SECTION 702 -- BITUMINOUS MATERIALS

Table 2 -- Anionic Asphalt Emulsion (English)										
Type	Rapid-Setting									
Grade	RS-1		RS-2		HFMS-2		MS-4		MS-5	
	min	max	min	max	min	max	min	max	min	max
Tests on emulsions: Viscosity, Saybolt Furol at 77 °F, s	20	100			100 see (1)		50	500	50	500
Viscosity, Saybolt Furol at 122 °F, s			75	400						
Storage stability test, 24-h, %		1		1		1		1		1
Coating ability and water resistance: Coating, dry aggregate Coating, after spraying Coating, wet aggregate Coating, after spraying					good fair fair fair		75+ see (2) (3) (4)		75+ see (2) (3) (4)	
Sieve test, %		0.10		0.10		0.10		0.10		0.10
Oil Distillate, %							2.0	7.0	0	3.0
Residue by distillation, %	55		63		65		65		65	
Tests on residue from distillation test: Penetration, 77 °F, 100 g, 5 s	100	200	100	200	100	200	200		150	250
Solubility in trichloroethylene, %	97.5		97.5		97.5		97.5		97.5	
Float test, 140 °F, s					1200		50		100	

Table 2E -- Anionic Asphalt Emulsion (Metric)										
Type	Rapid-Setting									
Grade	RS-1		RS-2		HFMS-2		MS-4		MS-5	
	min	max	min	max	min	max	min	max	min	max
Tests on emulsions: Viscosity, Saybolt Furol at 25 °C, s	20	100			100 see (1)		50	500	50	500
Viscosity, Saybolt Furol at 50 °C, s			75	400						
Storage stability test, 24-h, %		1		1		1		1		1
Coating ability and water resistance: Coating, dry aggregate Coating, after spraying Coating, wet aggregate Coating, after spraying					good fair fair fair		75+ see (2) (3) (4)		75+ see (2) (3) (4)	
Sieve test, %		0.10		0.10		0.10		0.10		0.10
Oil Distillate, %							2.0	7.0	0	3.0
Residue by distillation, %	55		63		65		65		65	
Tests on residue from distillation test: Penetration, 25 ° C, 100 g, 5 s	100	200	100	200	100	200	200		150	250
Solubility in trichloroethylene, %	97.5		97.5		97.5		97.5		97.5	
Float test, 60 °C, s					1200		50		100	

Numbers in parenthesis refer to notes on page 588.

TABLE 2 -- ANIONIC ASPHALT EMULSIONS
(continued)

(1) 50 + when material is used for sealing.

(2) Wet Coating: Weigh 100 ± 0.5 g of aggregate, 20 to 30 mesh (0.85 to 0.60 mm) standard Ottawa sand, into a 600 mL glass beaker and add soft tap water, approximately twice the volume of that of sand. Weigh into the beaker containing the sand and water 8 ± 0.2 g of the emulsion at room temperature and mix for two minutes with a stiff spatula. Cover the mixture with approximately twice its own volume of tap water and pour the water off without further mixing. Repeat this process. After the second rinse, at least 75 percent of the sand shall remain coated.

(3) Stripping: After evaluating the wet coating, place the mixture into a clear 600 mL glass beaker, cover the mixture with tap water, let stand for 12 to 16 hours, and examine. At least 75 percent of the sand shall remain coated.

(4) The coating and stripping tests may be waived when MS-5 is used for sand sealing. SECTION 703 – AGGREGATES

Table 1E -- Required Grading, Graded Coarse Aggregates (English)

Standard Stone Size	#4	#357	#467	#57	#67	#7	#89
Min to Max	3/4 in to 1-1/2 in	No. 4 to 2 in	No. 4 to 1-1/2 in	No. 4 to 1 in	No. 4 to 3/4 in	No. 4 to 1/2 in	No. 16 to 3/8 in
Sieve Size	Percentage by Weight Passing						
2-1/2 in	---	100	---	---	---	---	---
2 in	100	95-100	100	---	---	---	---
1-1/2 in	90-100	---	95-100	100	---	---	---
1 in	20-55	35-70	---	95-100	100	---	---
3/4 in	0-15	---	35-70	---	90-100	100	---
1/2 in	---	10-30	---	25-60	---	90-100	100
3/8 in	0-5	---	10-30	---	20-55	40-70	90-100
No. 4	---	0-5	0-5	0-10	0-10	0-15	20-55
No. 8	---	---	---	0-5	0-5	0-5	5-30
No. 16	---	---	---	---	---	---	0-10
No. 50	---	---	---	---	---	---	0-5

Table 1 -- Required Grading, Graded Coarse Aggregates (Metric)

Standard Stone Size	#4	#357	#467	#57	#67	#7	#89
Min to Max, mm	19.0 to 37.5	4.75 to 50	4.75 to 37.5	4.75 to 25.0	4.75 to 19.0	4.75 to 12.5	1.18 to 9.5
Sieve Size	Percentage by Weight Passing						
63 mm	---	100	---	---	---	---	---
50 mm	100	95-100	100	---	---	---	---
37.5 mm	90-100	---	95-100	100	---	---	---
25.0 mm	20-55	35-70	---	95-100	100	---	---
19.0 mm	0-15	---	35-70	---	90-100	100	---
12.5 mm	---	10-30	---	25-60	---	90-100	100
9.5 mm	0-5	---	10-30	---	20-55	40-70	90-100
4.75 mm	---	0-5	0-5	0-10	0-10	0-15	20-55
2.36 mm	---	---	---	0-5	0-5	0-5	5-30
1.18 mm	---	---	---	---	---	---	0-10
0.300 mm	---	---	---	---	---	---	0-5

SECTION 707 -- CEMENT MORTAR

Description

1.1 Cement mortar shall consist of either portland cement or masonry cement, mortar sand, and water.

Materials

2.1 Portland cement shall conform to 520.2.1.

2.2 Mortar sand shall meet the requirements of AASHTO M 45 except as shown in Table 1.

Table 1 - Gradation of Mortar Sand

Sieve Size	Percent by Weight Passing
No. 8 (2.36 mm)	100
No. 16 (1.18 mm)	60 - 100
No. 50 (0.300 mm)	15 - 35
No. 100 (0.150 mm)	2 - 15
No. 200 (0.075 mm)	0 - 5

Note: In lieu of the above, fine aggregate graded in accordance with 520.2.2.2.2 may be used in mortar for mortar rubble masonry and with concrete blocks for catch basins and drop inlets.

2.3.1 Testing for impurities shall comply with AASHTO T 21. Results that are darker than the standard shall be cause for rejection, except as provided in 2.3.1.1.

2.3.1.1 Sand for mortar not conforming to 2.3.1 shall be tested in accordance with AASHTO T 71 and shall meet the requirements of 5.2.3 of AASHTO M 45.

2.4 Water shall meet the requirements of 520.2.5.

Proportions and Procedures

3.1 Mortar shall be composed of one part by volume of portland cement, except as specified in 3.4, and two parts by volume of damp loose mortar sand with water as necessary to obtain required consistency.

