TRI-SERVICE 2007
CORROSION CONFERENCE
ARMY • NAVY • AIR FORCE • MARINES • COAST GUARD • NASA

Establishing a CP Data Baseline for Preventive Maintenance for the Las Vegas Valley Water District

Gregory Fehr
Parsons Water Infrastructure
Southern Nevada Water Authority
100 City Parkway
Las Vegas, Nevada 89106

Maurice DeLisle
Las Vegas Valley Water District
1001 S. Valley View Blvd.
Las Vegas, Nevada 89153

ABSTRACT

Beginning in 2004, the Las Vegas Valley Water District (LVVWD) began a project to identify the corrosion condition of their entire metallic piping system. This task was difficult as cathodic protection systems had been installed beginning in 1969 and had not been monitored or maintained. Future preventive maintenance and service life forecasting was planned from this baseline. This process included the updating of the existing corrosion monitoring database that contained limited historical initial native and cathodic protection (CP) pipe to soil potentials, capturing current test data from all 2400 existing test stations, establishing algorithms for determining pipes at risk, forecasting maintenance and useful life, and preparing maintenance schedules for both test stations and the piping infrastructure.

As with many similar efforts, many unexpected problems surfaced during the initial attempts to capture the latest test data. Additional problems dealt with having a range of pipe materials, foreign pipe issues, database inconsistencies, data collection errors, and third party damage.

This paper addresses the several lessons learned from managing a project of this size, serving approximately 1.2 million customers. Included are a format for successfully collecting data, describing a useful database, and applying the information to predict and increase pipeline service life. The process described here is applicable to any piping infrastructure system including military facilities.

Keywords: Terminology, test station, interpretation, reference electrode, maintenance, software.

INTRODUCTION

While corrosion mitigation is a challenge and quite mysterious to the lay person, it can be successfully applied. Our experience has been that corrosion monitoring and mitigation fall short of success because those in control of budgets often do not understand the cost saving effect of decent corrosion control. There are no breakthroughs in the state of the art in this document, but a comprehensive corrosion monitoring/mitigation program is described below. All of it is not applicable to all military facilities, but the basic concept surely is. Many of the tools and techniques can be used directly.

Military bases and other federal government facilities frequently have part of their metallic infrastructure protected by cathodic systems. Underground storage tanks UST's, above ground storage tanks, petroleum product piping, process and distribution water piping, piers, docks, and associated offshore structures are representative of this infrastructure.

In recent years, new or replaced water piping has been plastic, but fittings, valves, and fire hydrants are typically iron or steel. The installation of 6"-20" PVC initially seems like an answer to corrosion, until the realization is made that all of the elbows and tees used are made of ductile iron. These metallic parts may or may not have cathodic protection and the may or may not have corrosion monitoring test stations.

The application of this paper relates directly to installations where corrosion monitoring test stations exist, or where structure to soil potential can be measured with a voltmeter and a copper/copper sulfate reference electrode by contacting the structure directly such as in the case of fire hydrant, valve operators, and storage tanks.

While the details of the database, data collection, and data evaluation are taken from a large water utility, the principles, evaluation algorithms, and preventive maintenance programs are directly applicable to any military infrastructure capable of being monitored for corrosion attack.

BASIC CONSIDERATIONS

Once the decision has been made to perform a system wide cathodic protection assessment that will determine existing conditions and provide a basis for repairs and maintenance, the following steps should take place:

1. Determine the format of the database.
2. Agreement on terminology and definitions.
3. Gather and compile existing data and records.
4. The process for data collection should be understood by all.
5. Determine the desired contents of the evaluation.
6. Finally, and most importantly, develop a follow up to the findings of the assessment.

Format:

The software chosen needs to interface with the database and display all fields collected in a useful manner. It should also be able to graph variables over time and distance, and provide trend analyses. Test stations on a pipeline must be exhibited in the correct geographical relationship to each other and to the pipe.

The identification nomenclature for the stations should be carefully considered such that it ties into the pipeline identification and relative locations. Several data cells may be required to accommodate the station name, pipe name, size, material, GPS coordinates, and sequence of stations. Data cells will also be needed for distinguishing “on” readings from “off” readings, shunt readings, structure readings, casings, anode open potential, and other variations of installations. This will ensure an “apples to apples” approach later in the process.

Types of stations need to be specified, e.g. bonding stations, electric insulating stations, and cased pipe stations.

