DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
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METHOD OF TESTS FOR MEASURING EPOXY COATING THICKNESS ON STEEL REINFORCING BARS, WIRE MESH, AND DOWEL BARS USING TYPE 2 TEST INSTRUMENTS

CAUTION: Prior to handling test materials, performing equipment setups, and/or conducting this method, testers are required to read "**SAFETY AND HEALTH**" in Section I of this method. It is the responsibility of the user of this method to consult and use departmental safety and health practices and determine the applicability of regulatory limitations before any testing is performed.

A. SCOPE

This method covers the nondestructive spot measurement of thickness of non-magnetic epoxy coating over ferrous materials. These materials include steel reinforcing bars, welded wire mesh, and steel dowel bars. The procedures used for determining the green flexible (ASTM A775) and purple/gray rigid (ASTM A934) material thickness on steel are the same and are described in this test method in Part I. Parts II and III provide the testing method for the same coating materials on two other specialized construction products, wire mesh reinforcement 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 in the range of acceptable epoxy coating thickness specified in project documents.

B. DEFINITIONS

Calibration – Adjustment of the instrument 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.

Normalization – Adjustment of the coating thickness spot measurement instrument 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.

Lot – A load of materials, as defined in Section 52-1.02B of the Caltrans *Standard Specifications*, July 1999.

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

C. TESTING APPARATUS AND ACCESSORIES

1. A Type 2 coating thickness test instrument (as defined by the Society for Protective Coatings' *Paint Application Standard No. 2*, Publication 97-02 [SSPC PA2]) capable of measuring non-magnetic coating on a magnetic base material by the magnetic induction method.

2. A test probe with corresponding flexible cable to attach to the instrument housing. The probe outer diameter shall not exceed 9.5 mm and the contact ball diameter shall be no larger than 1.6 mm.

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 gauge reading. Additional shims shall be maintained to verify several points on the linear operating range of the thickness tester.

D. TEST 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 600-mm square 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.

E. TEST 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 gauge readings at regular intervals throughout the bare-blasted bar (between deformations and rib) for zero baseline on the rough surface. Use the instrument manufacturer's procedure for establishing instrument zero for these gauge readings.

2. Calibrate the instrument - 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 gauge readings throughout the length of the bar. Use the instrument 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 B. 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 ½-way 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 ½ 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 gauge readings shall be taken; three gauge readings equal one block (each side has 15 gauge readings and each side has 5 blocks). The average of three gauge readings at one block equals one spot measurement. Therefore, there are 30 gauge readings and 10 spot measurements per sample.

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

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

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

10. Gauge 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 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. (ASTM E 29, Section 3.4).

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

13. After the gauge readings are completed for the bar, ensure that the gauge reading and spot measurements are recorded on a *Test Form for Recording Epoxy Coating Thickness Results* (*"Test Form"*). An example of an appropriate *Test Form* is shown in Figure 1. Report the results on a *Sample Testing Report* ("*Test 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 gauge readings at regular intervals throughout the bare-blasted mesh for zero baseline on the rough surface. Normalize instrument as described above in E.I.1.

2. Calibrate the instrument as described above in E.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 of gauge

readings. Three gauge readings equal one block (each side has 36 gauge 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 gauge 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 gauge readings differ from each other by more than 2 mils then the spot measurement shall be discarded and repeated.

8. Gauge 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 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. (ASTM E 29, Section 3.4)

10. After the gauge readings are completed for the bar, record the gauge 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 gauge readings at regular intervals throughout the bare-blasted bar for zero baseline on the rough surface. Normalize instrument as described above in E.I.1.

2. Calibrate the instrument as described above in E.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 B. 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 gauge readings shall be made. Three gauge readings

equal one block (each side has 15 gauge readings and each side has 5 blocks). The average of three gauge readings at one block equals one spot measurement. Therefore, there are 30 gauge 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 gauge readings from the left end of the bar on S1. Place the probe on the measure mark, at a 90 degree angle (perpendicular) to the surface. Take three gauge readings consecutively. Complete each side of the bar.

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

10. Gauge 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. (ASTM E 29, Section 3.4).

12. After the gauge readings are completed for the bar, record the gauge 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 Sections E.I through E.III are applicable, the following special considerations should be noted:

1. Portable Type 2 coating thickness test instruments generally have less data recording capability than their desk-mounted counterparts. Individual gauge readings and/or spot measurements may have to be written down by hand. A modified version of the *Test Form* is provided in Figure 4 for this purpose.

