STATE OF NEW HAMPSHIRE
INTER-DEPARTMENT COMMUNICATION

DATE March 2, 2011

FROM Jerry S. Zoller, P.E.
Project Engineer

Office) Bureau of Bridge Design
Tel. 603-271-2731, Fax -2759

TO Steve Glines, P.E.
District Construction Engineer

Subject **Lincoln-Franconia 15603, A000(808)**
Franconia Notch Parkway
Duplex coating (Galvanizing and Powder Coat)

RE Submittal for Duplex Coatings, Special Provision 708-Appendix A

The Bureau of Bridge Design received the submittal for this project from Duncan Galvanizing for Special Provision 708, Paints- Appendix B- Duplex Coating - Powder Coating over Galvanizing. The coated color panels were received February 11 and the paperwork February 22, 2011.

The submittal included the following items:

Item #	Submittal:	Number
1	Verification coating/color panels (3" x 6" x 1/4" steel duplex coated samples)	11
2	Written Plan for Applying Duplex Coating for NHDOT Lincoln-Franconia 15603	2
3	Duncan Memo (6/12/09) for Repair of Thermoset Powder Coat	3
4	Tiger Drylac Ltr (2/14/11) Approved Applicator for Tiger Drylac powder coatings	1
5	Tiger Drylac Zinc Rich Primer 69/90500 Dryzinc -Product Data & MSD Sheets	4 / 4
6	Tiger Drylac Super Durable Series 38 - Product Data & MSD Sheets	4
7	Tiger Drylac Clear Flat Matte Series 16/00030 - Product Data & MSD Sheets	4 / 4

The submittal is approved as noted. Please note the following comments:

Item #1- Verification coating/color panels (3" x 6" x 1/4" steel duplex coated samples)

The color panels were reviewed by the Department and approved. Signed panels were returned to Duncan under separate cover. A scanned copy in .pdf format is attached to this memo.

Item #2- Written Duplex Coating Plan for Applying Duplex Coating

The Duplex Coating Plan has been marked up with a few notes, scanned, and attached as a.pdf file. The markup comment may be summarized as follows:

1. Be reminded that the NHDOT Special Provision 708-Appendix A applies to the work whether the Duncan Written Plan lists specific details or not.

2. Duncan needs to give assurance that fasteners supplied by others are coated to the spec requirements.

3. Protective measures for the finished product during handling must also be employed in the field as well as in the shop.

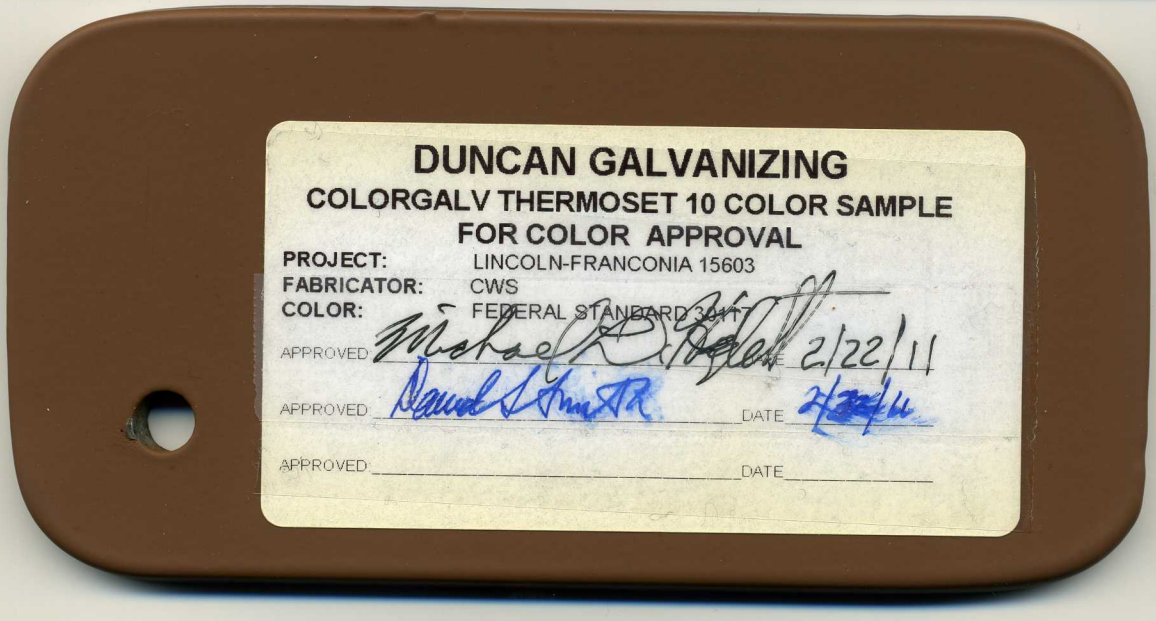
Item #3- Duncan Memo (6/12/09) for Repair of Thermoset Powder Coat

4. Field touchup liquid coatings should be stated in writing, and the repair procedures approved by the powder coating supplier.

