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, 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.

6.3.2 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 selected.

6.2.5 Contact Surfaces - locations are to be randomly 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 0.5 mil (13 µm) below that specified.

6.3.2 Contact Surfaces - the five readings may be within a range of 2.0 to 5.0 mils (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 Section 6.0.

6.5 DOCUMENTATION

6.5.1 Results of the readings will be documented on the attached work sheet (Attachment No. 5). 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 are 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 sub lots. Five random thickness readings will be taken, one from each sublot. 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 0.5 mil (13 µm) less than the specified thickness. To determine the percentage within tolerance use the following equation:

English

$$Q_L = \frac{X_5 - (L-0.5)}{R_5}$$

Metric

$$Q_L = \frac{X_5 - (L-13)}{R_5}$$ (Equation 1)

Where:

Q_L = lower quality index
X5 = average of five thickness measurements
L = minimum limit or specified coating thickness
R5 = 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 sublot) 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 0.5 MIL (13 µm) less than the specified thickness.

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

English

$$Q_L = \frac{X_{15} - (L - 0.5)}{R_3}$$

Metric

$$Q_L = \frac{X_{15} - (L - 13)}{R_3}$$ (Equation 2)

Where:

X_{15} = average of 15 thickness readings
R_3 = average range of three (3) R. values

When *QL* = 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 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 0.5 mil (13 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 0.5 mil (13 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:

English

$$Q_U = \frac{(U + 0.5) - X_5}{R_5}$$

Metric

$$Q_U = \frac{(U + 13) - X_5}{R_5} \qquad \text{(Equation 3)}$$

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 shall be taken as set forth in Paragraph 6.7.1.1. The paint film thickness shall be considered acceptable 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 0.5 MIL (13 um) 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 0.5 MIL (13 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:

English

$$Q_u = \frac{(U + 0.5) - X_{15}}{R_3}$$

Metric

$$Q_u = \frac{(U + 13) - X_{15}}{R_3}$$ (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 shall 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 shall 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 shall be repainted and reevaluated as set forth in Method A.

6.8.2 Contact Surfaces

6.8.2.1 Any LOT not meeting the criteria set forth in Paragraph 6.7.1.2 shall be reevaluated using Method A. Contact surfaces outside the limits set forth by the Division shall be corrected.

7.0 DOCUMENTATION

7.1 Readings shall be documented on a work sheet similar to Attachment No. 6. Each reading shall be identified in such a manner as to positively correlate said reading to a specified member and location.

Richard D. Genthner, P.E
Director
Materials Control, Soils, and Testing Division

TABLE 1

RANDOM NUMBERS

.858	.082	.886	.125	.263	.176	.551	.711	.355	.698
.575	.417	.242	.316	.960	.819	.444	.323	.331	.179
.417	.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	.215	.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	.659	.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	.680	.928	.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	.782	.739
.996	.729	.370	.129	.306	.858	.183	.464	.457	.863
.240	.972	.495	.696	.350	.642	.188	.135	.470	.769