2. Portable test instruments should be handled with care.

3. Pay careful attention to the sample temperature requirements in G.4.

F. REPORT

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.

G. 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 gauge readings shall be taken with the sample resting on a non-magnetic work surface, or alternatively, on a conductive surface covered with at least 12 mm 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 20°C and 30°C.

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 test instruments: the instrument 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 instrument can be normalized.

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

6. Gauge readings of coating thickness shall not be made within 25 mm 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.

H. HAZARDS

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

I. SAFETY AND HEALTH

Prior to handling, testing or disposing of any waste materials, testers are required to read: Part A (Section 5.0), Part B (Sections: 5.0, 6.0 and 10.0) and Part C (Section 1.0) of the *Caltrans Laboratory Safety Manual*. Users of this method do so at their own risk.

REFERENCES
ASTM Designations A 934, A 775, A 884, B 499, E 29, E 376; SSPC PA-2; Caltrans Standard Specifications Section 52-1.02B

End of Text
(California Test 687 contains 10 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

Sample No.: SM-041601
Lot No.: B6011
Material.: Fusion-bonded epoxy coating on A706 14 Rebar

Color of Coating: ☒ Gray/Purple
☐ Green

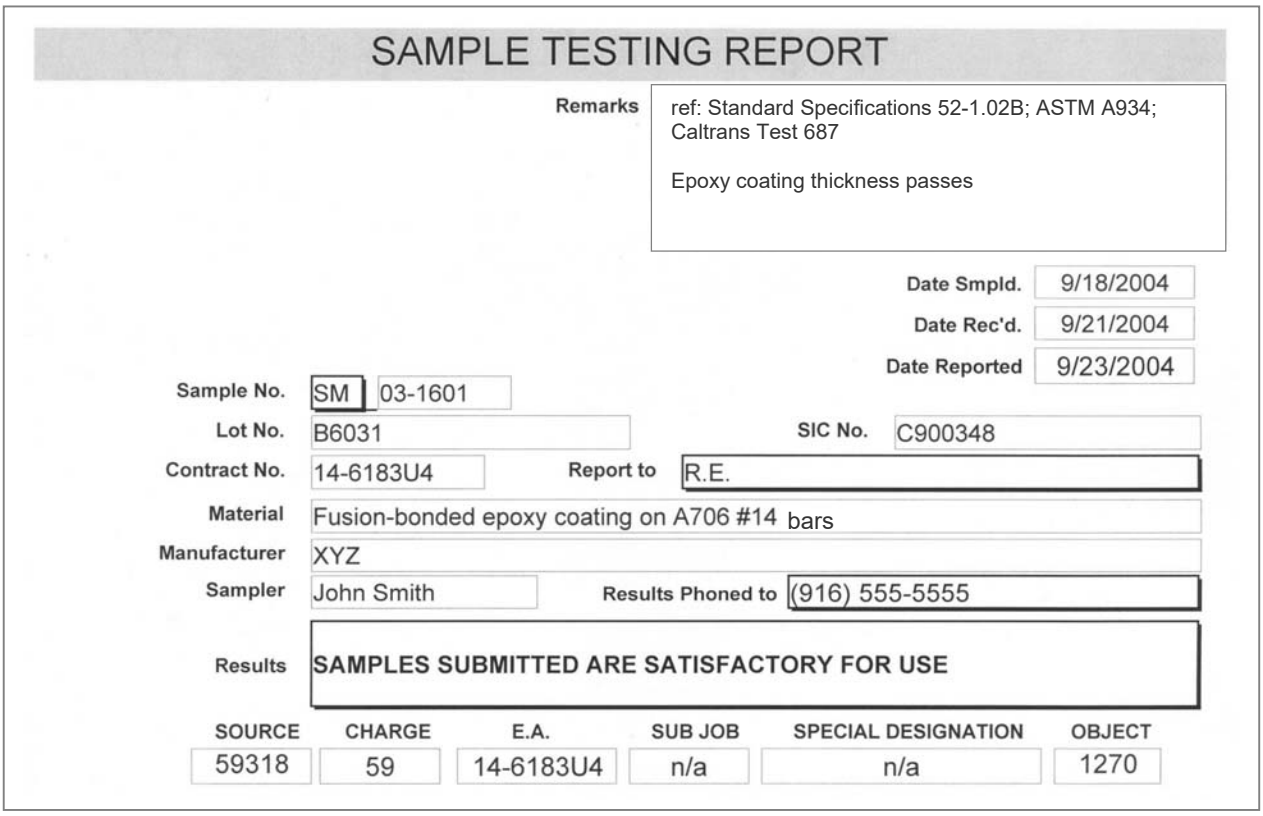
Manufacturer's Mark on Bar 1: NU36F

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 Testing Report



SAMPLE TESTING REPORT

Remarks: ref: Standard Specifications 52-1.02B; ASTM A934; Caltrans Test 687

Epoxy coating thickness passes

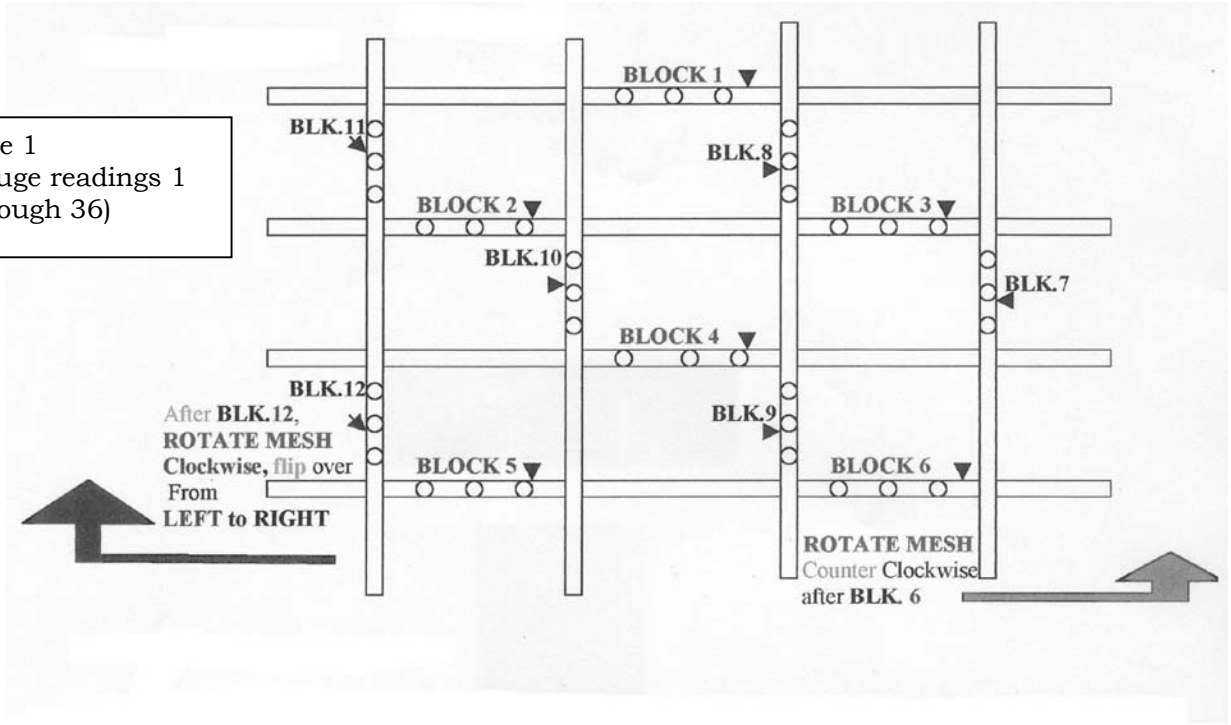
Date Smpld. 9/18/2004
Date Rec'd. 9/21/2004
Date Reported 9/23/2004

Sample No. SM 03-1601
Lot No. B6031 SIC No. C900348
Contract No. 14-6183U4 Report to R.E.
Material Fusion-bonded epoxy coating on A706 #14 bars
Manufacturer XYZ
Sampler John Smith Results Phoned to (916) 555-5555

