Paper No.
C2020-14770

Stray Current Corrosion Risks and Case Histories in Communication Tower and Electric Transmission Applications

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ABSTRACT

Stray current refers to electric current that flows elsewhere rather than along its intended path. Stray current is a well-known factor in pipeline maintenance and has been discovered to be an important consideration in communication and electric transmission structure maintenance. Corrosion caused by stray current is frequently many magnitudes greater than corrosion that occurs naturally in soil. Stray current may accelerate corrosion on guy anchors of communication towers and electric transmission towers which could lead to reduced service life or catastrophic failure.

In this paper, stray current corrosion risk for galvanized guy anchors is discussed in detail. Identification by structure-to-soil potential measurements is discussed. Stray current case studies are presented. Overall, this paper demonstrates that while stray current corrosion is a significant risk for guyed telecommunication and electric power structures, it can be detected and mitigated. This paper is an overview of the commonly accepted practices of stray current detection and mitigation used today.

Key words: stray current, guyed anchors, soil corrosivity, predictive modeling, cathodic protection, coating assessment, corrosive environment, corrosion resistance, scanning electron microscopy (SEM), and energy dispersive spectroscopy (EDS).

INTRODUCTION

Stray currents are the result of the leakage of current from some electrical system where a fraction of such current in its path through earth may encounter a metallic structure, for instance, pipelines, anchor shafts from telecommunication towers or buried storage tanks. Under these circumstances there is an opportunity for current to enter and leave the structure; at the points where the discharge occurs and anodic condition exists with the consequent corrosion of the structure[1], which can be evidentiated as pitting on the surfaces.

Stray currents, or interference, can be classified as being either static or dynamic. Static interference currents are those that maintain constant amplitude and constant paths (e.g., high-voltage DC transmission, High Voltage

Direct Current (HVDC), ground electrodes, and cathodic protection system rectifiers. Due to its steady state external DC voltage source on the metallic structure exist fixed anodic and cathodic areas.[2]

Dynamic interference currents are those that are continually varying in amplitude and/or continually changing their electrolyte paths. This type of interference can be manmade (e.g., DC welding equipment, railway systems, chloride plants) or also can be caused by natural phenomena; for instance, space weather events which are strong electrical currents driven along the earth surface during auroral events that can disrupt electric power grids and contribute to the corrosion of oil and gas pipelines. Dynamic stray currents can cause changes in current pickup and discharge areas on a structure which promote changes in the location of anodic and cathodic areas.

<u>Detection of Stray Current - General</u>

Detection and confirmation of static stray currents on pipelines is a straight-forward process and is well understood and regularly practiced by pipeline maintenance professionals. A summary of the procedure is as follows:

1. Detection typically starts when abnormal pipe-to-soil measurements are collected during annual test point surveys or during close-interval potential (CIP) surveys. Pipe-to-soil measurements that raise concern with operators are typically those that are abnormally electropositive.
2. Potential sources of stray current are identified. Common sources include foreign impressed current cathodic protection (ICCP) systems, DC light rail, welding operations, DC power transmission systems, and other DC electrical systems.
3. A CIP survey is performed in the suspected area of influence while interrupting the target pipeline's cathodic protection (CP) system. Some pipelines are protected by direct-connected sacrificial anodes, which makes current interruption unfeasible.
4. The CIP survey is repeated while interrupting the suspected source(s) of stray current. This step is most commonly performed when the offending current source is a foreign cathodic protection system.
5. The CIP survey is performed a third time with the target and foreign CP systems synchronously interrupting.
6. Data are evaluated to determine the area of stray current influence and the severity of influence.

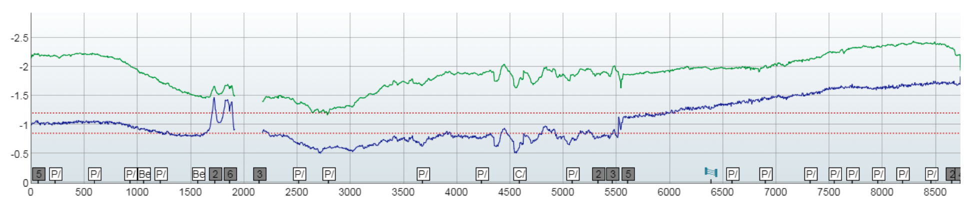

Figure 1A: CIP Survey Graph (Pipe-to-soil, V_{CSE} vs. Length [ft]) – Target Line ICCP Systems Interrupting.

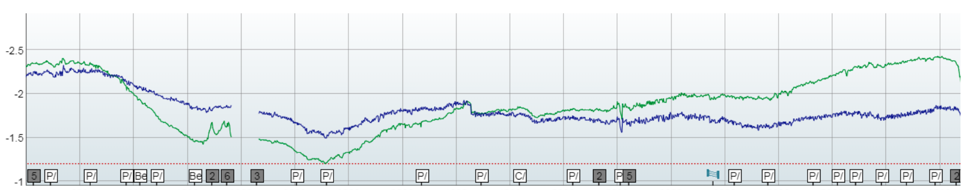

Figure 1B: CIP Survey Graph (Pipe-to-soil, V_{CSE} vs. Length [ft]) – Foreign Line ICCP Systems Interrupting.

