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WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

PROCEDURE FOR THE DETERMINATION OF
STRUCTURAL PAINTING FILM THICKNESS

- 1.0 PURPOSE
- 1.1 These procedures are to set forth guidance in the location and obtaining paint dry film thickness measurements from bridge structures.
- 1.2 These procedures are applicable for structures being fabricated and for existing structures.
- 2.0 SCOPE
- 2.1 These procedures are applicable to girder type spans of any length and design.
- 3.0 DEFINITIONS
- 3.1 Girder Member - span between field connections including flanges, web, stiffeners, connection plates, and etc.
- 3.2 Auxiliary Members - those members attached to or being a part of the girder or beam and generally known as: diaphragms, floor beams, wind bracing, sole, splice and masonry plates, expansion dams, drain materials, etc.
- 3.3 Contact Surfaces - areas of a member that have a bolted connection including the connection or splice plates.
- 3.4 Observation - individual gage measurement.

3.5 Readings - the average of two observations at the same location. The gage readings indicate that paint dry film thickness above the surface on which the gage is set. On blast cleaned steel, it is the paint dry film thickness above the peaks of the surface profile.

4.0 EQUIPMENT

4.1 Dry film thickness gage. Any gage referenced in ASTM D1186 is acceptable. All other gages have to be approved by the Division.

4.2 Standard shims

5.0 CALIBRATION

5.1 These procedures are intended to supplement manufacturer's instructions for the operation of the gages.

5.1.1 The gage is to be calibrated prior to the evaluation and every hour during continuous operation, or after the gage has been turned off for an extended period. Also, the gage is to be checked at the end of the operation.

The battery is to be checked every fifteen minutes during continuous operation.

5.1.2 The meter is to be calibrated in the following manner:

Place a standard shim of the expected paint thickness on the bare substrate that is to be painted. Adjust the gage in place on the shim so that it indicates the known thickness of the shim. If the paint has already been applied to the entire surface, then reference panels of similar steel and surface condition representative of the substrate to be measured may be used.

Confirm the gage setting by measuring the shim at several other areas of the base substrate.

Measure other shims, thicker and thinner than the setting. The gage should respond fully to the difference in the thickness of the shims.

- 6.0 PROCEDURE
- 6.1 Method A
 - 6.1.1 Take five readings randomly chosen, from each side of each girder web.
 - 6.1.2 Take five readings, randomly chosen, from the exposed flanges from each side of each girder.
 - 6.1.3 Take five readings, randomly chosen, from the stiffeners from each side of each girder.
 - 6.1.4 Take five readings from one primary contact surface on each side of each girder.
 - 6.1.5 Take five readings from one secondary contact surface on each side of each girder.
 - 6.1.6 Auxiliary Members - approximately ten percent of the members are to be measured.
 - 6.1.6.1 Take five readings from each selected member.
 - 6.1.6.2 Take five readings from one contact surface on each selected member.
- 6.2 LOCATION OF MEASUREMENT
 - 6.2.1 Web - the web will be considered a rectangular area and locations will be defined by random number coordinate positions. (See Attachment No. 1).
 - 6.2.2 Flange - the locations on the exposed flanges will be defined by random number coordinate positions. (See Attachment No. 1).
 - 6.2.3 Stiffeners - the locations on the stiffeners will be defined by random number coordinate positions. (See Attachment No. 1).
 - 6.2.4 Auxiliary - locations are to be randomly be selected.
 - 6.2.5 Contact Surfaces - locations are to be randomly be selected.

6.3 MEASUREMENT CRITERIA

6.3.1 The average of the five readings may be equal to or greater than the minimum specified thickness with no reading being more than 15 μm below that specified.

6.3.2 Contact Surfaces - the five readings may be within a range of 50 μm to 125 μm .

6.4 CORRECTION OF DEFICIENT AREAS

6.4.1 Any area not meeting the above criteria will cause the member's web, flange, stiffeners, auxiliary members, or contact surfaces to be repainted or repaired.

