DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
Transportation Laboratory
5900 Folsom Boulevard
Sacramento, California 95819-4612

METHOD OF TEST FOR MEASURING EPOXY COATING THICKNESS ON STEEL REINFORCING BARS, WELDED WIRE MESH AND DOWEL BARS USING TYPE 2 GAGES

A. SCOPE

This test method describes the procedure for nondestructive spot thickness measurements of non-magnetic green flexible (ASTM A775) and purple/gray rigid (ASTM A934) epoxy coatings over ferrous materials. These ferrous materials include steel reinforcing bars, welded wire mesh and steel dowel bars. The procedures used for determining material thickness on green flexible (ASTM A775) and purple/gray rigid (ASTM A934) steel reinforcing bars are the same and are described in Part I of this test method. Parts II and III provide the testing procedures for the same coating materials on welded wire mesh and dowel bars. Part IV covers special considerations for testing in the field rather than in the laboratory.

This method seeks to minimize the unavoidable variability of thickness coating measurements to acceptable limits. This variability is accounted for with the range of acceptable epoxy coating thickness values specified in project documents.

B. REFERENCES

ASTM A 775/775M – Epoxy-Coated Steel Reinforcing Bars
ASTM A 884/884M – Epoxy-Coated Steel Wire and Welded Wire Reinforcement
ASTM A 934/934M – Epoxy-Coated Prefabricated Steel Reinforcing Bars
ASTM B 499 – Measurement of Coating Thicknesses by the Magnetic Method
ASTM E 29 – Using Significant Digits in Test Data to Determine Conformance with Specifications
ASTM E 376 – Measuring Coating Thickness by Magnetic-Field or Eddy-Current Testing Methods
Caltrans Standard Specifications Section 52, "Reinforcement"
SSPC-PA 2 – Procedure for Determining Conformance To Dry Coating Thickness Requirements, SSPC Coating Application Standard No. 2

C. DEFINITIONS

Calibration – Adjustment of the gage to adapt the probe characteristics using a reference sample with a known coating thickness in the range of the coated samples to be measured and which corresponds to the substrate and coating material of the parts to be measured.

Lot – A load of materials in accordance with Section 52-1.01B of the Caltrans Standard Specifications.

Non-flexible – An alternative designation for "rigid".

Normalization – Adjustment of the coating thickness spot measurement gage to a zero value. This is done when the substrate changes or when results appear to exhibit long-term drift.

Sample No. – The identification number assigned to the sample(s) or groups of samples being tested.

D. APPARATUS

1. A Type 2 electronic coating thickness gage, (as defined by SSPC: The Society for Protective Coatings' Coating Application Standard No. 2, [SSPC-PA 2]), capable of measuring non-magnetic coatings on a magnetic base material by the magnetic induction method.

2. A test probe with corresponding flexible cable to attach to the gage housing. The probe outer diameter shall not exceed 3/8 in. and the contact ball diameter shall be no larger than 0.063 in.

3. A set of certified thickness shims, traceable to the National Institute of Standards and Technology (NIST). These shims shall represent at least two points within the specified range of spot measurement. One shim shall be as close as possible to the maximum thickness specification. It shall be at least 80 % of the specified maximum thickness gage reading. Additional shims shall be maintained to verify several points on the linear operating range of the thickness gage.

E. SAMPLES

1. Test samples shall be representative of the final product and shall be coated at the same time as the lot that the samples represent. Samples shall be as follows:

   a. For each straight section surface profile and lot, two straight coated bars and one bare-blasted bar sample shall be provided.

   b. For each curved bar surface profile and lot, two straight coated bars shall be provided for that size and lot along with a bare-blasted bar with identical profile.

   c. For welded wire mesh, two samples 2 ft × 2 ft shall be provided with a comparable bare-blasted wire size sample.

   d. For dowel bars, two straight coated bars and a bare-blasted dowel bar of equivalent diameter shall be provided for each lot of material.

