ELECTRIC POWER RESEARCH INSTITUTE

Cathodic Protection Design Specification Guidelines

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EPRI Project Manager

E. Sisk

This document does **NOT** meet the requirements of
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THE FOLLOWING ORGANIZATION, UNDER CONTRACT TO EPRI, PREPARED THIS REPORT:

Corrpro Companies, Inc.

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PRODUCT DESCRIPTION

This report covers the requirements for design, installation, maintenance, monitoring, and modifying or upgrading cathodic protection systems at nuclear generating stations. Although the primary focus of the report is buried piping, the guidance presented is also applicable to cathodic protection of other facilities within nuclear stations.

Background

The nuclear power industry has recognized the need to maximize the life of buried pipe and other buried assets within a nuclear station. This effort has been driven predominantly by safety and environmental considerations, including aspects related to service life extension and reliability associated with license renewal. Over the last several years, the Electric Power Research Institute (EPRI), the Institute of Nuclear Power Operations, and the U.S. Nuclear Regulatory Commission have worked closely with nuclear plant operators to establish benchmarking procedures and guidance on determining the current condition of the buried pipe assets.

As part of the buried pipe initiative, cathodic protection has been identified as an integral component for long-life corrosion control and regulatory compliance. Cathodic protection is a proven solution for controlling corrosion degradation of the external surfaces of buried piping. In a nuclear station, corrosion protection is particularly important because the consequences of corrosion-caused failures of safety-related and other critical piping can be high. Cathodic protection, in conjunction with protective coatings, represents the best long-term corrosion protection strategy.

Objectives

This report provides the basic framework for specifying outside contractor work for cathodic protection systems.

Approach

This report covers the following topics relating to cathodic protection:

- Designing a cathodic protection system, including the selection of a design consultant, detailed considerations, and deliverables
- Installing, modifying, or upgrading a cathodic protection system, including the selection of an installation contractor, considerations for performing this work inside a nuclear station, and as-built documentation
- Maintaining and monitoring a cathodic protection system, including the selection of a consultant or contractor, key components of the maintenance/monitoring program, and reporting and recordkeeping

Results

The information contained in this report is not a detailed instruction manual of cathodic protection means and methods, but rather a primer on key considerations. For more information, refer to the EPRI report *Cathodic Protection Application and Maintenance Guide* (1011905).

Applications, Value, and Use

This report is intended primarily for nuclear station engineering, design, and procurement personnel who manage the purchase, procurement, and installation of cathodic protection systems or who specify maintenance contracts for them.

Keywords

Buried pipe
Cathodic protection
Cathodic protection installation
Cathodic protection maintenance

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1 INTRODUCTION

This report covers requirements for design, installation, maintenance, monitoring, and modifying or upgrading cathodic protection systems.

This report is not a detailed “how to” manual of cathodic protection means and methods, but rather a primer on key considerations.

While the report focuses on buried piping at nuclear generating stations, it can also be used to address cathodic protection considerations in other areas of the plant and also for non-nuclear station facilities. The buried piping at nuclear stations and comparable facilities has adjacent buried electrical grounding conductors that are often electrically interconnected to the buried piping.

Cathodic protection is a proven solution for controlling corrosion degradation on the external surfaces of buried piping. In a nuclear station, corrosion protection is particularly important as the consequence of corrosion-caused failures of the safety related and other critical piping can be high. Typically, cathodic protection in conjunction with protective coatings represents the best long-term corrosion protection strategy.

Impressed current cathodic protection is most common for nuclear stations because of the relatively high cathodic protection current demand. Realizing the high current demand is generally not economically achievable using galvanic current (sacrificial anode) cathodic protection. Galvanic current cathodic protection would typically only be feasible for piping runs that are electrically isolated from interconnected structures and well coated. This is often not the case in nuclear stations.

This report is intended primarily for engineering, design, and procurement personnel at nuclear stations that have to manage the purchase, procurement, and installation of a cathodic protection system. The report also includes specifying a maintenance contract for a cathodic protection system.