3.2 Hand mixing of mortar shall require thorough mixing of the dry cement and damp sand, in a clean, tight mortar box until the mixture is of a uniform color. Water shall be added in such quantity as to form a mortar having the desired consistency.

3.3 Machine mixing of mortar shall require mixing of the dry cement and damp sand, then adding water, to an approved mixer, for not less than three minutes to reach workability.

3.4 Cement for mortar in ashlar or for mortar squared stone masonry shall consist of portland cement only.

3.5 Mortars shall be used and placed in final position within two and one-half hours after mixing.

3.6 Mortar for bridge curbs shall meet the requirements of 609.2.5 and shall be used as specified under 609.3.1.7.

SECTION 708 -- PAINTS

708.01 Description. These specifications are intended to specify paints that will meet service requirements for highway construction.

Paint shall be homogeneous, free of contaminant, and of a consistency suitable for use in the capacity for which it is specified. Finished paint shall be well ground, and the pigment shall be properly dispersed in the vehicle according to the requirements of the paint. The dispersion shall be of such nature that the pigment does not settle, does not cake or thicken in the container, and does not become granular or curdled. The paint shall be easily broken up with a paddle to form a smooth uniform product of the proper consistency and shall possess satisfactory properties in all respects which affect its application and curing.

The color shall match the established standard. The hiding power shall be sufficient to obtain complete hiding of the preceding coat with a single application when applied at normal spreading rates. The finish coat shall dry to a semi gloss finish, unless specified otherwise.

The final color of the paint specified for the work shall conform to FED-STD-595B and the specific color number specified below. The Department may approve a manufacturer's standard color provided it is very similar to that specified and color chips are submitted for approval before the paint is shipped.

Federal Standard Colors

Color	Federal Color Number
Light Green	24272
Dartmouth Green	14109
Dark Brown	20059
Aluminum	17178
White	17925
Black	27038

708.02 Packaging. All paint furnished must be shipped in original, sealed, strong, new containers having a capacity of not more than 5 gal (18.9 L) each. The containers shall be equipped with a lever-type ring seal or a lug-type cover and wire bails. Each container shall be so filled that the net weight of the material in the can is the product of the weight per gallon (liter) determined at 75º F- 80º F (24 to 27 °C) and the specified gallon (liter) capacity of the can.

All containers of paint shall be clearly labeled with the following information:

New Hampshire Paint Number, Name, and Color
Name of Product
Lot and Batch Number
Date of Manufacture
Volume and Weight of Contents
Volatile Organic Compounds (VOC) Contents
Instructions for opening, mixing, thinning and applying the paint
Names and Address of Manufacturer

708.03 Approval, Sampling and Testing. The Contractor shall submit the complete paint system in writing to the Department for approval prior to use on the project. The Engineer shall be furnished with a

Certificate of Compliance and Material Data Sheet for all paint prior to or upon delivery of painted structural steel to the project. (See 106.04.)

The paint may be sampled by lot either at the point of manufacture or application as required for testing by the Department to insure compliance with material specifications prior to use. Samples of paint furnished for field use shall be submitted at least ten working days before application, in order to allow the Engineer time for testing and accepting the paint. The Engineer may permit application of the paint in a shorter time upon approval of the manufacturer's Certificate of Compliance by the Bureau of Materials & Research.

Unless otherwise provided, the materials entering into the composition of the paint shall conform to the requirements of the applicable ASTM and AASHTO standards and FSS covering such materials. Testing shall be in accordance with the latest test methods of the ASTM and AASHTO. However, the Department reserves the right to make use of any information or methods of testing to determine the quality of paint and paint materials.

708.05 Traffic Paint Identification. To provide a means of identification, the applicable number and name taken from the following list, unless otherwise specified, shall be printed on the label.

Traffic Paints

NH 4.11	White Bead Binder
NH 4.12	Yellow Bead Binder

NH 4.11 Ready-Mixed White Traffic Paint

NH 4.12 Ready-Mixed Yellow Traffic Paint

1.1 General. This specification describes ready-mixed 100% acrylic type, low VOC, fast drying, white or yellow waterborne traffic paint that shall be used as a base for reflective beads , or for use as a plain non-reflective paint. The paint shall be suitable for either bituminous or concrete surfaces.

1.2 The paint shall be formulated and processed specifically for service as a binder for reflective beads, in such a manner as to produce maximum adhesion, refraction, and retroreflection. Any capillary action of the paint shall not be such as to cause complete coverage of the beads.

1.3 The paint shall be well mixed in the manufacturing process and shall be properly ground when incorporating the pigments in order to conform to the requirements as specified.

1.4 The paint shall not liver, thicken, curdle, gel, settle excessively, or otherwise show any objectionable properties during storage and shall be readily remixed manually to a smooth uniform consistency throughout.

1.5 The paint shall dry on a road surface to a strongly adherent uniform noncracking film that will not turn dark in sunlight or show considerable discoloration with age. It shall be easily and uniformly applicable with mechanical line-marking equipment and shall meet the opacity (contrast ratio) properties specified herein. The paint shall be suitable for binding glass beads so as to produce a highly weather resistant traffic line.

2.1 Paint. Paint shall be 100% acrylic, with or without methanol, rated non-combustible with the composition complying with the following:

White Traffic Paint

Property	Test Method	Requirements
Binder	ASTM D 2621 Infrared Analysis	100 % Acrylic
Polymer Emulsion within Binder	NHDOT Test #1-Fluorescent under a black light	Rohm & Haas FT3427 or approved equivalent.
Titanium Dioxide, Rutile Type II	ASTM D 1394	1 lb./gal. (120 g/l) Min.
Total solids	ASTM D 3723	76% Min. by weight 62% Min. by volume
% Pigment	ASTM D 3723	58% Min. to 62% Max.
% Vehicle	ASTM D 3723	38% Min. to 42% Max
% Non-volatile in vehicle	ASTM D 3723	42% Min. by weight
Lead	ASTM D 3335	0.06% Max.
VOC	ASTM D 3960	1.25 lb./gal.(150 g/l) Max.
Weight per gallon	ASTM D 1475	14.0 ± 0.3 lb./gal. (1680 ± 36 g/l)
pH		9.6 Min.
Flash Point (Close Cup)	D 3278 Setaflash	> 140º F (60 °C)
Color	Without beads a minimum of 24 hours after application	Fed-Std-595B No. 37886 - White

Yellow Traffic Paint

Property	Test Method	Requirements
Binder	ASTM D 2621 Infrared Analysis	100 % Acrylic
Polymer Emulsion within Binder	NHDOT Test 1 – Florescent under black light	Rohm and Haas FT3427 or approved equivalent. Pigment - Yellow #65 or #75
Titanium Dioxide, Rutile Type II	ASTM D 1394	0.2 lb./gal.(24 g/l) Min.
Total solids	ASTM D 3723	76% Min. by weight 62% Min. by volume
% Pigment	ASTM D 3723	58% Min. to 62% Max.
% Vehicle	ASTM D 3723	38% Min to 42% Max
% Non-volatile in vehicle	ASTM D 3723	42% Min. by weight
Lead	ASTM D 3335	0.06% Max.
VOC	ASTM D 3960	1.25 lb./gal.(150 g/l) Max.
Weight per gallon	ASTM D 1475	13.5 ± 0.3 lb./gal. (1620 ± 36 g/l)
pH		9.6 Min.
Flash Point (Close Cup)	D 3278 Setaflash	> 140º F (60 °C)
Color	Without beads a minimum of 24 hours after application	Fed-Std-595B No. 33538-yellow

