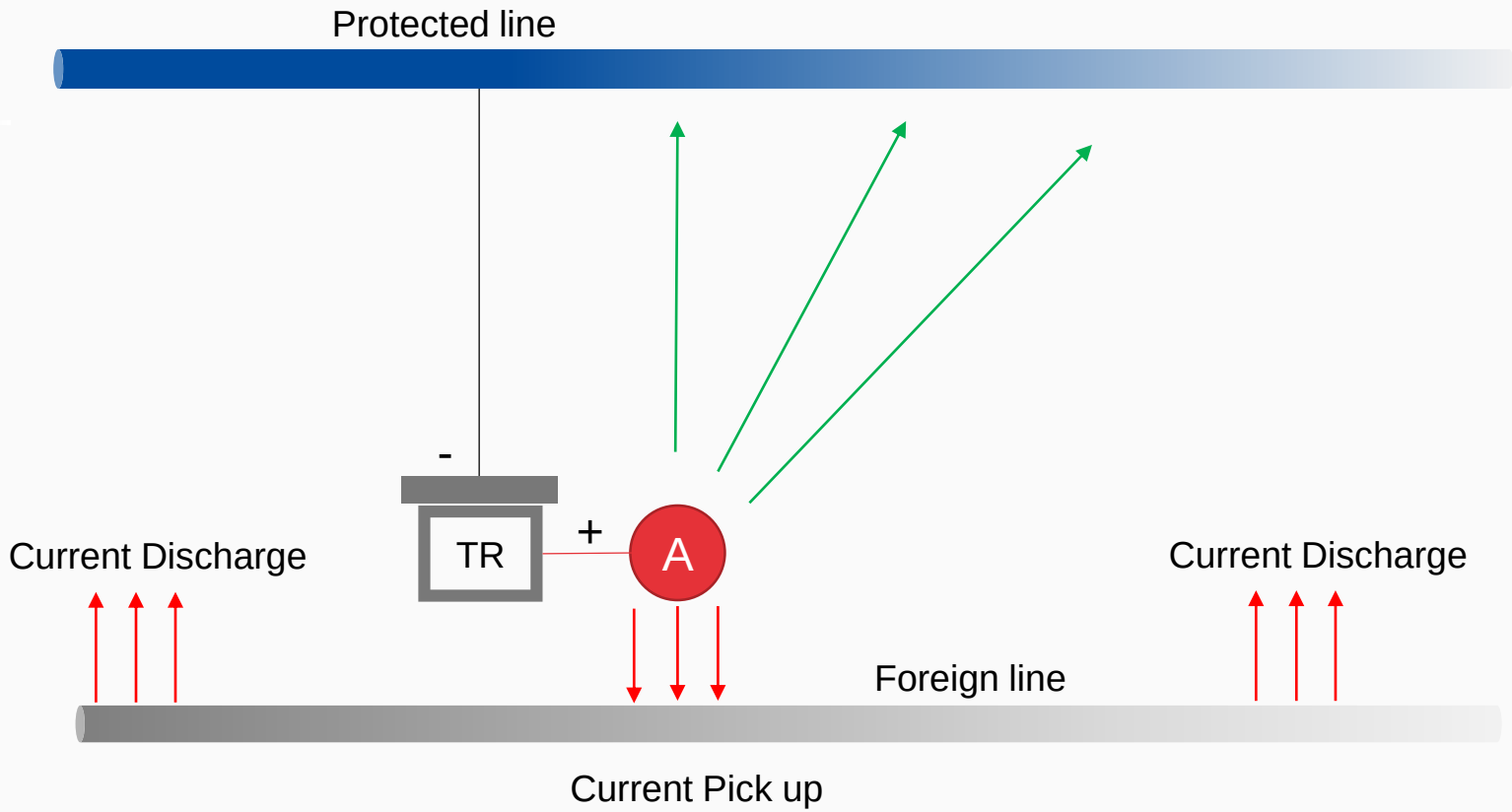
Static Stray Current

Cathodic Interference, When a foreign pipeline picks up CP current from remote and discharge it to the protected line at the first point of intersection (crossing or parallelism)