6.4.2 Any area repainted as a result of deficient thickness is to be reevaluated as set forth in Paragraph 6.0.

6.5 DOCUMENTATION

6.5.1 Results of the readings will be documented on the attached work sheet (Attachment No. 2). Each group of readings will be identified in such a manner as to correlate said readings to a specific number.

6.6 METHOD B

6.6.1 Purpose

6.6.1.1 To provide a method of estimating the percent of coating thickness meeting specification requirements.

6.6.1.2 To provide criteria upon which to base decisions to accept or reject the coating thickness.

6.6.1.3 To provide a method of action to be taken if deficiencies are found.

6.6.2 SCOPE

6.6.2.1 This acceptance procedure will be applicable for those projects which require the structural steel to be painted to a specified thickness or target value.

6.6.3 SAMPLING

- 6.6.3.1 The LOT size may consist of more than one girder and may include any number of auxiliary members.
- 6.6.3.2 The LOT size is to be selected by the fabricator or Contractor.
- 6.6.3.3 The locations for measurement is to be randomly selected by the Division.

6.7 MEASUREMENT CRITERIA

- 6.7.1 For the purpose of evaluation each LOT will be divided into five sublots. Five random thickness readings will be taken, one from each subplot. The paint film thickness is in tolerance if the following conditions are met:
 - 6.7.1.1 For surfaces other than contact surfaces, (1) the average of five readings is equal to or greater than the specified thickness, and (2) when determined by Section 106.3.1 of the Standard Specifications (West Virginia AP-A) at least 90 percent of the coating has a thickness greater than 15 μ m less than the specified thickness. To determine the percentage within tolerance use the following equation:

$$Q_L = \frac{X_5 - (L - 15)}{R} \quad (\text{Equation 1})$$

Where:

Q_L = lower quality index
 X_5 = average of five thickness measurements
 L = minimum limit or specified coating thickness
 R = range of five measurements (difference between the largest reading and the lowest reading).

When $Q_L = 0.50$ or greater for five readings, 90 percent or greater of the coating thickness is within tolerance.

If either of the above conditions is not met, two additional series of five thickness readings (two additional thickness readings from each subplot) are to be taken and these ten readings together with the original five readings are to be used to calculate the thickness average and the Range (R). The paint film thickness is in tolerance if the following conditions are met: (1) The average of the 15 readings is equal to or greater than the specified thickness, and (2) when determined by Section 106.3.1 of the Standard Specifications (West Virginia AP-A) at least 90 percent of the coating has a thickness greater than 15 μm less than the specified thickness.

To determine the percentage within tolerance, use the following equation:

$$Q_L = \frac{X_{15} - (L - 15)}{R} \quad (\text{Equation 2})$$

Where:

X_{15} = average of 15 thickness readings

R = average of three (3) R_s values

When $Q_L = 0.53$ or greater for 15 readings 90 percent or greater of the readings are within tolerance.

If either of the above criteria is not met, the entire LOT is to be rejected.

6.7.1.2 For Contact Surfaces

(1) The average of five readings is within the limits set forth by the Division. (2) When determined by Section 106.3.1 of the Standard Specifications (West Virginia AP-A), at least 90 percent of the coating has a thickness greater than 15 μm less than the lower limit. (3) When determined by Section 106.3.1 of the Standard Specifications (West Virginia AP-A), at least 90 percent of the coating has a thickness less than 15 μm more than the upper limit.

To determine the percentage within tolerance use Equation No. 1 in Paragraph 6.7.1.1 and the following equation:

$$Q_U = \frac{(U + 15) - X_5}{R} \quad (\text{Equation 3})$$

Where:

Q_U = upper quality limit

U = maximum limit or specified coating thickness

When Q_U and $Q_L = 0.50$ or greater for five (5) readings 90 percent or greater of the coating thickness is within tolerance.

