Analysis and Comparison of *In-Situ* Corrosion Rate Measurements with Co-Located Analytical Soil Corrosivity Parameters Along Buried Pipelines at Nuclear Power Facilities

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INTRODUCTION

The RSCS and CorrTech technical team has been implementing soil corrosivity, in-situ corrosion rate and electrical potential monitoring assessments at nuclear power facilities since 2013. These assessments have involved the collection of soil samples from the subsurface for industry standard analytical corrosivity analysis followed by installation of a permanent direct bury instrumentation, known as a Smart Stack where the soil sample was collected in the subsurface proximal to site structures of interest.

Soil corrosivity assessments paired with co-located Smart Stack monitoring has been implemented at 5 geographically, and geologically unique sites between 2013 and 2017 totalling 45 assessment locations with sufficient data sets (more locations pending). The data set includes more than 450 analytical results and more than 225 individual Smart Stack readings.

The analysis and comparison of empirical corrosion rates with soil corrosivity results at nuclear power facilities do not agree with industry guidance. These findings suggests that the system arrangement and subsurface environment at nuclear power facilities presents a unique condition that does not apply to current industry guidance. As a result soil corrosivity assessments performed along buried pipelines at nuclear power facilities may under predict, or over predict outside diameter corrosion rates of buried pipes and tanks. Incorrect system life projections could result in incorrect maintenance projections, license renewal delays and incorrect cost projections in plant extended periods of operation.

Background

The Smart Stack is a sonde of several instruments including electrical resistance (ER) probes, to measure in-situ corrosion rates, and coupons connected to a reference [half] cell to measure electrical potentials at structure depth. Each Smart Stack includes a structure bonded and native coupon and ER probe to simulate potentials and corrosion rates of similar size pipe or tank coating holidays.

Structure bonded and native corrosion rates are derived by trending changes in ER probe resistance over time, which is correlated to metal loss per unit time. To derive an accurate mean empirical corrosion rate, ER probes must be trended over a period sufficient to establish a statistical trend, which typically takes months.

Soil corrosivity assessments include analytical analysis of specific anions, cations, pH, Oxygen Reduction Potential (ORP) soil resistivity and soil particle size [1]. Evaluation of these parameters is generally perfomred to qualitatively assess the corrosivity of the buried pipe or tank environment using a relative point scoring method applied to each parameter [2]. The scoring of these parameters can be compared to a corrosivity index used for risk ranking and aging asset managemewnt [3]. Recent guidance has been issued that attempts to provide interim quanititative estimates of pitting and general corrosion rates for several soil corrosivity parameters including aeration (ORP), pH, and soil particle size fraction [3].

RESULTS

The results of this study show that there is no strong correlation between soil corrosivity parameters and co-located empirical corrosion rates in buried pipe environments at nuclear power facilities.

Soil resistivity is generally the most common soil parameter utilized to evaluate the corrosivity of soils in proximity to buried pipelines. Soil resistivity is most sensitive to soil particle size and mineralogy which controls the arrangement and abundance of soil pore water, and the type and abundance of ions in soil pore water solution.

Our evaluation demonstrated that there is a correlation between total ion abundance and soil resistivity i.e. as total ion abundance increases soil resistivity decreases (Figure 1), however the study results did not show a correlation between total ion abundance (Figure 2 or soil resistivity (Figure 3), which would be expected according to industry guidance [3].

The overall results of this study suggest that the dense, mixed metal buried pipe networks at Nuclear power facilities, which are typically bonded to the site copper grounding grid, creates a unique environment where atypical parameters and processes are controlling outside diameter corrosion rates. Further study will investigate galvanic corrosion processes, interferences resulting from cathodic protection systems and enhanced corrosion rates as a result of elevated pipe/soil temperatures.

References

[1] Electrical Power Research Institute, "Balance of Plant Corrosion - The Buried Pipe Reference Guide (Section 8: Soil Analysis)," 2010.

[2] American Water Works Association (AWWA), "ANSI/AWWA C105/A21.5-10 - Polyethylene Encasement fo Ductile-Iron Pipe Systems, APPENDIX A Table A.1 Soil Test Evaluation," June 2010.