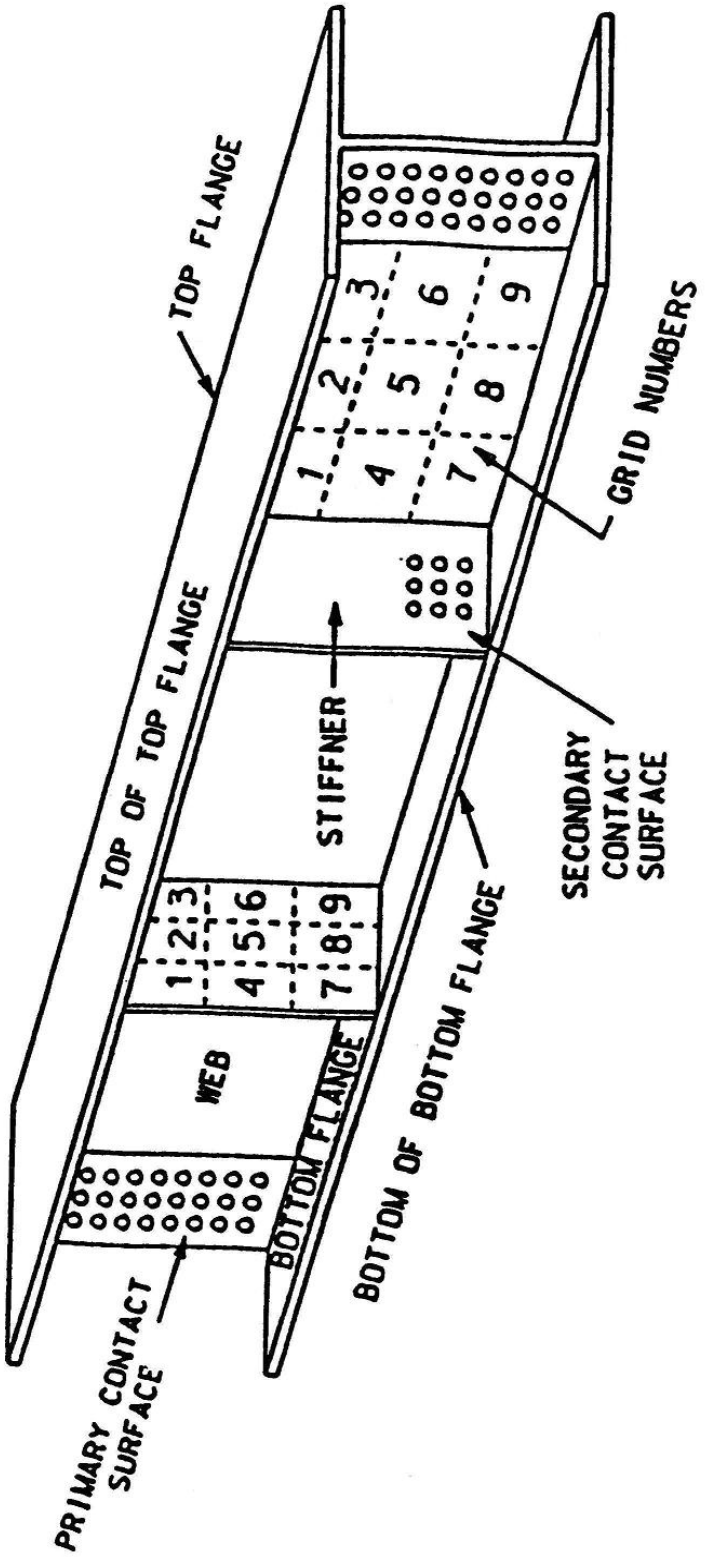


PLATE GIRDER

EXAMPLE: **METHOD A**

The Dry film thickness of the shop primer that is specified for this project is a minimum of 3 mils (75 µm).

The member that is to be evaluated is a built up girder, which is 90 feet (30 m) long and 8 feet (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.

.176
.819
.174
.423
.193

The first two numbers gives the panel number and the last number gives the location in the panel where the readings will be taken. (See Attachments 2 and 4).

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

176 - 8,6
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. 8, Grid No. 6. See Attachments 2 and 4
Panel No. 9, Grid No. 9. See Attachments 2 and 4
Panel No. 8, Grid No. 4. See Attachments 2 and 4
Panel No. 6, Grid No. 3. See Attachments 2 and 4
Panel No. 10, Grid No. 3. See Attachments 2 and 4

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. 5.

The evaluation is listed below.

Web - Average = 5.2 mils (130 µm) for five readings on five panels.
Lowest Reading = 4.2 mils (104 µm)

Bottom of Top Flange - Average = 4.8 mils (121 µm)
Lowest Reading = 4.3 mils (107 µm)

Top of Bottom Flange - Average = 4.3 mils (108 µm)
Lowest Reading = 4.0 mils (99 µm)

Bottom of Bottom Flange - Average = 4.4 mils (109 µm)
Lowest Reading = 3.9 mils (97 µm)