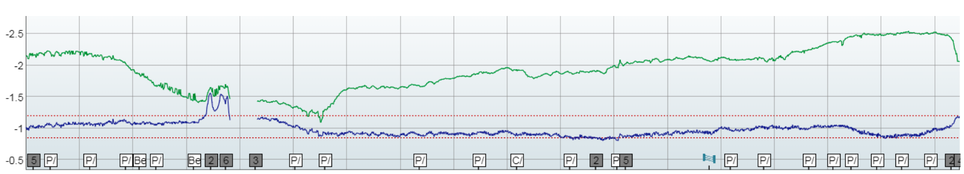

Figure 1C: CIP Survey Graph (Pipe-to-soil, V_{CSE} vs. Length [ft])– Target and Foreign ICCP Systems Synchronously Interrupting.

As shown in Figure 1A, the target ICCP system Off potentials (denoted by the blue line) are more electropositive than -0.850 V_{CSE}. Foreign pipelines cross the target pipeline near footage mark 1,750. The operator suspected stray current.

Figure 1B shows an area where the foreign rectifier On potentials (denoted by the red line) are more electronegative than the Off potentials (denoted by the blue line). The inverted potentials denote the area of detrimental influence.

Figure 1C shows the resulting potentials with both the target and foreign ICCP systems synchronously interrupting. In this example, the problem was already known and magnesium anodes had already been installed as denoted by the upward spikes between footage 1,500 and 2,000. Synchronous interruption of all current sources will indicate whether stray current mitigation is required.

Dynamic stray currents are more difficult to detect as they may not be present during periodic testing, and therefore may not be detected. When dynamic stray currents are typically evaluated using continuous data logging of structure-to-soil potentials over an extended period. Figure 2 shows an example dynamic stray current monitoring. The three-hour electropositive shift shown in the graph was caused by a dynamic stray current source.

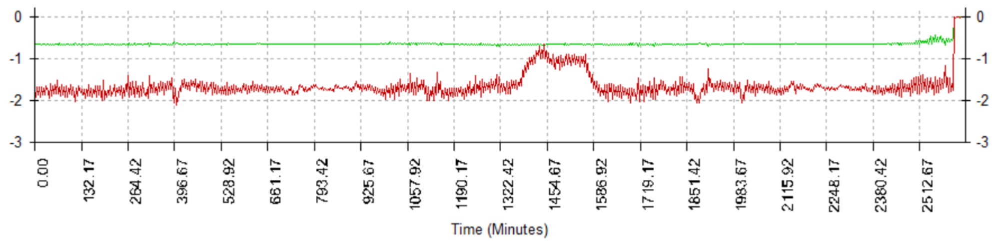

Figure 2: Dynamic Stray Current Monitoring on Pipeline.

Detection of Stray Current on Guy Anchors

Many guyed telecommunication towers and guyed power transmission towers utilize partially-buried galvanized steel guy anchors. The buried portions of the guy anchors are susceptible to stray current pickup and discharge like any other buried metal structure.

Anchor-to-soil potential measurements can be used to identify stray current pickup and discharge. For guyed telecommunication towers, potential measurements should be taken at the daylight point of the anchor (i.e. where the anchor penetrate the ground) and at other points around the anchor as shown in Figure 3.

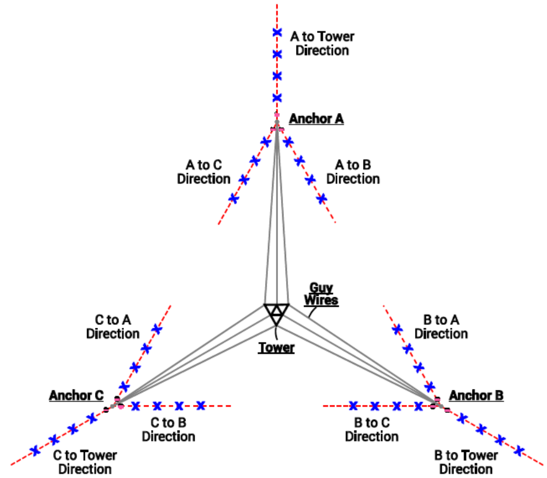

Figure 3: Diagram showing the locations where potential values must be collected at each anchor footing. Measurements must be performed at three different directions. Circle and cross signs indicate the location of reference electrode.

Potential measurements should be compared to identify possible stray current. For example, potentials at anchor A may be in the range of -1.000 V_{CSE} which is common for buried galvanized steel. The potentials near anchor B may be in the range of -2.500 V_{CSE} which may suggest stray current pickup. The potentials around anchor C may be in the range of +0.500 V_{CSE} which would suggest stray current discharge. The next step would be to search for current sources to determine the cause of variance in the anchor-to-soil potentials.