2. Notwithstanding the requirements for bare-blasted bars above, if the required bare-blasted bars are not provided, submitted test samples may be tested if other available bare-blasted bars can be used to perform the normalization and calibration required in Section F, Part I below.

F. PROCEDURE

PART I. QUALITY ASSURANCE TESTS FOR EPOXY COATING THICKNESS ON REINFORCING BARS

1. Perform normalization - place the bare-blasted bar sample (of the same surface profile) on a non-magnetic working surface. Take a minimum of 10 gage readings at regular intervals throughout the bare-blasted bar (between deformations and rib) for zero baseline on the rough surface. Use the gage manufacturer's procedure for establishing instrument zero for these gage readings.

2. Calibrate the gage - place shim on the bare-blasted bar between the deformations (cut the shim as necessary to fit between the deformations) then press the probe on top of the shim so that there is intimate contact between the bar surface and the shim. Take a minimum of three gage readings throughout the length of the bar. Use the gage manufacturer's procedure for processing these values for calibration.

3. Label the two test bars as follows:

   a. For the first bar, label the side with the manufacturer's identification as B1-S1-Sample No., where B1 stands for bar 1 (out of two bars), S1 stands for side 1 (out of two sides) and Sample No. is the number defined in Section C above.

   b. For the other side of the first bar, label it as B1-S2-Sample No.

   c. For the second bar, label the side with the manufacturer's identification as B2-S1-Sample No.

   d. For the other side of the second bar, label it as B2-S2-Sample No.

4. Find the midpoint along the first bar with a measuring tape and mark.

5. From the center mark, to the end of the bar, measure and mark the halfway points on the bar so that there are three evenly spaced testing locations. If the bar manufacturer's stamp interferes with the evenly spaced measure marks, measure half the distance between the bar stamp and the nearest measure mark and use this new location for spot measurements.

6. Testing locations shall be at the reference mark in three consecutive spaces between the deformations. Repeat for other half of the bar. Use a permanent marker to place reference marks where gage readings shall be taken; three gage readings equal one block (each side has 15 gage readings and each side has 5 blocks). The average of three gage readings at one block equals one spot measurement. Therefore, there are 30 gage readings and 10 spot measurements per sample.

7. Take all gage readings immediately next to the marked spots to prevent being influenced by the ink spot thickness.

8. Begin the gage readings from the left end of the bar on S1. Place the probe near the measure mark, at a 90° angle (perpendicular) to the surface. Take three gage readings consecutively between bar deformations. Complete each side of the bar.

9. If any two consecutive gage readings differ from each other by more than 2 mils then the spot measurement shall be discarded and repeated.

10. Gage readings shall be taken to the nearest $1/10^{th}$ of a mil.

11. The resulting average spot measurement shall be reported to the nearest whole mil. Spot measurements from 0.1 to 0.4 mils shall be rounded down and rounded up for measurements from 0.6 to 0.9 mils. When the spot measurement value ends in 0.5 mils, increase the value in the last place by 1 if the whole number integer is odd. Leave the figure in the last place unchanged if it is even, in accordance with ASTM E 29.

12. Repeat steps 4 through 11 for the second sample.

13. After the gage readings are completed for the bar, ensure that the gage reading and spot measurements are recorded on a test form for recording epoxy coating thickness result. An example of an appropriate test form is shown in Figure 1. Report the results on a Sample Testing Report. An example of an appropriate test report is illustrated in Figure 2.

PART II. QUALITY ASSURANCE TESTS FOR EPOXY COATING THICKNESS ON WIRE MESH

1. Place the bare-blasted mesh sample (of the same wire dimensions, preferably the same heat of mesh) on a non-magnetic working surface. Take a minimum of 10 gage readings at regular intervals throughout the bare-blasted mesh for zero baseline on the rough surface. Normalize gage as described above in Section F, Part I.1.

