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WATER CORROSION CONTROL DESIGN STANDARDS

8-11.0.0 WATER CORROSION CONTROL DESIGN STANDARDS

8-11.1.0 General

1.1 Purpose

This section describes design standards and requirements for corrosion control of public water projects.

1.2 Definitions

Section 8-18 contains a list of definitions, abbreviations, and acronyms. The following definitions are unique to this section.

A. "Cathodic Protection Design Report." A report based on the findings of the Corrosion Pre-Design Report or Corrosion Pre-Design Survey. This report provides Cathodic design and supporting information for the design of a Cathodic Protection System.

B. "Cathodic Protection." Electrical current applied to the water main to protect the metallic components from corrosion.

C. "Corrosion Letter Report." A report in letter form submitted by the designer at the close of a project. This report is not required if a Final Corrosion Report will be produced.

D. "Corrosion Monitoring System Design Report." A report based on the findings of the Corrosion Pre-Design Report or Corrosion Pre-Design Survey. This report provides design and supporting information for the design of a Cathodic Monitoring System.

E. "Corrosion Monitoring System." A series of CTSs to monitor the metallic components of the pipe to determine if there is any corrosion occurring.

F. "Corrosion Pre-Design Report." A report submitted by the designer identifying potential corrosion issues for any new pipe.

G. "Corrosion Pre-Design Survey." A report submitted by the designer identifying potential corrosion issues for any new pipe.

H. "CTS." Acronym for Corrosion Test Station.

I. "Final Corrosion Report." A report submitted by the designer at the close of a project.

J. "Metallic Water Mains." Any pipe used for water mains that have any metallic components, i.e., concrete cylinder pipe or ductile iron pipe.

K. "Modification." Reconstruction of any existing Tucson Water facilities that are in conflict with the proposed roadway construction. All new materials are used.

L. "Project limits." The limits of proposed construction as defined by the controlling agency.

M. "Relocated." Existing CTSs are relocated when in conflict with the proposed roadway construction. Relocation consists of furnishing and installing new components at a new location. Existing components are salvaged and returned to Tucson Water.

N. "Water System Modifications Design." An engineered design for reconstruction and replacement of water mains in conflict with proposed roadway or other improvements.

1.3 Applicability

Plans for new pipe or a connection to existing pipe shall be reviewed by the Corrosion Control Unit for corrosion prevention and monitoring requirements if the pipe meets the following criteria of material and size:

- Welded steel pipe, concrete cylinder pipe, prestressed concrete cylinder pipe, or ductile iron pipe,

- Transmission mains (sixteen-inch in diameter and larger).

8-11.2.0 Design Requirements, Corrosion Control

2.1 General Requirements Corrosion Test Stations

A. Corrosion Test Station Maximum Spacing

All corrosion test stations used for potential, current, or resistance measurements shall be at enough locations to facilitate data collection. The locations shall be a maximum of 1,000 feet apart.

B. Electrical Continuity
All pipelines shall be electrically continuous between corrosion test stations through joint bonding wires, bonding clips, or welded joints. All welded steel pipe will be concrete mortar lined and exterior coated.

C. Locations and Type Requirements
Locations and type requirements of corrosion test stations shall include, but not be limited to, the following:
1. Type I corrosion test stations are required at a maximum of 1,000 foot intervals and are required at rectifier installations;

2. Type II corrosion test stations are required at pipe casing installations where metallic casings are required;

3. Type III corrosion test stations may be required at foreign, cathodically protected, pipeline crossings.

4. Type IV corrosion test stations are required at electrically isolating joints; and,

5. Type V corrosion test stations are required at galvanic anode installations. No anodes shall be directly connected to the pipe.

D. Locations of Isolating Joints
Isolating Joints (and therefore Type IV corrosion test stations) are required in the following locations:Changes in pipeline materials, i.e. ductile iron pipe, concrete cylinder pipe, welded steel pipe, etc.;

2. Connections to existing piping, i.e. old and new piping;

3. Inlet and outlet piping of plant facilities;

4. Laterals from transmission mains; and,

5. Taps to existing ductile iron pipe, welded steel pipe, concrete cylinder pipe and prestressed concrete cylinder pipe.

2.2 Corrosion Reports

Corrosion Reports shall be required in accordance with the flowchart in Exhibit 11-1.

A. Corrosion Pre-Design Report
1. If no more than four hundred nintey-nine feet is required for modifications and if required by Tucson Water, the designer shall include a corrosion pre-design report as part of the preliminary design.

2. This report must be submitted for approval by the 50% design stage of the project and shall include analysis of electrochemical soil and groundwater samples collected by the geotechnical firm.