Electric transmission guy anchors may be evaluated in the same manner. It is important to note that while most telecommunication towers occupy a limited and isolated footprint, electric transmission towers may be electrically continuous to adjacent towers through their shield wires. This continuity will allow for stray currents to be picked up at one tower and discharged at another. Therefore, anchor-to-soil potentials should be compared between towers for entire circuits and not just between anchors of an individual tower.

CASE HISTORY 1: STRAY CURRENT CORROSION OF GUY ANCHORS, RIPLEY, WV

SUMMARY

A guyed telecommunication tower near Ripley, WV was evaluated for below-grade guy anchor corrosion risk. One of the tests performed was anchor-to-soil potential measurements. Significantly different potential measurements were obtained, prompting a stray current investigation. A brief survey of the surrounding area revealed an impressed current cathodic protection system and gas gathering lines. The anchors closest to the ICCP system and farthest from the system were excavated. Those farthest from the system, which exhibited the most electropositive potentials, exhibited severe corrosion damage. Those closest to the ICCP exhibited little corrosion.

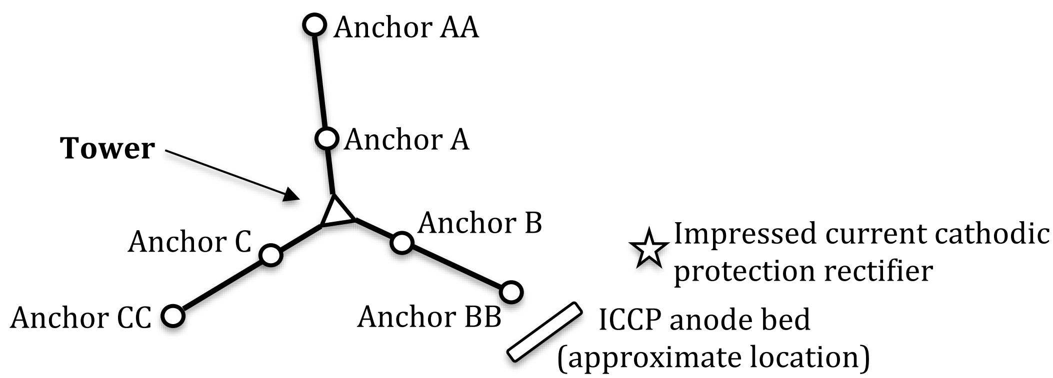

Figure 4: Diagram of guyed telecommunication tower, guy anchors, and nearby impressed current cathodic protection system. Drawing approximately to scale with ~300 feet between the tower and outer anchors.

Anchor-to-Soil Potential Testing

Anchor-to-soil potential testing was performed at each anchor. Testing was performed using a saturated copper-copper sulfate electrode (CSE) and high-impedance voltmeter. Potentials were measured with the electrode in contact with the ground over the anchor at the point of daylight and at five other points over the anchor. Test results are shown in Table 1.

The difference in potentials between anchors prompted a search for sources of stray current. A quick survey of the surrounding area revealed an impressed current cathodic protection rectifier. The owner of the rectifier revealed the approximate location of the shallow anode bed associated with the rectifier. The anode bed was near anchor BB. This was consistent with the high electronegative potentials measured on anchor BB.

Table 1
Anchor-to-Soil Potentials – Guyed Telecommunication Tower, Ripley, WV.

	Anchor-to-Soil Potentials (V_{CSE})					
Distance from point of daylight (ft)	**A**	**AA**	**B**	**BB**	**C**	**CC**
0	-0.088	-0.051	-0.578	-3.870	0.007	0.298
2	-0.127	-0.066	-0.594	-4.356	0.002	0.163
4	-0.047	-0.003	-0.606	-4.329	0.049	0.330
6	-0.027	0.039	-0.615	-4.330	0.068	0.350
8	-0.026	0.058	-0.580	-4.588	0.083	0.386
10	-0.027	0.076	-0.580	-4.957	0.091	0.386

Confirmatory Excavation

Confirmatory excavations were performed on anchors B and AA. Anchor CC was suspected of having the worst corrosion damage based on the potential measurements, however, anchor AA was excavated first because of site access issues. Anchor B exhibited loss of galvanizing and minor corrosion of the steel substrate as shown in Figure 5. These findings were consistent with the anchor-to-soil potentials which are in a normal range for steel in soil.

Figure 5: Single round shaft of anchor B. Galvanizing loss and minor surface corrosion below ground.

Anchor AA exhibited 60% cross-sectional corrosion loss on one of the two anchor shafts as shown in Figure 6. This finding was also consistent with the electropositive potentials measured at this anchor. Recommendations were made for temporary securement and excavation of the remaining anchors.

