UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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08/16, CHG 1: 11/16

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CORROSION INHIBITOR COATING OF CONCRETE SURFACES
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NOTE: This guide specification covers the requirements for corrosion inhibiting coatings for concrete surfaces.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

PART 1 GENERAL

1.1 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.
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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 260	(1997; R 2016) Standard Method of Test for Sampling and Testing for Chloride Ion in Concrete and Concrete Raw Materials

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 228.2R	(2013) Report on Nondestructive Test Methods for Evaluation of Concrete in Structures

ASTM INTERNATIONAL (ASTM)

ASTM C876	(2015) Standard Test Method for Corrosion Potentials of Uncoated Reinforcing Steel in Concrete
ASTM C900	(2015) Standard Test Method for Pullout Strength of Hardened Concrete
ASTM G59	(1997; R 2014) Standard Test Method for Conducting Potentiodynamic Polarization Resistance Measurements

1.2 SUBMITTALS

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NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G". Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for

Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force, and NASA projects, or choose the second bracketed item for Army projects.

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Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

List of Proposed Subcontractors; G[, [_____]]

List of Proposed Products; G[, [_____]]

Health and Safety Plan; G[, [_____]]

Reinforcement Corrosion Rate Testing Procedures and Equipment; G[, [_____]]

Environmental Protection Plan; G[, [_____]]

SD-02 Shop Drawings

Structure Corrosion Inhibitor System Application Areas; G[, [_____]]

Structure Repair Areas Prior to Inhibitor System Application; G[, [_____]]

Structure Testing Locations; G[, [_____]]

Structure Reinforcing Steel Test Wire Installation Locations and Installation Details; G[, [_____]]

SD-03 Product Data

Vapor Phase Corrosion Inhibitor; G[, [_____]]

Ionic Corrosion Inhibitor; G[, [_____]]

Surface Sealant; G[, [_____]]

Structure Repair Materials; G[, [_____]]

Structure Reinforcing Steel Test Wire; G[, [_____]]

Structure Reinforcing Steel Test Wire Enclosure; G[, [_____]]

Manufacturer's Storage and Handling Instructions; G[, [_____]]

SD-06 Test Reports

Corrosion Inhibitor Selection and Application Plan; G[, [_____]]

Pre-Project Test Application Report; G[, [_____]]

Daily Checklists; G[, [_____]]

Final Acceptance Test Report and Maintenance Test Procedure; G[, [_____]]

SD-07 Certificates

Manufacturer's Certificate; G[, [_____]]

Applicator's Certificate; G[, [_____]]

Evidence of Acceptable Variation Certificate; G[, [_____]]

SD-08 Manufacturer's Instructions

Safety Data Sheets (SDS); G[, [_____]]

Special Application Procedures For Extreme Temperatures; G[, [_____]]

SD-11 Closeout Submittals

Final acceptance Test Report; G[, [_____]]

1.3 QUALITY ASSURANCE

1.3.1 Qualifications

Submit Applicator's Certificate documenting a minimum of 5-years of experience in the application and testing of vapor phase and ionic corrosion inhibitors, including the test methods described herein. Submit a list of proposed subcontractors, including qualification statements, for review and approval if subcontractors will be utilized on the project.

1.3.2 Minimum Performance Requirements

1.3.2.1 Structure Life Extension

Submit Manufacturer's certificate that the proposed corrosion inhibitor system application will extend the structure service life a minimum of 10 years.

1.3.2.2 Corrosion Rate Reduction of Reinforcing Steel

Submit test data in the Final Acceptance Test Report that demonstrates a minimum reduction in reinforcement corrosion rate of 50 percent from the pre-application testing corrosion rate.

1.3.2.3 Water Penetration Rate Reduction of Concrete

Submit test data in the Final Acceptance Test Report that demonstrates a minimum reduction of 80 percent in the water penetration rate of concrete from the pre-application testing penetration rate.

1.3.2.4 Pullout Strength Increase of Concrete

Submit test data in the Final Acceptance Test Report that demonstrates a minimum increase of 3.4 MPa 500 psi in the pullout strength of the concrete from the pre-application testing strength.

1.3.3 Evidence of Acceptable Variation Certificate

Submit documentation of any variations from this section that certifies the variation will not prevent the inhibitor system application from achieving the minimum performance requirement.

1.4 REGULATORY REQUIREMENTS

1.4.1 Environmental Protection

Submit an environmental protection plan for the corrosion inhibitor system application project that addresses all requirements of the SDS for the products utilized and assures compliance with all applicable regulations.

1.5 DELIVERY, STORAGE, AND HANDLING

Deliver corrosion inhibitor products in sealed and properly labeled containers. Store and handle products in accordance with the manufacturer's instructions. Submit manufacturer's storage and handling instructions as part of the product data submittal.

