

Adhesive anchorages consist of a continuously threaded rod secured by an adhesive. Adhesive anchorage installers must hold current ACI-CRSI Adhesive Anchor Installer Certification credentials. Installers are required to check depth, diameter and condition of the drilled hole, clean the hole, and install the anchorage per the Manufacturer's Printed Installation Instructions (MPII). Record the name(s) of all certified installers on the RECORD OF CONTRACTOR/INSTALLER ACI-CRSI CERTIFICATION FORM available on the www.dot.state.mn.us/bridge/construction.html under "Construction forms and tools," and furnish the original of the completed form to the Project Engineer. Prior to installation of anchorages on the project, meet with the Project Engineer, Inspectors, and Installers to review the installation process and requirements. At the Pre-installation meeting, submit the RECORD OF CONTRACTOR/INSTALLER ACI-CRSI CERTIFICATION FORM with a copy of each installer's ACI-CRSI Adhesive Anchor Installer Certification card and a copy of the MPII to the Project Engineer.

Furnish only one of the systems listed on the Department's "Approved/Qualified Products List for Bridge Products, Concrete Adhesive Anchorages for Structural Applications," (www.dot.state.mn.us/products). Verify that the adhesive has an uncracked characteristic bond strength as specified in the plan. Install all anchors as specified by the MPII. Furnish a copy of the MPII that the installer will use to the Project Engineer. Install in sound concrete to a depth equal to the minimum depth specified in the plan or as specified by the supplier/manufacturer, whichever is greater.

Verify the anchor strength and installation procedures by proof testing anchorages in accordance with this specification. Perform all testing in accordance with ASTM E 488. Set up the testing device such that no portion of the device bears on the concrete surface within a distance equal to one and a half times the anchorage embedment depth. Test anchorages to not less than the required proof load as provided in the plan. If no anchor proof load is provided in the plan, contact the Project Engineer. Failure of an anchorage test is defined in ASTM E 488.

All damage to the concrete will be repaired at no cost to the Department. The repair must first be approved by the Project Engineer.

Perform all testing by an independent third party testing agency. Testing agent must have current ACI-CRSI Adhesive Anchor Installer Certification credentials.

Meet the following conditions prior to installation and testing:

- Allow concrete to set at least 14 days after pour;
- Ensure concrete surface is free of water prior to drilling;
- Ensure the hole is dry; and
- Install anchorages per Manufacturer's Printed Installation Instructions.

A dry hole is defined as a hole with no water present within the hole. If the hole is filled with water, partially filled with water, or water entered the hole during drilling, blow out the water using compressed air and allow 24 hours before cleaning the hole and installing the anchorage.

Ensure that the rail does not interfere with the testing apparatus during the proof test. Do not caulk the rail baseplate prior to testing.

Designer note: The highlighted areas in the specification below are numbered to correspond with the following bullet points. Fill in the blanks as follows:

- 1- Insert number equal to 10% of the anchorages on the bridge, no less than 10.***
- 2- Insert number equal to 5% of the anchorages on the bridge.***

3- Insert number equal to 10% of the anchorages on the bridge plus 5, no less than 15.

4- Insert number equal to 5% of the anchorages on the bridge, no less than 3.

Verify the anchor strength and installation procedure using one of the two following methods:

(1) Demonstrate the anchorage system at the first site of field installation. Five passing demonstrations are required to be able to move to the remaining production anchorage installations. Include a proof test in each demonstration installation. Failure of a proof test will require a modification of installation procedures or use of a different anchorage system and an additional five demonstrations of the modified or substituted system. Demonstration anchorages may be used in the railing system, however, no more than one demonstration may occur at any given post location and the Contractor assumes all liability for repairs that may need to be performed as a result of a failed test. Record all demonstration results on the PRE-PRODUCTION ANCHORAGES QUALIFICATION TEST REPORT available on the www.dot.state.mn.us/bridge/construction.html under "Construction forms and tools," and furnish the original of the completed form to the Project Engineer.

In addition to the five demonstrations stated above, test an additional **1** of the remaining anchorages on each bridge at a later date. The Project Engineer will randomly select the locations of the additional anchors to be tested. If a failure occurs while testing the additional **1** anchorages, more testing will be required at the rate of an additional **1** anchorages, per each failure, at no additional cost to the Department. If **2** of the anchorages on the bridge fail in concrete breakout, provide an anchorage replacement plan to the Project Engineer and remove the remaining anchorages without testing. Concrete breakout failure is defined as a spall a minimum of 2 inches in diameter by 1 inch deep. Compensation for costs of testing is included in the payment for the **_____**. Furnish a completed original of the PRODUCTION ANCHORAGES QUALIFICATION TEST REPORT available on the www.dot.state.mn.us/bridge/construction.html under "Construction forms and tools," and furnish the original of the completed form to the Project Engineer. No Ultrasonic Testing of anchorages need be performed.