5. Be reminded that field touchups shall be performed or supervised by personnel from the duplex coating facility. (3.7.4.1)

Please contact me if you have any questions.

JSZ/j
attachments
cc file



LINCOLN-FRANCONIA
15603

July 29, 2010

S P E C I A L P R O V I S I O N

AMENDMENT TO SECTION 708 -- PAINTS

Amend Appendix B to read:

APPENDIX B

DUPLEX COATINGS - POWDER COATING OVER GALVANIZING

Highlight these requirements:
- Apply galvanizing and powder coating within the same facility (see 1.2);
- Apply first powder coating over galvanizing within a maximum 12-hour window (see 3.4.1).

DESCRIPTION

1.1 GENERAL. This appendix specifies a duplex coating, consisting of hot dip galvanizing and high-performance, shop-applied, thermosetting-based, super-durable powder coatings, for fabricated steel products for exterior use, as shown on the plans or as directed.

1.2 DUPLEX COATING FACILITY. The galvanizer shall be qualified and have demonstrated a minimum of ten years experience in the successful application of hot dip galvanizing using the dry kettle process, and a minimum of five years experience in the successful application of powder coatings over galvanizing within the same facility.

1.3 SCOPE OF WORK. All fabricated products and components, as shown on the plans or as directed, shall be furnished with a duplex coating color finish as described. See Summary Table 1.3.

MATERIALS

2.1 GALVANIZING. Hot dip galvanizing shall conform to AASHTO M111 (ASTM A123) and utilize the dry kettle process in a bath of molten zinc. The galvanizing kettle shall contain special high grade zinc, nickel, and other earthly materials. The galvanizing process shall not include quenching with water or treatment with a chromate conversion coating. Provide thickness of galvanizing specified in the reference standards. Hardware shall be hot dip galvanized in conformance with AASHTO M232 (ASTM A153).

2.2 ABRASIVES. Provide abrasives that are dry and free of oil, grease, and corrosion-producing, or other deleterious contaminants. Provide an abrasive that is sized to produce a dense, consistent, sharp, angular, uniform anchor pattern with a profile height of 1.0-1.5 mils, unless the requirements of the coating manufacturer are more restrictive. The use of iron shot, steel shot, aluminum oxide grit, sand, or coal slag products as blast abrasives, and power wire brushes are NOT permitted. Use approved abrasives [e.g. garnet, stainless steel grit, Dupont StarBlast® XL (fractured), etc.] that will not leave a residue on the galvanized surface after blowing down with compressed air.

2.3 POWDER COATING. The duplex coating shall be a three-coat, shop-applied, oven-cured, high performance, exterior thermosetting powder coating consisting of a durable zinc-rich powder coating primer, a super-durable powder coating topcoat, and a clearcoat applied over hot dipped galvanized (HDG) steel substrates.

Scope of Work - Summary Table 1.3		
Surfaces to be powder coated As shown on the plans (e.g. Item No's) *	Duplex System (2.3) *	Final Color (satin)
563.31, Bridge Median Rail Base Plate 563.32, Tubular Bridge Plate for Br Approaches 606.000, Steel Beam for Beam Guardrail 606.0122, Steel Post Assemblies for Beam GR Posts 606.120, Beam GR (Standard Section Steel Post) 606.1454, Beam GR (Term. Unit Type EAGRT 50') 606.1457, Median Impact Attenuator (Xtension) 606.1458, Nu-Guard Transition Segment 606.147, Beam GR (Terminal Unit Type G-2) 606.25808, Double-Faced Steel Beam GR, Steel Posts (Nu-Guard) 606.25848 Double-Faced Steel Beam GR, (Nu-Guard) (3'-1 1/2" Spacing) 677.42 RWIS System 678.5 Bullnose Attenuator	Hot Dip Galvanizing, plus 3 powder coats (durable primer, super durable topcoat, and clearcoat)	Rusty Brown Fed # 30117
563.9133 Snow Screening (Tubular)	ditto	Dark Brown Fed # 30062

* Note: All surfaces receive the duplex system as described, except for ground-driven posts which must be galvanized full length and duplex coated for the top 36 inches (i.e. the above-ground portion plus four inches). At the supplier's option the duplex coating may be applied to the entire length of posts.