Figure 6: Dual round shafts of anchor AA. Maximum cross-sectional loss of 60% was measured on one of the two anchor shafts. Both shafts exhibited severe corrosion damage.

SUMMARY OF FINDINGS OF CASE STUDY 1

All anchors were excavated and replaced with concrete-encased anchors. Recommendations were made for stray current mitigation, including installation of magnesium anodes at the anchors affected by stray current corrosion because stray current affect concrete-encased steel as well as buried steel.

CASE HISTORY 2: STRAY CURRENT CORROSION OF GUYED ANCHORS, MOUNDSVILLE, WV

INTRODUCTION

This section describes the investigation of three (3) buried guyed anchors of a 345 feet (105.17 m) guyed telecommunication tower located at Moundsville, WV. The tower was installed in February 2010. The nominal diameter of the guyed anchor B above ground is 1.4575 inch (3.70 cm) and the nominal diameter of the guyed anchor C above ground is 1.4630 inch (3.72 cm).

As part of the investigation (1) visual examination, (2) galvanized shaft coating thickness measurements, (3) galvanized shaft diameter measurements. (4) potential measurements and (5) soil analysis was performed. These efforts are described in the following sections.

Visual examination, coating thickness and diameter measurements

The telecommunication tower considered for inspection is shown in Figure 7. A common design for anchor foundations in guyed telecommunication towers is schematically shown in Figure 8. Atmospheric and underground corrosion occur respectively at above-grade and below-grade sections of anchor foundations; however, the risk of structural failure is mostly associated with below-grade corrosion at buried sections, sometimes assisted by mechanical and microbiological actions, depending upon the nature of service environment. Common scenarios for structural corrosion in anchor shafts are shown in Figure 9.

Figure 7: Photograph showing the telecommunication tower considered for stray current corrosion survey.

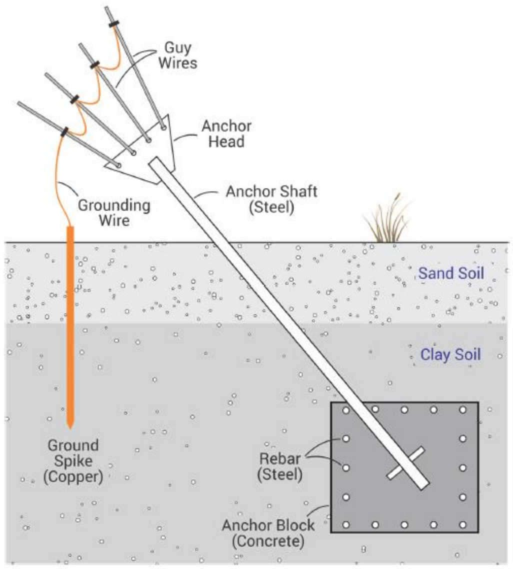

Figure 8: Schematic of a common design for anchor foundations in guyed telecommunication towers.

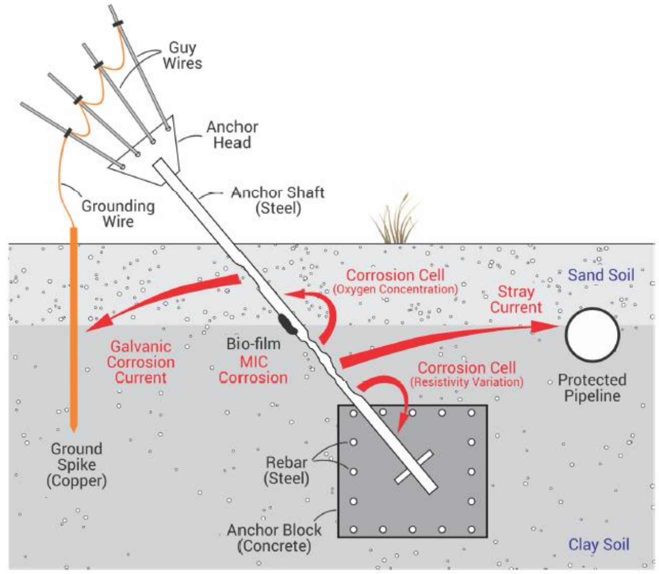

Figure 9: Different forms of corrosion at anchor shafts.

After digging, visual examination was performed on the buried guyed anchors up to 3 feet below ground level. Visual examination has revealed that anchor A is not corroded. However, visual examination of anchors B and C revealed that galvanized layer is almost consumed, and corrosion was observed on the anchors (Figures 10 and 11). Shallow pitting was observed on anchors B and C. Corrosion increased with the increase in the depth from the ground level.

Figure 10: Photograph showing corroded anchor B.

Figure 11: Photograph showing corroded anchor C.

Table 2 shows the shaft diameter values up to 3 feet from the ground level. From the table, it can be seen that reduction in the diameter of anchor B is 0.41% and in the anchor C is 0.55%.