Static Stray Current

Anodic Interference, When a foreign pipeline falls in the anodebed proximity that is intended to protect another structure, it picks up CP current from the interference area and discharge at remote site while looking for it's way back to the protected line

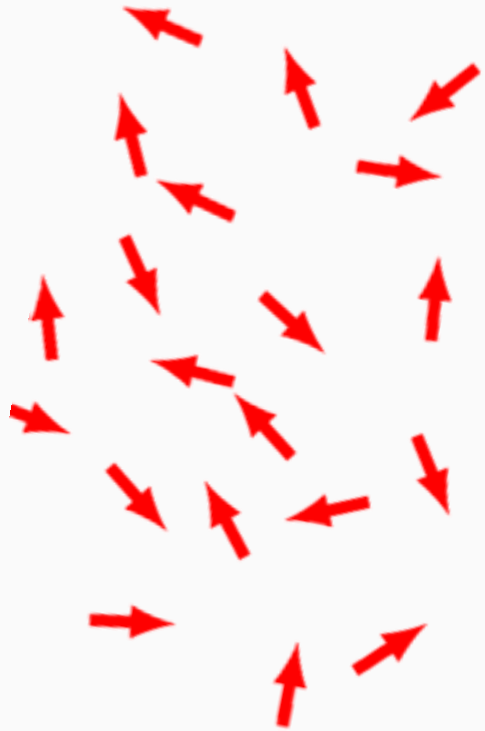


Stray Current Analysis

Identify the source(s) of stray current

Identify location of stray current pick up and its extent (Area)

Calculate the anticipated damage on the pipeline created by stray current



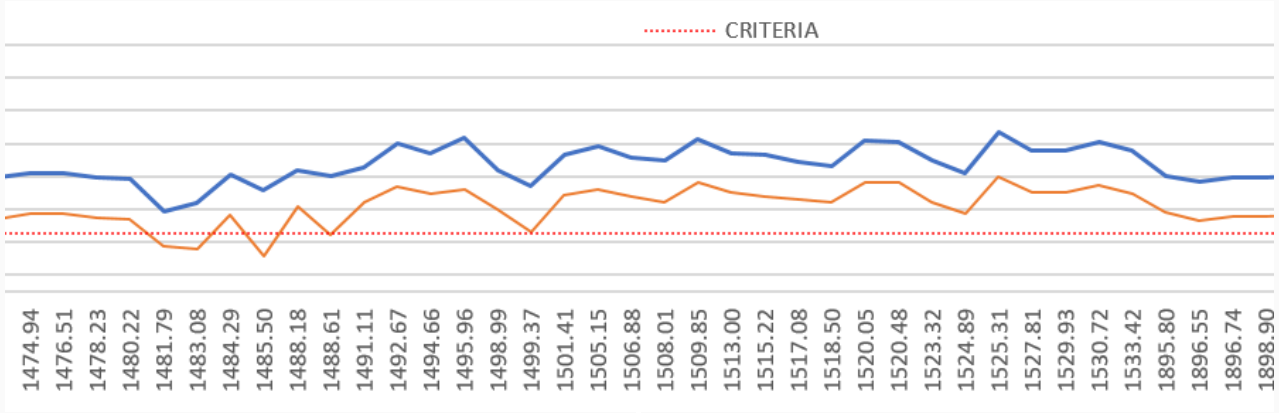
Identify location of stray current discharge and its extent (Area)

Determine the magnitude of stray current

Plan for the suitable stray current mitigation technique

Static Stray Current Detection (P-to-S Potential)

Structure-to-electrolyte potential changes on the interfered with structure (CIPS Survey is always recommended)



For unprotected pipelines, current discharge is indicated by the most positive readings which is the opposite of the way potential readings are interpreted for galvanic corrosion.

Pipeline was exposed at the dropped instant-off location and two abandoned non-bonded pipelines found crossing the pipe under investigation

Static Stray Current Detection (Potential Mapping)

In congested piping networks, e.g. station piping, surface soil potentials represent an averaging effect of all contributing structures nearby the RE location, Mixed Potential.