2.3.1 Furnish powder coating materials from one of the following approved suppliers:

1. AkzoNobel
2. PPG
3. Sherwin Williams
4. TIGER Drylac

2.3.2 The powder coating manufacturer shall certify in writing that:

1. The duplex coating facility applying the powder coating is certified to apply the powder by the coating manufacturer;
2. The powder coating meets or exceeds the following minimum performance requirements for use over hot dip galvanized surfaces:

A. Powder Coating PRIMER;

Test	Results
1. Thickness (SSPC PA2)	3 mils (min.)
2. Abrasion Resistance (ASTM D4060 CS17 Wheel, 1 kg load)	200 mg loss (max)
3. Adhesion (ASTM D4541)	1050 psi (min)
4. Corrosion Weathering (ASTM D5894, 13 cycles, 4368 hours)	
(per ASTM D714 blistering)	Rating: 10
(per ASTM D610 rusting)	Rating: 7
5. Impact Resistance (ASTM D2794 Direct)	160 in. lbs.
6. Flexibility (ASTM D522, 180º bend, 1" mandrel)	Passes
7. Pencil Hardness (ASTM D3363)	3B
8. Moisture Condensation Resistance (ASTM D4585, 100º F, 2000 hrs)	Passes, no cracking or delamination
9. Dry Heat Resistance (ASTM D2485)	250º F

B. Powder Coating TOPCOAT;

Test	Results
1. Thickness (SSPC PA2)	5 mils (min.)
2. Adhesion (ASTM D4541)	1050 psi (min)
3. Flexibility (ASTM D522, cylindrical mandrel)	Passes
4. Pencil Hardness (ASTM D3363)	2H
5. Salt Spray (ASTM B117) 2000 hrs	Passes
6. Humidity (ASTM D4585) 100º F, 2000 hrs	Passes, no cracking or delamination
7. Impact Resistance (ASTM D2794 Direct)	160 in. lbs.
8. Color Retention (ASTM D2244) 10 years	3ΔE (based on inorganic resins)
9. Chalk Resistance (ASTM D4214)	none
10. Gloss Retention (ASTM D523) 10 years	45% loss (max)
11. Xenon Arc Test (ASTM D 4798) 400 hrs	Passes

2.3.3 Provide each coat of powder coating in sufficiently contrasting color to facilitate proper coverage and to distinguish it from previously applied coatings. The previous coat shall be hidden by application of each coat at the specified minimum thickness.

2.3.4 Provide all powder coating materials in sealed, original, containers that are properly marked to allow verification, with applicable material safety data sheets, application instructions and precautions, including the manufacturer's name, type of material, brand name, color, shelf life, purchase order number, lot and batch numbers, and quantity.

2.3.5 Color. The final color of the painted product shall be (see Table 1.3) (satin) unless specified otherwise, closely matching the Federal Standard 595B or RAL Color Standard number, as follows:

Description	Fed Color #	RAL Color Standard
Rusty Brown	30117	
Dark Brown	30062	
Black	37038	

2.3.6 Touchup materials. Repair and touch-up materials shall be supplied by the powder coating applicator and applied in accordance with the powder coating manufacturer's recommendations.

2.4 EQUIPMENT.

2.4.1 Inspection Equipment. Provide inspection equipment needed to verify the quality of the entire galvanizing, surface preparation, and powder coating processes, including a Type II dry film thickness gage that can be calibrated, calibration standards, and a mirror for use by the Department.

DUPLEX COATINGS - POWDER COATING OVER GALVANIZING

3.1 GENERAL

3.1.1 Provide all materials, equipment, and labor necessary to perform the scope of work whether or not the material or equipment is specifically identified in this Item. Conduct all galvanizing, surface preparation, powder coating operations, handling, shipment, and installation in a workmanlike manner in conformance with SSPC-PA1, these requirements, and to the reasonable satisfaction of the Department.

3.1.2 [blank]

3.1.3 Specifications. Perform the work in conformance to the Contract requirements, the reference standards, and the coating manufacturer's instructions, respectively.

3.1.3.1 Reference Standards. The latest edition of the following standards and regulations in effect at the time of the Bid form a part of this Specification. A copy of the reference standards applicable to the work shall be available at the shop facility for use by the Department's representative.

a. American Society for Testing and Materials (ASTM)

1. ASTM A123, Standard Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
2. ASTM A153, Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware
3. ASTM A385, Standard Practice for Providing High-Quality Zinc Coatings (Hot Dip)
4. ASTM A780, Standard Practice for Repair of Damaged and Uncoated Areas of Hot Dip Galvanized Coatings
5. ASTM D610, Standard Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces
6. ASTM D6386, Standard Practice for Preparation of Zinc (Hot Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting.

b. American Association of State Highway & Transportation Officials (AASHTO)

1. AASHTO M111, Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
2. AASHTO M232, Zinc Coating (Hot Dip) on Iron and Steel Hardware

c. American Galvanizers Association (AGA)

1. The Inspection of Products Hot Dip Galvanized After Fabrication
2. *Powder Coating over Hot Dip Galvanized Steel*, Powder Coating Journal, Feb 2004, Philip Rahrig, AGA Executive Director
3. *Powder Coating over Galvanized Steel*, Tom Langill, AGA Technical Director

d. Society for Protective Coatings (SSPC)

1. SSPC-SP 1, Solvent Cleaning
2. SSPC-SP 7 / NACE No. 4, Brush Off Blast Cleaning
3. SSPC-PA 1, Shop, Field, and Maintenance Painting
4. SSPC-PA 2, Measurement of Dry Film Thickness with Magnetic Gages

3.1.4 Submittals.

3.1.4.1 Surface Preparation and Powder Coating Plan.

1. Provide a written plan to the Department for applying duplex coatings. Identify the manner of surface preparation, the powder coat system to be applied, film thickness, cure time between coats, repair materials and procedures of typical damage and defects in the duplex coating, and other information needed to successfully apply all coats of the duplex system.