[3] Electric Power Research Institute, "Interim Guidelines for Determining the Corrosion Rate for Use in Fitness for Service Evaluations of Buried Pipe, Report No. 3002003057," EPRI, Palo Alto, CA, December 2014.

[4] NACE International, "NACE SP0169-2007: Standard Practice: Control of External Corrosion on Underground or Submerged Metallic Piping Systems.," NACE International, Houston TX, 3/15/07.

[5] Nuclear Energy Institute, "NEI 09-14 Rev 3 - Guidline for the Management of Underground Piping and Tank Intergrity," Washington D.C. , April 2013.

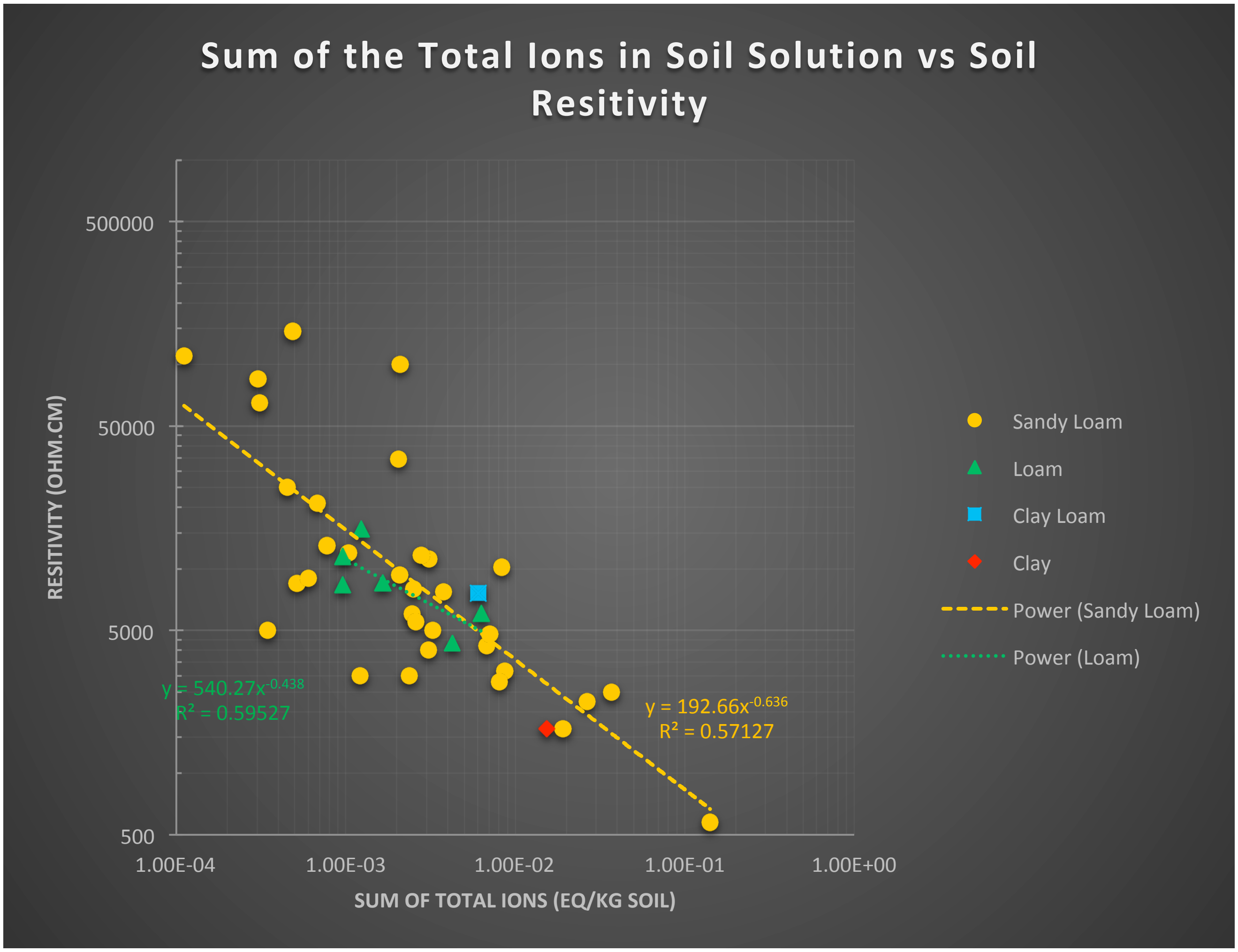