2.2 In addition, all traffic paint shall comply with the following requirements:

Property	Test Method	Requirements
Viscosity (Krebs Units)	ASTM D 562	78 Min. @ 77º F (25 °C)
Fineness of Grind	ASTM D 1210	4 Min.
Drying Time	-ASTM D 711 with wet film thickness of 15 mils NHDOT Test 2-Test plate-set for an hour	10 minutes Max. @ 77º F (25 ° C) Uniformed film and no cracking or flaking
Flexibility	FSS TT-P-1952D, Section 4.5.5, using 1/2" mandrel bend	No Cracking or Flaking
Dry Opacity (contrast ratio)	ASTM D 2244 with a wet film thickness of 15 mils	0.96 Min.
Daylight Reflectance	Federal Test Method No. 141c	85% Min. for White Paint 50% Min. for Yellow Paint
Bleeding (ratio)	FSS TT-P-1952D	0.97 Min.
Scrub Resistance	ASTM D 2486	Pass 300 cycles
Freeze-Thaw Stability	FSS TT-P-1952D	≤ 10% change
Heat Stability (Krebs Units)	FSS TT-P-1952D	≤ 10% change

2.2.1 Condition in Container: The paint shall show no livering, skinning, mold growth, putrification, corrosion of the container, or hard settling of the pigment in the container. Any settling shall be readily dispersed when stirred by hand with no persistent foaming.

2.2.2 No Track Time: Paint shall dry to a no tracking condition in no longer than three (3) minutes. The "no tracking" condition shall be determined by actual application on the pavement at a wet film thickness of 20 mils (508 microns) with white or yellow paint covered with glass beads at a rate of 8 pounds per gallon (960 grams per liter). The paint lines for this test shall be applied with the striping equipment with the paint at temperatures between 85º - 105º F (30 – 43 °C) at the spray orifice. This maximum tracking time shall not be exceeded when the pavement temperature varies from 50º F (10 °C) to 120º F (49°C), and under humidity conditions of 80% or less providing that the pavement is dry. The "no tracking" time shall be determined by passing over the paint line three (3) minutes after paint application, in a simulated passing maneuver at a constant speed of 30 to 40 miles per hour (48 to 64 kilometers per hour) with a passenger car. A line showing no visual deposition of the paint to the pavement surface when viewed from a distance of approximately 50 feet (15.3 meters) from the point where the test vehicle has crossed the line shall be considered as showing "no tracking" and conforming to the requirement for field drying conditions. This field dry time test shall be used for production samples only.

2.2.3 Dry Through (Early Washout): A 15 mil wet film thickness paint sample placed immediately in a humidity chamber maintained at 72.5º F ± 2.5º F (22.5 °C ± 0.5 °C) and 90% ± 3% relative humidity shall have a "dry-through" time less than or equal to paint film tested in accordance with ASTM D 1640, except that the pressure exerted will be the minimum needed to maintain contact between the thumb and film.

2.3 Material Safety Data Sheets (OSHA Form 20 or equivalent) pertinent to all materials in this product shall be within the striping vehicle.

APPENDIX A

GALVANIZE AND PAINT STEEL PRODUCTS

[redacted]

DESCRIPTION

1.1 General. This appendix specifies hot-dip galvanizing and shop-applied painting (i.e. duplex coating) of steel products (e.g. steel bridge rail, overhead sign structures, light poles, etc.) as shown on the plans or as directed, in accordance with ASTM A 385 (for material composition, cleanliness, drainage vents, etc.) and ASTM D 6386 (for preparing zinc surfaces for painting) and as stated herein.

1.2 Galvanizer. Paint shall be applied to galvanizing within the same facility. The galvanizer shall have previous successful experience in galvanizing and applying paint to galvanizing in the same facility where the work is to be performed for this project. The galvanizer shall have QC personnel on staff with NACE training and management personnel with a minimum of two years experience in duplex coatings.

1.3 Scope of work. All steel components as shown on the plans shall be galvanized, prepared, and shop painted as specified herein, except fasteners as noted. For bridge rail, stainless steel rail-to-post studs shall not be painted. The heads of rail-to-post through-bolts and hardware exposed to view after installation, such as bolt ends, nuts and washers, shall be field painted according to Section 3.6, Touch-up and Repairs, using paint from the same batch as used for the shop-applied coats as supplied by the paint manufacturer.

1.4 Paint manufacturer approvals. The paint manufacturer shall document in writing prior to the work that the surface preparation and application procedures are acceptable for their coatings.

1.5 The fabricator 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.

1.6 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.

1.6.1 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 D6386, Standard Practice for Preparation of Zinc (Hot Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting

1.6.2 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

1.6.3 American Galvanizers Association (AGA)

1. The Inspection of Products Hot Dip Galvanized After Fabrication

1.6.4 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 2, Measurement of Dry Film Thickness with Magnetic Gages

1.7 Submittals

1.7.1 Surface Preparation/Painting Plan.

1. Provide a written galvanizing/ surface preparation/ painting plan to the Department. Identify the manner of surface preparation, the paint system to be applied, paint manufacturer, film thickness, cure time between coats, repair of typical damage and defects in the galvanizing and paint, and other information needed to successfully apply all coats of the duplex system.

2. Provide material Product Data and MSD sheets.

3. Submit two 3-inch by 6-inch samples of shop-applied coatings and colors proposed for use for approval to the Department (Bureau of Bridge Design, Tel. 603-271-2731) prior to coating application.

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

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 0.05 to 0.09 percent nickel. The galvanizing process shall not include quenching with water or treatment with a chromate conversion coating. 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. Steel or metallic abrasives are NOT permitted. Use Black Beauty 30/60 (very fine), Dupont StarBlast® XL (fractured), or other approved abrasive. 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.

2.3 Paint

2.3.1 Approved paint system. The duplex system shall consist of galvanizing and the intermediate and finish coats of an approved paint system from a Special Provision or from the NEPCOAT Qualified Products List A, B, or C as listed at www.nh.gov/dot/ at the Business Center/Info for Engineers.

2.3.2 The galvanizing-paint duplex system shall consist of the following generic type and at the minimum coating thicknesses shown:

Coating	Description	Thickness (min.)
Galvanized:	Hot-dip galvanizing	per AASHTO
Surface prep:	SP1 Solvent Cleaning (as required); and SP7 Brush-Off Blast Cleaning, or approved mechanical means	
Intermediate (force-cure):	High build epoxy polyamide, or Single-component moisture-cure aromatic polyurethane with micaceous iron oxide	3 mils DFT
Finish (force-cure):	Aliphatic polyurethane, or Single-component moisture-cure aliphatic polyurethane	3 mils DFT

2.3.3 Film thicknesses shall be as shown in 2.3.2 unless the paint manufacturer's recommended thickness range differs. In such cases, the manufacturer shall provide written documentation that the range cited satisfies the Department's performance requirements.