2. Provide material product literature and MSD sheets for the coatings specified, along with test data indicating conformance to the performance criteria required.

3. Verification samples. Submit six 3-inch by 6-inch samples of shop-applied duplex coatings and colors proposed for use for approval to the Department (Bureau of Bridge Design, Tel. 603-271-2731) a minimum four weeks prior to coating application. Samples shall be made of the same or comparable material and thickness as production pieces.

4. Submit a Certificate of Compliance stating that the requirements of the contract specifications have been met, in conformance to 106.04.

3.1.4.2 Substitutions or Approved Equals.

1. Substitutions or 'Approved Equals' are defined as meeting the aesthetic, durability, and all other performance criteria described in this specification, and shall be accompanied by proof that the Substitution or 'Approved Equal' meets or exceeds these criteria. Approval is the discretion of the Department. Coatings or processes not matching or exceeding the approved specified process and aesthetic, durablility, and performance criteria shall be removed and replaced at the expense of the Contractor and all subcontractors that were involved with the supply of and application of the non-conforming product.

3.1.5 Supplier Coordination.

1. **Fabricator-Galvanizer Coordination**. Prior to fabrication and final submittal of shop

drawings to the Department, fabricators shall submit shop drawings to the galvanizer for all metal fabrications to receive shop-applied duplex coatings, to review fabricator's shop drawings for suitability of materials for galvanizing and coatings, and to coordinate any required modifications to fabrications required to be performed by the fabricator.

2. The supplier of steel products shall notify the galvanizer if the chemical composition of the steel to be galvanized exceeds the following limits in order to determine its suitability for processing: 0.25% carbon, 0.22% silicon, 0.04% phosphorous, and 1.3% manganese.

3.2 HOT DIP GALVANIZING (HDG)

3.2.1 Fabricated products shall meet the requirements of ASTM A385 (for material composition, cleanliness, drainage vents, etc.) prior to galvanizing, and galvanized surfaces shall meet the requirements of ASTM D6386 (preparing zinc surfaces for painting), as applicable and as stated herein.

1. Galvanizing: Galvanize materials in accordance with specified standards and this specification. Galvanizing shall provide an acceptable substrate for applied coatings. The dry kettle process shall be used to eliminate any flux inclusions on the surface of the galvanized material.

2. Prior to galvanizing, the steel shall be immersed in a preflux solution (zinc ammonium chloride). The preflux tank shall be 12-14 Baumé and contain less than 0.4 percent iron. The wet kettle process is prohibited.

3. Implement the following procedures to provide the appropriate surface for the material to be galvanized:

   a) Utilize and regularly inspect a monitoring recorder to observe any variances in the galvanizing bath temperature.

   b) The pickling tanks shall contain hydrochloric acid with an iron content less than 8 percent and zinc content less than 3 percent. Titrations shall be taken weekly at a minimum.

   c) All chemicals and zinc content will be tested at least once a week to determine compliance with ASTM standards. All testing will be done using atomic absorption spectrometry or x-ray fluorescence (XRF) equipment at a lab in the galvanizing plant.

3.2.2 Surface Preparation of Hot Dip Galvanizing (HDG)

1. Prepare all surfaces in conformance to the requirements of this Item, and the approved Surface Preparation/Powder coating Plan provided under 3.1.4, Submittals.

2. Prior to powder coating, clean and prepare galvanized surfaces as necessary to remove detrimental contaminants. (See *Powder Coating over Galvanized Steel*, Feb 2010 Tom Langill) for cautions regarding cleaning. If applicable apply cleaning materials with clean lint-free rags or soft bristle brushes frequently changed to prevent reapplying contaminants. After cleaning, rinse thoroughly with hot water and allow the part to dry completely.

3. Prepare galvanized surfaces with SSPC-SP7, Brush-Off Blast Cleaning, using non-metallic abrasives at a reduced nozzle pressure as recommended by the equipment manufacturer, or abraded by approved mechanical means using sanding disks with appropriate abrasive, to thoroughly roughen the entire surface and produce a dense, consistent, sharp, angular, uniform anchor pattern with a profile height of 1.0-1.5 mils, exhibiting a uniform gray color free of any bright, shiny spangles and to an appearance and feel similar to sandpaper.

4. The required thickness of the zinc coating shall be maintained and checked prior to powder coating. Surface preparation shall be acceptable to the powder coating manufacturer's requirements. Additional surface preparation or a tie coat may be considered if required by the powder coating manufacturer and approved by the Department.