Readers should have at least a basic understanding of cathodic protection principles and practices for buried pipe at a nuclear station. The reader should be cognizant that the issues associated with cathodic protection and other corrosion control facets in a nuclear station are markedly different from those associated with typical transmission and distribution piping systems in the petroleum, natural gas, and water industries.

2

DESIGNING A CATHODIC PROTECTION SYSTEM

2.1 Selecting a Design Consultant/Contractor

When selecting a consultant/contractor to design a cathodic protection system, it is critical that they possess and demonstrate technical expertise specific to nuclear generating stations or comparable complex industrial facilities.

2.1.1 Specifying and Evaluating the Acceptability of Prospective Design Firms

- The CP system design should be applied under the direct supervision of a Registered Professional Engineer or persons recognized by the National Association of Corrosion Engineers (NACE) International as a Corrosion Specialist and/or a Cathodic Protection Specialist, if their professional activities include suitable experience in cathodic protection for buried piping at nuclear plants or other comparable facilities.
- All firms should demonstrate their proficiency by providing comparable, satisfactory project descriptions and contact references for at least three successfully completed projects within the last seven years, at least one of which is a nuclear station or other power generating station of comparable complexity.
- The project descriptions should demonstrate a practical design approach verified by post-installation acceptance test results consistent with design expectations.
- Lead personnel gathering the requisite pre-design field data should possess a NACE CP Level 3 or higher certification.
- The lead designer should demonstrate ample knowledge and application of related regulations, codes and industry standard practices and guidelines.
- The design firm should demonstrate a strong safety culture.
- A work plan and schedule should be included in the prospective design firms' proposal. The work plan should include:
  - The availability of ample staff resources to complete the design in the specified timeframe should be documented.
  - The lead designer should spend a minimum of two days on-site during the course of the pre-design field evaluation to obtain direct site-specific knowledge of conditions that can impact the design.
- The request for proposal for the cathodic protection design services should include specific metrics to be used as a basis for the design, for example, the minimum acceptable polarized (IR-free) structure-to-earth potential within 30 days after cathodic protection start-up and the minimum design life. The design basis should include:
  - A design life of at least 20 years is common for cathodic protection systems.
- The design firm also should be responsible for start-up of the cathodic protection system, including the collection and analysis of baseline data and hands-on training of plant personnel in periodic maintenance and monitoring procedures.

2.2 Analyses Performed to Determine the Design

2.2.1 Key Considerations

Useful site specific information for a CP system design includes the following:

- Risk analysis, including obtaining insight/feedback from plant operations staff on the level of corrosion protection required and the extent of structures to be protected.
  - Safety related piping vs. secondary structures
  - Piping location
  - Pipe accessibility for repairs
  - Operational criticality
  - Consequences of a corrosion-caused failure
  - Expected useful service life without cathodic protection
- Information from prior corrosion evaluations that may have been performed to include
  - Soil type
  - Soil chemistry
  - Electrolyte resistivity
  - Original design basis for corrosion control
- Knowledge of sub-surface geology
  - At pipe depth in native soils
  - At pipe depth in fill areas
  - "Deep" depth, relative to the possible use of deep anodes for impressed current cathodic protection and cathodic protection current distribution
  - Groundwater influence
    - Possible seasonal variations
    - Depth of groundwater
    - Salinity
- Piping/tank records (original construction and as-built)
  - Drawings
  - Materials of construction
  - Protective coatings information
  - Electrical grounding, including details on plant grounding system
  - Electrical continuity
  - Electrical isolation
- Piping/tank modification records
  - Basis for modification
  - Drawings and other details

- Buried pipe leak records
  - Location
  - Month/year
  - Pipe/tank involved
  - Root-cause analysis
  - Repair method
- Excavation/inspection records
  - Planned/required vs. opportunistic
  - Pipe and coating condition
  - Corrosion pitting and or other signs of corrosion degradation
  - Photo documentation
  - Whether corrosion monitoring test facilities were installed
- Planned upgrades
  - Existing pipe to be modified
  - Planned new pipe installations
  - Ground system additions/modifications
  - Timeframe for implementation
- Information regarding existing CP systems
  - As-built drawings of existing systems
  - Initial CP system design and current requirement data
  - CP system commissioning data
  - CP system annual survey reports
  - Operating and maintenance data
- Feasibility of electrical isolation from foreign structures
- AC power availability
- Cathodic protection construction logistics/limitations
  - Pipe access
  - Equipment restrictions – overhead clearance, weight, etc.
  - Underground structure identification and marking
  - Work days/hours
- O&M considerations
  - Use of in-house staff vs. outsourcing
  - Automation, for example, remote monitoring
  - Data management system/process