Figure 1: Sum of the total ions is soil pore water solution vs soil resistivity for different soil types described at nuclear power facilities within the study. The results show a correlation between total ions and resistivity; however soil resistivity and total ions did not correlate with empirical corrosion rates measured were soil samples were collected.

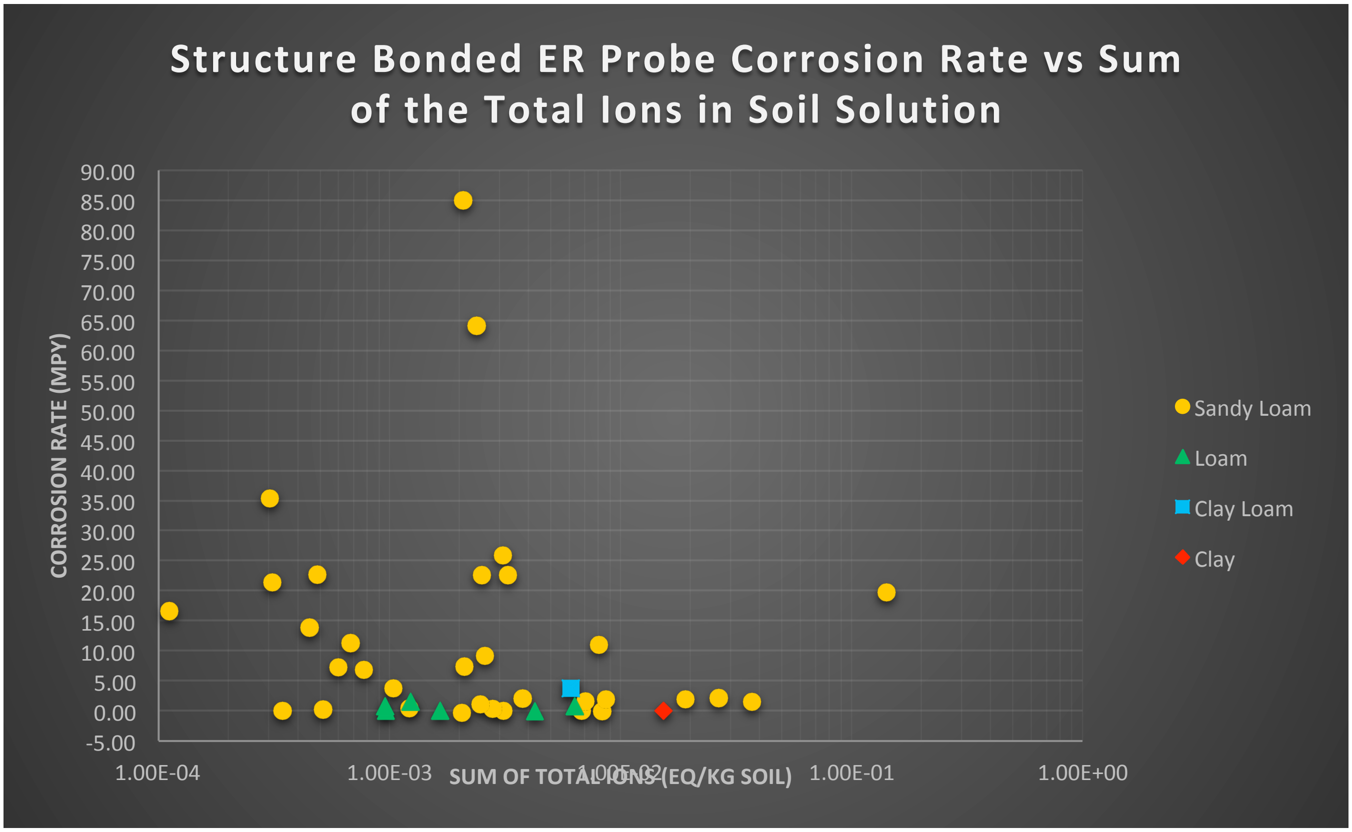

Figure 2: Co-located corrosion rates plotted as a function of total ions in soil pore water with soil particle size fraction shown. The distribution of results shows that there is no correlation between soil corrosion rate and total ions in solution.