If any of the above criteria is not met, additional samples are to be taken as set forth in Paragraph 6.7.1.1. The paint film thickness will be considered in tolerance if the following conditions are met:

(1) The average of 15 readings is within the limits set forth by the Division. (2) When determined by Section 106.3.1 of the Standard Specifications (West Virginia AP-A), at least 90 percent of the coating has a thickness greater than 15 μm less than the specified thickness. (3) When determined by Section 106.3.1 of the Standard Specifications (West Virginia AP-A), at least 90 percent of the coating has a thickness less than 15 μm more than the upper limit.

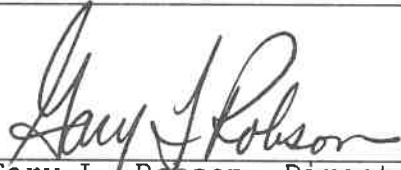
To determine the percentage within tolerance, use Equation No. 2 in Paragraph 6,7.1.1 and the following equation:

$$Q_U = \frac{(U + 15) - X_{15}}{R} \quad (\text{Equation 4})$$

When Q_U and $Q_L = 0.53$ or greater for 15 readings, 90 percent or greater of the coating thickness is within tolerance.

If any of the above criteria are not met the entire LOT is to be rejected.

- 6.8 CORRECTION OF DEFICIENT LOTS
 - 6.8.1 Non Contact Surfaces
 - 6.8.1.1 Any LOT not meeting the criteria set forth in Paragraph 6.7.1.1 is to be repainted and reevaluated as set forth in Method B or:
 - 6.8.1.2 At the fabricator's or contractor's option deficient areas may be isolated by the use of Method A. Those areas determined to be deficient are to be repainted and reevaluated as set forth in Method A.
 - 6.9 Contact Surfaces
 - 6.9.1 Any LOT not meeting the criteria set forth in Paragraph 6.7.1.1 is to be reevaluated using Method A. Contact surfaces outside the limits set forth by the Division are to be corrected.
 - 6.10 DOCUMENTATION
 - 6.10.1 Document the readings on a work sheet similar to Attachment No. 3. Identify each reading in such a manner as to positively correlate the reading to a specified member and location.
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Materials Control, Soils
and Testing Division

GLR:w

Attachments

TABLE 1

RANDOM NUMBERS

.858	.082	.886	.125	.263	.176	.551	.711	.355	.698
.575	.417	.242	.316	.960	.819	.444	.323	.331	.179
.587	.288	.835	.635	.596	.174	.866	.685	.066	.170
.063	.391	.739	.002	.159	.423	.629	.631	.979	.399
.140	.324	.215	.358	.663	.193	.215	.667	.627	.595
.574	.601	.623	.856	.339	.486	.065	.627	.458	.137
.966	.589	.757	.308	.025	.836	.200	.055	.510	.656
.603	.910	.944	.281	.539	.371	.217	.882	.324	.284
.215	.355	.645	.450	.719	.057	.287	.146	.135	.903
.761	.883	.771	.386	.928	.654	.815	.570	.539	.600
.869	.222	.115	.447	.658	.989	.921	.924	.560	.447
.562	.035	.302	.673	.911	.512	.972	.576	.939	.014
.431	.791	.454	.731	.770	.500	.980	.183	.385	.012
.599	.966	.356	.183	.797	.503	.180	.657	.077	.165
.464	.747	.299	.530	.675	.646	.385	.109	.780	.699
.675	.654	.221	.777	.172	.738	.324	.669	.079	.587
.279	.707	.372	.486	.340	.680	.928	.397	.337	.564
.338	.917	.942	.985	.838	.805	.278	.898	.906	.939
.316	.935	.403	.629	.130	.576	.195	.887	.142	.488
.011	.283	.762	.983	.102	.068	.902	.850	.569	.977
.683	.441	.572	.486	.732	.721	.275	.023	.088	.402
.493	.155	.530	.125	.841	.171	.794	.850	.797	.367
.059	.502	.963	.055	.128	.655	.043	.293	.792	.739
.996	.729	.370	.139	.306	.858	.183	.464	.457	.863
.240	.972	.495	.696	.350	.642	.188	.135	.470	.769