(2) Install all production anchorages. Test **3** of the anchorages on each bridge at a later date. If a failure occurs while testing the **3** anchorages, more testing will be required at the rate of an additional **3** anchorages, per each failure at no additional cost to the Department. If **2** of the anchorages on the bridge fail in concrete breakout, provide an anchorage replacement plan to the Project Engineer and remove the remaining anchorages without testing. Concrete breakout failure is defined as a spall a minimum of 2 inches in diameter by 1 inch deep. Compensation for costs of testing is included in the payment for the **_____**.

In addition to the proof load testing above, perform Ultrasonic Testing to verify anchorage embedment on the proof loaded anchorages plus an additional **4** anchorages as randomly selected by the Project Engineer. Furnish a completed original of the PRODUCTION ANCHORAGES QUALIFICATION TEST REPORT available on the www.dot.state.mn.us/bridge/construction.html under "Construction forms and tools," and furnish the original of the completed form to the Project Engineer.

Notify the Project Engineer immediately after any failure. Remove all anchors that fail the field test without damage to the surrounding concrete. Redrill holes to remove adhesive bonding material. Replace and test anchors using one of the two methods listed above at no cost to the Department.

Perform installation of anchorages in accordance with the manufacturer's recommendations and as specified in the plan.

Fill with caulk any voids occurring between the top of the anchorages and the concrete in which it is embedded, as approved by the Project Engineer.

D. Fabrication and Inspection Requirements

Fabricator shall supply QA/QC documentation verifying that all fabricated railing components are within the necessary tolerances for proper fit up and installation of the railing, including measurements between railing base plates that indicate that the as fabricated base plate hole locations are within $\frac{1}{8}$ inch of the specified plan dimensions, based on the plan specified rail post spacing.

Fabricate all metal railing in accordance with 2471, "Structural Metals," the plan, and the welding code AWS D1.1-Structural Welding Code-Steel. Submit Welding Procedure Specifications (WPSs) to the Engineer for approval prior to the start of fabrication.

Prior to fabrication, submit a Quality Control Plan (QCP) and fabrication drawings that are acceptable to the Engineer. Any work started prior to receiving approved drawings WPSs, and a QCP, is subject to 1512, "Unacceptable and Unauthorized Work". Also give the Engineer at least 5 working days' notice prior to beginning work so that Quality Assurance (QA) inspection may be provided.

DESIGNER NOTE: Only use next paragraph for complex railings with multiple unique pieces. Questions regarding this use may be directed to the Structural Metals Unit.

The fabricator shall tag/piece mark all metal railing prior to final storage, and include the following identification markings, as a minimum: individual piece marks, bridge and/or project number(s), fabricator and applicator job numbers. All markings shall not be visible to the public when the railing is in its installed position. Include the method of identification in the fabricators QCP.

The Department QA shop inspections are not intended to supplement or replace the Fabricator's Quality Control (QC). The Contractor is ultimately responsible for the correction of errors and faulty workmanship or for the replacement of nonconforming materials.

The Fabricator will visually inspect all parts of the fabrication and have the inspections documented by QC personnel. The Fabricator will ensure that the rail meets a straightness tolerance of $\frac{1}{8}$ inch in 10 ft. The Fabricator will perform and document any Nondestructive Testing required by the Contract Documents using an ASNT-TC-1A Level II qualified inspector.

Document parts found to be in nonconformance by using a Nonconformance Report form (NCR), and describe in detail the fabrication error and the proposed repair procedure(s) in accordance with the QCP. Repair(s) performed are subject to the written approval of the Engineer.

E. Galvanizing Requirements performed by the Galvanizing Applicator

Galvanize all railing material in accordance with 3394, "Galvanized Structural Shapes," after fabrication and then powder coat (Duplex Coat) using the methods described in this document.

Pre-Galvanized Procedure(s):

1. Calibrate dry film thickness gages in accordance with SSPC-PA 2-Measurement of Dry Coating Thickness with Magnetic Gauges.
2. Prepare all fabricated material surfaces by abrasive blast cleaning to a minimum of SSPC-SP 6/NACE No. 3-Commercial Blast Cleaning prior to galvanizing.