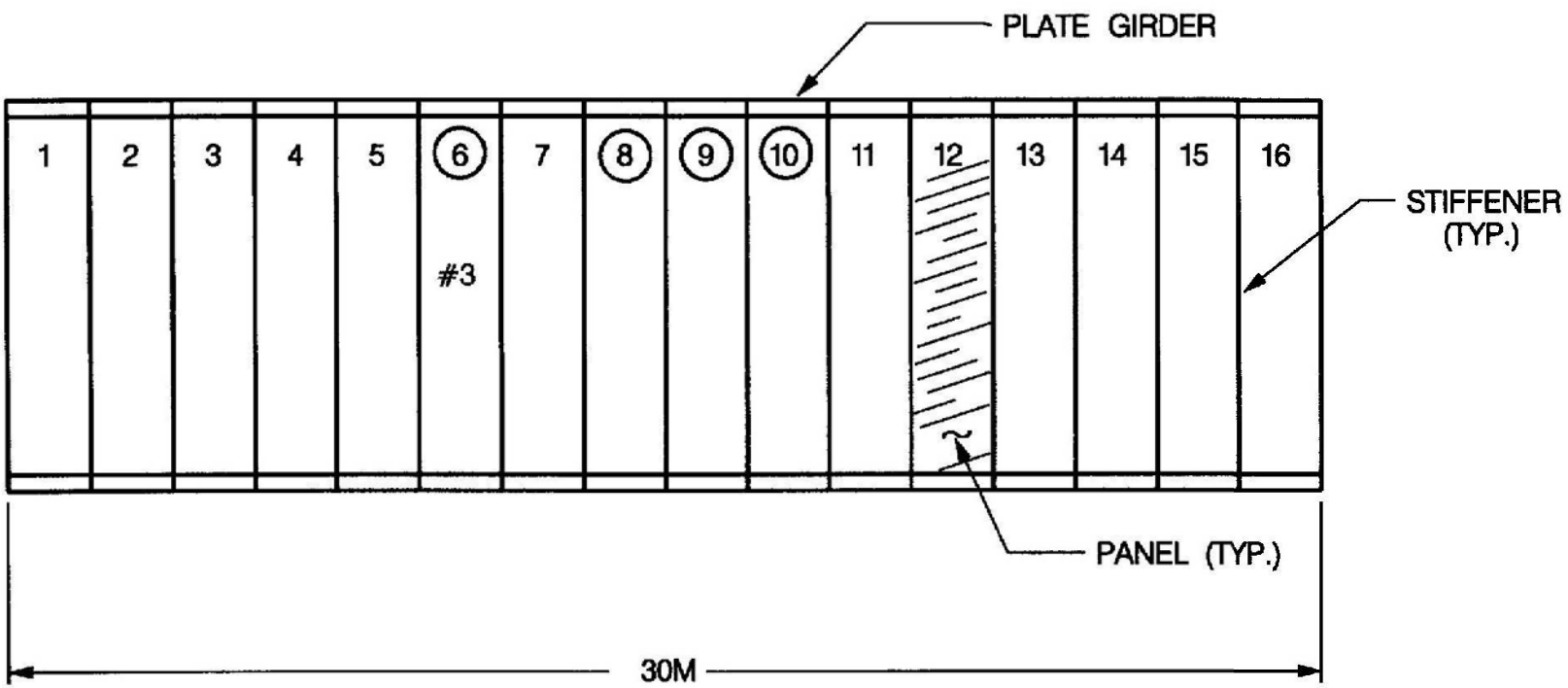
Stiffener - Average = 4.8 mils (120 µm)
Lowest Reading = 4.4 mils (109 µm)

Primary Connection Area - Average = 2.7 mils (67 µm)

Secondary Connection Area - Average = 3.1 mils (79 µm)