BRIDGE PAINTING DATA

PROJECT _____
BRIDGE _____
FABRICATOR _____
LOCATION _____
FABRICATOR'S INSPECTOR SIGNATURE _____
WVA DOH INSPECTOR SIGNATURE _____
DATE _____

MEMBER

#	Web	Top Flange	Stiffener	Bottom Flange	Bottom of Bottom	
Nearside						
	Avg.	Avg.	Avg.	Avg.	Avg.	

MEMBER

#	Web	Top Flange	Stiffener	Bottom Flange	Bottom of Bottom	
Farside						
	Avg.	Avg.	Avg.	Avg.	Avg.	

MEMBER #

MEMBER #

MEMBER #

Main Conn.	Secondary Conn.	Main Conn.	Secondary Conn.	Aux. Members Body	Aux. Members Conn.	
	Avg.	Avg.	Avg.	Avg.	Avg.	

BRIDGE PAINTING DATA

PROJECT _____

BRIDGE _____

CONTRACTOR _____

LOCATION _____

CONTRACTOR INSPECTOR _____

DOH INSPECTOR _____

DATE _____

LOT NO. _____

DESCRIPTION _____

SUBLOT	SAMPLE LOCATION	1ST READING	SAMPLE LOCATION	2ND READINGS	SAMPLE LOCATION	3RD READINGS

TOTAL _____

$$Q_L = \frac{\bar{X}_5 - (L - 15) Q_L}{R}$$

\bar{X}_5 _____

$$Q_U = \frac{(U + 15) - \bar{X}_5 Q_U}{R}$$

\bar{X}_{15} _____

R _____

$$Q_L = \frac{\bar{X}_{15} - (L - 15) Q_L}{R}$$

\bar{R}_{15} _____

$$Q_U = \frac{(U + 15) - \bar{X}_{15} Q_U}{R}$$

EXAMPLE: METHOD A

The dry film thickness of the shop primer that is specified for this project is a minimum of 75 μm .

The member that is to be evaluated is a built up girder, which is 30 m long and 2.5 m wide. There are 15 stiffeners on the near side and 16 stiffeners on the far side of the member. On each end of the member there are primary contact surfaces. Also, there are two (2) secondary contact surfaces on each side of the girder.

The near side of the girder will be evaluated first.

Based on the above information, there are 16 panels on the near side. A panel is the area from end of the girder to a stiffener and/or the area between two (2) stiffeners.

In accordance with the procedure we will select five (5) panels at random to evaluate.

By using the random number coordinates (See Attachment No. 1) the following numbers were selected.

.175
.819
.174
.432
.193

The first two (2) numbers gives the panel number and the last number gives the location in the panel where the readings will be taken. (See Attachment No. 7).

Since the near side of the number has only 16 panels these numbers cannot be used; however, the first two (2) numbers can be combined to read:

175 - 8,5
819 - 9,9
174 - 8,4
423 - 6,3
193 - 10,3

This group of numbers is within a range of 1 to 16; therefore, we can use them to select the panels to be evaluated.

Dry film thickness readings were taken at the following locations:

- Panel No. 6, Grid No. 3. See Attachment No. 7
- Panel No. 8, Grid No. 5. See Attachment No. 7
- Panel No. 8, Grid No. 4. See Attachment No. 7
- Panel No. 9, Grid No. 9. See Attachment No. 7
- Panel No. 10, Grid No. 3. See Attachment No. 7

One reading was taken on the girder web, bottom of top flange, top of bottom flange, bottom of bottom flange, and one of the stiffeners in each of the five (5) panels. Five (5) readings were taken on the primary contact surface near the piece mark on the left end. Five (5) readings were taken on the secondary contact surface on the fourth stiffener from the piece mark. The readings are shown in Attachment No. 2.

The evaluation is listed below.