2.2.2 Field Evaluation

A pre-design field evaluation is essential and should include the following as a minimum:

- Soil corrosivity characterization, for example, resistivity (inverse of conductivity), moisture content, chloride concentration, pH, and possible contamination, including whether there are seasonal variations and other time-dependent variations.
  - Procedures for determining soil corrosivity include laboratory analysis of soil samples (borings). Field measurement of soil resistivity can be done using a single-point probe (for example, “Collin’s Rod” or “Shepherd’s Cane”), and or the Wenner 4-pin surface measurement technique described in ASTM G57.
  - Soil samples from borings should typically be collected at pipe depth, at a minimum. Variations in soil type or appearance that may exist at shallower depths might warrant the collection of additional samples.
  - Care should be taken during the soil sample collection process to avoid damage to underground structures. Special procedures should be employed if contaminated soils are a possibility.
  - Wenner 4-pin soil resistivity measurements can be influenced by underground structures in the vicinity of the measurement, the impact of which should be included in the analysis.
  - The installation of corrosion monitoring sites including coupon test stations, permanent reference electrodes and/or electrical resistance probes placed in the soil boring holes provides a low-cost means for future monitoring of the cathodic protection system performance.
- Electrical potentials – DC and AC potential measurements should be made at representative locations. A sufficient sampling and proper analysis of this data will help identify corrosion hot spots and the need for cathodic protection. .
- Electrical continuity – Electrical continuity between all structures to be cathodically protected is essential for effective corrosion control. Electrical continuity measurements should be performed in sufficient quantity to adequately characterize pipe electrical continuity and identify possible electrical discontinuities that may require attention prior to implementation of the cathodic protection.
- Electrical isolation – If pipeline insulating flanges or other electrical isolation devices were installed in the piping, they should be tested for electrical integrity.
- Possible stray current influences – Sources of stray current should be identified and evaluated relative to cathodic protection current demand. This could include DC welding, cranes and gantries or other DC-powered equipment where portions of the electrification circuit may not be isolated from ground, and overhead and underground AC power conductors.
- Cathodic protection current demand tests – If feasible, cathodic protection current demand tests should be performed. Typically, testing only yields a general idea of the amount of cathodic protection current needed and how this current might distribute within the buried piping network. The tests should be performed for a sufficient number of areas to characterize the possible variations in current demand. Temporary anodes for current requirement testing may have to be constructed to simulate current distribution from a permanently installed system.

- Structures/systems that may be negatively impacted by the cathodic protection system – The pre-design field evaluation should thoroughly assess possible structures/systems that could be negatively impacted by earth current generated from the cathodic protection system. Provisions should be included in the design to control/minimize this impact. Facilities that can be effected include:
    - Ductile iron fire protection piping with rubber gasketed joints that aren't electrically bonded to provide electrical continuity.
    - Prestressed concrete cylinder pipe (PCCP) which is susceptible to potentially catastrophic failure because of stray current interference and galvanic corrosion attack, including hydrogen embrittlement of the high tensile strength prestressing wire.
    - Amphoteric metals (such as aluminum, lead and zinc) which are susceptible to cathodic corrosion as a result of high pH conditions from cathodic protection.
- Excavated/exposed pipe – If possible, the pre-design field evaluation should include direct assessment of pipe excavated/exposed at the time for other reasons.
    - Pipe and coating condition should be thoroughly evaluated and documented.
    - Similar to soil borings, the installation of corrosion monitoring test stations with wires attached to the pipe and coupons/probes provides a low-cost means for future monitoring of cathodic protection performance.