Difficulty to analyze data while viewing it in table format, hence a colored graphical display can help in analyzing data

Grid Potential Mapping can be used to evaluate the whole area CP system functionality

Identify areas that do not demonstrate adequate cathodic protection. Locate unintentional shorts and grounds

Static Stray Current Detection (Current Mapping)

Changes in the line current magnitude or direction caused by the foreign DC source (Current Test Station, PCM, or other NACE approved Techniques)

Identification of short circuits from pipelines to other structures

Very helpful in Congested areas at oil & gas complexes

Pipeline Current Mappers can do profiling of the CP current distribution on a pipeline network, magnitude and direction

Static Stray Current Detection (Direct Examination)

Localized pitting in areas near or immediately adjacent to a foreign structure.

Breakdown of protective coatings in a localized area near an anode bed or near any other source of stray direct current.

Pitting, 3mm detected at a pipeline parallelism diversion (Oman)

DROP QUIZ

Where does stray current corrosion takes place on a pipeline?

A. At current pick up area

B. At Current Discharge Area

C. At negative drain point

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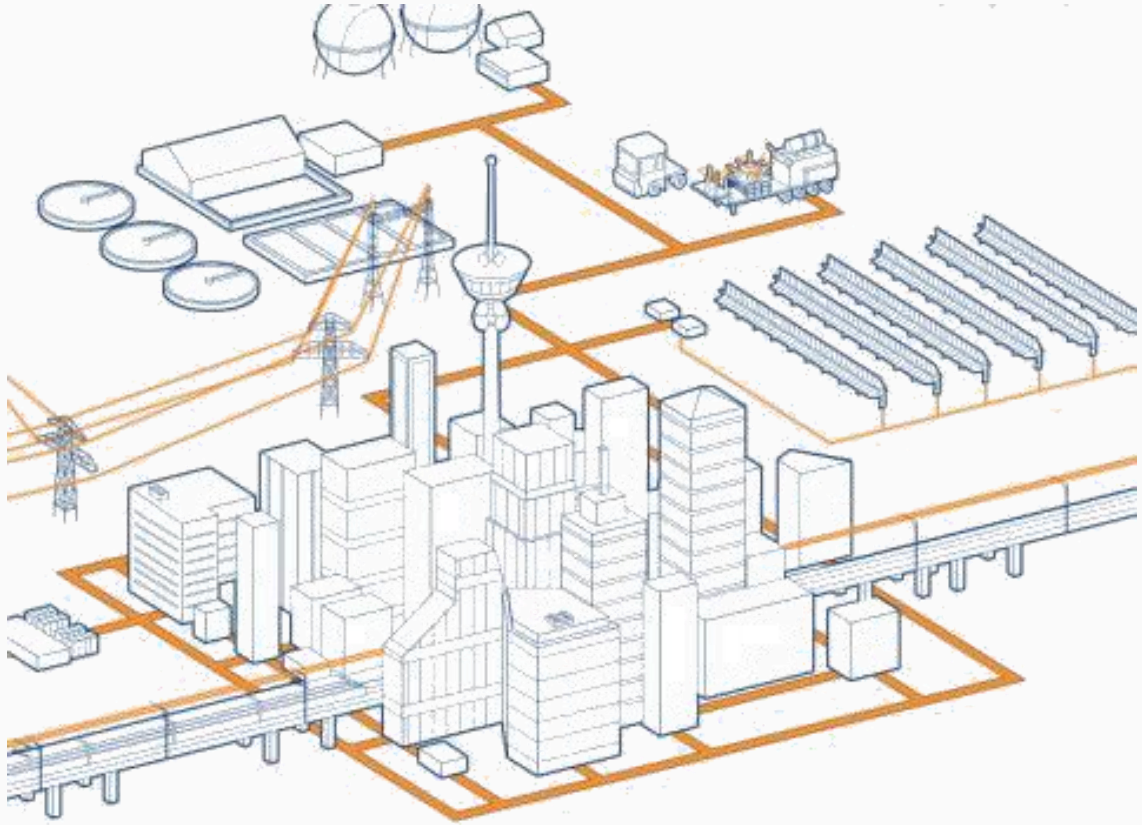
Plant Piping Interference with Grounding Networks

