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SOLDERABILITY STUDIES USING THE MENISCOGRAPH.(U)
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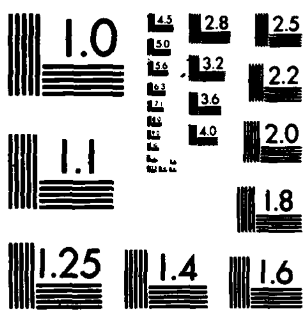

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Meniscograph solderability tests were conducted in-house on an extremely large number of specimens (7000) obtained as contract residue. Parameters evaluated were primary and secondary specimen coatings, thickness of coatings, environments that specimens had been exposed to, temperature of the solder bath, and type of flux. Results quantify the solderability of various coatings, and compare the results of the meniscograph test method with the visual test method.

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PROJECT ENGINEER'S EVALUATION

Mr. Cammarere recommended that meniscograph solderability be determined at an intermediate temperature, somewhere between 230°C and 260°C.* As the accuracy of the meniscograph solder pot temperature control is plus or minus 5°C, and upon review of Mr. Cammarere's report and data, it was decided to run further meniscograph tests at 230°C, 260°C and an intermediate temperature of 245°C.

Therefore, one lot of 30 hot dipped tin-lead coated samples, two lots of gold-plated samples (total - 90 parts) and three lots of tin-plated samples (total - 167 parts) were run at 230°C, 245°C and 260°C. All samples were steam aged for one hour (in accordance with Method 2022 of MIL-STD-883) prior to meniscograph testing. The following is a summary of the results:

1. Hot Dipped Tin-Lead Coating (SnPb):

Thirty samples total, with SnPb coatings of 400 to 700 microinches, all over nickel (Ni) plate, 100 microinches thick, over base metal Kovar. Ten samples were run at each temperature of 260°C, 245°C and 230°C. All samples passed meniscograph solderability test.

2. Ninty-nine point 9 (99.9)% Gold Plate (Au):

a. Sixty samples with 150 microinches of Au over 100 microinches of Ni, over base metal, Kovar. Twenty samples were run at each temperature. All samples passed meniscograph solderability test.

b. Thirty samples with 50 microinches of Au over 100 microinches of Ni, over base metal, Kovar. Ten samples were run at each temperature. All samples passed meniscograph solderability test.

*Eutectic alloy is Sn 63% - Pb 37%, melting point 183°C. Standard soldering alloy used is Sn 60% - Pb 40%, melting point 191°C.

3. Tin Plate (Sn):

a. Sixty samples with 300 microinches of Sn over 100 microinches of Ni, over base metal, Kovar. Twenty samples were run at each temperature. All samples passed meniscograph solderability test.

b. Sixty samples with 100 microinches of Sn over 100 microinches of Ni, over base metal, Kovar. Twenty samples were run at each temperature:

260°C - 12 passed, 8 failed

245°C - 1 passed, 19 failed

230°C - 0 passed, 20 failed

c. Forty-seven samples with 200 microinches of Sn over base metal, Kovar (no undercoat). Fifteen samples at 260°C, 16 each at 245°C and 230°C:

260°C - 15 passed, 0 failed

245°C - 6 passed, 10 failed

230°C - 2 passed, 14 failed

These results confirm Mr. Cammarere's findings and recommendations concerning the temperature of testing. The hot dipped tin-lead coated and the gold plated specimens, all of which met, or were in excess of, the lead finish requirements of MIL-M-38510E, Microcircuits, General Requirements for, passed the meniscograph solderability test at all temperatures. It is obvious that a solderable part will test good at any temperature that is 230°C or above. The tin coating on lot 3a of the tin plated parts was also well in excess of 38510 lead finish requirements, and was also quite solderable at all temperatures. Again, a solderable part will test good at any temperature. The coating on lot 3b tin coated parts did not meet the 38510 thickness requirements, but had an undercoat of nickel. Visually, after steam aging, the parts appeared oxidized prior to the solderability testing. The results at 230°C indicate that these were nonsolderable parts. However, at 260°C, 66% of these nonsolderable parts passed the test. At 245°C only one part out of 20 (5%) passed solderability.

The results of this lot indicate that 260°C is too high a temperature to test nonsolderable parts. Specimens tested at that temperature passed when really they were not solderable. The coating on the final lot of tin specimens, lot 3c just met 38510E lead finish requirements (i.e., minimum 200 microinches thick, no undercoat). Again, visual inspection, after steam aging, showed some oxidation prior to solderability testing. At 260°C, all specimens passed, at 230°C, 12% passed, and at 245°C, 37% passed. These results indicate that these parts are marginal solderability wise, that at 260°C, nonsolderable parts are being passed, at 230°C, possibly the tin coating is not being fused, and that testing at 245°C is an acceptable compromise.

Industry's and our previous experience with the visual test methods of MIL-STD-883 and 202 have lead us to believe that 260°C is higher than necessary, because parts were passing the solderability test, but being rejected at assembly. Also, tin plated parts that tested good at 230°C, were actually non-solderable, and the tin was not fusing during solderability testing. On assembly, the parts failed because of non-solderable surfaces under the tin.

All of these factors have lead us to concur with Mr Cammarere's recommendation to run solderability at an intermediate temperature, and have chosen 245°C as a viable compromise. We have already recommended that Method 2003.2 of MIL-STD-883B and Method 208C of MIL-STD-202E be changed to 245°C. In the case of Method 2022 of MIL-STD-883B, we will propose that 245°C also be used.

Finally, Mr. Cammarere recommended that the pass/fail criteria of Method 2022 (see Para 3.5 of Appendix I) should be changed because of the difficulty in determining the circumference of the part being tested, and other problems associated with quantitatively determining the absolute wetting force.