Table 2
Shaft Diameter Values (inches)

Anchor	Shape	Above-grade	Minimum below-grade / Thickness Loss (%)					
			1/2 ft.	1 ft.	1.5 ft.	2 ft.	2.5 ft.	3 ft.
B	Rod	1.4575	1.4625	1.4515	1.4520	1.4535	1.4670	1.4585
			-0.34%	0.41%	0.38%	0.27%	-0.65%	-0.07%
C	Rod	1.4630	1.4560	1.4550	1.4685	1.4560	1.4585	1.4575
			0.48%	0.55%	-0.38%	0.48%	0.31%	0.38%

Table 3
Shaft Galvanized Thickness Values (mils)

Anchor	Above-grade	Below-grade					
		1/2 ft.	1 ft.	1.5 ft.	2 ft.	2.5 ft.	3 ft.
B	8.8	7.8	6.0	5.1	2.4	2.9	0.65
C	8.5	0.45	2.6	1.95	5.0	3.2	1.35

Table 3 shows the galvanized thickness values up to 3 feet from the ground level. The nominal galvanized thickness value of the guyed anchor B above ground is 8.8 mils (223.52 microns) and the nominal galvanized thickness value of the guyed anchor C above ground is 8.5 mils (215.9 microns). From the table, it can be seen that galvanized thickness layer has reduced with the increase in the depth from the ground level.

Soil analysis

Soil samples at a depth of 3 feet were collected from anchors B and C. Table 4 shows lab analysis results for soil corrosivity. There are several techniques for measuring soil resistivity. A common method is described in ASTM [(1)] G57.[3] Analysis of soil samples revealed that the soils are corrosive and acidic i.e., pH of the soil from Anchor B is 4.34 and the pH of the soil from Anchor C is 4.53. Corrosion rate data was measured using Linear Polarization Resistance (LPR). Corrosion rate of 1.59 mpy (mils per year) was measured for water saturated soil sample collected from Anchor B and corrosion rate of 2.10 mpy was measured for water saturated soil sample collected from Anchor C.

Table 4
Lab Analysis Results for Soil Corrosivity

Location	Anchor B	Anchor C
Instantaneous Corrosion Rate (mpy)	1.59	2.10
Redox Potential (mV-SHE)	642.4	673.7
As received resistivity (Ω-cm)	34550	12800
Saturated Resistivity (Ω-cm)	20920	12510
pH	4.34	4.53
As received Moisture (%)	23	18
Chloride (ppm)	2.37	1.41
Sulfate (ppm)	87	16
Sulfide (ppm)	0.21	0.04

[(1)] ASTM International, 100 Barr Harbor Dr., West Conshohocken, PA

Corrosion Rate Prediction

Corrosion rate prediction of anchors B and C inspected at this site is shown in Figure 12. At the beginning, the corrosion rate is high because of the absence of a protective layer on the surface, however, the corrosion rate decreases after a few years as a protective oxide layer forms on the surface and stabilizes. This in-situ formed layer will provide a barrier against diffusion of oxygen and moisture moving towards the fresh steel surface.

Our experience in the field indicates the predicted corrosion rates from this model are in good correlation with field observations. The concrete at this tower base showed a compressive strength of over 3300 PSI. This value indicates there is no significant degradation of concrete foundation at this time.

