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SECTION 10 - CORROSION CONTROL

10.1 GENERAL

10.1.1 SCOPE

These Design Criteria provide the design basis for the corrosion control measures to be incorporated into all design stages for commuter rail projects. Specific requirements for soil and water, and atmospheric corrosion control systems are defined herein.

10.1.2 SYSTEM INTERFACES

Corrosion control requirements shall be coordinated with all other engineering disciplines to prevent the deterioration and/or premature failures of metallic and concrete structures.

10.1.3 REQUIREMENTS

All designs shall conform to structure life objectives for buried structures, and ensure the function, preservation, and appearance of structures exposed to the atmosphere. Corrosion control provisions shall be required for all new facilities regardless of location, owner, or material of construction when corrosion failure of such facilities may affect safety and/or continuity of rail operations.

10.2 STANDARDS AND CODES

The latest editions of the following organizations' standards, codes, and guidelines shall be used for the design of corrosion control systems:

- NACE International (formerly The National Association of Corrosion Engineers)
- RP0169 – Control of External Corrosion on Underground or Submerged Metallic Piping Systems
- American Society for Testing and Materials (ASTM)
- ASTM D512 – Standard Test Methods for Chloride Ion In Water
- ASTM D516 – Standard Test Method for Sulfate Ion in Water
- ASTM G51 – Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing
- American Railway Engineering and Maintenance-of-Way Association (AREMA)
- Federal Highway Administration (FHWA)
- Publication FHWA-NHI-00-044 – Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes

10.3 SOIL AND WATER CORROSION CONTROL

This Section provides criteria for the design of systems and measures to prevent corrosion of transit system fixed facilities due to contact with soil and groundwater. Designs shall be based on achieving a minimum 50-year design life for buried structures, with the exception of a 100-year design life for the stations, through consideration of the factors given below.

Structures to be protected include the following:

- New underground metallic utilities
- New underground concrete structures
- New atmospherically exposed metallic components of transit fixed facilities

All pressure and non-pressure piping and conduit shall be non-metallic, unless metallic materials are required for specific engineering purposes, utility owners' standards, or RTD Design Criteria.

10.3.1 BACKFILL MATERIAL

If non-native fill is to be used for backfilling concrete or ferrous structures, then it shall meet the following criteria:

pH 6 to 8 (ASTM G-51)

Maximum chloride ion concentration of 250 ppm (ASTM D-512)

Maximum sulfate ion concentration of 200 ppm (ASTM D-516)

Test reports shall be submitted for all imported backfill. Fill material, which does not meet one or any of the preceding criteria, shall be allowed only after review and approval by RTD.

10.3.2 RTD-OWNED PIPING

All new, buried, metallic pressurized piping owned by RTD shall be cathodically protected. Designs shall include the following:

Application of a protective coating to the external surfaces of the piping to be protected.

Electrical insulation from interconnecting piping and other structures, and segregation into discrete electrically insulated sections depending on the total length and/or configuration of the piping.

Electrical continuity through installation of insulated copper wires across all mechanical joints other than intended insulating fittings.

Permanent test facilities shall be installed at all insulating fittings, anode beds, casing interfaces, and at intervals not to exceed 200 feet.

Installation of sacrificial anodes.

10.3.3 UTILITY PIPING OWNED BY OTHERS

Installation of corrosion control measures for facilities owned by others, but designed as part of the transit project, shall be coordinated through RTD and the utility owner. Piping systems whose failure will not affect safety and/or continuity of rail operations are not subject to the corrosion control requirements for RTD-owned piping. Corrosion control measures shall conform to the existing standards and specifications of the Owner.

10.3.4 CATHODIC PROTECTION DESIGN

All cathodic protection (CP) designs shall be performed by a NACE International certified Cathodic Protection Specialist. Designs shall be in accordance with NACE Standard RP0169. All CP designs shall make use of sacrificial galvanic anodes, coating systems, electrical isolation, electrical continuity, and appropriate test facilities.

10.4.3.1 Coatings

Buried metallic piping structures requiring coating shall be provided with coal tar mastic, coal tar epoxy, polyurethane, petrolatum, or tape coating systems with high electrical resistance. The corrosion control design shall specify surface preparation, application procedure, primer, number of coats, and minimum dry film thickness for each coating system.

10.4.3.2 Electrical Insulation of Piping

Corrosion and CP designs shall establish the need for electrical isolation between dissimilar metallic components and to isolate CP systems from contact with adjacent metallic structures. Insulating fittings, casing spacers, non-metallic inserts, and plastic pipe saddles shall be considered.