3. Purchase Order(s) shall identify which specific items are to be duplex coated and which materials to be galvanized are reactive (e.g. 3309, "High-Strength Low-Alloy Structural Steel," etc.).

Galvanizing Procedure(s):

Galvanize per 3394, "Galvanized Structural Shapes," and this specification. All products supplied using this specification have higher aesthetic expectations than standard galvanized products. Produce the final product to comply with its intended use as an "architectural" railing with heightened aesthetics and/or visual qualities.

1. Process all metal railing to be galvanized utilizing a "dry" kettle. Preflux the metal railing prior to the galvanizing bath using an aqueous tank of zinc chloride/ammonium chloride. Do not use a "top flux" blanket on the molten zinc bath.
2. Air cool the metal railing to ambient temperature before handling for shipment and/or storage. Do not quench the metal railing or apply any post-galvanizing treatments.
3. Lumps, projections, globules, high spots, drip lines, heavy deposits, black and bare areas, blisters, flux deposits, thin spots, dross inclusions, etc., are considered unacceptable. Repair unacceptable zinc coatings in accordance with the Galvanizer's approved QCP and powder coating applicator approved method. Zinc, which will interfere with the "intended use of the product", will not be permitted.
4. Repair galvanized material that does not meet the requirements of this specification, ASTM D 7803, and/or 3394, "Galvanized Structural Shapes," in accordance with the Galvanizer's QCP.
5. Store galvanized metal railing in a manner that will prevent the formation of "white-rust" or wet storage staining. "White rust" or staining of the galvanize coating is not acceptable.
6. The Galvanizer shall provide the Engineer with all galvanizing process-related Quality Control documents which demonstrate compliance to this specification and referenced specifications prior to shipment of the galvanized product.
7. The Galvanizer will ensure the metal railings meet a straightness tolerance of $\frac{1}{8}$ inch in 10 ft prior to any subsequent coating applications.
8. It is the Galvanizer's responsibility to provide the Engineer with advanced notification of at least 5 working days of intent to galvanize so that the Engineer can perform a QA audit.

F. Coating Requirements performed by the Powder Coating Applicator

This portion of the specification documents specific criteria that powder coated components must conform to in order to meet the quality and intent of the finished product.

Definitions:

Lot: The amount of components that is baked at one time in a curing oven. If however, a continuous feed type curing oven is used, specifically identify the definition in the Quality Control Procedure for acceptance by the Engineer.

Applicator Qualifications and Documentation

At least 30 calendar days before starting work submit a Quality Control Procedure, meeting the requirements of this special provision to the Structural Metals Engineer, which outlines the program, procedures, and processes for assuring conformance to this special provision.

Establish powder coating quality control procedures in accordance with parameters set during the Powder Coating Applicator's Qualification Testing Procedure as defined in the "MnDOT Duplex Powder Coating Qualification Testing Procedure" located on the MnDOT Approved/Qualified Products web site www.dot.state.mn.us/products. Contact MnDOT Office of Materials Chemical Laboratory Director with any questions.

The following table represents the Properties and Specifications that are required for the Powder Coating Qualification Procedures.

| MnDOT Powder Coating Performance Requirements | | |
|---|---|--|
| Specification | Standard | Requirement |
| New Panels (initial testing) | | |
| Total Film Thickness | Mils | 4.0 mils minimum |
| Adhesion | ASTM D 4541- Type IV | Report |
| Color / Gloss | ASTM D 2244 ASTM D 523 - 60° | Color match to standard of $\Delta E < 2.0$ Gloss – report |
| Aged Panels (post testing) | | |
| UV-Con | ASTM D 4587 Cycle 4 (1500 hours) ASTM D 4541- Type IV | - Photos - Report change in color from standard (ΔE , 5.0 max) - Gloss – report - Adhesion – report |
| Salt Spray of the entire system (hot-dipped galvanized steel with Powder Coating) | ASTM B117 (2000 hours) ASTM D 4541- Type IV | - Photos - Rust Creep ASTM D 1654 Procedure A Method 1, ≥ 7 - Blister Resistance ASTM D 714; blister size rating ≥ 7 with a frequency rating of Few - Adhesion - report |

Perform QC inspections at the Powder Coating Facility in accordance with the Quality Control Procedure.

At least 30 calendar days before starting work, submit to the Quality Assurance Inspector (QAI) or the Engineer documentation showing that the coating manufacturer's technical representative trained the applicators, and Quality Control (QC) personnel how to properly apply the coating materials.

