Detection, Engineering Analysis and Mitigation of Dynamic Direct Current Interference on PG&E Gas Transmission Pipelines

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August, 2018
Background

- Per CFR 49; Subpart 192.473 (a) each operator whose pipeline system is subjected to stray currents shall have in effect a continuing program to minimize the detrimental effects of such currents
- PG&E risk ranking identifies external corrosion as a significant threat for pipelines and DC Interference is the number 1 external corrosion threat
- PG&E Corrosion Engineering has a robust program for identification, engineering analysis (EA) and mitigation of harmful DC stray current interference on PG&E pipelines
DC Interference Program at PG&E

- Perform Inspections, Engineering Analysis and Mitigation Projects to dispose of harmful DC Interference Items
- DC Electrical Interference of Gas Facilities Standard; TD-4183S, Published 01/28/15
- Whitepaper for evaluation of DC Interference; Published 06/16/2014
- PGE Procedure TD-4183P-120 for processes and procedures for effective future management and control of Dynamic DC Interference items; 2018
Direct Current (DC) electrical interference effects on PG&E pipelines result from either:

- **Dynamic Stray Currents** – Typically from DC transit systems and change in amplitude and direction

- **Static Stray Currents** – Typically from foreign cathodic protection systems. Static stray current is typically static in nature and do not change in amplitude and/or direction over time

- This Technical Presentation will only discuss Dynamic DC Stray Current Interference on PG&E Pipelines
DC Interference on PG&E Pipelines

The stray current will result in both a current pickup location and a current discharge location on the affected pipeline.

• At the current pickup region, the potential of the pipeline will shift electronegative (protection).

• At the current discharge location, the potential of the pipeline will shift electropositive (corrosion). Significant corrosion may occur if not mitigated.
Interference Current Corrosion

Foreign Structure not part of intended DC Circuit

Corrosion occurs at current discharge point

DC Current Source
Dynamic Stray Current

DC Power Supply (TPSS)

Load Current Required to Operate Train

Overhead Positive Feeder

Running Rails used for return of DC Current to TPSS

Current Pickup Area

Corrosion area due to Current Discharge
 Transit Dynamic DC Interference

- A Heavy Rail Transit train may operate at 1,000 VDC and 800 Amps DC or greater.

- Therefore, even if less than 0.1% of current strays to earth, PG&E pipelines can be severely affected.

- It is therefore important to consider and control dynamic DC interference.
Dynamic Stray Current Indications
Transmission Pipeline

Structure to electrolyte potential fluctuations
Severity of Corrosion From Interference Current Depends on:

- Separation and routing of Pipelines and Transit Systems
- Operating Characteristics of Transit = Location of TPSS, Track to Earth Resistance, other factors
- Magnitude and density of interference current on pipelines
- Pipeline Coatings
- Other factors - Soil Types, Existing CP Status, Mitigation Systems, etc.
Detection and Analysis of Dynamic Stray Current

Review of proximity of Pipelines and Transit Systems

Measurement of Pipe to Soil Potentials over Time

Measurement of Stray Current Flow in Pipelines over Time

Pipeline Integrity Dig Evaluation

Measurement of CTS Current Pick-Up and Discharge over Time

Computation, using Faraday’s Laws, of Coupon and Net Corrosion Rate in MPY before and after Mitigation Actions
Dynamic DC Stray Current Sources Near PG&E Pipelines – San Francisco Bay Area
Pipeline - Potentials Logged Over Time

File: UDL1603 - Line 153 at 5th St - Reads (March 14-15).csv
Pipeline Current Span - Logged Over Time

File: UDL1602 - Line 153 at 5th St - Current (March 14-15).csv

Date/Time (Pacific Daylight Time UTC-7:00)
Transmission Pipeline Investigative Dig - Oakland

Maximum 42% Wall Loss Due to External Corrosion
Stray Current Corrosion Control

Cathodic protection
DCIMS (DC Interference Mitigation Systems, Grounding Cells)
Interference Control Bonds
Protective coatings
Transit Improvements - Increase Track to Earth Resistance
Cathodic Protection

Effective to polarize piping and counteract adverse stray current corrosion.

Avoids the problems associated with bonds.

Impressed Current or DCIMS systems with Galvanic ground cell anodes are typically used and are placed in the area of current discharge.
Adverse DC Interference Effects Minimized Through Increasing CP
DCIMS – with Magnesium Anode Ground Cells

Used with diodes to continuously discharge Dynamic DC Interference Current to ground

CTS to allow current pickup/discharge and rate of corrosion to be evaluated

ER probes installed to allow rate of corrosion to be evaluated

DCIMS systems with Galvanic ground cell anodes are typically used and are placed in the area of current discharge.
Design/Installation of Mitigation Projects
DCIMS Ground Cell Installation
DCIMS Control Box with Ground Cells, Current Shunt, Spans, RMU, CTS and ER Probe
CTS Installation
DCIMS Current Discharge to Ground

DCIMS Current for 12+00

Current (A)

Time
Notes:
• Positive current is in the direction of increasing milepoint; in this case, south to north
• The ★ indicates which end the span was tested from
• Span data from this graphic were taken over 5 minutes
Current is consistently moving in the south direction (opposite the flow of gas).

As the previous slide showed, each span displays identical trends but of different magnitudes.

- Avg current: -4.23 A
- Avg current: -2.85 A
- Avg current: -3.05 A
- Avg current: -2.09 A
- Avg current: -4.69 A
- Avg current: -0.87 A
Nodes over 24 hours

- With ~24-hr data taken for current across the shunt ("DCIMS current") and current for each span, the net current in/out of each DCIMS can be determined:

<table>
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<th></th>
<th>27+00</th>
<th>12+00</th>
<th>02+00</th>
<th>south</th>
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</thead>
<tbody>
<tr>
<td>Current in (spans)</td>
<td>4.23</td>
<td>3.05</td>
<td>4.63</td>
<td>0.87</td>
</tr>
<tr>
<td>Current out (spans)</td>
<td>2.85</td>
<td>2.09</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>Current out (shunt)</td>
<td>0.17</td>
<td>0.53</td>
<td>1.48</td>
<td>1.57</td>
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<td>Net current</td>
<td>+1.21</td>
<td>+0.43</td>
<td>NA</td>
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</tbody>
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Note that current across the shunt was measured with a low resolution data logger and this may have resulted in less precise data.
The low corrosion rates confirm the effectiveness of the mitigation systems.
Thank You for Your Time and Attention

Questions and Answers