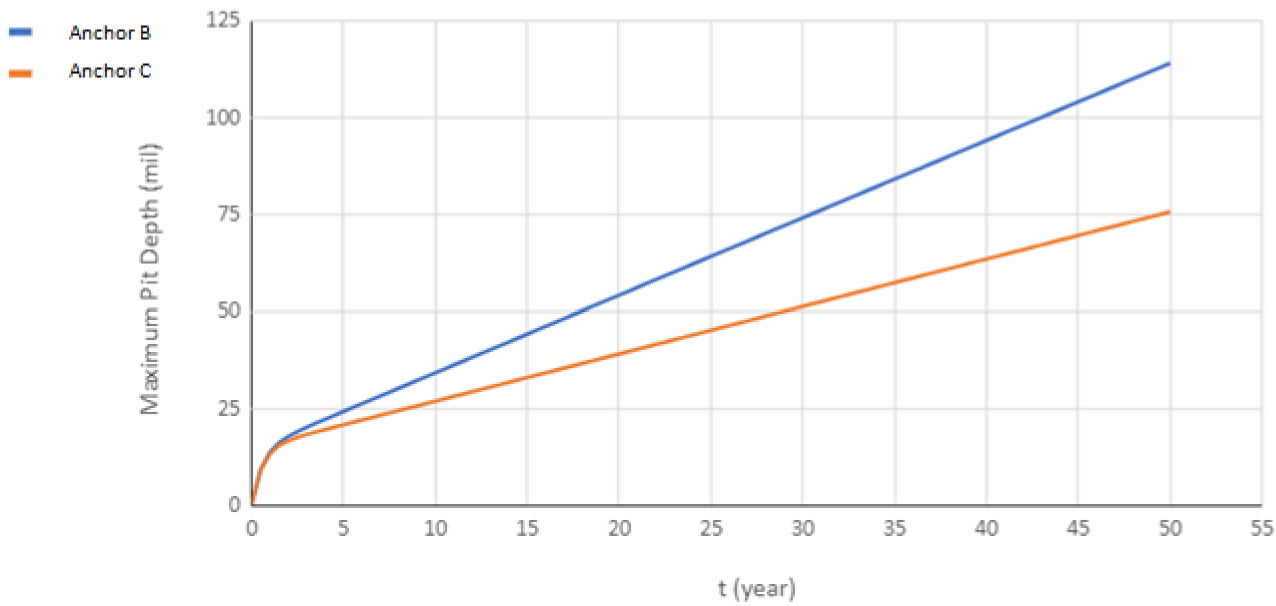

Figure 12: Plot showing corrosion rate prediction of anchors B and C.

Potential measurements

A close-interval survey (CIS) was conducted to map electrochemical potentials (structure-to-soil potentials) at anchor footings. A saturated copper-copper sulfate reference electrode (CSE) and a high-impedance multimeter were used for potential mapping. At each anchor footing, several potential values were collected at grade level. Measurements were conducted at three different directions at each direction. The measured values are listed in Tables 5, 6 and 7.

1. CIS revealed that the potentials around the anchor A is stable and in the range -446 to -494 mV_{CSE}.
2. Potential reads around the anchor B is fluctuating and in the range -468 to -1120 mV_{CSE}. High electronegative potential read (-1120 mV_{CSE}) was observed at a distance of 20 feet (B – A direction) from the anchor B.
3. Potential reads around the anchor C is fluctuating heavily and in the range +437 to -1717 mV_{CSE}. High electronegative potential read (-1717 mV_{CSE}) was observed at a distance of 25 feet (C – A direction) from the anchor C. High electropositive potential read (+437 mV_{CSE}) was observed at a distance of 30 feet (C – A direction) from the anchor C.

Note: In Tables 5, 6 and 7, readings in red text are abnormal values and the readings in black text are normal/typical values.

Table 5
Anchor-to-Soil Potential Values (mV$_{CSE}$) of Anchor A

Direction	Distance						
	0.5 ft.	5 ft.	10 ft.	15 ft.	20 ft.	25 ft.	30 ft.
A – B	-484	-460	-460	-450	-448	-452	-450
A – C	-494	-466	-454	-455	-450	-447	-451
Tower – A	-479	-466	-453	-453	-454	-446	-452

Table 6
Anchor-to-Soil Potential Values (mV$_{CSE}$) of Anchor B

Direction	Distance						
	0.5 ft.	5 ft.	10 ft.	15 ft.	20 ft.	25 ft.	30 ft.
B – A	-503	-510	-563	-622	-1120	-838	-763
B – C	-468	-537	-525	-570	-660	-622	-704
Tower – B	-481	-588	-569	-589	-596	-636	-638

Table 7
Anchor-to-Soil Potential Values (mV$_{CSE}$) of Anchor C

Direction	Distance						
	0.5 ft.	5 ft.	10 ft.	15 ft.	20 ft.	25 ft.	30 ft.
C – A	-511	-535	-609	-614	-877	-759	-782
C – B	-468	-690	-687	-894	-1527	-1717	+437
Tower – C	-532	-551	-579	-510	-564	-521	-492

MITIGATION MEASURES FOR STRAY CURRENT

The following procedure is recommended for the mitigation of corrosion due to stray current interference on guyed towers. Stray current can have several sources. The most important of these is currents due to cathodic protection systems, installed on nearby assets.

Identifying Stray Current Interference

Firstly, it is important to establish that stray current affecting a particular site. Indications: 1) Proximity to industrial or municipal assets, 2) Inconsistent, and repeatably inconsistent, potential readings at different locations, 3) Anomalously electropositive or electronegative potential readings, 4) Rapidly time-varying potentials (can be identified at the time of CP system reading), 5) Slowly, or occasionally, time-varying potentials (use a data logger for confirmation), 6) Electrochemical Potential Surveys show a potential gradient, indicating large IR field, and 7) Excessive localized corrosion loss, with low buildup of corrosion product.

Mitigation of Stray Current Interference

In general, there are three measures that can be taken to mitigate the effects of stray current on a structure. Bear in mind that the stray current could originate from assets owned by third party entities. In order of increasing involvement with the other entity, we can:

- Install “drain” anodes to provide safe, controlled, points at which the stray current can exit (and enter) the structure
- Barriers can be constructed to physically interrupt the stray current path
- Bonding

Table 8
Potential Reads After CP Installation

Direction	Distance					
	0.5 ft.	2 ft.	4 ft.	6 ft.	8 ft.	10 ft.
A – B	-972	-946	-909	-860	-813	-765
A – C	-966	-924	-871	-818	-787	-756
Tower – A	-982	-1002	-1045	-1082	-1073	-913
B – A	-894	-826	-746	-696	-640	-606
B – C	-916	-833	-722	-680	-616	-579
Tower – B	-934	-990	-980	-878	-705	-585
C – A	-892	-875	-834	-790	-740	-698
C – B	-893	-868	-858	-821	-768	-731
Tower – C	-894	-884	-871	-839	-796	-745