5. The substrate surface shall be dry and free from dust, dirt, oil, grease or other contaminants.

3.2.3. Discontinuities. All visually evident detrimental surface imperfections (e.g. flux inclusions, dross inclusions, oil) that are present on galvanized surfaces shall be cleaned, and any high spots, rough areas and edges, spikes, and sharp protrusions shall be removed by grinding to produce a smooth surface. Disbondment (peeling) of galvanizing is not acceptable and the piece shall be regalvanized, or investigated for extent and severity and a repair solution proposed to the Department for approval before corrective action is taken.

3.2.4 Surface profiling shall be performed prior to the formation of "white rust" on the galvanized surface. If any "white rust" is detected by visual means, the galvanizing shall be stripped off and the steel re-galvanized in conformance with these specifications. "White rust" shall be as defined in the Inspection of Products Hot Dip Galvanized After Fabrication, Table IV, by the American Galvanizers Association.

3.2.5 Prior to powder coating galvanized products shall not be nested, stacked or stored with adjacent surfaces touching but shall be kept separated to be remain dry and permit the circulation of air between products.

3.3 GALVANIZED STEEL OUTGASSING.

3.3.1 The galvanized parts shall be subjected to a thermal cycle (i.e. outgassing) after surface profiling and before powder coating application. The thermal cycle should be set at the appropriate temperature and duration for the thickness of the product recommended by the powder coating manufacturer.

3.4 POWDER COAT APPLICATION.

3.4.1 Time limits. The first coat of powder coating shall be applied within twelve (12) hours of galvanizing and within one hour of surface preparation of the galvanized surface and outgassing, at the galvanizer’s facility, and in a controlled environment meeting applicable atmospheric requirements, as recommended by the coating manufacturer.

3.4.2 Powder coating application. Pretreatment and powder coating application and curing shall be performed after galvanizing in conformance with the powder coating manufacturer's recommendations and shall consist of the following, unless approved otherwise:

1. Verify that the galvanized surface exhibits the specified degree of cleaning immediately prior to powder coating.

2. The coating and curing facility shall be maintained free of airborne dust and dirt until coatings are completely cured.

3. The powder coating shall be electostatically applied according to the coating manufacturer's written specifications, maintaining even coverage on all parts. The powder shall only be applied when both the ambient temperature is 65º F. or above, and the part surface temperature is between 60º and 95º F., and is (min.) 5º F. higher than the dew point. Relative humidity shall be less than 85 percent (max.).

4. After applying the powder, all parts shall be placed in an oven, cured and bonded at the manufacturer's recommended levels (e.g. approximately 392º F. for 25 minutes). The Contractor shall ensure that a stable transfer exists between the powder application system and the curing oven to prevent the loss of powder from the parts.

5. The powder coating shall be applied to a minimum dry film thickness of 3 mils primer and 5 mils topcoat, and in a manner that will ensure a uniform coating without holidays, runs, or detrimental build at edges. A clear coat shall be applied at the manufacturer's recommended thickness.

6. Each coated part shall be visually inspected. Measure the coating thickness with a thickness gauge. Any part that does meet the specified coating thickness may be recoated immediately after lightly abrading (sanding) the surface. Once cured, all parts shall be allowed to cool sufficiently before further handling.

3.4.3 Surface smoothness - Duplex coatings shall exhibit a smoothness (i.e. rugosity) not greater than 4 rug (16-20 microns of variation) when measured by a profilometer over a 1-inch straight line on the surface of metal products less than 24 lbs/ linear foot. The profilometer shall be capable of operating in 1 micron increments.

3.4.4 All fasteners shall be galvanized and fastener components visible to view shall be powder coated. Furnish an application procedure to the Department including which fastener components are to be powder coated. Coating procedures for fasteners are not restricted to the same-facility (1.2) and 12-hour maximum window (3.4.1) restrictions, due to the nature of fastener supply.

1. Bolts - Powder coat bolt heads visible to view. Minor overspray is permitted on the threads.
2. Nuts - Powder coat the exterior surfaces of nuts visible to view and mask off interior surfaces. Nuts not visible to view (e.g. W-beam splice bolts) need not be powder coated.
3. Washers - Powder coat all washers visible to view. Minor overspray is permitted on washer surfaces that are not required to be powder coated.

3.5 INSPECTION.

3.5.1 Quality Control (QC). The applicator is required to conduct and document quality control inspection of the cleaning and powder coating operations including at a minimum, measurements of surface profile, surface cleanliness, dry film coating thickness, and visual inspection for coating defects.

The data shall be recorded in a log maintained at the site and available for the Department's review during working hours.

3.5.2 Quality Assurance (QA). The work is subject to QA inspection by the Department.

1. Facilitate QA inspection as required, including proper notification, allowing adequate time for inspections, and providing access to the work. Furnish, until final acceptance of the coating system, all equipment, reference documents, and instrumentation needed to inspect all phases of the work.

2. Measure the thickness of each coat using nondestructive magnetic dry film thickness gages. Comply with SSPC-PA2 for the calibration and use of gages and the minimum frequency of thickness measurements. QA Inspectors will not be limited by the frequency of thickness measurements of PA2 but will take measurements sufficient to assure that proper thickness is achieved on all surfaces as specified.