2.3 Deliverables That Should Be Provided by the Design Consultant/Contractor

2.3.1 Design Memorandum

A design memorandum that summarizes the design activity should be provided. It should generally be written in layman's terms and easy for the intended audience to read. Specific components include:

- Listing of structures included in the cathodic protection system, as well as those not included.
- Design overview including basis for cathodic protection.
- Design calculations, typically based on quality of protective coating, degree of electrical interconnectivity to the plant electrical grounding system, soil characteristics, and normalized cathodic protection current demand.
- Key supporting field and other data presented in tabular and or graphical format.
- Framework for cathodic protection maintenance. Baseline data to be collected, instrumentation, personnel experience/training requirements, monitoring protocol including frequency, and generalized troubleshooting procedures should be included.
- Budget cost estimate for implementation of the cathodic protection that is broken down by major component/phase, for example, materials, rectifier and anode installation, test station installation, baseline/start-up evaluation including updated maintenance procedures, and 6-month performance evaluation.

2.3.2 Drawings

Drawings and details should be developed that include:

- Site plan and equipment locations based on and coordinated with plant facility drawings and GIS.
- Rectifier requirements, including:
  - AC power feeds
  - Input AC voltage and current rating
  - Output DC voltage and current rating
  - No normally exposed "live" electrical components when the rectifiers are accessed for monitoring
  - Structure and anode circuit cabling
  - Built-in precision synchronized current interrupters or other means to aid in determining polarized (IR-free) structure-to-soil potentials
  - Remote monitoring
  - Remote control
  - Safety features such as touch-safe barriers, warning labels, interruption ports/terminals and tap-switch adjustments

Figure 2-1
"Touch Free" Safety Rectifier with Remote Monitoring and Control

2.3.3 Anode Systems

- Location – Anode system location should be selected to maximize current distribution, minimize stray current interference on structures not included in the cathodic protection system, minimize excessive structure potential which can result in cathodic disbondment of protective coatings and other pipe degradation, avoid damage to the anode, and facilitate repair or replacement that may be required in the future.
- Anode configuration, for example, deep anode, shallow anode bed, distributed anode bed, and or linear anode system.
- Anode quantity and type, for example, mixed metal oxide, high silicon cast iron, and graphite.
- Anode backfill, typically metallurgical coke breeze or calcined petroleum coke breeze depending on application.
- Cabling with conductor size and insulation dependent on particular service.

Figure 2-2
Mixed Metal Oxide Tubular Anodes for Impressed Current Cathodic Protection – 1.3” Diameter by 4’ Long, 8-Ampere Rating for 20-Year Life

2.3.4 Test Stations

- Test stations should include details on structure wiring. Test station wiring connected to the plant electrical grounding system should be done only after sufficient electrical continuity between the grounding and buried pipe has been determined via the pre-design records review and field evaluation.

- Test station wiring connected directly to the buried piping should be done at sufficient representative locations to assure accurate measurement of pipe-to-soil potentials used to gauge cathodic protection performance. At least two test stations per rectifier that are connected directly to the buried piping and strategically located is advised.
- Test station wiring should not carry cathodic protection or other current that can cause extraneous voltage drops in the wiring and result in distortion of structure-to-soil potential measurements.
- The use of buried ("permanent") reference electrodes, IR-drop free coupons, and or corrosion rate probes at/near pipe depth can increase the accuracy of potential and other electrical measurements used to gauge cathodic protection performance.
  - Reference electrodes should have a proven long-life design and be the appropriate type for the soil conditions encountered, for example, copper/copper sulfate, silver/silver chloride and high purity zinc.
  - Coupons and corrosion rate probes should be manufactured from the same material and comparable metallurgy as the pipe they are intending to emulate. Exposed metallic sense elements for this equipment should be sized to replicate a typical coating defect.
  - Proper placement of this equipment is particularly valuable in assessing cathodic protection system effectiveness for deeper piping and dense multiple pipe runs where electrical shielding can be an issue.
- Test station types include post mount, junction boxes, and flush-to-grade. Test station designs should be as simplistic as possible and facilitate easy access for routine surveillance. Large flush-to-grade test boxes with heavy bolted covers are discouraged unless specifically required because of location-specific requirements.
- Structure test stations readily facilitate repeat measurement locations, thereby allowing for accurate trending of the data over time.