Grounding systems used for above ground equipment which are usually associated with piping networks

Historically, bare copper wires and rods have been widely used



CP systems & Grounding networks share the same electrolyte

Low resistance grounding circuits, when compared to well coated pipelines, CP current would prefer to travel into the grounding network instead

Plant Piping Interference with Grounding Networks (Impact)

Stray current on grounding networks would lead to corrosion of copper wires and compromise the grounding system

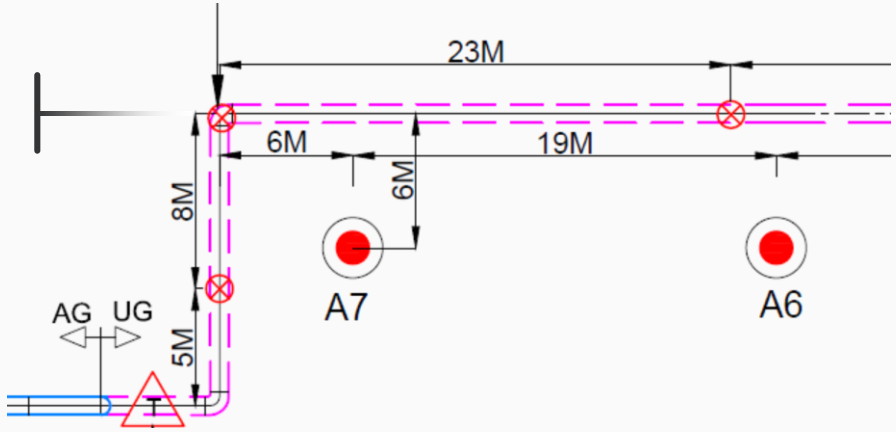
Current drain into copper would lead to drop in CP potential on pipelines, **at un-identified locations**

High CP current demand to overcome grounding network requirement

Polarization of copper surfaces would reduce the effectiveness if its grounding capabilities, due to impact on copper to earth resistance.

Plant Piping Interference with Grounding Networks (Pro-active Design Measures)

Design for hot spot distributed anode system at interference areas or failed isolation flanges. Retrofits.



Earth potential rise, distributed anode system. Anodes arranged in close proximity of pipelines

Deep well / remote earth systems are not recommended in complex plants. Even if piping is isolated from grounding.

Wire anodes installed in the same trench of pipeline, allows perfect distribution of current over the piping

Plant Piping Interference with Grounding Networks (Pro-active Design Measures)

Use insulated copper wires for grounding networks

Isolate grounding network from pipelines, either by using isolating flanges or DC De-couplers

Isolate bare copper wires intersecting with pipelines, either by taping or PVC conduits