2.3.4 The maximum VOC limit is 3.5 lb./gal. until Jan 1, 2007 and 2.8 lb/gal thereafter, at the time of application including thinners.

2.3.5 Use the same manufacturer for all coats on a given structure, including thinners and additives.

2.3.6 Provide each coat of paint 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.

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

2.3.8 Color. The final color of the painted product shall be as specified in the plans or proposal. The required finish color shall match the Federal Standard 595 color number as follows:

Description	Fed Color #	Description	Fed Color #
SAGE GREEN	24227	DARK BROWN	20059
ODOT GREEN	24272	ALUMINUM	17178
DARTMOUTH GREEN	14109	BLACK	27038

2.4 EQUIPMENT

2.4.1 Surface Preparation and Painting Equipment. Provide all abrasive blast cleaning equipment, sanding discs, and other surface preparation equipment necessary to conduct the work as specified in this Item. Use equipment and materials that are clean and sized properly to accomplish the work, including

the required surface profile and finish as required by this Item. Provide spray equipment, paint brushes, rollers, and daubers to conduct the work as specified in this Item.

2.4.2 Compressed Air Cleanliness. Provide compressed air that is free from moisture and oil contamination. Conduct a white blotter test in conformance to ASTM D 4285 to verify the cleanliness of the compressed air. Conduct the test at least once per shift for each compressor system. Sufficient freedom from oil and moisture is confirmed if soiling or discoloration are not visible on the paper. If air contamination is evident, change filters, clean traps, add moisture separators or filters, or make other adjustments as necessary to achieve clean, dry air.

2.4.3 Personal Protective Equipment. Provide any necessary personal protective equipment (PPE) for one Department representative per shift to assure protection from hazards during surface preparation, cleaning activities, and paint application. Repair or replace PPE as necessary.

2.4.4 Inspection Equipment. Provide all of the inspection and testing equipment needed, for use in the shop or in the field, to verify the quality of the entire galvanizing, surface preparation, and painting processes, including a Type II dry film thickness gage that can be calibrated, calibration standards, wet film thickness gage, sling psychrometer and psychometric tables, and a mirror to inspect hard to reach areas. Make the equipment available for use by the Department.

GALVANIZING AND SHOP PAINTING

3.1 General

3.1.1 Provide all materials, apparatus, and labor necessary to perform the scope of work whether or not the material or apparatus is specifically identified in this Item. Conduct all galvanizing, surface preparation, and painting operations in a workmanlike manner to the satisfaction of the Department.

3.1.2 Specifications. The work shall be performed in conformance to the Contract requirements, the reference standards (1.6), and the coating manufacturer's instruction, respectively.

3.1.3 Quality Control. The applicator is required to conduct and document quality control inspection of the galvanizing, surface preparation, cleaning and painting operations, including at a minimum, measurements of ambient conditions, surface profile, surface cleanliness, dry film coating thickness, and visual inspection for coating defects.

3.2 Surface Preparation

3.2.1 Surface Preparation Plans. Prepare all surfaces in conformance to the requirements of this Item, and the approved Surface Preparation/Painting Plan provided under 1.7, Submittals.

3.2.2. 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.

3.2.3 Surface preparation. Prior to painting, galvanized surfaces shall receive surface preparation consisting of SSPC-SP1, Solvent Cleaning, as required to remove detrimental contaminants, and SSPC-

SP7, Brush-Off Blast Cleaning, with non-metallic abrasives at a reduced nozzle pressure of 50-70 psi, or abraded by approved mechanical means using sanding disks with 36-grit 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. The required thickness of the zinc coating shall be maintained and checked prior to painting. Surface preparation shall be acceptable to the paint manufacturer's requirements (see 1.4). Additional surface preparation or a tie coat may be considered if required by the paint manufacturer and approved by the Department.

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 painting galvanized products shall not be nested, stacked or stored with adjacent surfaces touching but shall be kept separated to permit the circulation of air between products. Galvanized products shall be sloped to drain and kept as dry as possible.

3.2.6 Quality of Surface Preparation Prior to Painting. Verify that the surface exhibits the specified degree of cleaning immediately prior to painting. Apply the first coat before degradation of the surface occurs, but in no case allow the prepared surface to stand for more than 12 hours prior to painting.

3.3 Paint Application

3.3.1 Paint within twelve hours. The first coat of paint shall be shop applied to the galvanized product within twelve (12) hours of galvanizing at the galvanizer's facility in a controlled environment meeting applicable atmospheric requirements as recommended by the coating manufacturer.

3.3.2 Force Cure. The intermediate and finish paint coats shall each be maintained in a protected environment within a min-max temperature range of 80-120°F for the duration of the cure-to-recoat cycle listed on the paint product data sheet, unless the paint manufacturer's requirements are more restrictive.

3.3.3 Ambient Conditions During Paint Application. Apply paint under the following conditions unless the requirements of the paint manufacturer are more restrictive. Do not apply paint under less restrictive conditions without written approval of the paint manufacturer, and specific written authorization from the Department.

1. Surface and air temperatures between 40°F and 100°F. For system C 35°F min. temperature.

2. Relative humidity – Less than 85%. For coating system C, R.H. less than 98%.

3. Dew Point – Surface temperature 5°F min. above the dew point. For system C 2°F, and do not apply the coating to surfaces that are visibly damp.

4. Frost/Rain - Do not apply paint to surfaces containing frost or damp, or during rain, fog, or similar detrimental weather conditions, but only to surfaces that are thoroughly dry. Remove and replace any paint that is exposed to unacceptable conditions (e.g. rain) prior to adequate curing.

3.3.4 Methods of Application - Apply all coats by spray, unless other methods are necessary. If conventional spray is used, verify that the compressed air supply is clean and dry as determined by the blotter test (see 2.4.2).

3.3.5 Recoat Times. Apply each coat of paint only after the previous coat has been allowed to dry as required by the manufacturer's written instructions, but as soon as possible to minimize the length of time that the coating is exposed to dust and contamination. Do not allow any coat to remain exposed for longer than 14 days prior to overcoating.

3.3.6 Coverage and Continuity

1. Apply each coat in a workmanlike manner to assure thorough wetting of the substrate or underlying coat, and to achieve a smooth, streamline surface free of dryspray, overspray, and orange peel. Shadow-through, pinholes, bubbles, skips, misses, lap marks between applications, or other visible discontinuities in any coat are unacceptable. Runs or sags may be brushed out while the material remains wet.

2. Remove dryspray and overspray (e.g. by sanding) prior to the application of the next coat. When present on the finish, remove as directed by the Department and apply another coat of finish to the area. Remove all other defective coating to sound material and reapply.

3. Thoroughly coat all surfaces with special attention to hard-to-reach areas, and irregular surfaces. When coating configurations such as bolts, apply the material from multiple directions to assure complete coverage.

3.3.7 Paint Adhesion. Apply all coats in such a manner to assure that they are well adhered to each other and to the substrate. If the application of any coat causes lifting of an underlying coat, or there is poor adhesion between coats or to the substrate, remove the coating in the affected area to adjacent sound, adherent coating, and reapply the material.