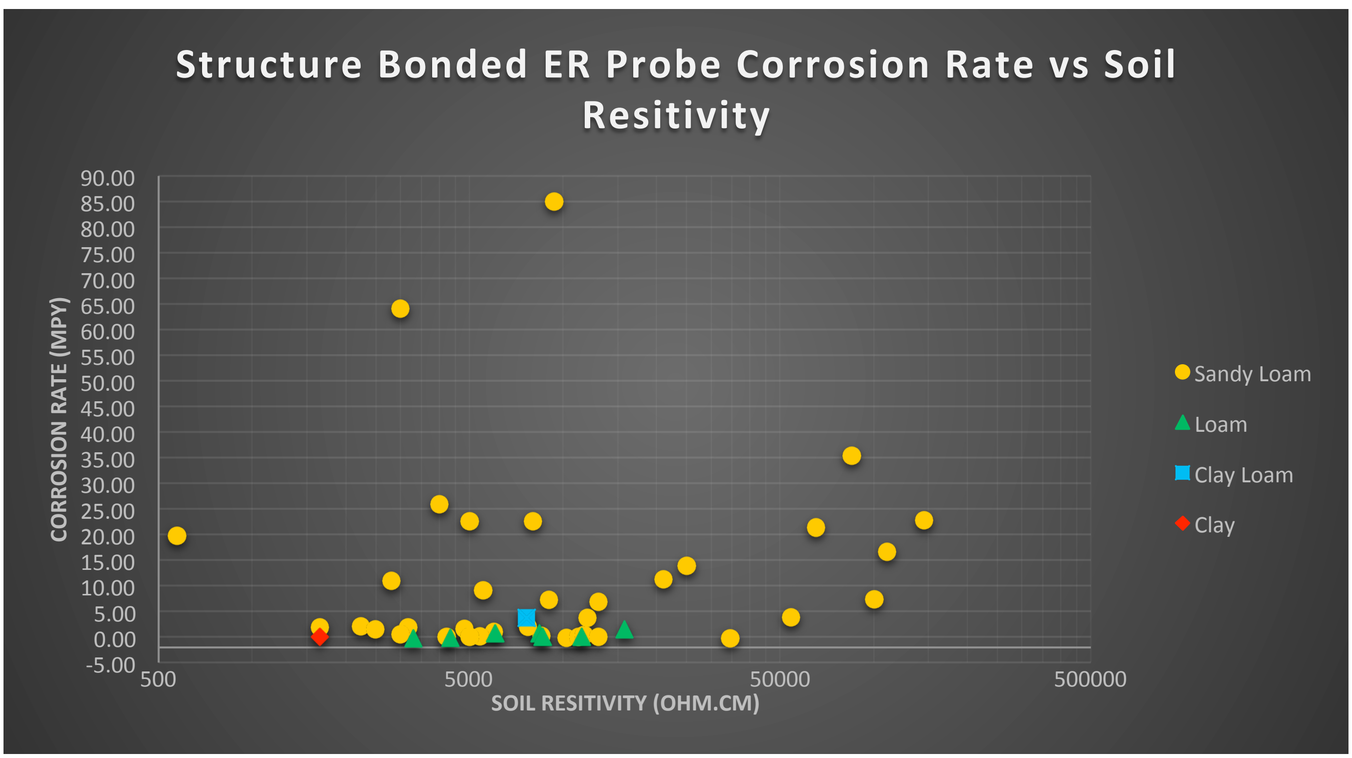

Figure 3: Co-located corrosion rates plotted as a function of soil resistivity with soil particle size fraction shown. The distribution of results shows that there is no correlation between soil corrosion rate and soil resistivity.