Thwaites, et al[7], has demonstrated that the time it takes the meniscograph trace to reach two-thirds its maximum value is actually more indicative of good solderability, rather than an absolute force measurement. This has been confirmed by R. H. Oehme, G.E. Company, Utica NY. Cassidy and Lin[8] have also reported that specimens indicating faster meniscograph wetting times were more solderable specimens. Mr. Cammarere's experimental work supports this conclusion. Therefore, we will propose that Para 3.5b of Method 2022 be changed to read:

"That the recorded signal trace reaches two-thirds of its maximum value in 1 second or less of test time."

INTRODUCTION

In modern times, when microcircuits are discussed, most individuals begin to think in terms of very sophisticated, sensitive, and condensed electronic components performing arrays of memory and processing functions. However, although this is all true, if the link between the sophisticated electronics of the microcircuit and the outer world is broken, the reliability of the package and its electronic chip is all but worthless. Since a vast amount of the chips in use are soldered into their circuit positions, and soldering techniques have become quicker and more automated, the importance of the solder connections, or joints, is of prime importance.

Most exterior package leads are made of an iron-nickel-cobalt alloy that has a thermal expansion factor approximately equal to the ceramic of the package. This reduces failures due to thermal stresses under burn-in conditions. The surface of the material, however, is very rough, and solder will not adhere readily to it. It is common to plate a metal such as nickel over the base to smooth it, and then to apply a smooth surface plating of gold or tin over that, since solder adheres most readily to these. The object is to find the best combination of material, thickness, and surface treatment to allow the greatest solderability. Solderability tests, therefore, are of the utmost importance.

Until very recently, the military solderability tests were all visual. Soldered specimens were viewed under a microscope, and depending on the "look" of the finish and the percentage of the metal surface to which the solder did not adhere, a judgment was made as to whether or not the specimen passed or failed. The following visual tests are in use at the present time:

1. MIL-STD-202E, Method 208C
2. MIL-STD-883B, Method 2003.2
3. MIL-STD-750B, Method 2026.3.

These three tests differ slightly in their respective inspection criteria, but they are similar in that they are subjective tests, all depend somewhat upon the inspector, and they all measure the amount of dewetting the sample undergoes.

The meniscograph was developed duringthe past ten years by General Electric Corporation of England, [1] [2] [3] [4] and gives a quantitative analysis of the wetting that a sample undergoes. In recent years, it was written in as Method 2022 of MIL-STD-883B,[5] [6] and will be studied henceforth. Figure 1 is an illustration of the meniscograph.

PURPOSE

The purpose of this project was to ascertain whether or not the results of meniscograph solderability tests are compatible with results obtained from visual examination. Also, it was to determine if MIL-STD-883B, Method 2022 is accurate and sufficient as is, or if it should be revised. A copy of Method 2022 is included as Appendix I.

THEORY

The meniscograph solderability test works on the principle of wetting. The results depend upon how quickly wetting takes place, and the extent to which it occurs. (It is therefore indirectly related to the wetting Angle θ). Diagram I shows molten solder wetting a metallic surface, and some of the forces involved. Assume that the metal sample in the diagram is actually being run on the meniscograph. If such was the case, the sample would be suspended from a load cell inside the machine. The load cell merely changes force variations to electrical impulse variations according to some linear relationship. Before commencing with the test, the experimenter would have calibrated and adjusted the instrument so that the weight of the sample is equivalent to a zero reading on the instrument's force meter. Hence, the weight of the sample is neglected during the test, and only external forces on the sample are measured. Flux* was applied to all of the samples to clean the