1.6 SAFETY METHODS

Comply with all applicable OSHA and local authority standards for personal protection, including the required record keeping and training. Submit compliance plan as part of the Health and safety plan submittal.

1.7 ENVIRONMENTAL CONDITIONS

1.7.1 Weather and Substrate Conditions

Consider present and forecasted weather conditions for each structure prior to product application. Do not apply inhibitor system if rain is forecasted during the application or within 4 hours after the application is completed. The substrate temperature, air temperature, humidity and other environmental conditions must be within the limits recommended by the manufacturer for proper application. Document all relevant environmental conditions and include in the Daily Checklist submittals.

1.8 EQUIPMENT, TOOLS, AND MACHINES

Apply the inhibitor system utilizing methods, tools, and equipment approved by the manufacturer. Application equipment may include brushes, rollers, power rollers, spray equipment, squeegees, brooms, and pressure injection systems. Include the proposed application equipment and methods in the Corrosion Inhibitor Selection and Application Plan submittal.

1.9 SEQUENCING AND SCHEDULING

1.9.1 Structure Repair Areas Prior To Inhibitor System Application

Repair damaged and delaminated concrete areas and cracks in accordance with Section 03 01 00 REHABILITATION OF CONCRETE. Exothermically weld or pin braze a test wire to the reinforcing steel where reinforcing steel is exposed during the repair process. Prepare the surface of the wire attachment area in accordance with the coating manufacturer's recommended procedures and apply a 100 percent solids epoxy coating to the test wire attachment location that covers all bare wire and affected areas of the reinforcement. Allow the coating to cure in accordance with the manufacturer's instructions prior to proceeding with placement of structure repair materials. Terminate the test wire in an enclosure. Prepare and submit shop drawings showing the location of all repair areas and proposed test wire installations. The submittal shall include a list of all proposed repair materials, repair material SDS, and manufacturer's recommended application procedures. The Designer of Record will review and approve the structure reinforcing steel test wire installation locations and installation details required prior to installation.

1.9.2 Surface Preparation of Concrete

Remove all existing coatings, laitance, contaminants, and any other substances that could interfere with the inhibitor penetration. Select removal methods appropriate for the structure and materials to be removed. Include proposed removal methods in the Corrosion Inhibitor Selection and Application Plan submittal.

1.9.3 Pre-Application Testing

1.9.3.1 Reinforcement Corrosion Rate Testing Procedures And Equipment

Measure and document the corrosion rate of the reinforcing steel prior to inhibitor application. Document the location of test wires or reinforcing steel connections utilized for the corrosion rate measurements and each measurement location. Document the specific conditions of concrete moisture and surface temperature during the test. Identify a minimum of two separate test areas for each structure to be treated. Include a minimum of 25 measurement points in each test area. Utilize a combination of half-cell potential measurements collected in accordance with ASTM C876 and linear polarization resistance measurements collected in accordance with ASTM G59 to determine the corrosion rate of the reinforcing steel. Submit a list of all proposed corrosion rate testing procedures and test equipment within 2 weeks of the contract award. Alternate corrosion rate measurement techniques, such as electrochemical impedance spectroscopy (EIS) must be submitted to the Designer of Record for review and approval prior to testing. Report the corrosion rate in microamperes per square centimeter of reinforcing steel surface area in the test or in micrometers of steel loss per year.

1.9.3.2 Chloride Content of Cement

Measure the total chloride ion content of the structure's concrete sand/cement paste at the depth of the first course of reinforcing steel in accordance with AASHTO T 260. A pre-project test application of inhibitor is required for total chloride levels above 3,000 ppm in accordance with paragraph PRE-PROJECT TEST APPLICATION OF INHIBITOR. Include the chloride ion testing results and identify areas where pre-project test applications

are required, if any, in the Corrosion Inhibitor Selection and Application Plan submittal.

1.9.3.2.1 Pre-Project Test Application of Inhibitor

A pre-project test application of inhibitor is required for structures with total chloride levels above 3,000 ppm. Apply the test application to a representative section of the high-chloride structure area to be treated. Follow the application procedures included in the Corrosion Inhibitor Selection and Application Plan and PART 3 EXECUTION. Include all pre-application and post-application testing in order to ensure the minimum performance requirements can be achieved. Prepare and submit a Pre-Project Test Application Report to the Designer of Record for review and approval prior to proceeding with inhibitor application to high-chloride structures.