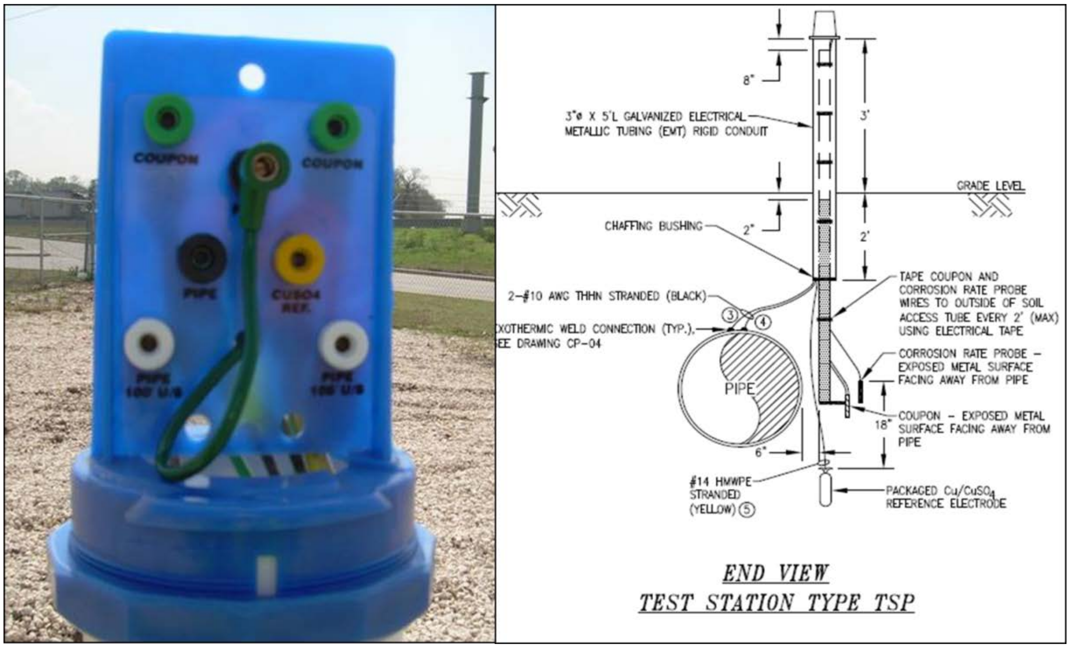

Figure 2-3
Post-Mount Test Station with Corrosion Rate Probe, IR-Coupon, and Reference Electrode

2.3.5 Soil Access Ports

- Soil access ports provide a consistent means of direct earth contact for placement of a portable reference electrode when the measurement location is covered with asphalt or other paving.
- Measurements using a portable reference electrode placed on the pavement may result in erroneous readings. One approach often used to address this possibility is drilling small holes in the pavement so the reference electrode is in direct contact with the soil.

2.3.6 Installation Specifications

- Installation specification format should be per Construction Specifications Institute unless an alternate format is specifically required by the power plant operator.
- The specifications should require the contractor to submit for approval product data sheets, catalog cuts, or similar for all major materials and equipment prior to procurement.
- The specifications should adequately cover the work to be performed as well as coordination with other activities in the area, division of responsibility, and quality assurance.
- The specifications should require the contractor to submit for approval a work plan and schedule, including safety measures and contingency provisions consistent with the work being performed and plant procedures.
- Specific measureable criteria should be included in the specifications to determine compliance with the specifications and acceptance of key aspects of the work, for example:

  - Anode current distribution at rated rectifier voltage
  - Volume of anode backfill material
  - Test station wire continuity
  - Comparison of pipe potentials measured using a permanent reference electrode vs. a portable reference electrode
  - Baseline field readings of installed corrosion rate probes consistent with factory measurements
- The contractor's obligation regarding as-built documentation should be clearly delineated. As a minimum this should include as-built drawings, sub-meter GPS coordinates for all aboveground equipment or other suitable location identification records, acceptance data required by the specifications, a listing of changes (as approved by the designer), and basic statements that the cathodic protection system was installed in accordance with the specifications.
- Materials listing
  - Companion to the design drawings and specification should be a materials listing that, to the extent possible, identifies acceptable products including manufacturer and part number. Alternate materials submitted by the contractor for consideration should be allowed provided they comply with the intended form and function.
  - The contractor should be responsible for determining material quantities to comply with the design drawings and specifications.