*Type R Flux of QQ-S-571

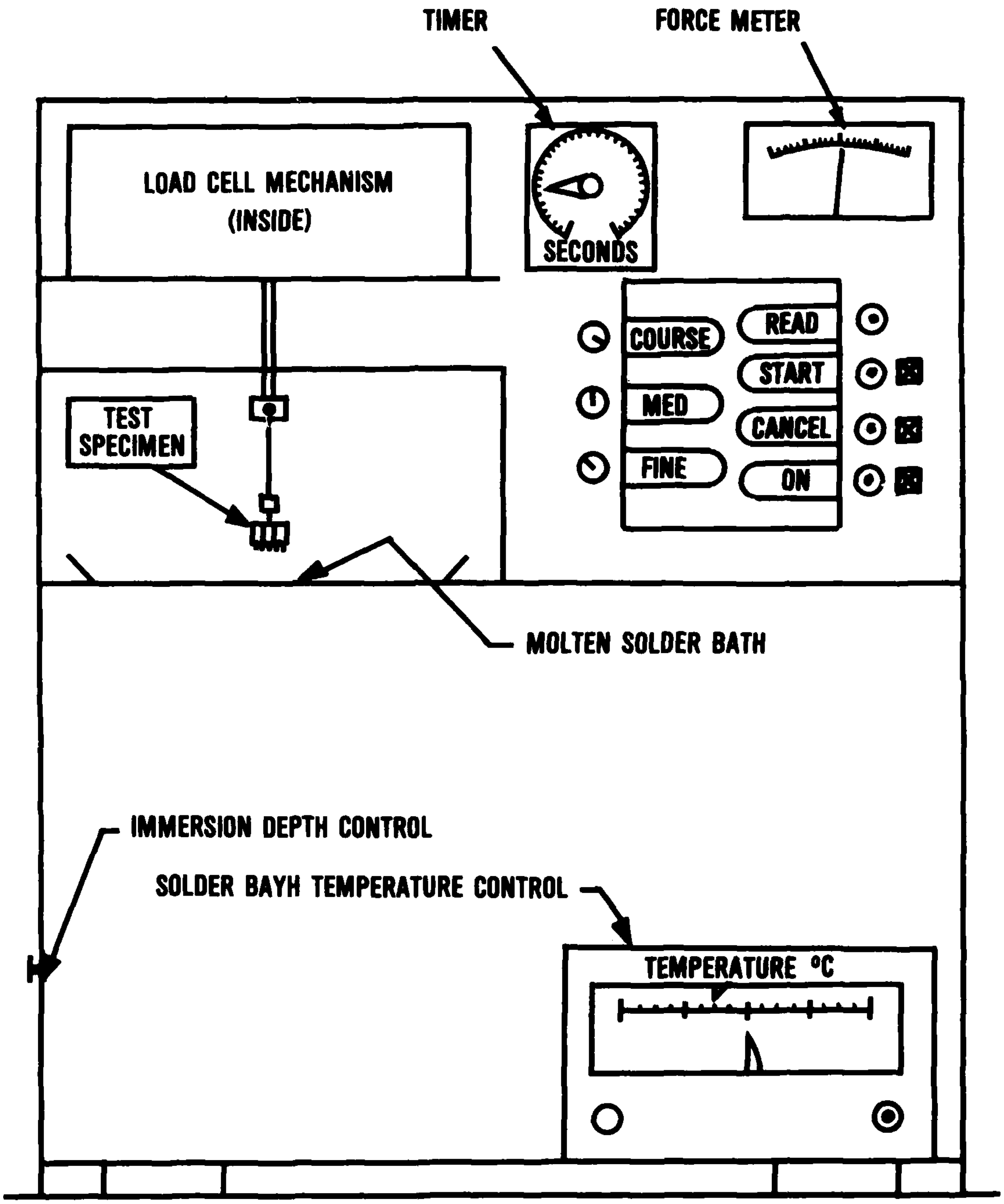


FIGURE 1 MENISCOGRAPH SOLDERABILITY TESTER

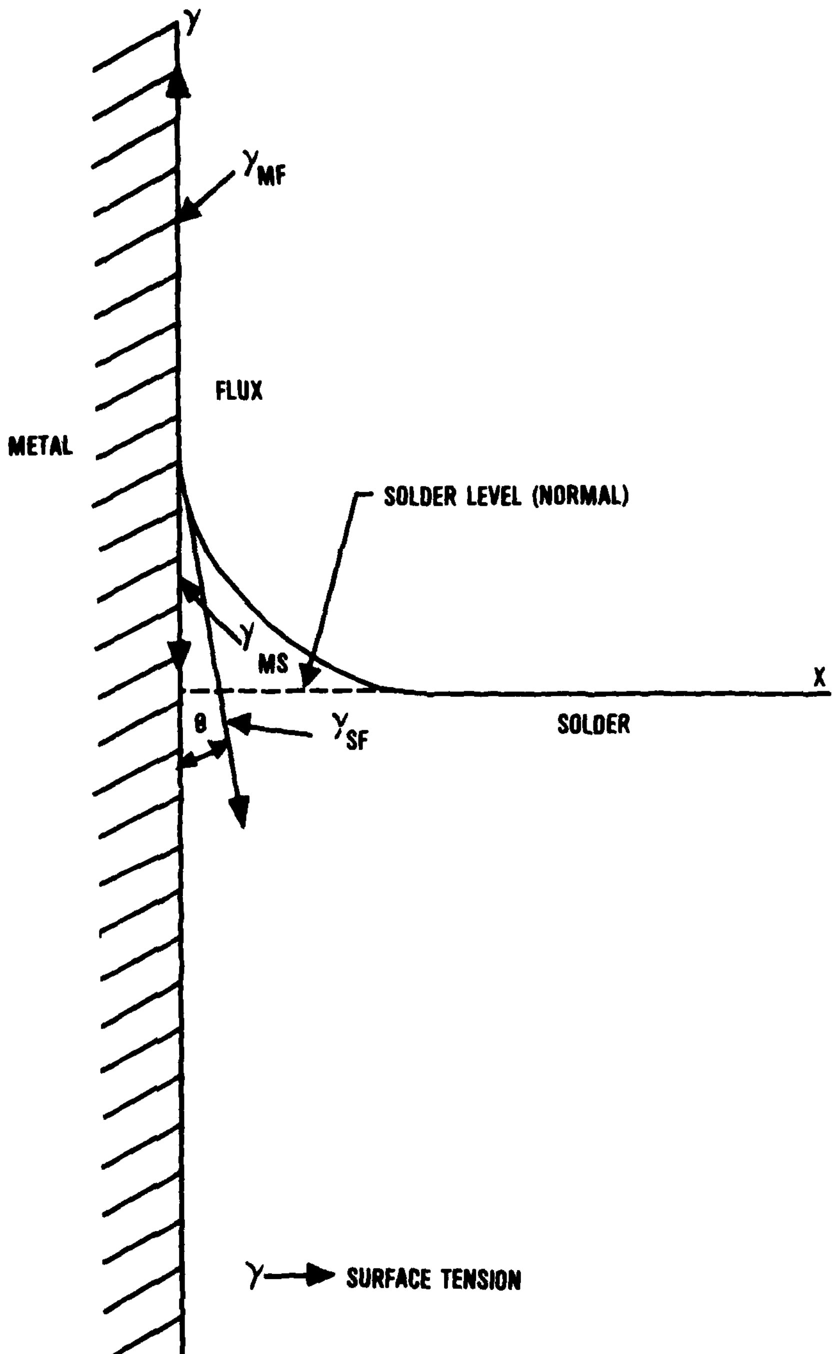


DIAGRAM 1 FORCE DIAGRAM OF SOLDER WETTING METAL

surface so that the solder would more readily adhere to it. The object is to get a large Y_{MF} value. It is the Y_{MF} value that pulls the solder up the sides of the specimen. Once the solder rises over the normal solder level, its' weight exerts a downward force on the sample which the meniscograph's force meter picks up via the load cell. As θ approaches zero, Y_{MF} increases, and so a small wetting angle is desired to produce a greater surface tension. This can be shown by the following equation:

$$Y_{MF} = Y_{MS} + Y_{SF} \cos \theta.$$

This was obtained by resolving the forces in the Y direction. From this equation, it can be seen that as θ approaches zero, cos θ approaches one, and Y_{MF} approaches a maximum value of $Y_{MS} + Y_{SF}$. If the sample is non-wetting, the opposite takes place. The solder is pulled down lower than the normal level (Diagram II), and therefore the weight of the displaced solder gives rise to a buoyant upward force on the metal that the load cell equates to a "negative force" on the force meter.

PROCEDURE

The procedure followed was Method 2022 of MIL-STD-883B, with the only change being that all samples were run at both 230°C and 260°C. The procedure listed below is the procedure that was used when running each individual sample.

1. The sample was placed in the most suitable holder for that type of sample.

2. A light coating of flux was applied. (See Footnote, Page 8).

3. The sample was suspended from the meniscograph's load cell mechanism.

4. Coarse adjustments to the force meter were made.

5. The instrument was placed in the "READ" mode, and final adjustments made.

6. The specimen was dipped in the molten solder bath.

7. The specimen was cleaned in methanol and saved for future reference, if necessary.

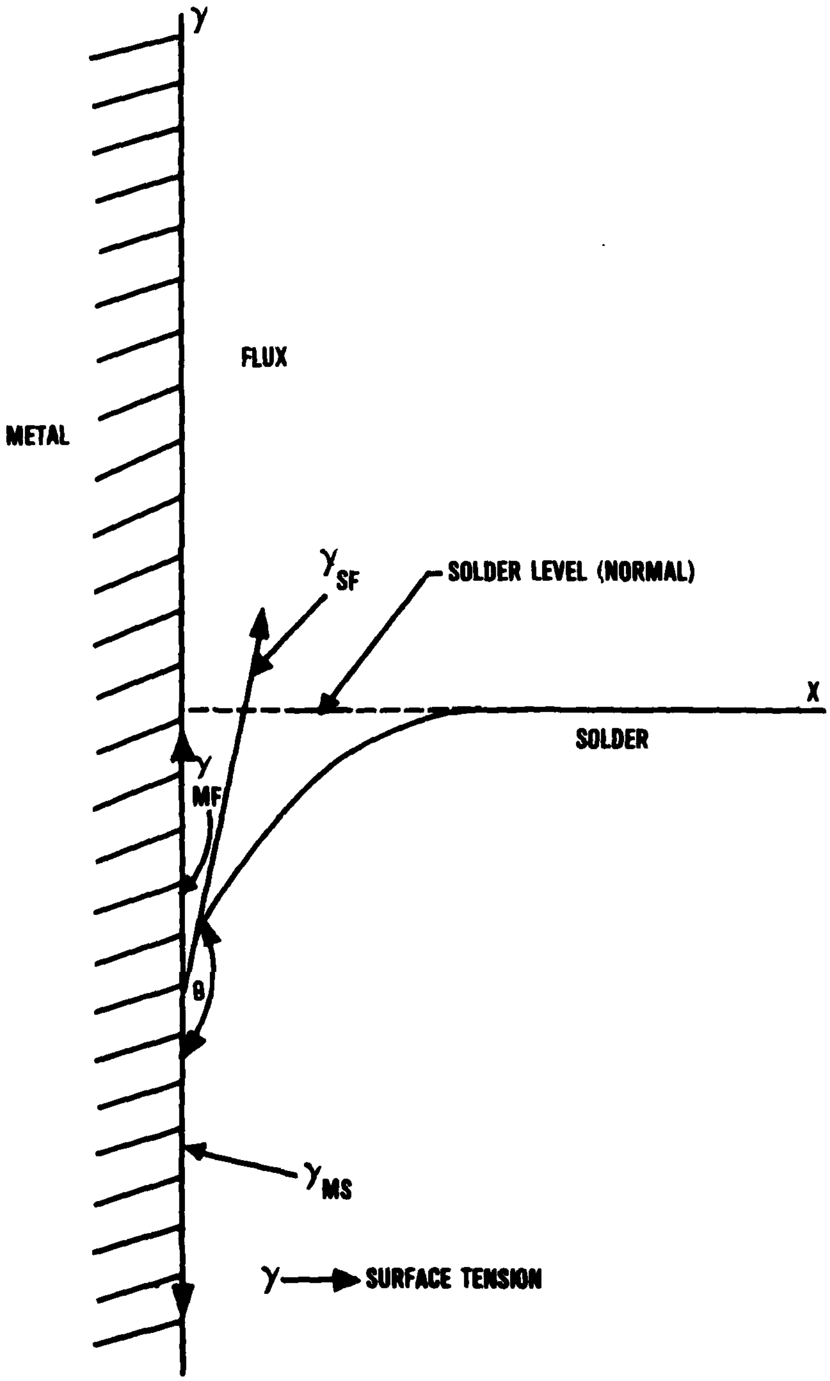


DIAGRAM 2 FORCE DIAGRAM AT SOLDER~METAL SURFACE FOR NONWETTING PART

DISCUSSION

Before the actual experiments were started, it was necessary to determine the relationship between the force exerted on the meniscograph load cell, and the corresponding displacement on the particular X-Y recorder used. This was done by finding the displacements associated with forces of known magnitude. From this, a graph of displacement vs. force was produced, see Diagram III, and from the slope of the determined line, a template was produced, so that a sample of virtually any circumference (or outside perimeter) could be evaluated quickly (see Diagram IV for a copy of the template).