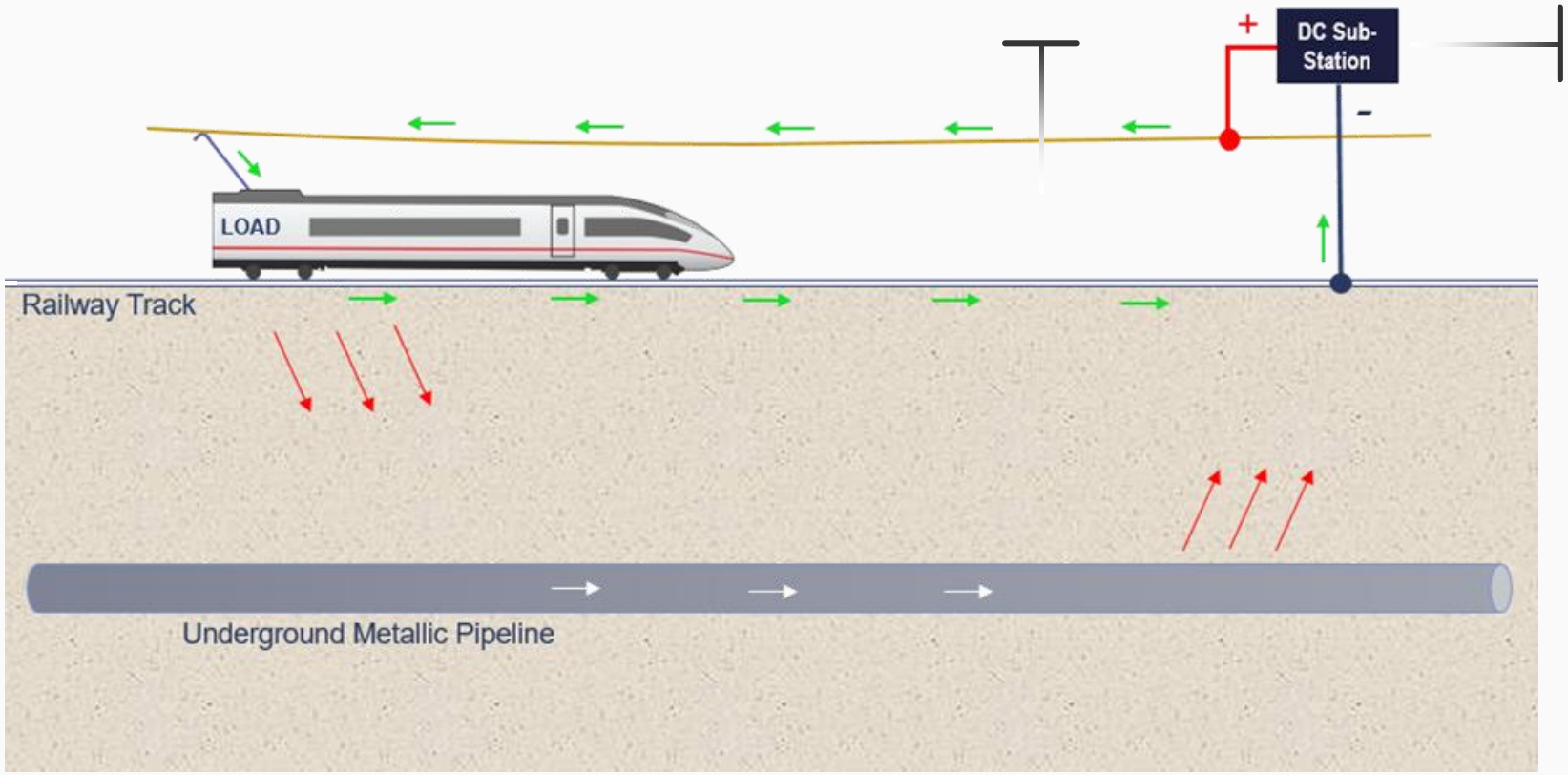
Dynamic Stray Current

- DC Transit Systems, Automated People Movers (APM)
- Welding with improper ground
- Geomagnetic earth current (Telluric)
- HVDC (High Voltage Direct Current) Transmission

DC Transit System Stray Current

A third rail is used as a Positive circuit

Mostly the rails are used as a negative return



Powered by DC traction stations runs at hundreds/thousands of voltages and amperes