2. Calibrate the gage as described above in Section F, Part I.2.

3. Testing locations shall be at the reference mark in three consecutive spaces between the depressions. Use a permanent marker to place reference marks where spot measurements shall be made. See Figure 3 for location and pattern of gage readings. Three gage readings equal one block (each side has 36 gage readings and each side has 12 blocks). The average of one block equals one spot measurement. Therefore, there are 24 spot measurements per sample.

4. If wire mesh has deformed indents or deformations, spot measurements shall be taken between the deformed indents or deformations.

5. Make all spot measurements just off the marked spots to prevent being influenced by the ink spot thickness.

6. Begin the gage readings from the top wire at the center of the mesh. Proceed with the testing pattern as shown in Figure 3.

7. If any two consecutive gage readings differ from each other by more than 2 mils then the spot measurement shall be discarded and repeated.

8. Gage readings shall be taken to the nearest $1/10^{th}$ of a mil.

9. The resulting average spot measurements shall be reported to the nearest whole mil. Spot measurements averages shall be rounded down for 0.1 to 0.4 mils and rounded up for 0.6 to 0.9 mils. When the spot measurement value ends in 0.5 mils, increase the value in the last place by 1 if the whole number integer is odd. Leave the figure in the last place unchanged if it is even, in accordance with ASTM E 29.

10. After the gage readings are completed for the bar, record the gage readings and spot measurements on a form similar to the test form shown in Figure 1. Report the results on a test report similar to that illustrated in Figure 2.

PART III. QUALITY ASSURANCE TESTS FOR EPOXY COATING THICKNESS ON DOWEL BARS

1. Place the bare-blasted bar sample (of the same diameter) on a non-magnetic working surface. Take a minimum of 10 gage readings at regular intervals throughout the bare-blasted bar for zero baseline on the rough surface. Normalize the gage as described above in Section F, Part I.1.

2. Calibrate the gage as described above in Section F, Part I.2.

3. Label the two test dowel bars as follows:

    a. For the first bar, label one side as B1-S1-Sample No., where B1 stands for bar 1 (out of two bars), S1 stands for side 1 (out of two sides) and Sample No. is the number defined in Section C. above.

b. For the other side of the first bar, label it as B1-S2-Sample No.

c. For the second bar, label the side with the manufacturer's identification as B2-S1-Sample No.

d. For the other side of the second bar, label it as B2-S2-Sample No.

4. Find the midpoint along the first bar with a measuring tape and mark.

5. From the center mark, to the end of the bar, measure and mark the halfway point on the bar. This gives you three evenly spaced testing locations.

6. Testing locations shall be at the reference mark in three consecutive locations. Use a permanent marker to place marks where gage readings shall be made. Three gage readings equal one block (each side has 15 gage readings and each side has 5 blocks). The average of three gage readings at one block equals one spot measurement. Therefore, there are 30 gage readings and 10 spot measurements per sample.

7. Make all spot measurements just off the marked spots to prevent being influenced by the ink spot thickness.

8. Begin the gage readings from the left end of the bar on S1. Place the probe on the measure mark, at a 90° angle (perpendicular) to the surface. Take three consecutive gage readings. Complete each side of the bar.

9. If any two consecutive gage readings differ from each other by more than 2 mils, then the spot measurement shall be discarded and repeated.

10. Gage readings shall be taken to the nearest $1/10^{th}$ of a mil.

11. The resulting average spot measurements shall be reported to the nearest whole mil. Spot measurements averages shall be rounded down for 0.1 to 0.4 mil and rounded up for 0.6 to 0.9 mil. When the spot measurement value ends in 0.5 mil, increase the value in the last place by 1 if the whole number integer is odd. Leave the figure in the last place unchanged if it is even, in accordance with ASTM E 29.

12. After the gage readings are completed for the bar, record the gage readings and spot measurements on a form similar to the test form shown in Figure 1. Report the results on a test report similar to that illustrated in Figure 2.