After this was accomplished, the actual tests were run. During the course of these tests, some interesting observations were made. These are noted here, so that in future studies, problems caused by them may be addressed and solved. It was discovered that on like specimens, a heavier coating of flux (see Footnote, Page 8) caused a decrease in the maximum force reached by the specimen. From that point forward, more care was taken to insure a light coating. Also, it was discovered that in two similar samples of unequal circumference, the smaller circumference part seems to have more chance of passing. No actual figures are available due to lack of time; however, that is what preliminary indications would seem to suggest. If this is indeed the case, further investigation should be made to insure a higher degree of accuracy on later tests.

The samples used in these tests were obtained as contract residue from AFML Contract Number F33615-78-C-5084, Manufacturing Technology for Nickel-Boron Plating. RADC is indebted to Mr. Donald Knapke, MLTE/AFML for arranging for the use of these samples. Visual evaluations were made by the contractor personnel and have been reprinted to compare the results of the visual test method at 260°C with meniscograph results at 230°C and 260°C.

Reprinting all of the meniscograph traces is not feasible. Sketches of the

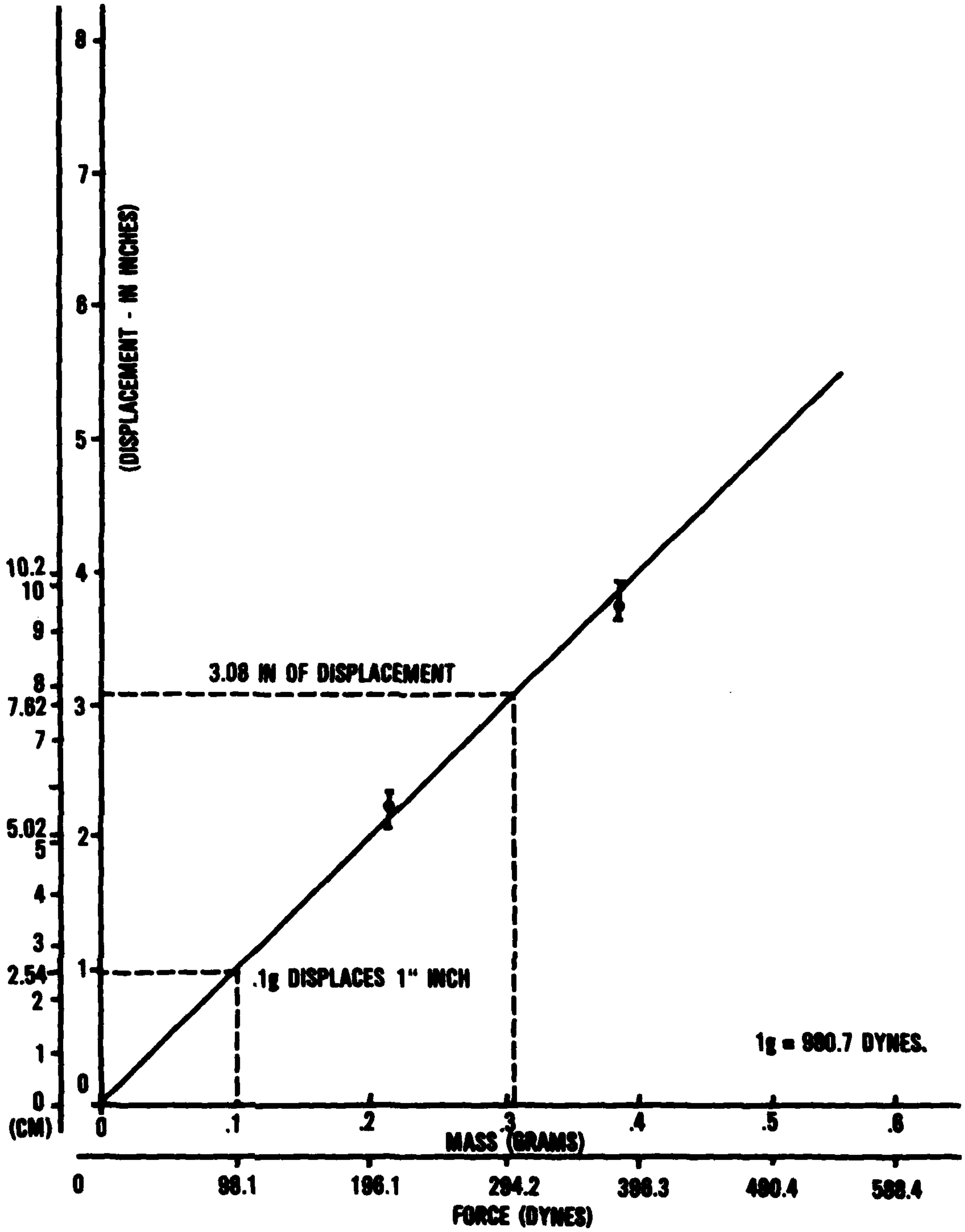

(DISPLACEMENT - IN INCHES)
(CIRCUMFERENCE - CM)
3.08 IN OF DISPLACEMENT
.1g DISPLACES 1" INCH
1g = 980.7 DYNES.
MASS (GRAMS)
FORCE (DYNES)
(CM)
0
.1
.2
.3
.4
.5
.6
98.1
196.1
294.2
398.3
490.4
588.4
10.2
7.62
5.02
2.54