DC Transit System Stray Current

Mainline, Shop, and Yard are electrically isolated

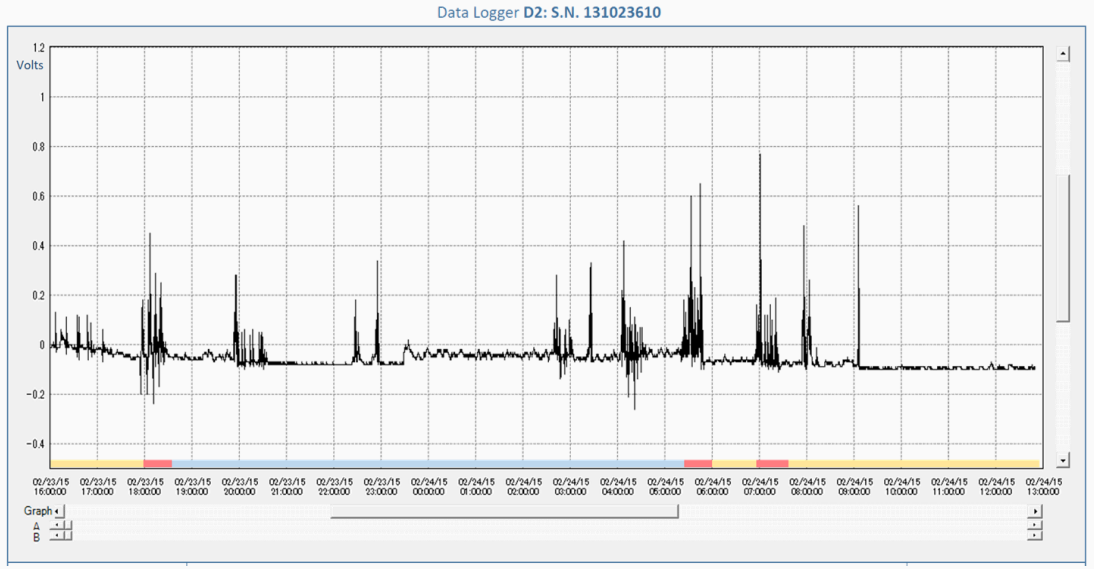
Shop and Yard grounded for safety reasons