PART IV. QUALITY ASSURANCE TESTING IN THE FIELD

Testing for epoxy coating thickness may be done in the field rather than in the laboratory. While the procedures given in Section F, Parts I, II and III are applicable, the following special considerations should be noted:

1. Portable Type 2 coating thickness gages generally have less data recording capability than their desk-mounted counterparts. Individual gage readings and/or spot measurements may have to be written down by hand. Use the test form in Figure 4 for this purpose. Report the results on a Sample Test Report Form similar to that shown in Figure 2.

2. Portable thickness gages should be handled with care.

3. Pay careful attention to the sample temperature requirements in Section H.4 below.

G. REPORTING OF RESULTS

The test report shall include the following information, as necessary for the user:

1. Date sampled;
2. Date received;
3. Date reported;
4. Sample no.;
5. Lot no.;
6. Contract no.;
7. Person results reported to;
8. Material;
9. Manufacturer;
10. Sampler; and
11. Results

H. GENERAL REQUIREMENTS

1. The thickness-measuring device shall be certified on a yearly basis for accuracy over the normal operating range by the manufacturer.
2. All gage readings shall be taken with the sample resting on a non-magnetic work surface, or alternatively, on a conductive surface covered with at least ½ in. of non-conductive material.
3. Keep the test surface and the test probe free of contamination as this can prevent direct contact between the probe and the surface of the coating.
4. Temperature of the test samples for bending must be between 68°F and 86°F. Record the temperature.
5. Make sure that no electrical power equipment (transformers, motors, etc.) is within the range of influence of the testing work surface. The range of influence varies depending on the power of the equipment, but it can be determined as follows:
    a. For desk-mounted Type 2 thickness gages: the gage cannot be normalized on a bare bar within the range of influence. Move one meter further away from the electrical power equipment and attempt to normalize. Repeat until the gage can be normalized.

b. For portable Type 2 thickness gages: the gage cannot be calibrated using calibration shims. Move one meter further away from the electrical power equipment and attempt to calibrate. Repeat until the gage can be calibrated.

6. Gage readings of coating thickness shall not be made within 1 in. of the sample end.

7. Care should be taken to prevent deforming the tested epoxy surface with the probe contact ball.

8. Calibration shims shall be replaced frequently to prevent indentations affecting their accuracy.

9. Protect the probe from impact. Re-calibrate and re-normalize if the probe is dropped.

I. PRECAUTIONS

The test samples are heavy and may contain sharp edges or burrs. Use appropriate safety measures.