Another piece of valuable information is the age of the structure. The composition of the electrolyte (soil, water, etc.) is helpful as pipes in ground water and wet corrosive soils represent higher risks; however the effect of the electrolyte will be present in the readings. For each test station, the design, structure attached to, previous readings, baseline readings, material, and age should be known. If not originally available, then provide a process to collect this information while taking the next series of potential readings.

Terminology:

For all persons involved, an agreement on terminology and definitions needs to be arrived at. Definitions on the status of the test station, or codes for status, should be written. Something as simple as “broken wire” can be a point of misunderstanding. For the LVVWD, the term is meant to identify a wire that is broken underground, whereas the consultant used it when a wire was broken off of a test board connection. The same is true for definitions, or codes, for deficiencies found and repairs needed. There should be an agreed upon method for data collection. All should understand the definition and values for all data fields that will be used. The LVVWD database utilized readings in millivolts. However, some of the consultants made entries in volts. Shunt readings were particularly frustrating as the initial measurement is to be in millivolts. Then a conversion to milliamps is made utilizing the shunt factor. The data can not be accurately evaluated as an entry can be in volts, millivolts or milliamps depending on the consultant doing the work. Everyone should understand how the owner installed the cathodic protection, including the methods and practices utilized during the installation. All test stations are not the same. The LVVWD has 21 different types of test stations documented and more are being added. Knowledge of what is being tested is paramount. In a large system, hundreds of man hours per year can be expended in deciphering the wires in a test station, and that process typically is repeated each time the station is checked. It is well worth the time to positively identify all the wires in all test stations with clear markings. When new designs are created, they must be entered into the O & M Manual to minimize confusion in the field.

Existing Data:

If a system is not currently operating, previous data – if usable – must be collected for entry into the database. Some or all of these measurements will form the initial base line from which trends are developed.

Compiling existing data and records can be a daunting task. This information is often scattered and is seldom in a uniform format. The quantity of test stations and their locations must be assembled. A uniform system to identify them should be in place or developed, including the configuration of the test station terminal board and what structures they are attached to. Each test station configuration should be clearly presented in the Operations and Maintenance Manual.

The first lessons learned were:

1. Existing data frequently were not in the desired format either on hard copy or electronic file.
2. The locations of the test stations were not always correct.
3. Many of the readings had obvious errors e.g. being off by an order of magnitude or voltages greater than galvanic anodes can produce.
4. Recording of “anode on” appeared to, on occasion, be confused with readings of “anode off.”
5. Test stations that used to exist when the commissioning recordings were made were found to no longer exist – removed by earth moving equipment, buried under pavement, etc.

Baseline readings are extremely valuable if available and trustworthy. These are the readings taken when the structure was first installed. Any previous readings should be reviewed to determine if they are valid, *including* the date they were collected. If readings on ten year old pipe show unprotected sections, it is helpful to know that they were originally in a protected state. Included in the data for the test station should be the material of the structure being protected. For example, a copper pipe will have different parameters for corroding ranges and protected potentials than a steel pipe. Mortar coated pipes tend to begin with significantly different potentials than dielectric coated pipe.

New Data Collection:

Establish the type of reference electrode to be used for collecting readings such as copper-copper sulfate, zinc, silver-silver chloride, etc. Confusion and conversions will abound if this is not established.

After all the existing data are collected, organized and understood, the process of new data collection may begin. Do not rush to this step. Without completing the aforementioned tasks, the likelihood of collecting bad data is high. A proper assessment cannot be made without accurate and adequate data. To collect good data, a process is needed to verify that the readings have been taken at the correct location. As obvious as this may seem, data are frequently assigned to the wrong test station. Good record drawings with as-built information proved invaluable in finding and verifying the location of many test stations.

Personnel collecting data should be competent at reading and understanding them. The data will need to be recorded correctly in the units the owners utilize in their database. Broken wires *will* provide readings. A stable mortar coated pipe typically will exhibit a potential between -150 to –250 mV using a copper/copper sulfate reference electrode. Copper wires exhibit a potential of approximately -200 mV.

Another lesson learned: Many times, the consultant read a broken copper wire assuming it was a valid reading from a mortar coated pipe.

Training of technicians to identify broken wires is imperative. Do not allow values for broken wires to be recorded in a database. Continuity of wire leads must be made before potential readings are taken to insure a connection exists.