3. The presence or activity of Department QA inspections in no way relieves the Contractor of the responsibility to comply with all requirements of this Item, and to provide adequate inspections of its own to assure compliance with the requirements of this Item.

4. Finished products will be stamped "Approved" only after the loading has been completed and approved. No material shall be shipped without the prior approval of the Department.

3.6 HANDLING / SHIPPING / INSTALLATION.

3.6.1. **Cure**. Duplex-coated materials shall not be lifted, placed on supports, or loaded for shipment until the shop coating has been adequately cured and inspected.

3.6.2. Protective measures. Exercise care in handling shop-coated materials in the shop, and during storage, shipping, field installation, and subsequent construction to protect the coating from any scraping, marring, or other damage to the surface finish. Coated material shall be insulated from lifting devices and from the scraping and rubbing of parts that would damage the coating, by the use of lifting softeners, nylon slings, padded cables, storage pallets, separators, cushioners, tie-downs, and other approved supports. Individual parts shall be wrapped or padded with effective protective material (e.g. foam, not paper or cardboard).

3.6.3. **Mechanical damage.** Installation operations involve tasks which may damage the finish coating on some areas of the finished product, such as from driving posts, overlapping sections of rail, and installing fasteners. The Contractor shall exercise reasonable care to minimize damage to the coating during installation.

3.7 TOUCH-UP AND REPAIRS.

3.7.1 The total repair area shall be less than <u>one quarter of one percent</u> (<u>0.25%</u>) of the area of an individual member*, or the member shall be rejected and regalvanized and recoated with the duplex coating. [The repair area definition is comparable to <u>Rust Grade 7</u> in ASTM D610, *Standard Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces.*] [*Note - The areas listed in Section 3.6.3 subject to mechanical damage during installation shall be repaired as required but are excluded from the total repair area calculation.]

3.7.2 HDG- Repair damaged galvanizing and bare steel surfaces in accordance with ASTM A780, Standard Practice for Repair of Damaged Hot Dipped Galvanized Coatings, Annex A2. Thoroughly clean damaged areas to produce a clean, bare and dry bright metal surface with a roughened profile and feather into the edges of adjacent undamaged galvanizing. Use a power sanding disk per SSPC-SP3. For bolts use a thorough hand wire brushing and SP1 cleaning as a minimum.

3.7.3 Apply an approved organic zinc-rich repair paint containing 95 percent (min.) zinc by weight in the dry film, according to the manufacturer's recommendations, in two to four coats to a thickness equivalent to the surrounding galvanizing. Silver paint, brite paint, or aluminum paint is not acceptable.

3.7.4 Powder coating - The repair to the powder coat may be a liquid and brushed on or an aerosol and sprayed, whichever is appropriate to achieve an aesthetic finish and as long as the coats, cure, and minimum thickness of the original system are achieved. The Contractor shall provide a dry film thickness gage and check the thickness of the repair areas. Touch-ups shall be such that the repair is not noticeably visible from a distance of six feet.

1. The field-touch-up of shop-applied finish coatings shall be performed or supervised by personnel from the duplex coating facility for the warranty to apply.

2. Touch up fasteners in the field after installation, assuming there may be mechanical damage to nuts during tensioning fasteners.

3. Touch-up repair kits in sufficient quantity and touchup instructions shall be provided to the field for each type of shop-applied finish. Additional touchup repair kits and instructions shall be furnished to the Department for use after project acceptance for maintenance repairs.

3.8 FINAL ACCEPTANCE.

Although the Department's QA Inspector may accept the finished duplex coated fabricated products before shipment to the jobsite, final acceptance of the duplex coat system by the Department will occur at the jobsite after installation of the product, and after all coats and repairs have been completed.

3.9 FIVE-YEAR WARRANTY.

Should the duplex system fail within five years after the project has been accepted, the coating shall be repaired or replaced by the Contractor at no cost to the State. The extent and method of repair must be acceptable to the Department. System failure does not include damage from external agents, such as scraping from snow removal equipment, vandalism, debris impacts, collisions, etc., or normal loss of gloss and color. Once the duplex system has been accepted, a failure shall mean any visible corrosion, blistering, checking, cracking, or delamination (peeling) of the galvanizing or powder coating resulting from the installation of the product or from the performance of the duplex coating.

[REFERENCE DOCUMENT - page 1 of 4]

POWDER COATING OVER GALVANIZED STEEL

Thomas J. Langill, Ph.D., Technical Director

American Galvanizers Association
Centennial, CO

Abstract: Powder coating over hot dip galvanized steel is an extremely effective corrosion protection system. However, careful surface preparation techniques need to be used to alleviate potential coating failures. The age and characteristics of the galvanized coating should be used to determine what type of surface preparation is needed.