J. HEALTH AND SAFETY

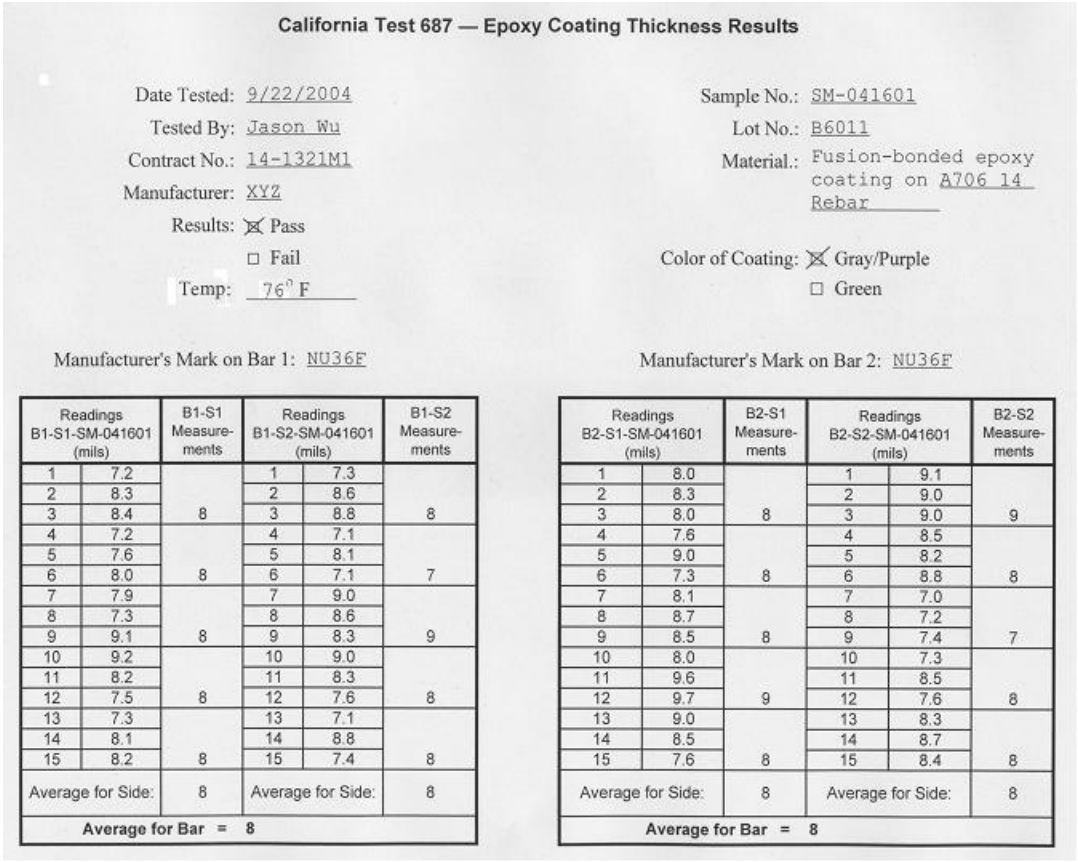
It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Prior to handling, testing or disposing of any materials, testers must be knowledgeable about safe laboratory practices, hazards and exposure, chemical procurement and storage, and personal protective apparel and equipment.

Caltrans Laboratory Safety Manual is available at:

http://www.dot.ca.gov/hq/esc/ctms/pdf/lab_safety_manual.pdf

End of Text
(California Test 687 contains 11 pages)

Figure 1. Test Form for Recording Epoxy Coating Thickness Results



California Test 687 — Epoxy Coating Thickness Results

Date Tested: 9/22/2004
Tested By: Jason Wu
Contract No.: 14-1321M1
Manufacturer: XYZ
Results: ☒ Pass ☐ Fail
Temp: 76° F

Sample No.: SM-041601
Lot No.: B6011
Material.: Fusion-bonded epoxy coating on A706 14 Rebar
Color of Coating: ☒ Gray/Purple ☐ Green

Manufacturer's Mark on Bar 1: NU36F

Readings B1-S1-SM-041601 (mils)		B1-S1 Measure-ments	Readings B1-S2-SM-041601 (mils)		B1-S2 Measure-ments
1	7.2		1	7.3	
2	8.3		2	8.6	
3	8.4	8	3	8.8	8
4	7.2		4	7.1	
5	7.6		5	8.1	
6	8.0	8	6	7.1	7
7	7.9		7	9.0	
8	7.3		8	8.6	
9	9.1	8	9	8.3	9
10	9.2		10	9.0	
11	8.2		11	8.3	
12	7.5	8	12	7.6	8
13	7.3		13	7.1	
14	8.1		14	8.8	
15	8.2	8	15	7.4	8
Average for Side:		8	Average for Side:		8
Average for Bar = 8					

Manufacturer's Mark on Bar 2: NU36F

Readings B2-S1-SM-041601 (mils)		B2-S1 Measure-ments	Readings B2-S2-SM-041601 (mils)		B2-S2 Measure-ments
1	8.0		1	9.1	
2	8.3		2	9.0	
3	8.0	8	3	9.0	9
4	7.6		4	8.5	
5	9.0		5	8.2	
6	7.3	8	6	8.8	8
7	8.1		7	7.0	
8	8.7		8	7.2	
9	8.5	8	9	7.4	7
10	8.0		10	7.3	
11	9.6		11	8.5	
12	9.7	9	12	7.6	8
13	9.0		13	8.3	
14	8.5		14	8.7	
15	7.6	8	15	8.4	8
Average for Side:		8	Average for Side:		8
Average for Bar = 8					