Insulation between rails and earth is essential

Tram rails embedded in streets is a concern

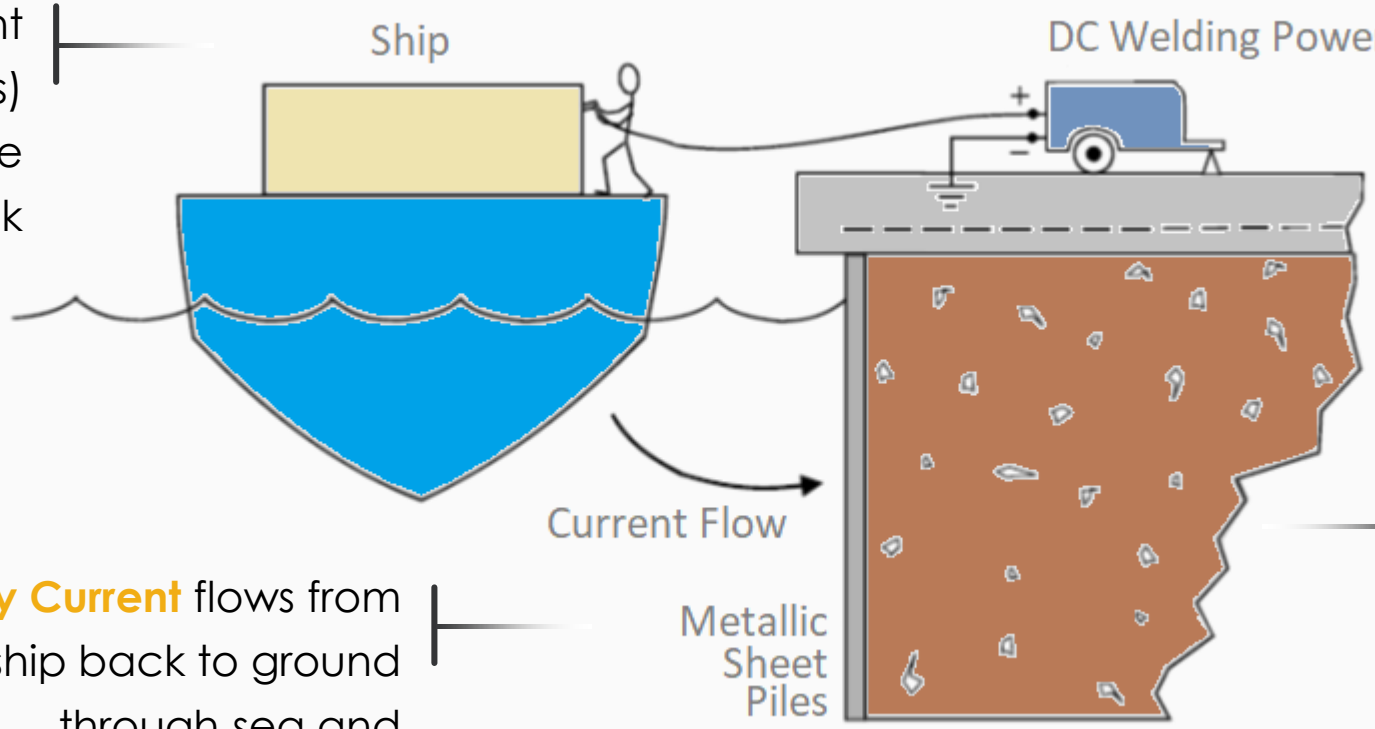
Mainline not grounded

Every section runs on a separate power circuit



Improper Welding Grounding Stray Current

DC Welding current (hundreds of amperes) discharges from the ship to the dock



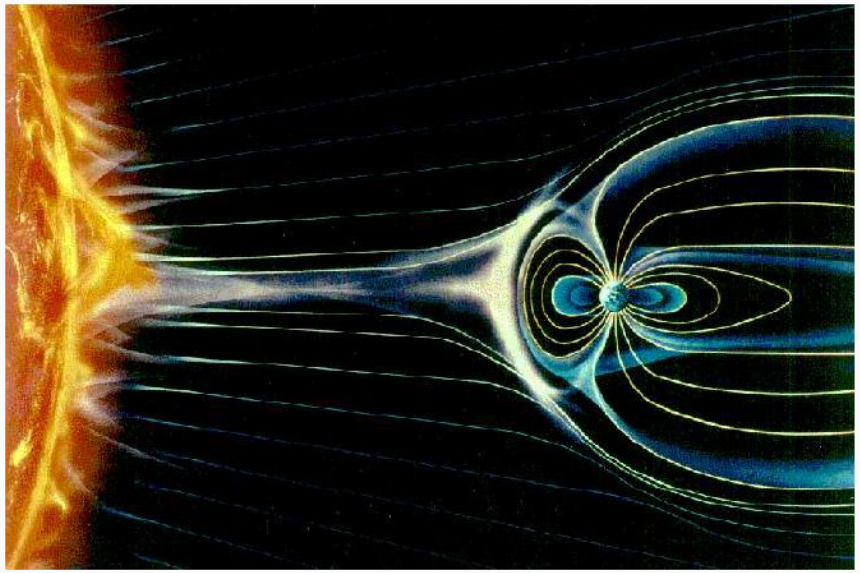
The negative of the welding generator is connected to electrical ground on the dock

Stray Current flows from the ship back to ground through sea and collected by sheet piles