INTRODUCTION

Hot dip galvanized steel parts or assemblies are often required to be painted or powder coated. The reason for powder coating can be to identify the particular structure, for architectural reasons, to provide a particular type of protection, or to extend the service life of an existing structure. The combination of a powder coating system with a hot dip galvanized coating is often referred to as a "duplex system" (1). When powder coating and galvanized steel are used together, the corrosion protection is superior to either protection system used alone (2).

The application of a powder coating system onto a hot dip galvanized surface requires careful surface preparation and a good understanding of both corrosion protection systems. The margin for error is very small when dealing with newly galvanized steel surface preparation. However, there have been many examples of powder coating adhesion problems on older or more moderately aged galvanized steel surfaces, and the most common cause is improper or incomplete surface cleaning and preparation (3). When the surface is cleaned and prepared correctly the combined powder coating and galvanized steel corrosion protection system gives extremely long lifetimes (4). If the powder coating is properly maintained on the galvanized surface there is practically no limit on the life of the structure in terms of corrosion attack.

The adhesion of powder coating onto galvanized steel becomes a very small problem when the galvanized coating has weathered for at least a one-year period. The zinc corrosion products form a very dense, insoluble protective layer that accepts a powder coat readily. A brand new galvanized coating also experiences few adhesion problems within the first 24 to 48 hours after coating. The intermediate period from 24 hours to one year can present some challenges to surface preparation but the corrosion products that are formed on the galvanized surface can be cleaned and the surface can be successfully powder coated.

GALVANIZED COATING

Hot dip galvanized coatings can be applied in two different ways. The parts can be fed into a liquid zinc bath in a continuous roller process where the coating characteristics are highly dependent on the speed of the steel through the liquid zinc bath. The two most common steel products that are hot dip galvanized using the continuous process are sheet and wire. The objective of the continuous process is

to deposit a zinc coating that is smooth, thin and composed of nearly all zinc bath metal with very little zinc-iron intermetallic. The coating can be alloyed to form a dull gray intermetallic coating which has a good surface profile and can be easily powder coated.

The second type of hot dip galvanizing process is often called the "batch" process since individual steel pieces or assemblies are dipped in a molten zinc bath as individuals or as groups. The coating is formed by the interdiffusion of zinc and iron. The coating forms four distinct layers or intermetallics. During the batch hot dip galvanizing process, a number of process variables can affect the coating thickness. The primary determiner of coating thickness is the steel chemistry, with the most influential elements being silicon and phosphorous. These two elements promote the interdiffusion of zinc and iron and cause the hot dip galvanized coating to become thick and filled with intermetallic. The coating produced when the steel is reactive contains mainly intermetallics of iron and zinc. This means that the surface will not be bright and shiny, but rather dull gray and slightly rough. This intermetallic surface makes a very good anchor for powder coating systems. The main concern with reactive steel galvanized coatings is the thickness of the coating. If the coating is too thick it may become brittle and will be susceptible to applied stresses that may separate the galvanized coating from the steel underneath. Knowing the silicon and phosphorous content is very important to producing a quality galvanized coating.

GALVANIZED STEEL SURFACE PREPARATION

Successful surface preparation is the key to producing adherent powder coatings and realizing the benefits of a duplex system. There are three basic steps to preparing galvanized surfaces for powder coating: surface cleaning, surface profiling, and out-gassing of the coating.

Surface Cleaning

When cleaning a galvanized surface prior to powder coating, the goal is to remove any dirt, grease or oils. At the same time, care must be taken not to remove too much of the galvanized coating. Alkaline cleaning, ammonia cleaning and solvent cleaning are the most common ways of removing dirt from a galvanized surface. As some cleaners may react differently with different powder coating systems, the powder manufacturer should be consulted for specific reaction problems.

Oil, grease and dirt can be removed by using an alkaline solution in the pH range of 11 to 12, but not greater than 13 as this will damage the zinc coating. Most alkaline cleaning solutions are nominally 2 to 5 percent sodium compounds with small additions of emulsifying or chelating agents. The solution can be applied through dipping, spraying or brushing. If brushing is used, apply the solution with a soft bristle brush, preferably of nylon, definitely not copper or steel bristle brushes. If dipping or spraying the solution, the temperature range that works best is between 140^{o} and 185^{o} F. For newly galvanized steel, a water-based emulsifier can be used to remove contaminants. After cleaning, thoroughly rinse the surface with hot water and allow the part to dry.

Mineral spirits, turpentine, high flash naphtha, and other typical cleaning solvents can be used to clean galvanized surfaces provided they are applied with lint-free rags or soft bristle brushes. The rags and brushes must be changed often to prevent reapplying the contaminants. After cleaning, rinse thoroughly with hot water and allow the part to dry completely.

[REFERENCE DOCUMENT - page 3 of 4]

A solution of 1 to 2 percent ammonia applied with a soft bristle brush can also be used to clean galvanized surfaces, although this method is typically reserved for cleaning parts with zinc skimmings residue. As a piece of steel is removed from the galvanizing kettle, it may pick up particles of oxidized zinc from the bath surface, otherwise known as zinc skimmings. Skimmings residue must be removed prior to painting. After cleaning, thoroughly rinse the surface with hot water and allow the part to dry completely.