1.9.3.3 pH of Concrete

Extract an approximate 25 mm 1 in. diameter core of concrete to a minimum depth of the first course of reinforcing steel. Apply a multiple range pH indicator dye to the core in accordance with the dye manufacturer's procedures. Report the depth from the concrete surface at which a pH value of 11 or greater is indicated. Include the pH testing data in the Corrosion Inhibitor Selection and Application Plan submittal.

1.9.3.4 Water Penetration Rate of Concrete

Measure the water penetration rate of the concrete surface in accordance with the Initial Surface Absorption Test described in ACI 228.2R for at least two locations within the area to be treated with the inhibitor system. Include the results of the testing in the Corrosion Inhibitor Selection and Application Plan submittal.

1.9.3.5 Pullout Strength of Concrete

Measure the pullout strength of the concrete in accordance with ASTM C900 at a minimum of two locations in the area to be treated with the inhibitor system. Include the test results in the Corrosion Inhibitor Selection and Application Plan submittal.

1.9.4 Corrosion Inhibitor Selection and Application Plan

Prepare and submit a specific plan for structure corrosion inhibitor system application areas included in the project. At a minimum, include the product selections, structure areas to be treated, surface preparation requirements, application methods, application sequence and timing, and application rates that are based on the pre-application testing results. Include all pre-application testing data and analysis in the plan. Include shop drawings identifying the structure testing locations. Identify areas that require pre-project test applications based on excessive chloride ion levels. Submit the Corrosion Inhibitor Selection and Application Plan for review by the Designer of Record.

1.9.5 Corrosion Inhibitor Application

Apply the corrosion inhibitor system in accordance with the approved plan. Monitor and record the quantity of inhibitor applied to the surface, application method, surface temperature, and any other data or observations required by the plan. Inspect the surface for residue upon

completion of the inhibitor application to ensure all of the inhibitor has penetrated the concrete surface. Apply a light spray of water if necessary to aid inhibitor penetration. After the corrosion inhibitor application and penetration is complete clean the concrete surface of any remaining residue in accordance with the manufacturer's recommendations.

1.9.6 Post-Application Testing and Minimum Performance Requirements

Perform post-application testing a minimum of 60 days after completion of the corrosion inhibitor system application. Perform post-application testing utilizing the same instrumentation and test procedures at the same locations as those utilized during the pre-application testing. Include the post-application testing results in the Final Acceptance Test Report. The minimum acceptable performance criteria are included in paragraph MINIMUM PERFORMANCE REQUIREMENTS.

1.9.6.1 Corrosion Rate of Reinforcing Steel

Compare the pre-application test results and the post-application test results to determine the extent of corrosion rate reduction.

1.9.6.2 Water Penetration Rate of Concrete

Compare the pre-application test results and the post-application test results to determine the reduction in water penetration rate.

1.9.6.3 Pullout Strength of Concrete

Compare the pre-application test results and the post-application test results to determine the increase in pullout strength.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

The corrosion inhibitor system will consist of an organic vapor phase inhibitor, an ionic inhibitor or a combination of both inhibitors. Apply the organic vapor phase inhibitor first when a combination of inhibitors is utilized. In addition to the inhibitor system a reactive silicone surface sealant or surface protection coating will be applied. Submit a list of proposed products for the corrosion inhibitor system application. Include product Safety Data Sheets (SDS), warranty information and the manufacturer's recommended special application procedures for extreme temperatures and testing procedures in the submittal.

2.2 MATERIALS

2.2.1 Penetrating Vapor Phase Corrosion Inhibitor

A solution of organic amine carboxylate compounds that migrate in the gas phase through the cement pores to form a corrosion inhibiting film on the reinforcing steel surface.

2.2.2 Penetrating Ionic Corrosion Inhibitor

A solution containing chemically reactive water-soluble inorganic silicates designed to act as an anodic inhibitor on the surface of the reinforcing steel.

2.2.3 Surface Sealant

A chemically reactive water dispersion of a silane/siloxane mixture that forms an insoluble cross-linked silicone membrane within the concrete matrix.

2.2.4 Structure Reinforcing Steel Test Wire

Type THWN stranded copper conductor, not less than No. 10 AWG, of sufficient length to extend from the structure connection to the test wire enclosure without splicing. Terminate structure test wires in the test wire enclosure with solderless copper lugs.

2.2.5 Structure Reinforcing Steel Test Wire Enclosure

A surface/wall or post mounted enclosure to suit field conditions. Enclosure and cover constructed of non-metallic materials or hot-dip galvanized steel containing an insulated terminal board. Mounting post, where necessary, constructed of galvanized rigid conduit fitted with insulating bushings to protect the test wire from damage.