Galvanic cathodic protection (CP) systems with 17 pound high-potential magnesium anodes are designed, installed, and tested at anchor footings of the tower. According to the NACE SP0169-2013,[4] to assess the performance of cathodic protection systems the following criteria was used:

- Potential criterion: -850 mV vs. saturated copper-copper sulfate reference electrode.
- Polarization criterion: -100 mV cathodic polarization shift with respect to native potential.

From Table 8, it is evident that potential reads after CP installation satisfied 100mV shift NACE CP criteria.

SUMMARY OF FINDINGS OF CASE STUDY 2

From the CIS, it is evident that stray current is present on Anchors B and C. The possible source of stray current could be electrical housing at the base of the two towers. Moreover, client informed about the possibility of presence of coal mines under the soil at the anchors B & C.

The installed CP systems eliminate the risk of stray current corrosion at anchor shafts and protect the shafts against corrosive soil environment.

CASE HISTORY 3: STRAY CURRENT CORROSION OF UNDERGROUND PIPELINE

INTRODUCTION

A polypropylene jacketed coated pipe with extensive localized corrosion, including through-wall perforation, was examined for determination of primary cause of the leak and corrosion perforation. Corrosion was found on the external surface of the coated pipe where the coating was delaminated and mechanically damaged. The pipe was leaking from a small corrosion anomaly, approximately 1 inch diameter, at approximately 4 o'clock position on the pipeline. With the exception the area around the leak, there was no deep corrosion on the pipe elsewhere at other mechanically damaged areas of the jacket coating. There was no evidence of internal corrosion.

A laboratory failure analysis of the perforated pipe was performed to determine the presence or absence of stray current. The corroded pipe along with soil samples surrounding the pipe were tested.

LABORATORY INVESTIGATION

Figure 13 shows the as-received perforated pipe. Delaminated polypropylene jacketed coating is shown in Figure 14. The corrosion attack of the pipe is highly localized. No other part of the pipe exhibited this extent of corrosion attack. The laboratory investigation also included Fourier transformer infrared (FTIR) analysis, scanning electron microscope (SEM) equipped with an elemental dispersive spectroscopy system (EDS) and X-ray diffraction (XRD), detailed as follows.

Figure 13: Photograph showing as-received perforated pipe sample.

Figure 14: Photograph of the plastic extruded coating separated from the pipe.

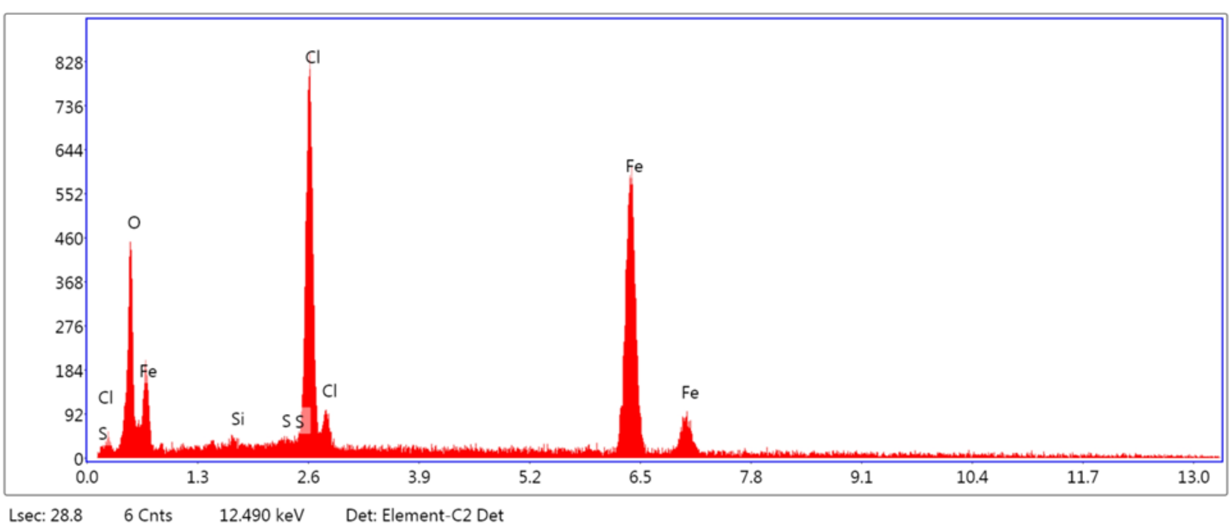

Figure 15: SEM/EDS analysis showing extremely high concentrations of chloride containing compounds in corrosion products.