DIAGRAM 3

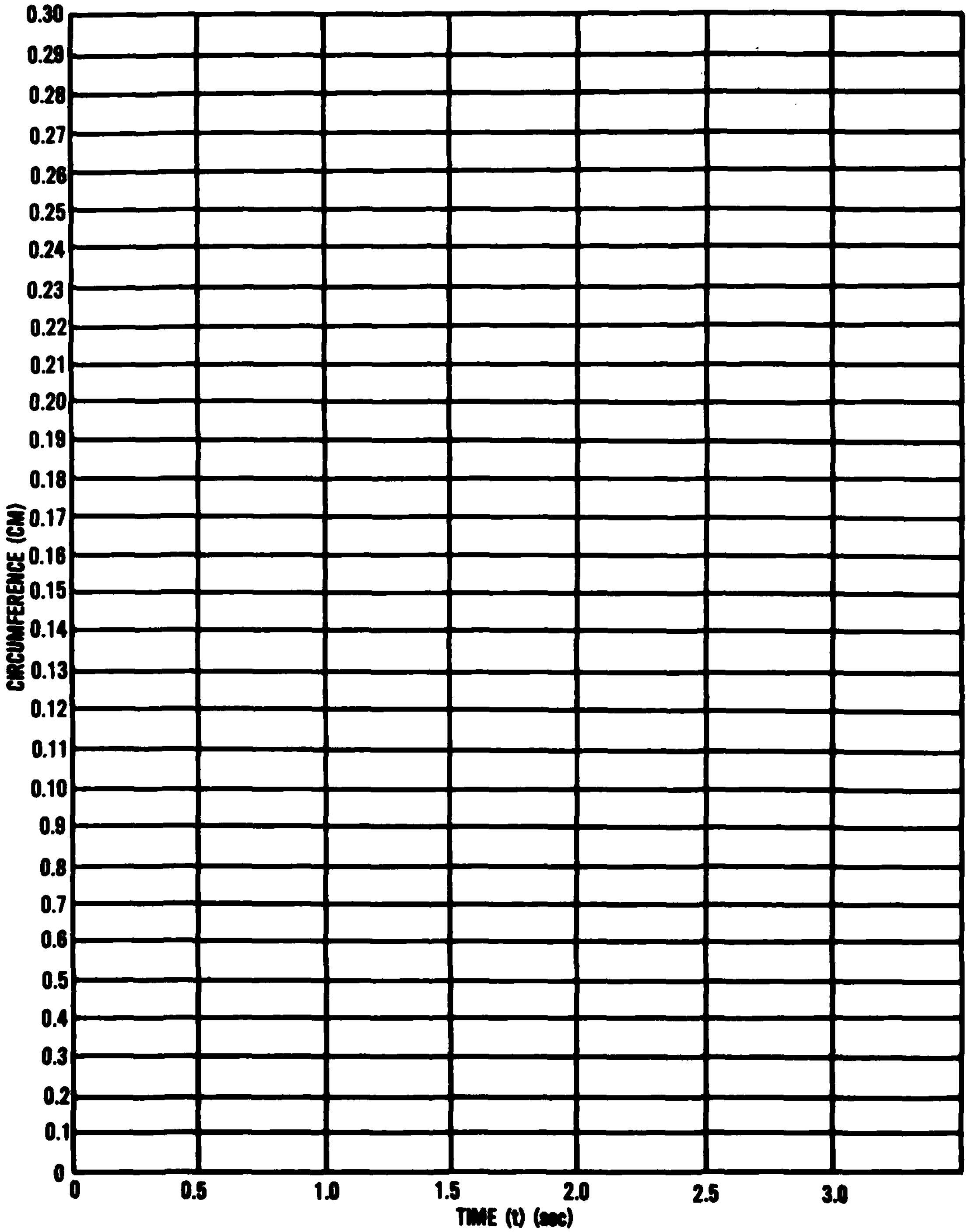

0.30
0.29
0.28
0.27
0.26
0.25
0.24
0.23
0.22
0.21
0.20
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.10
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
CIRCUMFERENCE (CM)
0
0.5
1.0
1.5
2.0
2.5
3.0
TIME (t) (sec)

DIAGRAM 4

various types of meniscograph traces are included as Figures 2, 3, and 4. One hundred percent represents a wetting force of 300 dynes/cm. Inclusion of the complete tabulation of all the data is also not feasible as it fills some 250 pages. Only a portion of the data is included.

Table 1 reports the percentage of samples passing and failing 80% of the acceptance criteria of Method 2022 at both 230°C and 260°C, and compares these results with the visual results at 260°C only (data on visual results from the AFML report).

Sample types Au 40 through Au 71 were various thicknesses of 99.7 % electroplated gold over various thicknesses of electroless or electrolytic nickel undercoatings. Sample types Au 40A through Au 71A were various thicknesses of 99.9% electroplated gold over various thicknesses of both types of nickel undercoatings.

Tin sample types were various thicknesses of bright acid tin electroplate over various thicknesses of both types of nickel or electroless copper. The tin-lead sample types were hot dipped, all over various thicknesses of both types of nickel undercoatings.