10.4.3.3 Electrical Continuity of Piping

Electrical continuity bonds shall be used to provide a low resistance path for CP current on piping systems with mechanical and slip-on pipe joints. Welded, threaded, and soldered joints do not require bonding. Continuity bonds shall be made with insulated copper wires exothermically welded to the piping.

10.4.3.4 Test Facilities

Types and locations of test facilities shall be specified in the corrosion control designs. Test facilities shall be designated according to the type of installation as described in these Criteria. They shall include structure wires, reference electrodes, and anode lead wires as required to accurately evaluate the performance of the corrosion control system.

10.3.5 BURIED PIPING AND CONCRETE STRUCTURES

The following paragraphs establish the protective measures to be considered for utilities and buried structures.

10.5.3.1 Pressure Piping

All new and relocated buried ductile iron, copper, and steel pressure piping within RTD right-of-way (ROW) shall be cathodically protected as described in Section 10.3.2.

10.5.3.2 Gravity Flow Piping (Non-Pressurized)

Corrugated steel piping shall be internally and externally coated with a sacrificial metallic coating and a protective organic coating. Cast or ductile iron piping shall be designed and fabricated to include the following provisions:

- An internal mortar lining with a bituminous coating on ductile iron pipe only (not required for cast iron soil pipe).
- A bonded protective coating on the external surfaces in contact with soils.
- A bituminous mastic coating on the external surfaces of pipe 6 inches on each side of a concrete/soil interface.
- Reinforced concrete non-pressure piping shall include the following provisions:
 - Water/cement ratios meeting the minimum provisions of the American Water Works Association (AWWA).
 - Maximum 250-ppm chloride concentration in the total concrete mix (mixing water, cement, admixture, and aggregates).
 - Use Type I cement, except as noted in Table 10-1:

TABLE 10-1 - ACCEPTABLE CEMENT TYPE BASED ON SULFATE CONCENTRATIONS OF SOIL AND GROUNDWATER

Acceptable Cement Type	Percent Water Soluble Sulfate (as SO₄) In Soil Samples (ppm)	Sulfate (as SO₄) in Groundwater (ppm)
Type I	0 to 0.10	0 to 150
Type II	0.10 to 0.20	150 to 1,000
Type V	Over 0.20	Over 1,000

10.5.3.3 Casing Pipe

Pipeline casings, if required below the tracks, shall be installed bare. Casing wall thickness shall conform to AREMA requirements for non-coated, non-cathodically protected casing pipes.

10.5.3.4 Electrical Conduits

Buried metallic conduits shall be galvanized steel with polyvinyl chloride (PVC) or other coating acceptable for direct burial, including couplings and fittings. The PVC coating is not required when conduits are installed in concrete.

10.5.3.5 Buried Concrete/Reinforced Concrete Structures

The design of cast-in-place concrete structures shall be based on the following provisions:

- Use Type I cement, except as noted in Table 10-1. Use of a concrete mix with a cement type not specifically listed in Table 10-1 must be reviewed and Approved by RTD.
- Water/cement ratio and air entrainment admixture in accordance with specifications presented in the structural criteria to establish a dense, low permeability concrete.
- Maximum chloride concentration of 250 ppm in the total mix (mixing water, aggregate, cement, and admixtures).
- Concrete cover over reinforcing steel shall comply with American Concrete Institute (ACI) codes and provide a minimum of 2 inches of cover on the soil side of reinforcement when pouring within a form and a minimum of 3 inches of cover when pouring directly against soil.

- The need for additional measures, as a result of localized special conditions, shall be determined on an individual basis. Additional measures may include application of protective coating to concrete, reinforcing steel, or both. Precast standardized facilities, such as vaults and manholes, must be reviewed on an individual basis to determine alternative criteria when they cannot be practically modified to meet some or all of the provisions specified herein. Precast segmented concrete ring construction shall meet the requirements of this Section or be reviewed on an individual basis to determine alternative criteria when they cannot be practically modified to meet some or all of the provisions specified.

10.5.3.6 Support Pilings

The following is applicable only to support piling systems, which are to provide permanent support. Pilings used for temporary support do not require corrosion control provisions. Designs based on the use of metallic supports exposed to the environment, such as H or soldier piles, shall include the use of a barrier coating. The need for special measures, such as cathodic protection, shall be determined on an individual basis, based on type of structure, analysis of soil borings for corrosive characteristics, and the degree of anticipated structural deterioration caused by corrosion.