SEM/EDS Analysis

EDS analysis is used to perform elemental analysis of the corrosion products. Using this analytical technique the corrosion product samples taken from the perforated area of the pipe were examined. Extremely high concentrations of chloride containing compounds were detected in corrosion products (Figure 15).

X-Ray Diffraction

The same corrosion products deposits were tested by X-ray diffraction. X-ray diffraction testing determines crystal structure and phase identification. Testing revealed high concentration of chloride and carbonate compounds in corrosion products. This confirmed that a high concentration of negative ions were present in the discharged area where perforation has taken place.

Soil analysis

The soil samples were tested for corrosivity and corrosion rate against carbon steel probes. The corrosion rate is reported as mils per year (mpy) quantifying the mass removal in saturated condition of the soil. Table 9 exhibits the test results. The soil samples are mildly corrosive and do not contain high concentrations of corrosive ions. Soil resistivity also indicates a moderately corrosive soil.

Table 9
Lab Analysis Results For Soil Corrosivity

	Sample ID	As Received Resistivity Ω-cm	Saturated Resistivity Ω-cm	LPR mpy	Sulfates ppm	Chlorides ppm	pH	Moisture %	Redox mV	Sulfides
1	North - Right 9 1/2'	60,560	6,550	2.09	16	37.4	6.72	2	400.0	< 0.04
2	North - Left 9 1/2'	57,220	6,700	1.33	0	56.9	7.42	2	420.0	< 0.04
3	North - Left 9 1/2' 2	5,864	4,359	4.77	35	57.1	7.81	13	411.2	< 0.04
4	East 6'	19,350	6,501	2.9	15	59.7	7.36	12	389.0	< 0.04
5	East 2'	16,350	6,612	2.36	18	34.9	6.89	17	405.3	< 0.04
6	Failure Pit 10 1/2'	6,258	6,497	2.31	16	7.69	7.08	20	391.4	< 0.04
7	Failure Pit 11'	6,032	4,400	3.72	52	73.5	7.14	13	377.3	0.17
8	Failure Pit 10'	43,780	6,440	2.4	56	29.1	7.18	3	404.0	< 0.04

OBSERVATIONS FROM FIELD TESTING

The perforation of one of the polypropylene jacketed coated pipes resulted in a leak. There was no indication of corrosion on the other sections of the coated pipes. The coated pipes were intended to be electrically isolated from the station’s ground grid, and “floating” under native potential, but were instead electrically continuous with the ground grid. The ground at the substation was also used as an anode bed for impressed current cathodic protection system of a nearby pipeline. A potential survey indicated that the yellow jacketed pipes were in electrical continuity with the ground grid and were acting as an extension of the anode bed for the nearby pipeline. The protected pipeline under cathodic protection met the -850 mV_{CSE} NACE CP criteria and all other piping was not being protected. Additionally, the potentials indicated the presence of galvanic action and galvanic corrosion risk.

EVIDENCE FOR STRAY CURRENT CORROSION AS THE PRIMARY CORROSION MECHANISM INCLUDES:

- Extensive chloride containing compounds were found on the surface in the perforated area. This is an indication of negative ion transfer due to positive charge on the anodic area.
- Chlorides and carbonates are attracted to the anodic area due to negative charge and concentrate.
- These corrosion products require high energy and would not form under normal conditions in soil environments.
- Chloride migration and concentration on to the pipe surface in the mechanically damaged area is a known occurrence due to charge attraction.
- Electrochemical potentials indicated noble potentials at discharge area.

Based on the above, it is reasonable to conclude that the stray current corrosion resulted in accelerated localized corrosion of the polypropylene jacketed coated pipe in a rather short time.

SUMMARY OF FINDINGS OF CASE STUDY 3

The polypropylene jacketed coated pipe corroded due to stray currents. Stray current interference on a pipeline can cause severe localized corrosion that could lead to a hazardous situation, product leakage and costly repairs. Therefore, every effort should be made to avoid interference problems and, if they exist, to mitigate their effects. Stray current control at the source is the best method of stray current mitigation. The stray current corrosion is due to faulty cathodic protection design. Sacrificial anodes can also be used to mitigate stray currents.

CONCLUSION

Even in the presence of best coating system, stray current from external sources can still result in accelerated corrosion in a rather short time. Stray current corrosion is the result of electrical interference, protection currents follow through paths other than the intended circuit. The extent of corrosion damage and loss in thickness is directly proportional to the magnitude of stray current. This type of corrosion is localized in coated structures and takes place at discharge points such as pinholes and mechanically damaged areas. Stray current corrosion can be prevented by eliminating the source, shielding or cathodic protection. The following steps can be followed to identify and mitigate stray current corrosion:

- Perform potential measurements at guy anchors or pipeline locations
- If CP present, perform “Instant Off “ measurements
- Perform current measurements at different locations
- Determine discharge location and perform directional potential measurements
- Install auxiliary anode and measure current if stray current present
- Turn off the possible source and do the same for each

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