No electrical bond between the dock and the vessel

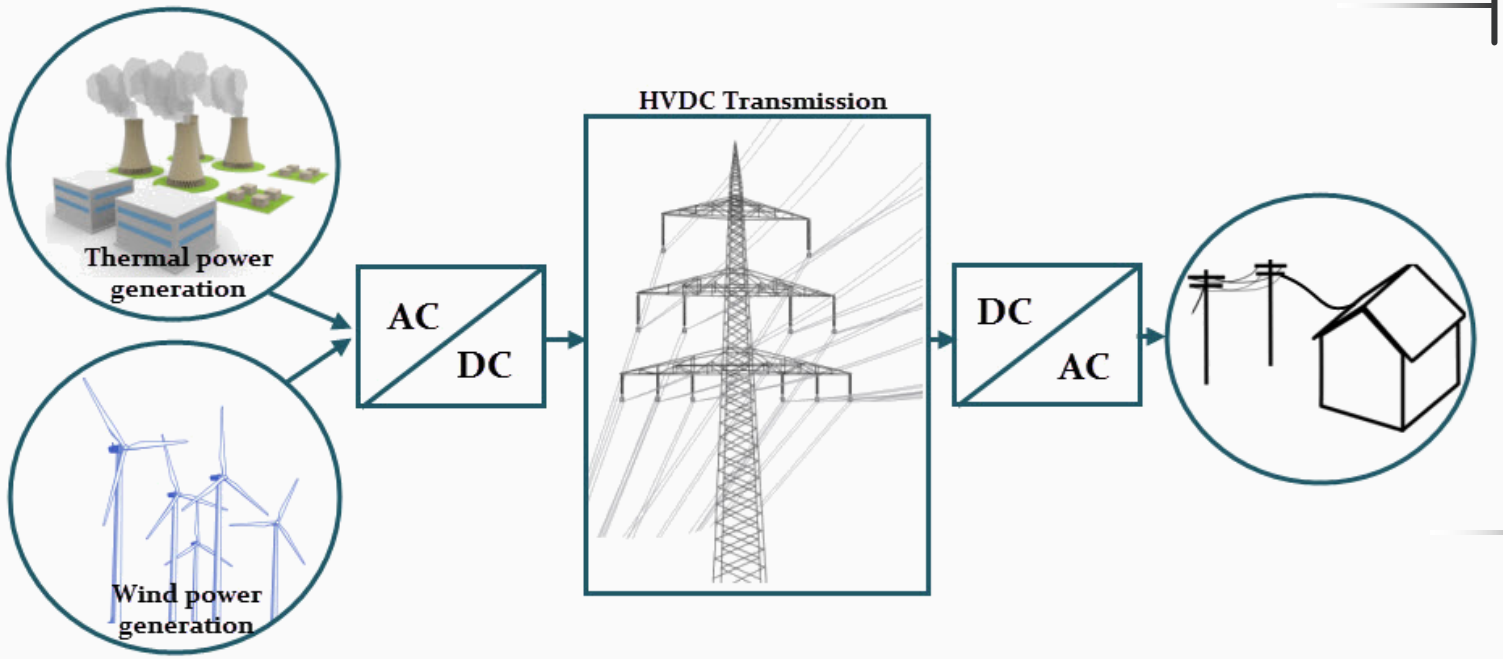
Geomagnetic earth current (Telluric)

- **Telluric** currents are generated by the interaction of the solar wind (high energy particles given off by the sun) with the earth's magnetic field.
- **The current** shifts in magnitude and direction over time. Telluric currents are more severe with increased sun spot activity.
- **Naturally** Occurring Earth Currents
- **Highest** Magnitude Near Earth Magnetic Poles
- **Affects** Cathodic Protection Testing
- **Variable,** Low Frequency Alternating Current
- **Produce** Dynamic Changes in Pipe Potential and Line Current Flow



Source: Place, Trevor and Sneath, T. Owen, Practical Telluric Compensation for Pipeline Close-Interval Surveys, NACE Corrosion 2000, Paper No. 741, Orlando, Florida, March 2001 *(PowerPoint Presentation) (MP, Vol. 40(9), 2001 p.22*

HVDC Stray Current



Converts AC to DC, transmit DC, Convert DC to AC

No Inductive or Capacitive losses along the transmission system, unlike HVAC

Less expensive construction e.g. two wires, smaller towers, smaller rights-of-way.

Large grounding electrodes at each terminus

Mitigation Means

Electrical Bond

- At pipeline crossings and parallelism with variable resistors
- The resistance bond limits the amount of current flowing on the structure being protected.
- At ductile iron pipeline joints, even if no CP is provided
- Reverse switches or diodes can be used to allow current flow in one way
- The minimum current flow through the resistance bond reduces stray current attracted to the protected structure, thus reducing stray current through the soil.

Mitigation Means

Design Prevention

Proper location of CP systems and pipelines

Survey for possible interfering structures during design stage

Proper isolation techniques with grounding networks

Metallic Bond

At isolation devices

Between railway substations and pipelines

Mitigation Means

Cathodic Shielding

A bare metallic shield installed between foreign pipeline and anode bed. Less practical solution due to high costs associated.

Protection Coating

Apply extra coating on the current pick up area of a foreign pipeline. Thus current finds less holidays to penetrate and then stray current amplitude reduces.

Mitigation Means

Auxiliary Drainage

Sacrificial anodes installed at discharge are to facilitate current flow out of the pipeline instead of creating corrosion at the pipeline surface.

Forced Drainage

A potential controlled transformer rectifier with stationary reference electrode to maintain pipeline potential at acceptable levels.
Normally forced drainage used at interference with DC railway systems.

THANK YOU!

Glad to answer any question!

References available upon request:
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