Surface Profiling.

In order to provide a good adhesion profile for the powder coating, the galvanized surface must be flat with no protrusions and slightly roughened to provide an anchor profile. During the removal of the galvanized article from the zinc bath, the excess zinc runs down the edges of the part and can sometimes build up at a protrusion or irregular edge. The zinc can also form tears at the edge where it drains off the part. These high spots and tears must be removed before powder coating as they will be very difficult to coat. The high spots and tears are usually ground off with hand tools or power grinders. Care must be taken when performing this operation to insure that the galvanized coating is not removed below the specified thickness.

In order to roughen the typically smooth galvanized surface after cleaning, an abrasive sweep or brush blast may be used. Care should be taken to prevent removing too much of the zinc coating. Particle size for a sweep blast of galvanized steel should range between 200 and 500 microns. Aluminum/magnesium silicate has been used successfully in the sweep blasting of galvanized steel as seen in Fig. 1. Organic media such as corn cobs and walnut shells or minerals such as corundum, limestone and sands with a Mhos hardness of five or less may also be used.

The temperature of the galvanized part when blasting can have a significant affect on the finished surface profile. Sweep blasting while the galvanized part is still warm from the galvanizing process, 175^{o} to 390^{o} F, provides an excellent profile for powder coating. Ambient conditions for sweep blasting are recommended to be less than 50 percent relative humidity and a minimum temperature of 70^{o} F.

The process of sweep blasting should not be confused with the near-white blasting that is used to clean uncoated steel before applying powder coating systems. This near-white blasting will remove the galvanized coating and negate the corrosion protection afforded by the zinc. The process of sweep blasting is best performed by an experienced applicator. If the sweep angle becomes near perpendicular to the galvanized part, the blasting can quickly remove the protective zinc rather than the zinc oxide particle on the surface of the coating.

Galvanized Steel Outgassing

The removal of surface entrapped water and solutions is accomplished by a thermal cycle of the hot-dip galvanized part. Zinc on the surface of the coating can potentially retain air or moisture. Upon heating during the curing stage of the powder coating process the entrapped air or water can release causing pinholes of blisters in the powder coating. The thermal cycle should take place after surface profiling and before the actual powder coating. The thermal cycle should be 25^{o} F or 14^{o} C above the curing temperature of the particular powder coating system. This removal of trapped air or water will significantly lower the potential of pinholes or blisters in the powder coating. For some surface

treatments on the galvanized coating there will be a maximum temperature for the thermal cycle since the surface treatments may be adversely affected by higher temperatures.

POWDER COATING SELECTION

The proper selection of a powder coating system for a certain engineering need is the province of the architect and the engineer. There are many options depending on the intended use of the duplex coated part, the application method and place for the powder coating system, environmental concerns, and aesthetics of the total system. Many powder coating companies offer good powder coating systems that are designed to work with galvanized steel. Consult your powder coating manufacturer for the proper powder coating selection.

DUPLEX SYSTEM PERFORMANCE

When hot dip galvanized steel is powder coated, the duplex system provides a more sophisticated manner of corrosion protection. The galvanized coating protects the base steel by providing both cathodic and barrier protection. The powder coating acts as a barrier protection for the hot dip galvanized coating and significantly reduces the corrosion rate of the zinc. The overall affect on the base steel is that the duplex system not only provides hot dip galvanized life plus the paint life but also provides a multiplication factor of 1.5 to 2.3 on the sum of these two lifetimes. This means that a galvanized coating with a lifetime of 75 years and a powder coating system with a lifetime of 30 years together would have a lifetime of 157 to 240 years as a Duplex System. The increased lifetime that can be provided with a combination of powder coating over galvanized steel makes this type of corrosion protection system very attractive for structures designed to last a long time in aggressive atmospheres.

SUMMARY

The powder coating of galvanized steel has been a difficult task for many people. The secret of good powder coating on galvanized steel is the surface preparation of the galvanized surface. If the surface is newly galvanized, that is less than 48 hours out of the zinc kettle, the surface can be powder coated after a surface roughening procedure and a thermal outgassing cycle. If the surface of the galvanized part has been exposed to the environment for more than one year then the surface can be powder coated after the dirt, grease and oils have been removed and the part has been thermal cycled. The most difficult time to powder coat galvanized steel is between one day and one year after it has been galvanized. Following the correct surface preparation procedures can give a satisfactory duplex system.

REFERENCES

(1) J.F.H. van Eijnsbergen, Duplex Systems, Elsevier Science, New York (1994).
(2) F. Porter, Zinc Handbook, Marcel Dekker, Inc., New York (1991).
(3) J.F. Malone, “Painting Hot Dip Galvanized Steel”, Materials Performance, Vol. 31, No. 5, pp. 3942 (1992).