3.3.8 Wet Film Thickness. Use wet film thickness gages in conformance to ASTM D4414 to verify the thickness of each coat at the time of application.

3.3.9 Dry Film Thickness and Corrective Action for Thickness Deviations

1. 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.

2. If there are questions regarding the non-destructive measurements of coating thickness, a Tooke Gage (destructive scratch gage) may be used when authorized by the Department. Conduct measurements in conformance to ASTM D 4138, but limit the use of the gage to a minimum number of locations. Mark and repair all damage caused by the destructive testing, whether created by the Department or the Contractor and at no cost to the Department.

3. Apply additional coating of the same type to areas of insufficient thickness. Use care during application to assure that all repairs blend in with the surrounding material.

3.4 Inspection

3.4.1 Quality Control (QC). The applicator is required to conduct and document quality control inspection of the cleaning and painting operations. The data shall be recorded in a log maintained at the site and available for the Department's review during working hours.

3.4.2 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 and instrumentation needed to inspect all phases of the work.

2. 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.

3. Provide the QA Inspector with his/her copy of the Reference Documents listed in 1.6.

4. Galvanized and painted material shall not be lifted, placed on supports, or loaded for shipment until the shop coating has been adequately cured and inspected. The steel members 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.

3.5 Handling. Care shall be exercised in handling coated steel in the shop, during shipping, field erection, and subsequent construction of the bridge. 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, padded slings, storage pallets, separators, cushioners, tie-downs, and other approved supports. The paint applicator shall be responsible for the condition of the finished coating until the material arrives at the job site.

REPAIR PAINTING

3.6 Touch-up and repairs.

3.6.1 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 wire brushing and SP1 cleaning as a minimum.

3.6.2 Apply an approved organic zinc-rich repair paint containing 92 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. The total repair area shall be less than 3% of the area of the member, or the member shall be rejected and regalvanized. Repair paints shall be approved. The repair paint 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 minimum thickness of the original system and cure 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.

3.7 Final Acceptance. Although the Department's QA Inspector may accept the shop painted fabricated items before shipment to the jobsite, final acceptance of the paint system by the Department will occur at the jobsite after erection of the steel, and after all coats and repairs have been completed.

3.8 Three-year warranty. Should the duplex system fail within three years after the project has been accepted, the coating shall be repaired 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 paint resulting from the installation of the product or from the performance of the duplex coating.

APPENDIX B

GALVANIZE AND POWDER-COAT METAL PRODUCTS

DESCRIPTION

1.1 General. This appendix provides an alternative to a galvanize-paint finish by specifying shop-applied powder coating over hot-dip galvanizing for steel components of metal products (e.g. W-beam guardrail, pedestrian railing, etc.) as shown on the plans or as directed. The requirements of 708 Appendix A, Galvanize and Paint Metal Products, shall apply except for the provisions modified herein for powder coating, including field touchup and three-year inspection.

1.2 Powder Coating applicator qualification. Powder coating applicators shall have a minimum of two years continuous and successful experience with in-line powder coating of industrial metal highway products or equal.

MATERIALS

2.1 Color. The final color of the product shall be as specified in the plans or proposal.

2.1 Coating System. The finish of the steel product shall be a factory-applied, oven-baked, powder coating consisting of weather resistant super-durable triglycidyl isocyanurate (TGIC) polyester thermoset powder coatings applied to galvanized metal substrates. The powder coating manufacturer shall certify in writing that the powder coating meets the performance requirements of American Architectural Manufacturers Association (AAMA) specification 603.8.

GALVANIZING AND POWDER COATING

3.1 Powder Coating. 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:

a. SSPC-SP1, Solvent Cleaning to remove detrimental contaminants (e.g. wash parts with Simple Green®);
b. SSPC-SP7, Brush-Off Blast Cleaning with a steel shot-grit abrasive mixture, or abraded by approved mechanical means, to thoroughly roughen the entire surface and produce a maximum anchor profile of 1 mil (25 microns);
c. The Contractor shall take all necessary measures to ensure that prepared parts are kept clean and not exposed to dirt, dust, grease, or oil while being handled or staged.
d. The galvanized parts shall be gassed off before powder coating by preheating to 250º F. for 30 minutes;
e. 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 and part temperatures are 50º F. or above, and shall not be applied to damp, frosted, or ice-coated surfaces.
f. After applying the powder, all parts shall be placed in an oven, cured and bonded at approximately 400º F. for 20 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.
g. The powder coating shall be applied to a minimum dry film thickness of 6 mils and in a manner that will ensure a uniform coating without holidays, runs or excess build at edges.

h. Each coated part shall be visually inspected. A thickness gauge shall be used to measure the coating thickness. Any part that does meet the specified coating thickness, may be recoated immediately without undergoing additional preparation and pretreatment. Once cured, all parts shall be allowed to cool sufficiently before further handling.

3.2 Hardware

a. Bolts - Powder coat bolt heads. Minor overspray is permitted on the threads.
b. Nuts - Powder coat exterior nut surfaces and mask off interior surfaces.
c. Washers - Powder coat all washer surfaces.

3.3 Protective measures

a. Coated parts shall be carefully handled, stored, and shipped to protect the coating from any scraping, marring, or other damage to the surface finish. Parts shall be wrapped or padded with protective material. Sufficient dunnage shall be used to prevent parts from shifting.
b. The coating applicator is responsible for the condition of the coating until the product arrives at the jobsite.
c. Repair and touch-up materials shall be supplied by the coating applicator and applied in accordance with the powder coating manufacturer's recommendations.

SECTION 711 -- PREFORMED RETROREFLECTIVE PAVEMENT MARKING TAPE

Description

1.1 Description. Preformed retroreflective pavement marking tape shall be either removable or non-removable as specified. Removable tape shall be capable of being removed intact or in large strips. Non-removable tape shall be designed to remain in place.

1.2 General. Tape shall consist of glass spheres of a high optical quality imbedded into a binder on a suitable backing that is pre-coated with a pressure-sensitive adhesive. The spheres shall be of uniform gradation and shall be distributed evenly over the surface of the tape. The color of the tape shall conform to FHWA color standards for pavement markings and shall be readily visible when viewed under automotive headlights at night.

1.2.1 The marking tape, when applied in accordance with the manufacturer's recommended procedures, shall be weather resistant and shall show no appreciable fading, lifting, or shrinkage during the useful life of the marking. The tape, as applied, shall be of good appearance and free of cracks, and the edges shall be true, straight, and unbroken.

Materials

2.1 Short Term Pavement Marking Tape, Removable.

2.1.1 Composition. The removable preformed pavement marking tape shall not contain metallic foil and shall consist of a mixture of high quality polymeric materials and pigments, with glass beads throughout the pigmented portion of the film, and a retroreflective layer of beads bonded to the top

surface. The films shall be precoated with a pressure-sensitive adhesive. A non-metallic medium shall be incorporated to facilitate removal.

2.1.2 General. The glass beads shall not be easily removed when the material surface is scratched with a thumbnail. The tape shall be precoated with a pressure-sensitive adhesive and shall be capable of adhering to hot bituminous pavement in accordance with the manufacturer's instructions without the use of heat, solvents, or other additional adhesive means. The tape shall be immediately ready for traffic after application.