10.5.3.7 Reinforced Concrete Retaining Walls

Cast-in-place concrete retaining walls shall be in accordance with the requirements in Section 10.3.5.5. Modular-type retaining walls with restraining devices or reinforcing strips placed beneath the tracks shall meet the requirements in Section 10.3.5.5, and FHWA Publication No. FHWA-NHI-00-044. Designers must provide for soil corrosion control for modular retaining walls with structural support component beneath the Commuter Rail tracks. Modular-type retaining walls that do not place critical structural components beneath the tracks shall also meet the requirements in Section 10.3.5.5, and FHWA Publication No. FHWA-NHI-00-044.

10.4 ATMOSPHERIC CORROSION PROTECTION

Methods for controlling atmospheric corrosion shall include, but not necessarily be limited to the following:

Materials selection – Acceptable materials shall have proven performance records for the service application.

Protective coatings – Barrier or sacrificial coatings shall be used on steel.

Design – Recess moisture traps and dissimilar metal couples shall be avoided.

Sealants – Accumulation of moisture in crevices shall be prevented by the use of sealants.

All wayside electrical equipment such as signals and communications equipment, electrical motors, control panels, switchgear, etc. shall be enclosed in temperature controlled environments or otherwise incorporate design techniques to prevent moisture condensation and corrosion of integral parts.

10.4.1 METALLIC MATERIALS (GENERAL)

Structures that may be affected by atmospheric corrosion shall be identified, including, but not necessarily limited to:

Exposed metallic surfaces on mainline structures

Exposed metallic surfaces at passenger stations

Catenary installations and related metallic hardware

Right-of-way and enclosure fences

Electrical, mechanical, signal, and communication devices and equipment, and signal and traction power substation housings

Vehicles

10.4.2 STEEL AND FERROUS ALLOYS

Carbon steel and cast iron exposed to the atmosphere shall have a coating applied to all external surfaces. Rail and rail fasteners do not require coatings except when used for the purpose of dielectric insulation. High strength low alloy steels shall be protected in a manner similar to carbon steels except where used as weathering steel exposed to outside environments. Coating of metallic contacting surfaces, crevice sealing, and surface drainage shall be addressed in the designs. Staining of adjacent structures shall be considered.

10.4.3 COPPER ALLOYS

Copper and its alloys can be used where exposed to the weather without additional protection. Bimetallic couples shall be avoided.

10.4.4 ZINC ALLOYS

Zinc alloys can be used without additional protection. Bimetallic couples shall be avoided.

10.4.5 ALUMINUM ALLOYS

Use an anodized finish to provide the best weather resistant surface. Bimetallic couples shall be avoided.

10.4.6 COATING SYSTEMS

Coatings shall have established performance records for the intended service and be compatible with the base metal to which they are applied. Coatings shall be able to demonstrate satisfactory gloss retention, color retention, and resistance to chalking over their minimum life expectancies. Coatings shall have minimum life expectancies, defined as the time prior to major maintenance or reapplication, of 15 to 20 years.

10.5 QUALITY CONTROL TESTING

10.5.1 CATHODIC PROTECTION

Cathodic protection testing includes verification of electrical continuity, electrical isolation, anode output current, correct test wire configurations, and determining compliance with cathodic protection criteria in accordance with NACE International Standards. The following paragraphs establish the guidelines for developing the quality control test procedures for verification of property cathodic protection levels:

All structures that are required to have cathodic protection shall be tested in accordance with NACE International RP0169.

A test plan shall be submitted by the testing agency to be approved by RTD.

Specific reporting requirements for the cathodic protection testing shall be incorporated into the project documents.

Selection criteria for the test entities to perform the quality control testing shall be incorporated into the project documents. The criteria shall include the qualifications of the agency, personnel requirements, and equipment requirements. A minimum of 5 years of experience performing this work is required.

10.5.2 COATINGS

The quality control measures required for the verification of proper application and handling vary depending on the coating type. The following guidelines establish general procedures for the quality control testing:

- Coatings shall be tested in accordance with the manufacturer's recommendations and in accordance with NACE International Recommended Practices.
- A quality control plan shall be implemented for surface preparation, application, and testing of all coated surfaces.

- All shop coated surfaces shall be tested, witnessed, and accepted at the coating facility.
- Selection criteria for the test entities to perform the quality control testing shall be incorporated into the project documents. The criteria shall include the qualifications of the agency, personnel, and equipment requirements.

END OF SECTION