Figure 2. Sample Test Report

State of California
Department of Transportation

Structural Materials Testing Laboratory
5900 Folsom Boulevard, Sacramento, CA 95819

TEST REPORT

A2LA ACCREDITED
TESTING CERT # 2364.01

Remarks ref: Standard Specifications (52-1.02B); ASTM A934; TM 07. Heat #SE13101901, SE13101318. Load 99.

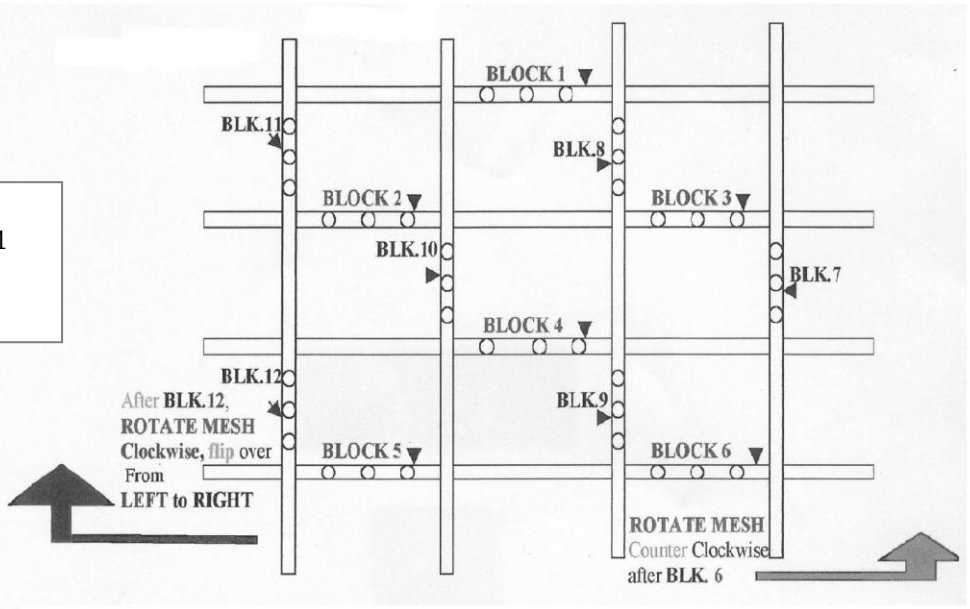
Sample No: SM-13-0701
Date Sampled: 06/05/13 **Date Rec'd:** 06/10/13 **Date Reported:** 06/13/13
Lot No: B3136513 **TL-101 / SIC No:** C646189
Contract/Permit No: 02-3E7604
Material: A934 #6/19mm Purple Epoxy Coated Rebar.
Manufacturer: Farwest Steel Reinforcing
Sampler: Dennis Combs

Results: **SAMPLE(S) SUBMITTED COMPLY WITH SPECIFICATIONS**

Note: Results relate only to the items tested

Figure 3. Location of Gage Readings on Wire Mesh

Side 1
(gage readings 1 through 36)



Side 2
(gauge readings 37 through 72)