PART 3 EXECUTION

3.1 DAILY CHECKLISTS

Complete a checklist for each day of work on the structures included in the project. Record, at a minimum, the following information on the daily checklist: concrete surface temperature immediately prior to and after inhibitor application, or every 2 hours if there is a possibility of extreme temperature; concrete surface cleaning and preparation equipment and methods; concrete relative moisture immediately prior to inhibitor application; time of application and application equipment for each component; rate of application of each component; extent of surface treated; application method utilized; tests performed; testing locations; and any other requirements identified in the Corrosion Inhibitor Selection and Application Plan.

3.2 SURFACE PREPARATION

Examine all surfaces for cleanliness prior to application. Clean surfaces of visible contamination, coatings, sealants, debris, oils and fuels, and other similar materials. Treatment areas may be damp but no water ponding is permitted on flat horizontal surfaces. Measure and record concrete surface temperature immediately prior to inhibitor application. Do not apply inhibitor if concrete surface temperature is below 2 degrees C 35 degrees F. Consult the manufacturer for special application procedures if the concrete surface temperature is in excess of 38 degrees C 100 degrees F. Submit the special application procedures to the Designer of Record for review prior to application. Prepare the concrete surface for inhibitor application in accordance with the manufacturer's recommendations. Provide protection for equipment and structures in close proximity to the inhibitor application area to guard against overspray or product spillage. Use plastic sheeting to protect glass and decorative structure components and equipment from unintended inhibitor contact.

3.3 APPLICATION OF VAPOR PHASE CORROSION INHIBITOR

Apply the vapor phase inhibitor to the structure surface at the rate identified utilizing the methods, tools and equipment identified in the

Corrosion Inhibitor Selection and Application Plan. Verify that the recommended amount of inhibitor has penetrated the structure surface. Multiple applications may be required to achieve the recommended application rate. Do not overspray or allow the inhibitor product to be lost due to run off. Replace any lost product with sufficient additional product to achieve the recommended application rate. Apply a light spray of water to the treated surface after each application to assist the inhibitor penetration into the concrete. Inspect the treated surface following application. Minimal to no residue should remain following the application. Clean the concrete surface of any residue in accordance with the manufacturer's recommendations. Perform post-application testing identified in this section.

3.4 APPLICATION OF IONIC CORROSION INHIBITOR

Apply the ionic inhibitor to the structure surface at the rate identified utilizing the methods, tools and equipment identified in the Corrosion Inhibitor Selection and Application Plan. Verify that the recommended amount of inhibitor has penetrated the structure surface. Multiple applications may be required to achieve the recommended application rate. Do not overspray or allow the inhibitor product to be lost due to run off. Replace any lost product with sufficient additional product to achieve the recommended application rate. Inspect the treated surface following application. Minimal to no residue should remain following the application. Clean the concrete surface of any residue in accordance with the manufacturer's recommendations. Perform post-application testing identified in this section.

3.5 APPLICATION OF COMBINED VAPOR PHASE AND IONIC CORROSION INHIBITOR SYSTEM

Apply the vapor phase organic inhibitor first when a combination of vapor phase and ionic inhibitors are used together on the same structure. Follow the manufacturer's recommendations regarding the time period between application of the vapor phase inhibitor and the ionic phase inhibitor. Utilize the application specifications identified above for each type of inhibitor. Perform post-application testing identified in this section.

3.6 APPLICATION OF SURFACE PROTECTION COATING

3.6.1 Surface Sealant

Prepare the concrete surface in accordance with the manufacturer's recommendations. Apply surface sealants to the structure surface at the rate identified utilizing the methods, tools and equipment identified in the Corrosion Inhibitor Selection and Application Plan. Verify that the recommended amount of sealant has penetrated the structure surface. Multiple applications may be required to achieve the recommended application rate.

3.6.2 Protective and Decorative Coatings

Inspect and clean the concrete surface of residue that may interfere with the bonding of a surface protective or decorative coating. Separate specifications will be provided when protective and decorative coatings are included in the project. Perform post-application testing prior to the application of the protective and decorative coatings.

3.7 FINAL ACCEPTANCE TEST REPORT AND MAINTENANCE TEST PROCEDURE

Prepare and submit a Final Acceptance Test Report. Include, at a minimum, the following: as-built drawings showing all structure repair areas, test wire installation locations, pre-application test locations, inhibitor application areas, and post application test locations; all post-application test results; post-application test data analysis and evaluation of acceptance criteria for corrosion rate reduction of the reinforcing steel, water penetration rate reduction of the concrete, and pullout strength increase of the concrete; a statement that the corrosion inhibitor system application will extend the life of the structure a minimum of 10 years; and recommended maintenance testing procedures and frequency to ensure compliance with the minimum 10 year structure life extension requirement.

-- End of Section --