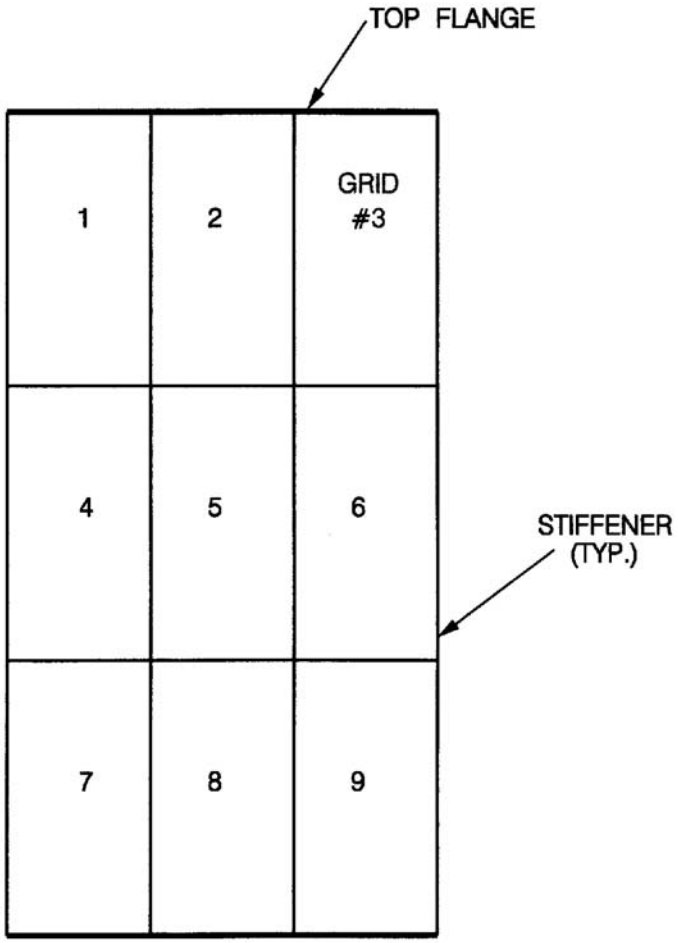
Based on the above results, the coating applied to the near side of the girder meets the specification requirements.

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



EXAMPLE: METHOD "A"

EXAMPLE: METHOD "A"



PANEL # 6

METHOD A

BRIDGE PAINTING DATA

PROJECT _____
BRIDGE _____
FABRICATOR _____
LOCATION _____
FABRICATOR'S INSPECTOR SIGNATURE _____
WVDOH INSPECTOR SIGNATURE _____
DATE _____

MEMBER

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

MEMBER

#	Web	Bott. of Top Flange	Stiffener	Top of Bottom Flange	Bottom of Bottom
Far side					
	Avg.	Avg.	Avg.	Avg.	Avg.

MEMBER# MEMBER# MEMBER#

Primary Conn	Secondary Conn	Primary Conn	Secondary Conn	Aux Members Body	Aux Members Conn
	Avg.	Avg.	Avg.	Avg.	Avg.

METHOD A

BRIDGE PAINTING DATA

PROJECT ER-106(4)
BRIDGE 5285
FABRICATOR Johnson Fabricating Company
LOCATION Cincinnatti, OH
FABRICATOR'S INSPECTOR SIGNATURE John Doe
WVDOH INSPECTOR SIGNATURE Bill Hinkle
DATE 7-7-94

MEMBER

#	Web	Bott. of Top Flange	Stiffener	Top of Bottom Flange	Bottom of Bottom
Nearside	mils (µm)	mils (µm)	mils (µm)	mils (µm)	mils (µm)
6-3	4.2 (104)	5.1 (127)	4.4 (109)	4.0 (99)	3.9 (97)
8-4	6.2 (155)	5.0 (124)	4.5 (112)	4.2 (104)	4.3 (107)
8-6	5.2 (130)	5.0 (124)	5.0 (124)	4.2 (104)	4.3 (107)
9-9	5.2 (130)	4.8 (122)	5.1 (127)	4.5 (112)	4.5 (112)
10-3	5.2 (130)	4.3 (107)	5.2 (130)	4.8 (122)	4.8 (122)
AVG.	5.2 (130)	4.8 (121)	4.8 (120)	4.3 (108)	4.4 (109)

MEMBER

#	Web	Bott. of Top Flange	Stiffener	Top of Bottom Flange	Bottom of Bottom
Far side					
Avg.					

MEMBER#

Primary Conn	Secondary Conn	Primary Conn
mils (µm)	mils (µm)	mils (µm)
2.4 (61)	3.2 (81)	
2.6 (64)	3.0 (76)	
2.8 (69)	3.1 (79)	
2.6 (69)	3.0 (76)	
2.9 (71)	3.2 (81)	
Avg. 2.7 (67)	Avg. 3.1 (79)	Avg.

MEMBER#

Secondary Conn	Aux Members Body
mils (µm)	mils (µm)
Avg.	Avg.