Having some one review collected data is so standard that it hardly needs repeating here. However, a lesson was learned here. Reviewing the numbers weeks or months after they were collected raised more questions than were answered. Always have data reviews performed immediately after they are entered into the system. Never discard original data sheets.

A small but critical item: Upon what does the technician record the readings? Typically a spreadsheet format is used with either hard copies or electronic entry. The information on the spreadsheets usually resembles the format of the database itself. Electronic entries can be downloaded directly into the database. If there is little variation in the test station terminal boards, either of the above methods will work. However, if there are significant variations in the terminal boards, it will prove beneficial to record values on a data collection sheet that mirrors the terminal board itself. If voltmeter connections are made directly to structures, a sketch of the connection is invaluable. Interpreting data is relatively easy. Knowing that the numbers are valid *and* taken at the correct location are absolute requirements. Otherwise, spend your evaluation time on your favorite hobby; it will do as much good.

This paper is not meant to be a tutorial on instruments and processes, but there are known methods for reducing measurement errors. These should be spelled out in any O & M Manual. The following is a list for consideration:

- Temperature correction for the reference electrode
- Photovoltaic considerations for the reference electrode in the field
- Check field reference electrodes against a master set
- Copper sulfate solutions to be saturated
- Check for contaminated solution
- Use high impedance/megohm voltmeter
- Check for stray currents

DATA EVALUATION

An initial evaluation will most likely provide candidates for a further more detailed evaluation. Define the evaluation to the needs of the utility or organization. Determine if the needs are to know if existing systems are working, whether “missing” test stations are to be found, if remaining anode or structure life is to be determined, or if rehabilitation recommendations and designs are to be provided.

Depending upon material, the LVVWD established millivolts ranges for assigning a condition value. Pipelines are classified as stable, protected, corroding, needs further evaluation, or not assessed.

These evaluation ranges are programmed into the database to alarm when there are excursions from the safe zones.

The LVVWD limits for pipeline cathodic protection are based on NACE Standard Recommended Practice RP0169 *Control of External Corrosion on Underground or Submerged Metallic Piping Systems.* For unprotected structures, engineering judgment is applied.

Contents of Evaluation:

It should be clear what information the evaluation is to produce, prior to beginning the evaluation. Establish what the desired outcome is from the process.

Example of interpretation difficulties:

> The LVVWD received reports that entire pipelines were corroding based on the individual readings collected. One of the pipelines listed as corroding had no anodes or impressed current. It was connected to another pipeline with anodes. The insulating flange specified at the connection of the pipelines was either not installed or is not working. This caused two problems. It made one pipeline appear as if it were corroding as the adjacent pipeline attempted to polarize it. The pipeline with anodes appeared to corroding as it could not produce enough current to protect itself. However, the pipeline itself was not evaluated considering other factors.

MAINTENANCE and FUTURE MONITORING

These subjects are linked because high risk infrastructures are targeted for closer monitoring as well as immediate or near term maintenance.

The evaluation process takes into consideration the following:

- Risk level for a failure regarding the importance of the pipe or structure
- Risk level for near term corrosion failure
- Structure to soil potential
  1. Protected by CP
  2. CP below protection levels
  3. Not protected, but in safe range
  4. Not protected, and drifting towards more active corrosion
  5. Not protected, and in danger zone
- Leak history
- Aggressive soil zones
- Change in soil conditions
- Change in service conditions

The worst conditions may be slated for immediate replacement. The next level may suggest pot holing and/or more physical inspection. The less dangerous conditions may fall into the category of more frequent testing to see if the conditions stabilize or are trending towards faster corrosion. Those locations where the CP is above minimums or the unprotected pipe has stable and low potentials (less negative than -300 mV for example for steel or ductile iron) may be tested less frequently.

Based on the above, algorithms for replacement, repair, and testing frequency should be developed to schedule these activities.

The algorithms need to be linked to the database, and automatically adjust the direction to change the maintenance and testing schedules as additional test data are entered.

CONCLUSION

The most salient point precipitating from the above information is that it takes more people and time to properly manage a corrosion monitoring and maintenance effort than is usually assigned. Based on the authors' experience, few utilities budget for a sufficient staff to perform all of the duties described.

Historically, a proper cost analysis will easily show that minimizing replacement and repairs justifies sufficient budget to employ the necessary staff of database practitioners, field technicians, and program management.

With the system outlined in the body of the text, a proposal can be made that will present a cogent system to optimize corrosion protection and minimize cost.