Results: SAMPLES SUBMITTED ARE SATISFACTORY FOR USE

SOURCE	CHARGE	E.A.	SUB JOB	SPECIAL DESIGNATION	OBJECT
59318	59	14-6183U4	n/a	n/a	1270

Figure 3. Location of Gauge Readings on Wire Mesh



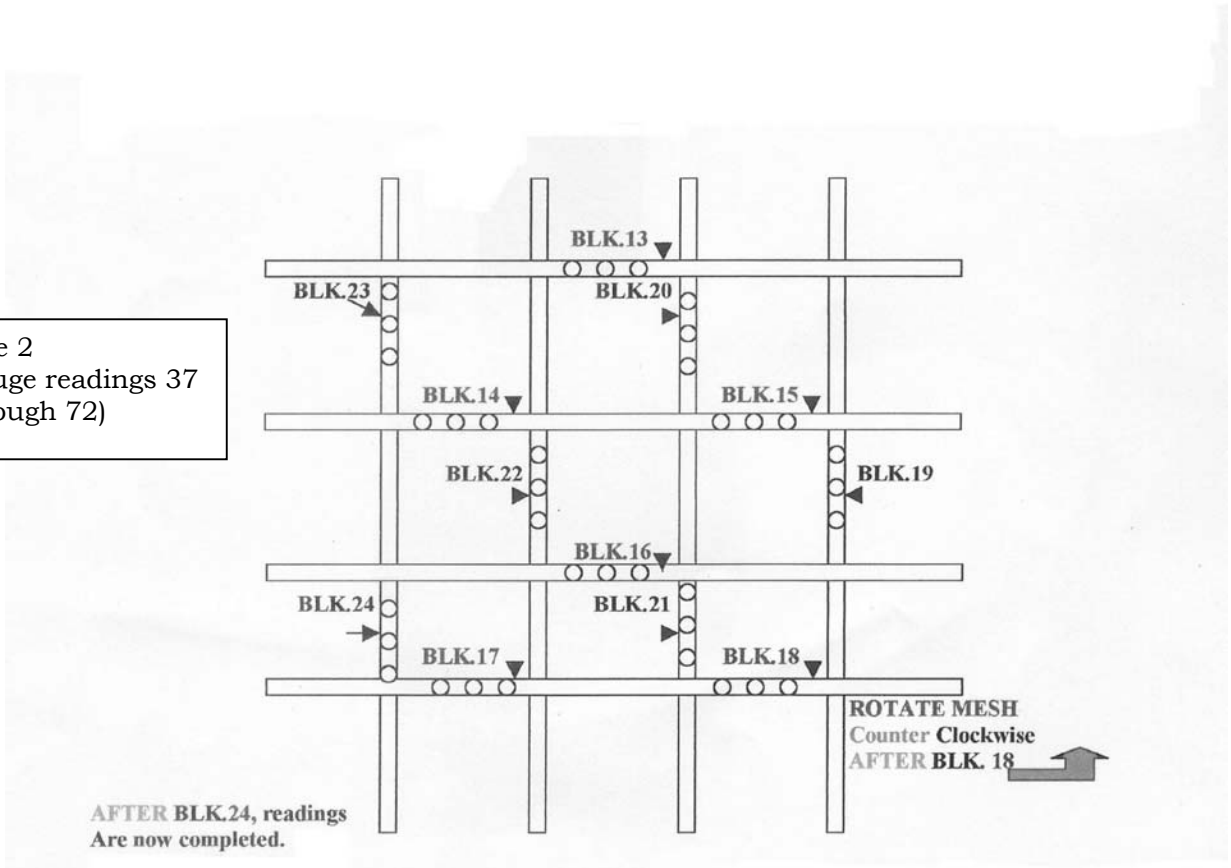


Figure 4. Test Form for Recording Epoxy Coating Thickness Results
(for field use)

California Test 687 — Epoxy Coating Thickness Results

Date Tested: ______________ Sample No.: ______________

Tested By: ______________ Lot No.: ______________

Contract No.: ______________ Material: ______________

Manufacturer: ______________

Results: ☐ Pass ☐ Fail

Color of Coating: ☐ Gray/Purple ☐ Green

Manufacturer's Mark on Bar 1: ______________

Readings B1-S1-SM-____ (mils)		B1-S1 Measurements	Readings B1-S2-SM-____ (mils)		B1-S2 Measurements
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 Measurements	Readings B2-S2-SM-____ (mils)		B2-S2 Measurements
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 =					