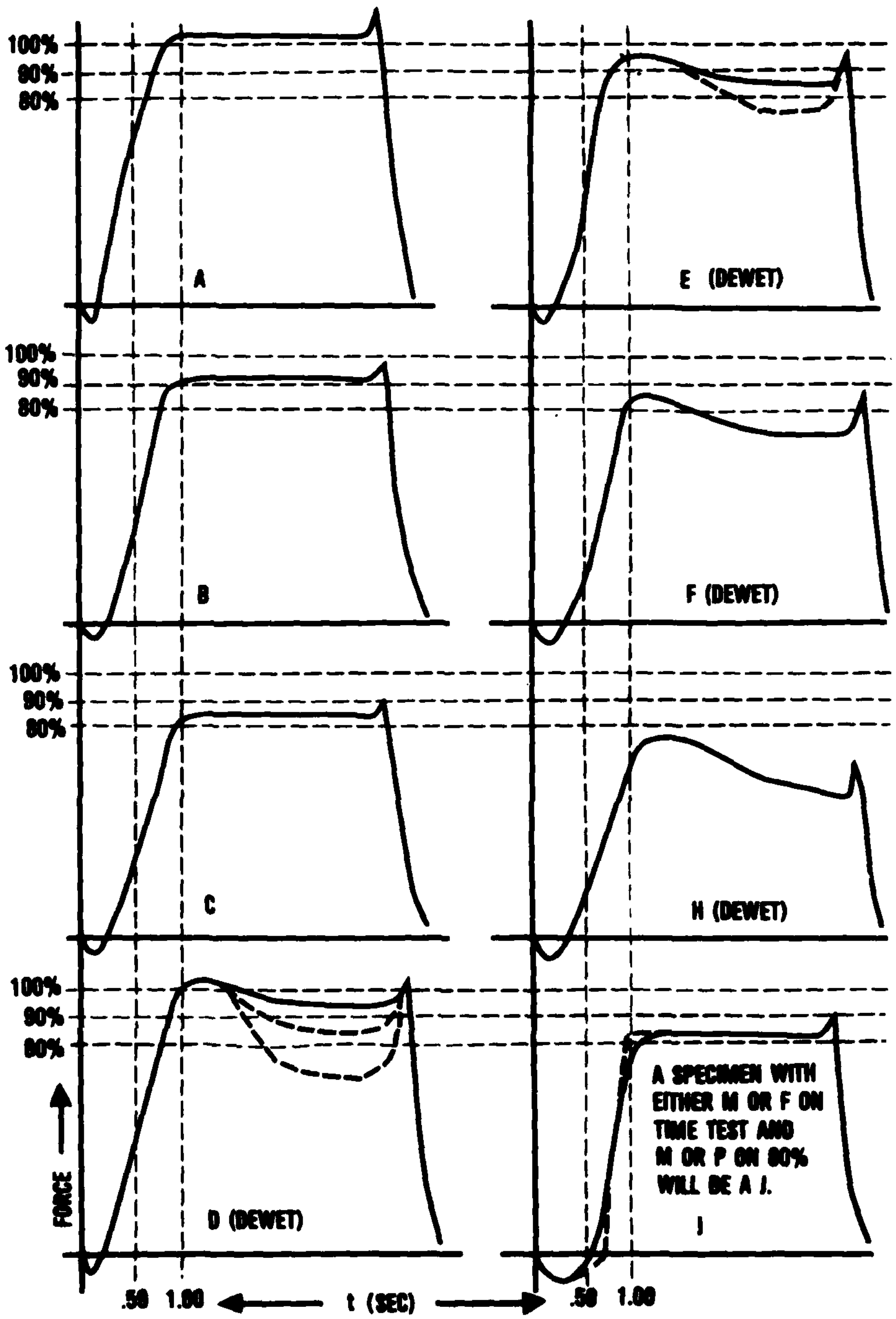
Data on these coatings is contained in Appendix 2, which is a reprinting of Table 22, MIL-M-38510 Component Finishing from the AFML report.

CONCLUSIONS AND RECOMMENDATIONS

Before any attempt is made to come to any conclusions, a few observations and explanations are necessary.

Since the time factor on this project was limited, and the person performing it had but limited experience in this field, this report is more a collection of reduced data (as in depth as was possible), so that individuals with more experience could reach specific conclusions.