Provide the minimum requirements and frequencies in the Quality Control Procedure as shown in this table.

| Powder Coating Inspection Requirements | | |
|---|---|--|
| Requirement | Criteria | Frequency/Extent |
| Date and time | Each lot of work | Each lot of work |
| Compressed air test | ASTM D4285 | Daily – When abrasive blasting or blow down operations are occurring |
| Final Coat Dry Film Thickness (DFT) | (4 mils - minimum) | SSPC-PA 2 |
| Surface Preparation | | |
| Abrasive blast clean | SSPC-SP 16/ASTM D7803 | Each component to be powder coated |
| Pre-Bake for Outgassing | | |
| Surface cleanliness | SSPC-PA 1 | 100% Visual examination prior to coating |
| Pre-bake oven temperature | Same procedure used to pass qualification in Section "F" | Each lot of work prior to each out-gassing event |
| Baking procedure | ASTM D7803 in conjunction with the same procedure used to pass qualification in Section "F" | Each lot of work |
| Prime Coat | | |
| Powder product number | Track for each lot | Each batch of powder |
| Surface cleanliness inspection | SSPC-PA 1 | Visual examination prior to coating (within 1 hr of coating) |
| Prime coat oven temperature | Same procedure used to pass qualification in Section "F" | Each lot of work |
| Temperature of component at time of coating | Same procedure used to pass qualification in Section "F" | Each lot of work |
| Verification of prime coat coverage | 100% Coverage of powder | 100% Visual Inspection |
| Top Coat | | |
| Powder product number | Track for each lot | Each batch of powder |
| Surface cleanliness inspection | SSPC-PA 1 | Visual examination prior to coating |
| Top coat oven temperature | Same procedure used to pass qualification in Section "F" | Each lot of work |
| Final cure temperature of component | Same procedure used to pass qualification in Section "F" | Each lot of work |
| Curing time | Per manufacturer Technical Data Sheet | Each lot of work |
| Coating evaluation / repair | Visual Inspection Coating shall be smooth and uniform free of runs, drips, sags, pinholes, blisters, and other deleterious conditions. (Pinhole density shall not be greater than 5 pin holes per sq. ft. in any given area) | 100% Visual Inspection |

Provide written documentation of the measurements to the QAI or to the Engineer, when requested, during the work, and in its entirety at the completion of the job. The QAI or the Engineer may reject the coating system or reduce payment if the Contractor did not adhere to the Quality Control Procedure or provided inadequate documentation of adherence to the Quality Control Procedure. Conduct subsequent testing with the QAI or the Engineer's approval, at no additional cost to the Department, to determine compliance.

1. Perform preparation of galvanized surfaces prior to application of powder coating in accordance with SSPC SP16 "Brush-off Blast Cleaning of Non-Ferrous Metals," and ASTM D 7803.

Inspect brush-off blasted surfaces for fins or tears, or any surface that shows that the galvanized coating has been damaged. Repair damaged areas using procedures in accordance with the applicator's Quality Control Procedure. Repair surface of insufficient galvanize coating Dry Film Thickness (DFT) readings using the powder coating applicator's Quality Control Procedure repair procedure.

The QAI or Engineer will inspect the surface preparation as it is done, after its completion, or review the Quality Control Procedure documentation, or any combination of the three. Notify the QAI or the Engineer at least 5 working days before beginning surface preparation.

DESIGNER NOTE: For the following paragraph, insert color(s) as recommended by the MnDOT Bridge Office Architectural Specialist [(651) 366-4465].

Match the color of the finish coat to Federal Standard 595 C No. **(fill in coating color here)** with a semi-gloss finish.

1. Powder coat all sweep blasted galvanized railing with the subsequent coat(s) within the time frame defined in ASTM D 7803, or within the same 8-hour shift, maintaining manufacturer defined control and environmental conditions. The powder coating applicator's QC personnel shall document that all parameters were followed.
2. Apply all powder coating material in accordance with this special provision and the manufacturer's Product Data Sheet (PDS) and application guides for the material and system specified.
3. Accomplish QC inspections of coated products with an observer with normal color vision in a "well lighted" area during each coating phase and prior to final acceptance.

"Well-lighted" is defined as a minimum of 50 foot candles of artificial light or natural daylight. Use a light meter with readings in foot candles to verify the adequacy of the lighting.

4. Ensure the color of the first coat presents a distinct contrast from other coat(s).

Handling and Shipping by the Powder Coating Applicator of Duplex Coated Metal Railing:

Do not handle coated metal railing until the coating has cured as defined by the manufacturer of the powder coating, and is cooled to ambient temperature. Protect completed metal railing during handling and shipping to eliminate damage to the coating.