3. The designer shall perform a corrosivity study along the proposed water main route and shall develop corrosion prevention and monitoring design requirements and recommendations based upon the corrosivity study.

4. The Corrosion Pre-Design Report shall include the following:
   - Field soil resistivity measurements;
   - Soil and groundwater sample analyses;
   - Stray DC earth current and foreign line cathodic protection system activity; and,
   - Identification of potential corrosion problems.

B. Corrosion Pre-Design Survey Report

1. If more than four hundred nintey-nine feet is required for modifications and if required by Tucson Water, the designer shall include a corrosion pre-design survey in the preliminary design. This report must be submitted for approval by 50% of the project design stage.

2. The designer shall perform a corrosion survey along the proposed water main route. The designer shall develop corrosion prevention and monitoring design requirements and recommendations based upon the corrosion survey. The corrosivity study, corrosion prevention, monitoring, design requirements, and recommendations shall be documented in the “Corrosion Pre-Design Survey Report.”

3. The Corrosion Pre-Design Survey Report will include:
   - Field soil resistivity measurements;
   - Stray DC earth current and foreign line cathodic protection system activity; and,
   - Identification of potential corrosion problems.

8-11.3.0 Soil Test Requirements, Corrosion Control

3.1 Field Soil Resistivity Measurements

A. Soil Resistivity Measurement Method

Soil resistivity shall be measured and recorded to various depths by the four-pin Wenner method in accordance with ASTM G57 at 1,000-foot maximum intervals along the entire length of the proposed water main route. Included shall be measurements in wash areas and changes in terrain.

B. Depths of the Measurements
The depths of the measurements at each test location shall be at five-foot increments from grade to the depth of the pipe invert. The data shall then be analyzed for each five-foot layer using the Barnes layer analysis method, where applicable.

C. Placement of Soil Pins
Placement of soil pins for soil resistivity testing shall avoid all underground metallic structures. Where it is not possible to avoid underground metallic structures, the soil pins shall be either parallel to or perpendicular to the existing underground metallic structures.

3.2 Soil and Groundwater Sample Collection and Analyses

A. Soil Borings
Soil borings for soil and groundwater sample collection shall be performed at a maximum of 2,000-foot intervals along the entire length of the proposed water main route and shall be made as follows:

- For pipe seventy-two-inch and less in diameter, two soil samples shall be collected, one at the planned crown of the pipe and one at the planned invert of the pipe.

- For pipe greater than seventy-two-inch in diameter, three soil samples shall be collected; one at the planned crown of the pipe, one at the planned spring line of the pipe and one at the planned invert of the pipe.

When groundwater is encountered, a sample of ground water shall be collected by bail for laboratory analysis.

B. Soil Analysis
Soil samples shall be analyzed in a laboratory approved by Tucson Water. Analyses shall quantify the following constituents and characteristics using either of the indicated analyses methods:

Test Parameter	ASTM Method	EPA Method
Moisture Content	D-2216	Loss @ 105 C
Conductivity	D-1125	120.1
pH	D-2976	SW 846-9045B
Chloride Ion Concentration	D-512	300.0
Sulfate Ion Concentration	D-516	300.0
Sulfide Ion Concentration		EPA 376.1376.1
Type Classification	USDA Std	USDA Std

C. Groundwater Analysis
When available, groundwater samples shall also be analyzed in a State-certified laboratory and shall quantify the following constituents and characteristics using either of the indicated analyses methods:

Test Parameter	ASTM Method	EPA Method
Conductivity	D-1125	120.1
pH	D-2976	150.1
Chloride Ion Concentration	D-512	300.0
Sulfate Ion Concentration	D-516	300.0

8-11.4.0 Laboratory Data Evaluation

All field and laboratory data obtained the study shall be used to develop corrosion prevention and monitoring design recommendations. General guidelines for interpreting the data are as follows:

A. Soil Moisture Content
The higher the moisture content of soil, the greater the anticipated corrosivity of the soil. Soil moisture contents can range from 1% in very dry sands to 40% in clays holding large quantities of water. Typical values are 10% to 15%. Contents in excess of 20% are considered very high.

B. Conductivity
For a given corrosion cell with a fixed potential difference between the anode and cathode, the higher the conductivity the greater the corrosion rate. Conductive readings greater than 350 micro ohms are considered very high and corrosion prevention shall be evaluated.

C. pH
Acidic soils and groundwater are more conducive to corrosion of ferrous materials than are alkaline soils and groundwater. Where the pH of soils and groundwater is less than 5.0, protective measures shall be implemented to prevent corrosion of ferrous components.