MEMBER#

Aux Members Conn
mils (µm)
Avg.

METHOD B

BRIDGE PAINTING DATA

PROJECT _____

BRIDGE _____

CONTRACTOR _____

LOCATION _____

CONTRACTOR INSPECTOR _____

DOH INSPECTOR _____

DATE _____

LOT NO. _____

DESCRIPTION _____

_____

****

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

****

_____ –

English Metric

TOTAL _____ $Q_L = \frac{X_5 - (L - 0.5)}{R}$ $Q_L =$ $Q_L = \frac{X_5 - (L - 13)}{R}$ $Q_L =$

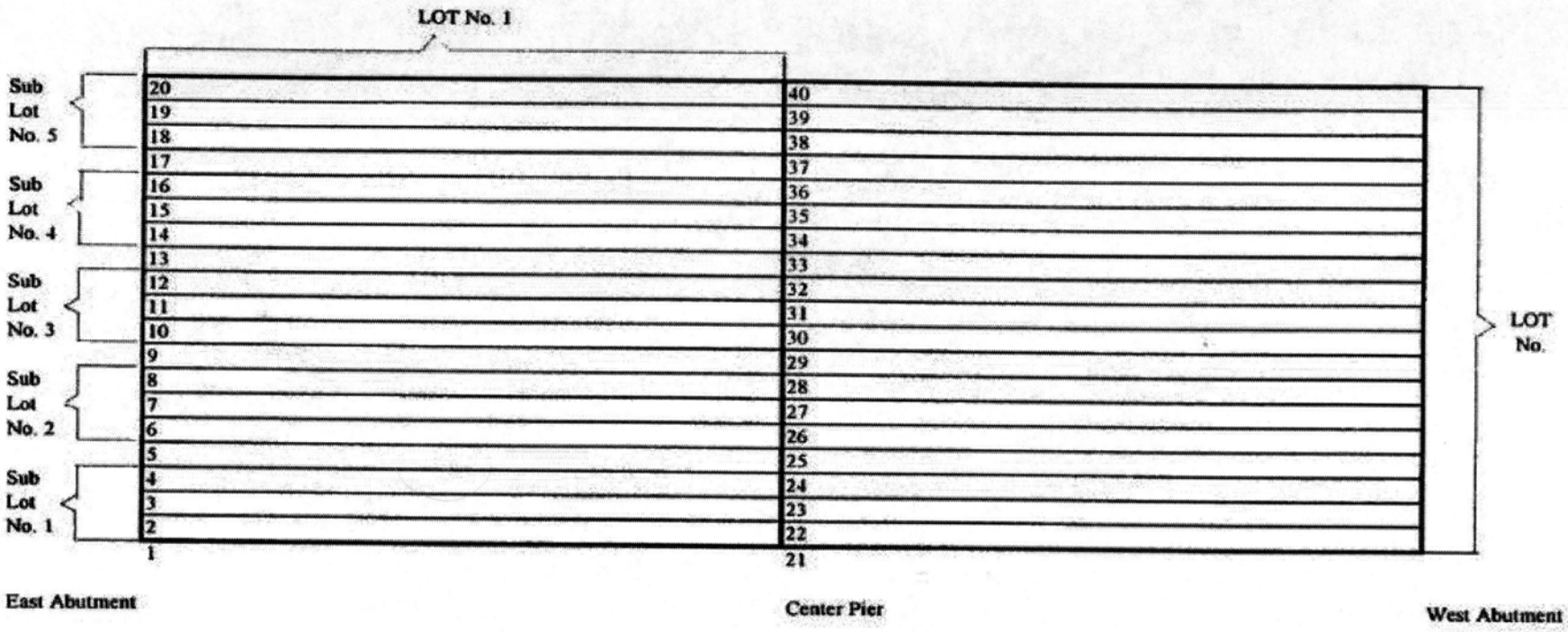
X_5 _____ $Q_U = \frac{(U + 0.5) - X_5}{R}$ $Q_U =$ $Q_U = \frac{(U + 13) - X_5}{R}$ $Q_U =$