Any damaged coated surfaces, identified through either Quality Control or Quality Assurance inspections as being unacceptable, either after the application of the powder coating or during handling of the Powder Coating Applicator, is subject to the provisions of 1512, "Unacceptable and Unauthorized Work" or will be repaired as described in the Powder Coating Applicators repair procedure.

Storage of Coated Metal Railings:

Store all completed coated metal railing in accordance with 1606, "Storage of Materials," and the following:

Provide the Engineer with advance notification of at least 5 working days of intent to ship, so that the Engineer can perform a QA audit prior to shipping.

G. Construction Requirements

DESIGNER NOTE: Only use the following two paragraphs when a drilled-in anchorage alternate is NOT permitted by the contract (when metal railing(s) are intended to resist crash loads).

Provide the Engineer with a QA/QC plan that will be used to ensure that the cast-in-place anchorages are installed in the correct location using templates or other means ensuring that the exposed threads of the anchorages will not be damaged or contaminated and that the anchorages will not be displaced or allowed to move during concrete placement.

If cast-in-place anchorages have been installed in the forms, but prior to placing the barrier concrete, the Contractor shall provide written documentation verifying that all of the anchorages are within the necessary tolerances to place the tubular railing without modifying the railing base plate configuration.

Adjust the steel posts to obtain the grade and alignment as shown in the plans using the following method:

Shim the steel posts with galvanized steel shims or washers to the proper grade and alignment, not to exceed $\frac{1}{4}$ inch of shim height. Before attaching the nuts, **coat the entire surface between the base plate and concrete rail with an approved "Silicone Joint Sealant," as found on the Department's Approved Products website.** Tighten the anchor rod nuts (as per section "C"-Anchorages) and neatly smooth the caulk around the perimeter of the railpost base plate.



Ground all metal railings. Install all electrical grounding in accordance with the applicable provisions of 2557, "Fencing," and the National Electrical Code. Clamp or braze the ground wires to the grounding device, then practicably route and attach to the nearest rail by clamping, brazing, or any other approved means that will provide a permanent positive connection. If rail has non-continuous sections, use a #6 AWG solid copper wire to connect adjacent railing panels.

If the bridge does not include exposed electrical equipment, then ground the rails at points directly below or adjacent to the railing at all abutment corners. Ensure the grounding system consists of a #6 AWG solid copper wire connected to the railing which in turn is connected to a copper coated steel rod having a nominal diameter of $\frac{5}{8}$ inch or more and a minimum length of 8 ft installed to an elevation approximately flush with the ground surface.

If the bridge includes exposed electrical equipment, such as roadway lighting, traffic signals, variable message signs, surveillance cameras, or ramp metering, then bond the railing grounding system to the exposed electrical equipment grounding system. Refer to the electrical plans and electrical special provisions for details regarding bonding multiple electrical grounding systems.

H. Repairs of Coated Metal Railings once received at the job site

Any damaged coated surfaces, identified by the Project Engineer as being unacceptable is subject to the provisions of 1512, "Unacceptable and Unauthorized Work", and will be replaced or repaired. Submit a Non-conformance repair plan to the Project Engineer for acceptance. Once accepted in writing by the Project Engineer, perform repairs using the accepted methods and procedures authorized by the Project Engineer. (Note: Alkyd Enamels will not be allowed when used directly in contact with galvanizing).

Coating damage is classified in two extent types:

Type 1 – damage is any type of abrasion that caused a surface imperfection not exposing the galvanized surface or exposes an area of galvanized surface that is smaller than a nickel in size. This damage may be repaired in the field or the shop using an accepted Non-conformance repair plan as stated above.

Type 2 – damage is any type of surface imperfection that exposes the galvanized surface larger than a nickel and/or reduces the original thickness of galvanizing in an area larger than a dime. Remove sections of damaged rail from the site and repair in the powder coating applicator's shop.

I. Method of Measurement

Measurement will be by length in feet based on plan dimensions between the outside ends of metal railings (with deductions for the lengths of concrete end posts).

J. Basis of Payment

Payment for Item No. 2402.583 "ORNAMENTAL METAL RAILING TYPE SPECIAL PC" will be made at the contract price per foot and shall be compensation in full for all costs of fabrication, surface preparation, galvanizing, brush blasting of galvanized surface, coating, delivery, and installation, as described above. Failure to comply with any of these requirements will result in rejection of the material and/or reduction in payment.