D. Chloride Ion Concentration
Breakdown of passive film on mortar embedded steel with subsequent corrosion of the steel and accelerated corrosion of other metallic pipe (steel, cast iron and ductile iron) can occur if chlorides are present at the steel or metal surface. The threshold for passive film breakdown and accelerated corrosion activity is approximately one pound of chloride ions per cubic yard of soil. Chloride ions usually reach metallic surfaces by groundwater transmission. Many soils have chloride ion concentrations less than ten parts per million. Chloride ion concentrations greater than fifty parts per million are considered significant and corrosion prevention shall be considered.

E. Sulfide Ion Concentration
The presence of any detectable sulfide ions in soil samples indicates anaerobic conditions that may cause deterioration of the pipeline by microbiologically influenced corrosion. Corrosion prevention shall be applied under these conditions.

F. Sulfate Ion Concentration
Naturally occurring sulfates of sodium, potassium, calcium, and magnesium are sometimes contained in soils or dissolved in groundwater. These sulfates have been known to chemically attack concrete and mortar. The sulfates react with the calcium aluminate hydrates to form sulfurluminates. This attack has been most common in partially buried pipe where capillary action may build up high sulfate concentrations at the ground level.

G. Cement Concentrations
AWWA C301-84 specifies that the cement for concrete and mortar work used for concrete pressure pipe shall conform to ASTM C150 types II or I. Under known levels of sulfate ion concentrations, specific cements shall be used as follows in parts per million (ppm):

- ASTM C150, Type I Less than 150 ppm
- ASTM C150, Type II From 150 ppm to 500 ppm
- ASTM C150, Type IV From 500 ppm to 1500 ppm
- ASTM C595, Type IS From 1500 ppm to 2500 ppm
- ASTM C595, Type IP From 2500 ppm to 4000 ppm

H. Soil Resistivity
Soil resistivity is a parameter commonly used to evaluate the corrosivity of soil. Resistivity is essentially the inverse of conductivity and is measured in units of ohm-centimeters. Corrosivity is often an inverse function of resistivity with low resistivity soils being more corrosive than high resistivity soils. Resistivity is also related to concentrations of salts with low resistivities indicating high concentrations of salt. Resistivities less than 3,000 ohm-centimeters are considered corrosive and corrosion prevention is required.

8-11.5.0 Field Data Evaluation

A. Corrosion Prevention Study
The corrosion prevention study shall include field investigations to detect and identify stray DC earth current activity, foreign (to the project being designed) line cathodic protection systems, and other situations that may result in corrosion problems. These field investigations shall be conducted concurrently with field soil resistivity measurements and soil and groundwater sample collections.

B. Direct Current Activity Survey
The entire proposed water main route shall be surveyed for stray direct current activity. The survey shall include structure-to-soil potential measurements (or earth gradient measurements where points of contact on existing structures are limited) on existing structures in the immediate area of the proposed water main. These measurements shall be made at as many points as practicable. The maximum intervals between test points shall not exceed 1,000 feet.

Test points may include fire hydrants, power poles, ground rods, and foreign pipelines.

C. Utility Survey
The entire proposed water main route shall be surveyed with respect to crossings of foreign pipelines and paralleling utility systems. Information on cathodic protection systems on foreign lines shall be collected including the locations of foreign line test stations, rectifier DC outputs, and foreign line coating condition. This information shall be used to produce preliminary estimates of requirements for interference bonding and other interference mitigation techniques. Locations with availability of commercial electric power shall also be identified and documented in the event impressed current cathodic protection should be required.

D. Alternating Current Power Lines
Where pipelines are to be installed parallel to high voltage alternating current power lines, the conditions shall be evaluated for potential problems from induced alternating current. Consideration shall be given to personnel safety during construction and access to pipeline appurtenances during operation. Ground systems for mitigating induced alternating current systems shall be compatible with the proposed corrosion prevention system.

8-11.6.0 Corrosion Report Content Standard

Upon completion of all testing, a written report shall be submitted which includes all data, data analyses and a general description of the corrosion prevention recommendations. The report shall include recommendations for the following items as appropriate for the proposed water main route:

- Pipe of material other than that planned for use
- Non-standard concrete and mortar
- Other pipeline and utility locations crossing or near proposed mains
- Dielectric coating materials
- Electrical isolation recommendations
- Cased crossings
- Treatments for connecting water mains and services
- Stray current control devices
- Cathodic protection system type(s) incorporating a minimum usable life of 20 years
- Anode requirements incorporating a minimum usable operating life of 20 years
- Other special or non-standard design considerations
- Induced alternating current mitigation requirements

8-11.7.0 Exhibits

Exhibit 11-1, Distribution Design, Control Guideline Flowchart

Exhibit 11-1, Distribution Design, Control Guideline Flowchart