X_{15} _____ $Q_L = \frac{X_{15} - (L - 0.5)}{R_3}$ $Q_L =$ $Q_L = \frac{X_{15} - (L - 13)}{R_3}$ $Q_L =$

R _____ $Q_U = \frac{(U + 0.5) - X_{15}}{R_3}$ $Q_U =$ $Q_U = \frac{(U + 13) - X_{15}}{R_3}$ $Q_U =$

R_3 _____

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



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ATTACHMENT NO.: 7
PAGE NO.: 1 OF 1

EXAMPLE: **METHOD B**

The dry film thickness for the paint system is a total 6.0 mils (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 lots:

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

This lot is divided into five (5) sublots, each sublot containing four (4) stringers (See Attachment No. 7).

The following random numbers were selected;

0.467
0.429
0.862
0.942
0.826

0.467 X no. of stringers in sublot no. 1

0.467 x 4 =1.86 say 2, **stringer no. 2 – sublot no. 1**
0.429 x 4 + 4 =5.71 say 6 , **stringer no. 6 –sublot no. 2**
0.862 x 4 + (4+4) = 11.44, say 11, **stringer no. 11 –sublot no. 3**
0.942 x 4 +(4+4+4) = 15.76, say 16, **stringer no. 16 –sublot no. 4**
0.826 x 4+ (4+4 +4+4) = 19.3, say 19 , **stringer no. 19, sublot no. 5**

Sampling locations:

Select five (5) random numbers (one for each sublot) – (see attachment no. 1):

0.287
0.815
0.921
0.972
0.980

Stringer no. 2 – 0.287 x length of stringer no. 2

0.287 x 65.5 ft (20 m) = 19 ft (6 m) from the east abutment **(sampling location no. 1).**

Stringer no. 6: 0.815 x 65.5 ft (20 m) =53 ft (16 m) from the east abutment **(sampling location no. 2).**

Stringer no. 11: 0.921 x 65.5 ft = 60 ft (18 m) from the east abutment **(sampling location no. 3).**

Stringer no. 16: 0.972 x 65.5 ft = 64 ft (19 m) from the east abutmrnt **(sampling location no. 4).**

Stringer no. 19: 0.980 x 65.5 ft = 64 ft (19 m) from the east abutment **(sampling location no. 5).**

The following readings were obtained.

Stringer No. 2 – 6.2mils (155 µm)
Stringer No. 6 – 6.9 mils (173 µm)
Stringer No. 11 – 6.0 mils (150 µm)
Stringer No. 16 – 9.4 mils (235 µm)
Stringer No. 20 – 6.6 mils (166 µm)

Average of the five (5) readings is 7.0 mils (175 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 – 7.0 mils (175 µm)
L = minimum limit – 6.0 mils (150 µm)
R_5 = range of five (5) readings – 3.4 mils (85 µm)

English	Metric
$Q_L = \frac{7.0 - (6.0 - 0.5)}{3.4}$	$Q_L = \frac{175 - (150 - 13)}{85}$
$Q_L = \frac{7.0 - 5.5}{3.4}$	$Q_L = \frac{175 - 137}{85}$
$Q_L = \frac{1.5}{3.4}$	$Q_L = \frac{38}{85}$
$Q_L = 0.44$	$Q_L = 0.45$

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:

7.1 mils (178 µm)	7.2 mils (180 µm)
7.2 mils (180 µm)	7.2 mils (180 µm)
7.4 mils (185 µm)	7.4 mils (185 µm)
7.2 mils (180 µm)	7.1 mils (178 µm)
7.4 mils (185 µm)	7.4 mils (185 µm)

The average of the fifteen (15) readings is 7.2 mils (179 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 – 7.2 mils (179 µm)
L = minimum limit – 6.0 mils (150 µm)
R_3 = average of three (3) R_5 values – 1.3 mils (33 µm)

English	Metric
$Q_L = \frac{7.2 – (6.0 – 0.5)}{1.3}$	$Q_L = \frac{179 - (150 - 13)}{33}$
$Q_L = \frac{7.2 – 5.5}{1.3}$	$Q_L = \frac{179 - 137}{33}$
$Q_L = \frac{1.7}{1.3}$	$Q_L = \frac{42}{33}$
$Q_L = 1.31$	$Q_L = 1.27$

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.