2.1.3 Retroreflectance. The white and yellow tapes shall have the following initial minimum retroreflectance values at 0.2 and 0.5 degree observation angles and 86.0 degree entrance angle as measured in accordance with the testing procedure of FED-STD-370. The photometric quantity to be measured shall be specific luminance (SL) and shall be expressed as millicandelas per square foot per footcandle (millicandelas per square meter per lux). The test distance shall be 50 ft (15.24 m) , and the sample size shall be a 2.0 by 2.5 ft (0.61 by 0.76 m) rectangle. The angular aperture of both the photoreceptor and light projector shall be six minutes of arc. The reference center shall be the geometric center of the sample, and the reference axis shall be taken perpendicular to the test sample.

	White		Yellow	
Observation Angle [degrees]	0.2	0.5	0.2	0.5
SL [mcd/ft²/fc] ([mcd/m²/lx])	1770	1270	1310	820

2.1.4 Adhesion. The manufacturer shall be required to demonstrate that the properly applied pavement marking tape adheres to the roadway under climatic and traffic conditions normally encountered in the construction work zone.

2.1.5 Skid resistance. The surface of the markings shall provide an initial minimum skid resistance value of 50 BPN when tested in accordance with ASTM E 303. The acronym BPN is defined in ASTM E 303.

2.1.6 Removability. The marking tape shall be removable from asphalt and portland cement concrete intact or in large pieces, either manually or with a roll up device, at temperatures above 40 ºF (4 °C) without use of heat, solvents, grinding, or blasting. The manufacturer shall be able to show that the marking film has met this requirement after the following minimum traffic exposure based on transverse test decks with rolling traffic :

(a)	Time in Place:	632 days
(b)	ADT per Lane:	9 000 (23 percent trucks, 3.5 axles per unit)
(c)	Minimum Axle Hits:	13 000 000

2.2 Short Term Pavement Marking Tape, Non-Removable.

2.2.1 Composition. The non-removable preformed pavement marking tape shall consist of retroreflective films on a conformable backing, precoated with a pressure-sensitive adhesive. This tape shall not be readily removed and shall be intended to be obliterated by over-paving or removal of pavement on which it is placed.

2.2.2 General. The glass beads shall not be easily removed when the material surface is scratched with a thumbnail. The tape shall be precoated with a pressure-sensitive adhesive and shall be capable of adhering to hot bituminous pavement in accordance with the manufacturer's instructions without the use

of heat, solvents, or other additional adhesive means. The tape shall be immediately ready for traffic after application.

2.2.3 Retroreflectance. The white and yellow tapes shall have the following initial minimum retroreflectance values at 0.2 and 0.5 degree observation angles and 86.0 degree entrance angle as measured in accordance with the testing procedures of FED-STD-370. The photometric quantity to be measured shall be specific luminance (SL) and shall be expressed as millicandelas per square foot per footcandle (millicandelas per square meter per lux). The test distance shall be 50 ft (15.24 m) , and the sample size shall be a 2.0 by 2.5 ft (0.61 by 0.76 m) rectangle. The angular aperture of both the photoreceptor and the light projector shall be six minutes of arc. The reference center shall be the geometric center of the sample, and the reference axis shall be taken perpendicular to the test sample.

	White		Yellow	
Observation Angle [degrees]	0.2	0.5	0.2	0.5
SL [mcd/ft²/fc] ([mcd/m^2/lx])	1360	760	820	510

2.2.4 Adhesion. The manufacturer shall be required to demonstrate that the properly applied pavement marking tape adheres to the roadway under climatic and traffic conditions normally encountered in the construction work zone.

2.2.5 Skid resistance. The surface of the markings shall provide an initial minimum skid resistance value of 35 BPN when tested in accordance with ASTM E 303.

2.2.6 Abrasion resistance. Samples of the test material shall not wear through to the conformable backing surface in less than 125 cycles when tested in accordance with FED-STD-141C NOT 2, Method 6192, except using an H-22 wheel and 250 g load.

SECTION 716 -- SPECIFICATIONS FOR THE WELDING OF ALUMINUM ALLOYS FOR HIGHWAY STRUCTURES

1. General.

1.1 Description. These specifications apply to the welding of aluminum alloys used in bridge railing, structural supports for highway signs, luminaires, traffic signals, and the like.

1.2 Specifications.

1.2.1 The welding terms used in these specifications shall be interpreted in accordance with the definitions given in the latest edition of Welding Terms and Definitions, ANSI/AWS A3.0.

1.2.2 The welding symbols used on the plans will be those shown in the latest edition of Symbols for Welding, Brazing and Nondestructive Examination, ANSI/AWS A2.4. Special conditions will be fully explained by added notes or details.

1.2.3 The welding of aluminum bridge railing shall conform to Section 10 of the ANSI/AWS D1.2 "Structural Welding Code – Aluminum" including Part E "Workmanship Class II Structures". The fabrication and erection of bridge railing shall conform to Section 6 of the Specifications for Aluminum Structures, published by the Aluminum Association.

1.2.4 The welding of aluminum sign supports, luminaires, and traffic signals shall conform to Section 10 of the ANSI/AWS D1.2 "Structural Welding Code – Aluminum" including Part D "Workmanship Class I Structures".. The fabrication and erection of aluminum sign supports, luminaires, and traffic signals shall conform to the requirements of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals. Special consideration may be given to certain support structures, which may be fabricated according to the provisions of 1.2.3.

2. Base Metals.

2.1 The aluminum alloys to be welded under these specifications may be any of the following alloy designations:

Wrought non-heat-treatable alloys
- Alloy 3003
- Alloy 3004
- Alloy 5052
- Alloy 5083
- Alloy 5086
- Alloy 5456

Wrought heat-treatable alloys
- Alloy 6061
- Alloy 6063

Cast heat-treatable alloy
- Alloy 356.0

2.2 Material used for permanent backing shall be at least equivalent in weldability to the base metal being welded.

3. Welding Processes.

3.1 These specifications include provisions for welding by the gas metal-arc process and the gas tungsten-arc process. Other processes may not be used except as permitted.

4. Filler Metal.

4.1 Bare wire electrodes for use with the gas metal-arc process and welding rods for use with the gas tungsten-arc process shall conform to the requirements of the latest edition of Specification for Bare Aluminum and Aluminum Alloy, Welding Electrodes and Rods, ANSI/AWS A5.10.

4.2 Tungsten electrodes for the gas tungsten-arc process shall conform to the requirements of the latest edition of Specification for Tungsten and Tungsten Alloy Electrodes for Arc Welding, ANSI/AWS A5.12.

4.3 Filler metals to be used with particular base metals shall be as shown in Table 1. Other filler metals may be used as approved.

Table 1 - Filler Metal Guide for Gas Shielded Arc Welding

Base Metals	Filler Metal
3003 to 3003	ER1100
3004 to 3004	ER4043
5052 to 5052	ER5654*
5083 to 5083	ER5183*
5086 to 5086	ER5356*
5456 to 5456	ER5556*
6061 to 6061	ER4043*
6063 to 6063	ER5356*
356.0 to 6061	ER4043
356.0 to 6063	ER4043

* ER5183, ER5356, and ER5556 may be used interchangeably for these base metals.