- Web - Average = 130 μm
Lowest Reading = 104 μm
- Bottom of Top Flange - Average = 121 μm
Lowest Reading = 107 μm
- Top of Bottom Flange - Average = 108 μm
Lowest Reading = 99 μm
- Bottom of Bottom Flange - Average = 109 μm
Lowest Reading = 97 μm
- Stiffener - Average = 120 μm
Lowest Reading = 109 μm
- Primary Connection Area - Average = 67 μm
- Secondary Connection Area - Average = 79 μm

Based on the above results, the coating applied to the near side of the girder meets the specification requirements.

The far side of the member was also evaluated using the above procedure.

EXAMPLE: METHOD B

The dry film thickness for the paint system is a total 150 μm .

The structure that is currently being painted consists of the following members;

The bridge is a simple beam span which consists of twenty (20) stringers from the east abutment to the center pier and twenty (20) stringers from the center pier to the west abutment.

The contractor divides the structure into two (2) LOTS:

LOT No. 1 - east abutment to center pier - (20 members)

This LOT is divided into five (5) sublots, each subplot containing four (4) stringers (See Attachment No. 6).

It is determined by random sampling that the following members will be measured in LOT No. 1:

- Sublot No. 1 - Stringer No. 3
- Sublot No. 2 - Stringer No. 5
- Sublot No. 3 - Stringer No. 11
- Sublot No. 4 - Stringer No. 14
- Sublot No. 5 - Stringer No. 17

The readings were taken on the members at the following locations: (See Attachment No. 7)

Stringer No. 3, approximately 3 m from the east abutment at sampling point No. 3.

Stringer No. 5, approximately 5.5 m from the east abutment at sampling point No. 6.

Stringer No. 11, approximately 7.5 m from the east abutment at sampling point No. 5.

Stringer No. 14, approximately 3 m from the east abutment at sampling point No. 7.

Stringer No. 17, approximately 9 m from the east abutment at sampling point No. 4.

The following readings were obtained:

Stringer No. 3 - 155 μm
Stringer No. 5 - 173 μm
Stringer No. 11 - 198 μm
Stringer No. 14 - 193 μm
Stringer No. 17 - 180 μm

Average of the five (5) readings is 180 μm which is greater than the minimum specified.

Next the lower quality index Q_L is determined from the following data:

X_5 = average of five (5) readings - 180 μm
 L = minimum limit - 150 μm
 R_5 = range of five (5) readings - 43 μm

$$Q_L = \frac{180 - (150 - 15)}{43}$$

$$Q_L = \frac{150 - 137}{43}$$

$$Q_L = \frac{13}{43}$$

$$Q_L = 0.30$$

The lower quality index (Q_L) is below 0.50, therefore LOT No. 1 does not meet the specifications requirements.

Two (2) additional sets of readings were taken from LOT No. 1.

178 μm	180 μm
180 μm	180 μm
185 μm	185 μm
180 μm	178 μm
185 μm	185 μm

The average of the fifteen (15) readings is 181 μm , which is greater than the minimum specified.

The lower quality index (Q_L) is determined from the following data:

X_{15} = average of 15 readings - 181 μm

L = minimum limit - 150 μm

R_{15} = average of three (3) R_5 values - 181 μm

$$Q_L = \frac{181 - (150 - 15)}{20}$$

$$Q_L = \frac{181 - 137}{20}$$

$$Q_L = \frac{44}{20}$$

$$Q_L = 2.2$$

Q_L is greater than 0.53.

The average of the fifteen (15) readings is greater than the specified thickness and Q_L is greater than 0.53; therefore, the paint film thickness is acceptable for LOT No. 1.

Simple Beam Span - Top View
(Each numbered horizontal line
represents a member)

LOT No. 1

Sub	20	40	
Lot	19	39	
No. 5	18	38	
	17	37	
Sub	16	36	
Lot	15	35	
No. 4	14	34	
	13	33	
Sub	12	32	
Lot	11	31	
No. 3	10	30	
	9	29	
Sub	8	28	
Lot	7	27	
No. 2	6	26	
	5	25	
Sub	4	24	
Lot	3	23	
No. 1	2	22	
	1	21	

LOT
No.

West Abutment

Center Pier

East Abutment