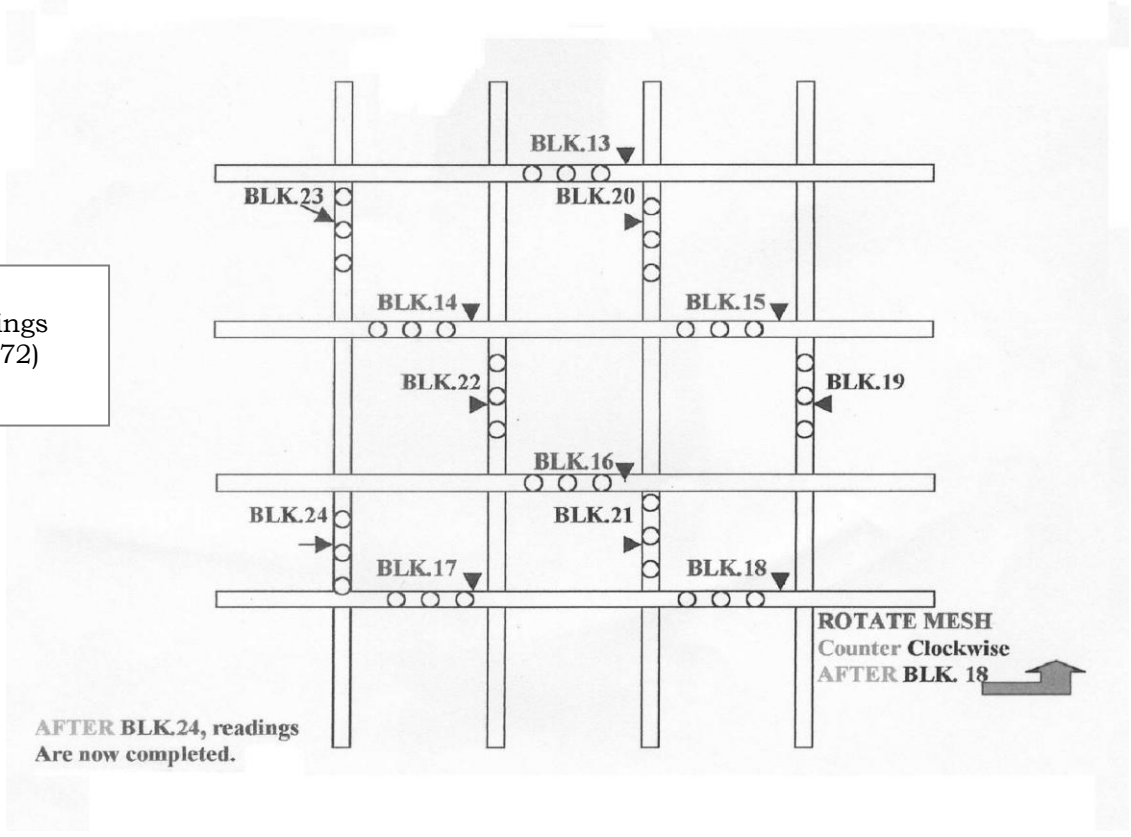


Figure 4. Test Form for Recording Epoxy Coating Thickness Results (for field use)

California Test 687 - Epoxy Coating Thickness Results

Date Tested: ____________________
Tested By: ____________________
Contract No.: ____________________
Manufacturer: ____________________
Temperature: ____________________

Sample No.: ____________________
Lot No.: ____________________
Material: ____________________

Results: ☐ Pass
☐ Fail

Color of Coating: ☐ Gray/Purple
☐ Green

Manufacturer's Mark on Bar 1: ____________

Readings B1-S1-SM-_____ (mils)		B1-S1 Measure ments	Readings B1-S2-SM-_____ (mils)		B1-S2 Mearsure ments
1			1		
2			2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
10			10		
11			11		
12			12		
13			13		
14			14		
15			15		
Average for Side:			Average for Side:		
Average for Bar =					

Manufacturer's Mark on Bar 2: ____________

Readings B2-S1-SM-_____ (mils)		B2-S1 Measure ments	Readings B2-S2-SM-_____ (mils)		B2-S2 Mearsure ments
1			1		
2			2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
10			10		
11			11		
12			12		
13			13		
14			14		
15			15		
Average for Side:			Average for Side:		
Average for Bar =					