4.4 Filler metals shall be kept covered and stored in a dry place at relatively uniform temperatures. Original rod or wire containers shall not be opened until ready for use. Rod and wire shall be free of moisture, lubricant, or other contaminants. Spools of wire temporarily left unused on the welding machine shall be kept covered to avoid contamination by dirt and grease collecting on the wire. If a spool of wire is to be unused for more than a short length of time, the spool shall be returned to the carton, and the carton shall be tightly resealed.

5. Shielding Gases.

5.1 Shielding gases shall be welding grade or better.

5.2 Shielding gas for gas metal-arc welding shall be argon, helium, or a mixture of the two (at least 50 percent helium).

5.3 Shielding gas for gas tungsten-arc welding done with alternating current shall be argon.

5.4 Shielding gas for gas tungsten-arc welding done with direct current, straight-polarity, shall be helium.

5.5 Hoses used for shielding gases shall be made of synthetic rubber or plastic. Natural rubber hoses shall not be used. Hoses that have been previously used for acetylene or other gases shall not be used.

6. Preparation of Materials.

6.1 Joint details shall be in accordance with design requirements and detail drawings. The locations of joints shall not be changed without approval.

6.2 Edge preparation shall be by sawing, machining, clipping, or shearing. Gas tungsten-arc or gas metal arc cutting may also be used. Cut surfaces shall meet the ANSI surface roughness rating value of 1000. Oxygen cutting shall not be used.

6.3 Surfaces and edges to be welded shall be free from fins, tears, and other defects which would adversely affect the quality of the weld.

6.4 Dirt, grease, forming or machining lubricants, or any organic materials shall be removed from the areas to be welded by cleaning with a suitable solvent or by vapor degreasing.

6.5 On all edges and surfaces to be welded, the oxide shall be removed just prior to welding by wire brushing or by other mechanical methods, such as rubbing with steel wool or abrasive cloth, scraping, filing, rotary planing, or sanding. If wire brushing is used, the brushes shall be made of stainless steel. Hand or power driven wire brushes which have been used on other materials shall not be used on aluminum.

6.6 Where mechanical methods of oxide removal are found to be inadequate, a standard chemical method shall be used. Welding shall be done within 24 hours after chemical treatment.

6.7 When gas tungsten-arc welding with direct current, straight polarity, is being used, all edges and surfaces to be welded shall have the oxide removed by a standard chemical method.

6.8 Welding shall not be done on anodically treated aluminum unless the condition is removed from the joint area to be welded.

7. Welding Procedure.

7.1 All butt welds requiring 100 percent penetration, except those produced with the aid of backing, shall have the root of the initial weld chipped or machined out to sound metal before welding is started from the second side. Butt welds made with the use of backing shall have the weld metal thoroughly fused with the backing. Where accessible, backing for welds that are subject to computed stress or that are exposed to view on the completed structure, and that are not otherwise parts of the structure, shall be removed and the joints ground or machined smooth. In tubular members, butt welds subjected to computed stresses shall be made with the aid of permanent backing rings or strips.

7.2 The procedure used for production welding of any particular joint shall be the same as used in the procedure qualification for that joint.

7.3 All welding operations, either shop or field, shall be protected from air currents or drafts so as to prevent any loss of gas shielding during welding. Adequate gas shielding shall be provided to protect the molten metal during solidification.

7.4 The work shall be positioned for flat position welding whenever practicable.

7.5 In both shop and field, all weld joints shall be dry at the time of welding.

7.6 The size of the electrode, voltage, amperage, welding speed, gas or gas mixture, and gas flow rate shall be suitable for the thickness of the material, design of joint, welding position, and other circumstances attending the work.

7.7 Gas metal-arc welding shall be done with direct current, reverse polarity.

7.8 Gas tungsten-arc welding shall be done with alternating current or with direct current, straight polarity.

7.9 When the joint to be welded requires specific root penetration, the Contractor shall make a sample joint and a macroetched cross-section of the weld to demonstrate that the joint welding procedure to be used attains the required root penetration. The sample joint shall have a length of at least 1 ft (300 mm)) and shall be welded with the electrode, polarity, amperage, voltage, speed, gas mixture, and gas flow rate that are proposed to be used in production welding. The Engineer, at his discretion, may accept evidence on record in lieu of the preceding test.

7.10 Where preheat is needed, the temperature of preheat shall not exceed 350 ºF (175 °C) for heat-treated alloys and 600 ºF (315 °C) for non-heat-treated alloys. The temperature shall be measured by temperature-indicating crayons or by pyrometric equipment. Heat-treated alloys shall not be held at the maximum preheat temperature or at temperatures near the maximum for more than 30 minutes.

8. Weld Quality.

8.1 Regardless of the method of inspection, the acceptance or rejection of welds shall be determined by the following conditions:

(a) Cracks in welds or adjacent base metal will not be acceptable.
(b) Copper inclusions will not be acceptable.
(c) Porosity in excess of that permitted by Section 3 and Section 10 of the ANSI/AWS D1.2 "Structural Welding Code – Aluminum" will not be acceptable.
(d) Lack of fusion, incomplete penetration, or tungsten or oxide inclusion will be acceptable only if small and well dispersed.

8.2 Undercut shall not be more than 0.01 inch (0.25 mm) deep when its direction is transverse to the primary stress in the part that is undercut. Undercut shall not be more than 1/32 inch (0.80 mm) deep when its direction is parallel to the primary stress in the part that is undercut.

8.3 No overlap shall be allowed.

8.4 All craters shall be filled to the full cross-section of the welds.

8.5 Welds having defects greater than the levels of acceptance specified above shall be considered as rejected unless corrected in accordance with 716.10.

9. Inspection.

9.1 To determine compliance with Section 7, all welds shall be visually inspected, and in addition, all welds subject to computed stress shall be inspected by the dye penetrant method except as specified in 9.4.

9.2 For truss-type highway sign structures, the dye penetrant method shall be used on butt welds in columns and main chord members, on fillet welds connecting columns to bases and main chord members, including the associated flanges, gussets, or main load carrying brackets or members, and also on fillet welds connecting flanges to the main truss chord members. On pole type and common light standards, the dye penetrant method shall be used on butt welds in columns and on fillet welds connecting columns to bases.

9.3 The dye penetrant tests shall be performed in accordance with the requirements of ASTM E 165, Method B, Procedures B-2 or B-3.

9.4 Dye penetrant inspection may be omitted provided that the Inspector examines each layer of weld metal with a magnifier of 3X minimum before the next successive layer is deposited.

10. Corrections.

10.1 In lieu of rejection of an entire piece or member containing welding that is unacceptable, the corrective measures listed below may be permitted by the Engineer, whose approval shall be obtained prior to making each repair.

10.2 Defective welds shall be corrected by removing and replacing the entire weld, or as follows:

(a) Cracks in welds of base metal: Determine the full extent of the crack by the dye penetrant method or other positive means, then remove the crack throughout its length and depth, and reweld.
(b) Excessive porosity, lack of fusion: Remove the defective portions and reweld.
(c) Copper or tungsten inclusions: Remove the defective portions and reweld.
(d) Excessive concavity of the crater, undercut, or undersize weld: Clean and deposit additional weld metal.
(e) Overlap: Reduce by removal of excess weld metal.