3
INSTALLING A CATHODIC PROTECTION SYSTEM

3.1 Considerations When Selecting a Cathodic Protection Installation Contractor

When selecting a contractor to install, modify or upgrade a cathodic protection system, it is critical that they possess and demonstrate engineering and construction expertise specific to nuclear generating stations or comparable complex industrial facilities. The nature of the work is such that selection of an installation contractor should be based on a combination of qualifications and price.

It is typically best to hire a contractor that has the resources to handle all work in-house. When subcontractors are needed, they should be identified when the work is proposed. The prime contractor and any subcontractors should provide evidence of a strong safety culture. The prime contractor and any subcontractors should possess insurance coverage consistent with the power plant's requirements for the nature of work to be performed.

The following are items to look for in the contractor being selected:

- Technical oversight for the installation should be by a Registered Professional Engineer that is also fully certificated by NACE International (corrosion engineering professional society) as a Cathodic Protection Specialist and or Corrosion Specialist.
  - This individual should demonstrate prior work experience in a comparable capacity for comparably complex projects, including a minimum of three successfully completed projects within the last seven years.
  - This individual should participate in the project kick-off to review all aspects of the work and during the course of the work as needed to assure satisfactory performance and compliance with the specifications.
  - The as-built submittal for the completed work should be reviewed and certified by this individual, including statements that the work is in complete compliance with the specifications and any approved changes.
- Personnel to perform any acceptance testing required by the specifications should be identified prior to the start of the work and their proficiency in same should be demonstrated.
  - This individual should possess a NACE CP Level 2 or higher certification.
- Equipment to be used should be identified prior to the work with evidence that it is properly licensed, properly insured, and in good working condition.

3.2 Considerations for Installation of a Cathodic Protection System in a Nuclear Generating Station

A work plan and schedule should be submitted in advance of the work and updated weekly. The work plan should identify the following, as a minimum:

- Personnel, including contact information and compliance with all security requirements.
- The specific work to be performed, including details on acceptance testing and other quality assurance measures.
- An understanding of and compliance with all safety requirements.
  - Verification of compliance with all safety and other project training requirements should be included.
  - Daily tailgate safety meetings and completion of job safety analyses (JSAs) should be an integral part of the process.
- Work areas, including whether any special access or security measures are necessary, for example, overhead clearance restrictions and equipment size/weight restrictions.
- An assessment of underground structure conflicts and means to avoid underground and other structure damage.
- Coordination with plant personnel.
- Work days/hours.
- Contingency plan(s) in the event of unforeseen conditions.

Figure 3-1
Deep Anode Installation

Figure 3-2
Horizontal Directionally Drilled Linear Anode System

Figure 3-3
CorrFlex® Mixed Metal Oxide Linear Anode System – 1.4” Diameter, 20 to 205 Milliampere per Foot Current Capacity for 20-Year Life Depending on Rating

4

MAINTAINING A CATHODIC PROTECTION SYSTEM USING A CONSULTANT/CONTRACTOR

4.1 Specification for Maintenance of Cathodic Protection System

The scope of work for the contractor and the division of responsibility between the contractor and plant personnel should be clearly defined for example, is the contractor tasked only with collecting field data for analysis and management by plant staff, or the contractor responsible for implementation of all facets.

The requirements and selection process for maintenance/monitoring contractor are comparable to those stated in Chapter 2. Essential qualifications and capabilities for the firm and for the specific individuals involved include:

- Experience in developing a cathodic protection surveillance program for a nuclear station or comparably complex facility, if this is part of the desired work and has not already been established.
  - A well planned and documented maintenance/monitoring program including procedures, test locations, instrumentation, experience/training requirements, data reporting forms, etc. is paramount to a successful corrosion control program.
- Experience in collecting the requisite field data, including the safety, security and other nuances of performing this activity in a nuclear station.
  - As the details of a cathodic protection system can vary widely, the contractor's experience should be gauged against the details of the particular plant.
- Ample instrumentation for performing the field measurements, including troubleshooting. All electrical test equipment should bare evidence of being purchased new or calibrated within one year of their use.
- Experience in analyzing the data relative to compliance with established performance criteria and, if deficiencies are detected, experience in establishing an appropriate course of corrective action.
- Experience in cathodic protection troubleshooting and repairs.
- Experience in cathodic protection data management.
- Experience in accurately estimating costs for cathodic protection repairs and upgrades.
- Experience in remote monitoring of cathodic protection systems, in the event remote monitoring is part of the maintenance program or may be considered in the future.
- Ample staff resources to monitor the cathodic protection system following prescribed procedures and frequencies.
  - Typically it is best that over time the same personnel be involved in the data collection and analysis.
  - Resources should be sufficient to respond in a timely manner and address any system deficiencies that may be detected.

4.2 Testing and Analysis Requirements

The minimum requirements for data collection and acceptance should be in accordance with NRC & INPO guidelines, and in accordance with the plant-specific maintenance manual.

- Typical measurements include:
  - Rectifier DC voltage and current – no less frequent than every 60 days Polarized (IR-free) structure-to-soil potential – annually
  - IR-drop free coupon and corrosion rate probe measurements, if installed – concurrent with the structure-to-soil potential measurements
- Measurement locations should be clearly defined and easy to access. Repeatability of procedures and test point locations is essential for proper gauging of the cathodic protection performance and the health of the buried piping.
- The data should be collected, analyzed, and managed in such fashion to facilitate predictive monitoring and maintenance.
  - Predictive analyses can identify pending problems, often times be used for reducing the extent of monitoring without compromising effectiveness, and is a useful tool for economically programming cathodic protection system upgrades or replacement.
  - In addition to gauging cathodic protection performance, depending on facility particulars, trending of the cathodic protection data over time can also provide insight on coating quality.

Figure 4-1
Electrical Resistance Type Corrosion Rate Monitoring Probe with AC/DC Potential and Current Monitoring Datalogger and Remote Monitoring Unit

4.3 Requirements for Test Reports and Summaries

- Tabulated data should be provided in such manner that it will readily feed into a data management process for predictive trending, etc.
  - The contractor should be provided with the data reporting forms and instructions for processing
- The metrics for identifying corrosion control compliance should be established at the start. Results provided by the contractor should include statements relating the measured values to established thresholds along with the corrosion control significance of any anomalous conditions.
- The extent of the analyses should be in accordance with the contracted scope, that is, what is the contractor responsible for vs. what are plant operations responsible for.
- Corrective actions and or other recommendations should be clearly delineated, typically in tabular format.
  - The recommendations should be prioritized, for example, suggested timeframes for implementation should be provided
  - Budget cost estimates should be included
  - The potential consequences of not implementing the recommendations within the suggested timeframe should be opined

4.4 Plant Actions for Test Results

- All data should be captured in the data management system with other records retention measures in accordance with plant requirements.
- Recommendations should be reviewed shortly after they are submitted relative to validation, expected costs and prioritization.
  - Validated recommendations should be implemented in a timely manner
  - Procedures and timelines for implementation of recommendations should be clearly delineated in the cathodic protection O&M manual
- Periodic trending of the data can help with long-term planning.

Inspection Recommendations

Material	Preventive Actions	Inspection Quantities Not to Exceed (NTE) Number of Inspections		
		Years 30 – 40	Years 40 – 50	Years 50 - 60
Steel Copper Aluminum	C	0.5%, NTE 1	0.5%, NTE 1	0.5%, NTE 1
	D	1%, NTE 2	1%, NTE 2	1%, NTE 2
	E	5%, NTE 7	6%, NTE 10	7.5%, NTE 12
	F	10%, NTE 15	12%, NTE 20	15%, NTE 25

Summary of Preventive Actions
C – CP installed and meeting availability and effectiveness goal
D – External corrosion control not required
E – CP not practical or CP goals not met, however coatings, backfill, soil, and OE are acceptable
F – Above preventive actions not met

Figure 4-2
Pipe Inspection Recommendations

5
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