10.3 The defective areas shall be removed by chipping or machining. Oxygen cutting shall not be used. Before rewelding, the joint shall be inspected to ensure that all of the defective weld has been removed. If dye penetrant has been used to inspect the weld, all traces of penetrant solutions shall be removed with solvent, water, heat, or other suitable means before rewelding.

11. Qualification of Procedures, Welders, and Welding Operators.

11.1 Joint welding procedures that are to be employed in executing contract work under these specifications shall be previously qualified by tests prescribed in Section 5 of the ANSI/AWS D1.2 "Structural Welding Code – Aluminum". The qualifications shall be at the expense of the Contractor. At the Engineer's discretion, evidence may be accepted of previous qualification of the joint welding procedures to be employed.

The fabrication shop shall maintain a file of certificates of qualification for its welders and welding operators and make the file available to the Engineer upon request. Each certificate of qualification shall state the name of the welder or welding operator, the name and title of the person who conducted the examination, the kind of specimens, the position of the welds, the results of the tests, and the date of the examination.

Upon request, the fabrication shop shall submit a letter of compliance to the Engineer listing by name all welders and welding operators employed on the fabrication of material for the project. The letter shall certify that these welders or welding operators have been prequalified and that they have been continuously engaged in gas metal-arc or gas tungsten-arc welding with no lapse in such employment in excess of six months since being prequalified.

11.2 All welders and welding operators to be employed under these specifications shall be previously qualified by tests as prescribed in Section 5 of the ANSI/AWS D1.2 "Structural Welding Code – Aluminum". At the Engineer's discretion, evidence may be accepted of previous qualification of the welders and welding operators to be employed. The same process and type of equipment that is required for execution of the construction work shall be used in qualifying welders and welding operators.

SECTION 718 -- RETROREFLECTIVE SHEETING

718.01 Description. Retroreflective sheeting shall consist of a retroreflective non-exposed glass bead lens and/or microprismatic system having a smooth outer surface. When adhesive backing is used, the sheeting shall have a pre-coated adhesive on the back side protected by an easily removable liner.

718.02 Detail Requirements. Reflective sheeting and overlay film shall be selected from the Department's Qualified Products List. Reflective sheeting and overlay film overlay products will be included on the qualified products list after the Department determines conformance to the specifications and the manufacturer has supplied written information indicating conformance to the warranty requirements as noted under the acceptance criteria of the Qualified Products List. Determination of conformance will include, but will not be limited to, the evaluation of test data from AASHTO's National Transportation Product Evaluation Program (NTPEP) or other Department approved facilities except when otherwise indicated.

Retroreflective sheeting shall conform to the requirements of ASTM D4956 including supplementary requirement S2 and any exceptions and/or additions included herein.

718.021 Retroreflective sheeting used on all Type A, AA, B, and BB signs, shall conform to the requirements of Type III material except those specifically indicated otherwise herein.

718.0211 Retroreflective sheeting for the copy, border, and shields on overhead structures including bridge mounts shall conform to Type VII, VIII, IX, or X material unless otherwise noted in the plans.

718.022 Retroreflective sheeting for all Type C or CC shall conform to the requirements of Type I material except specifically indicated otherwise herein.

718.023 Retroreflective sheeting for the following signs shall conform to the requirements of Type III material.

- All Type C or CC "Warning Signs" as described in the MUTCD
- Traffic Control signs or devices per Section 619
- "Stop" (R1-1)
- "Yield" (R1-2)
- "Do Not Enter" (R5-1)
- "Wrong Way" (R5-1a)
- "Type I Object Markers" (OM1-3)
- "Type III Object Markers" (OM-3L, OM-3C, OM-3R)
- "End of the Roadway Markers" (OM4–3)

718.024 Fluorescent Retroreflective sheeting for the following signs shall conform to Type VII, VIII, IX, or X material.

- Fluorescent yellow-green sheeting shall be used for school zone warning signs, school and the "SCHOOL" portion of the S-5-1.

- Fluorescent yellow sheeting shall be used for Chevron (w1-8) signs for speed limits 50 mph or greater and any other type warning sign as called out in the contract plans.
- Fluorescent orange sheeting shall be used on permanent orange construction and maintenance activity signs as prescribed under Section 619.

718.025 Overlay films shall consist of highly durable, transparent, acrylic colored films coated with a transparent pressure sensitive adhesive protected by a removable translucent, synthetic, release liner. The films are designed to be cut on knife over roll (sprocket fed or friction fed) and flat bed electronic cutting dimensionally stable, and be designed to optimally cut, week, lift, and transfer.

718.0251 Test Methods: Testing conditions and panels for the following test shall follow ASTM 4596

718.02511 Color Requirements. When electronic cuttable film is applied to retroreflective sheeting, the resulting color of the composite sheeting will conform to Federal Specification FP-92, Section 718.01 and ASTM D 4956.

718.02512 Coefficient of Retroreflection, R_A. When transparent colored electronic cuttable film is applied per the manufacturer's recommendations over white retroreflective sheeting, the colored composite will conform to the percentage specified in Table 1. The coefficient of retroreflection shall be determined in accordance with ASTM E-810.

Table 1

Coefficient of Retroreflection R_A * for applied Overlay Films
(expressed as % of white retroreflective sheeting background)

Transparent Color	**Minimum**	**Maximum**
Green	13.0	20
Blue	6.5	20
Red	14	24
Yellow	60.0	80
Orange	30	-
Brown	5.0	-
Blue	1.4	-

R_A (cd/lux/m2) measurements shall be made at 0.2º observation angle, -4º entrance angle, and 0º rotation, per ASTM E-810. The ratio of the R_A (color) to R_A (white shall be calculated and converted to a percentage to determine the film transmission values).

718.0252 Processing and Cuttability. The electronic cuttable film shall permit cutting weeding, masking with transfer tape, lifting, and application to retroreflective sheeting when use in accordance with manufacturer's recommendations at temperature between 65º and 95 ºF (18.3º and 35.0 ºC) and relative humidity between 30% and 70%. The film shall lay flat with minimal edge curl and be dimensionally stable.

718.02513 The following ASTM 4596 requirements shall meet the specific color of overlay film: Daytime Color

- Accerlated Outdoor Weathering

- Color Fastness
- Shrinkage
- Flexibility
- Liner Removal
- Adhesion
- Impact Resistance
- Spectular Gloss

718.0253 Adhesive Liner. the protective lay flat liner shall be a synthetic film liner resistant to moisture absorption and curl and shall be removable by peeling, without breaking, tearing, or removing any adhesive from the electronic cuttable film. The liner shall have a controlled release from the adhesive coated film sufficient to allow cutting and weeding without the film popping off from the liner, while still allowing the liner to easily be peeled from the film during application. The liner shall be printed with an indelible mark indicating the name of the film manufacturer. Film with punched edges for use on sprocket fed knife over roll cutters shall be edge scored and weeded to remove film in the punched area as a means of eliminating adhesive build up on the sprockets.