On the whole, the evidence received from the 260°C meniscograph tests agreed



TYPE I

FIGURE 2 MENISCOGRAPH SOLDERABILITY TRACES

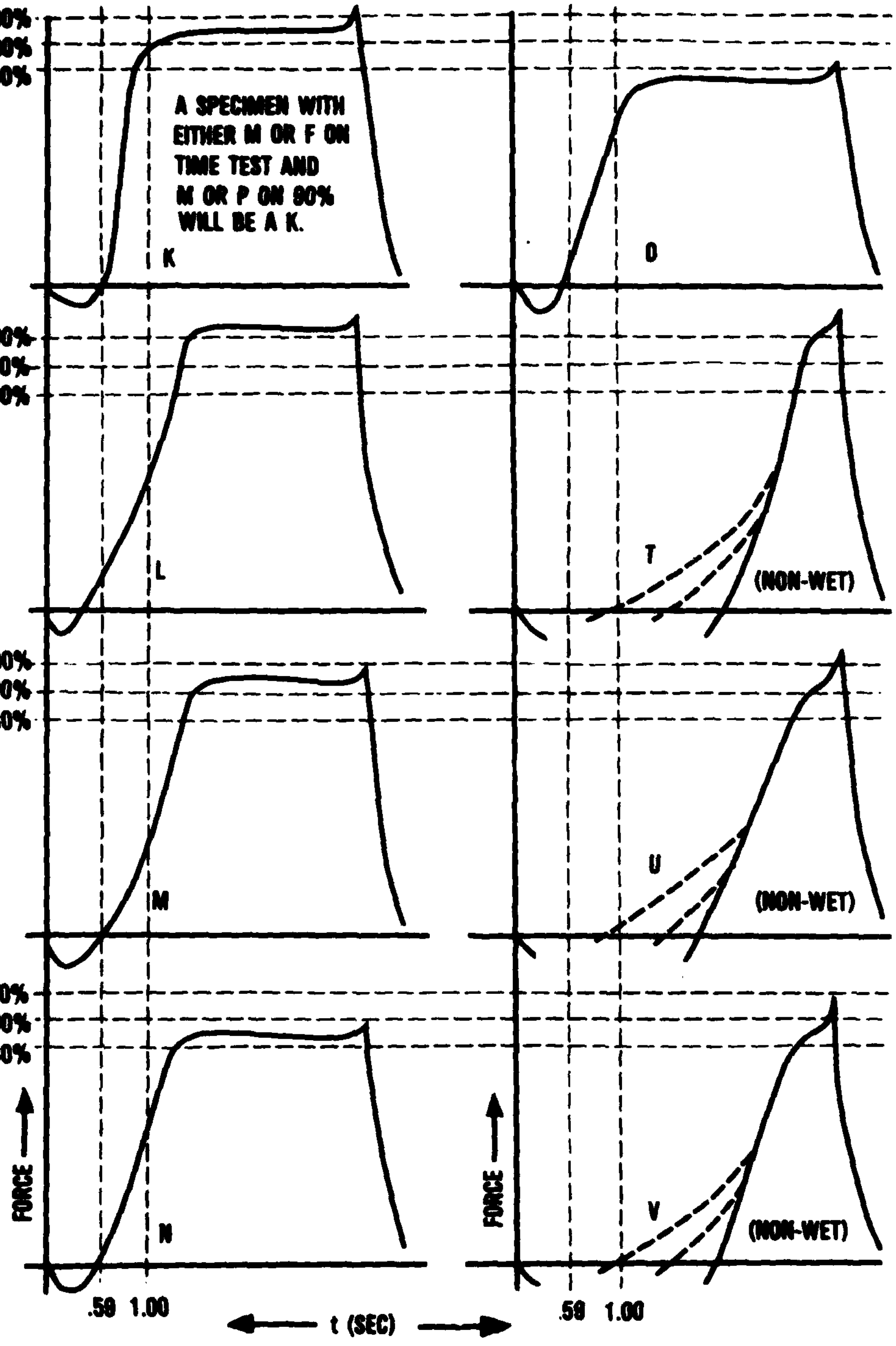


FIGURE 3 MENISCOGRAPH SOLDERABILITY TRACES

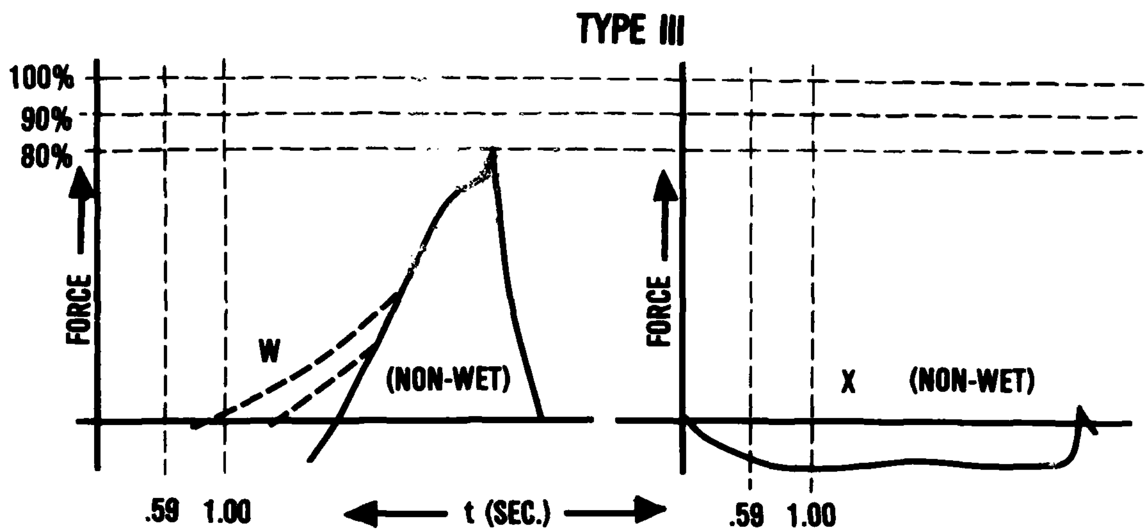


FIGURE 4 MENISCOGRAPH SOLDERABILITY TRACES

TABLE I
FINAL COMPARISON TABLE
F ≥ 240 DYNES, AFTER BURN-IN & STEAM AGING SAMPLES

80%
AFTER BURN-IN & AGING

	230°C			260°C			
	%P	%F	%M	%P	%F	%M	VISUAL
Au 40	33.3%	50.0%	16.7%	83.3%	16.7%	0.0%	Poor, Dewet, Pinholes
Au 41	83.3%	0.0%	16.7%	100.0%	0.0%	0.0%	Poor, Dewet, Pinholes
Au 42	33.3%	66.7%	0.0%	83.3%	16.7%	0.0%	Poor, Dewet, Pinholes
Au 43	83.3%	0.0%	16.7%	40.0%	60.0%	0.0%	Poor, Dewet, Pinholes
Au 44	66.7%	33.3%	0.0%	66.7%	33.3%	0.0%	Poor, Dewet, Pinholes, Non-Wet
Au 45	83.3%	16.7%	0.0%	83.3%	16.7%	0.0%	Poor, Dewet, Pinholes, Non-Wet
Au 46	85.7%	0.0%	14.3%	20.0%	80.0%	0.0%	Poor, Dewet, Pinholes
Au 47	100.0%	0.0%	0.0%	50.0%	50.0%	0.0%	5 Good, 10 Dewet, Non-Wet
Au 48	100.0%	0.0%	0.0%	66.7%	33.3%	0.0%	Poor, Dewet, Pinholes
Au 49	14.3%	71.4%	14.3%	50.0%	33.3%	16.7%	Poor, Dewet, Pinholes, Non-Wet
Au 50	0.0%	100.0%	0.0%	40.0%	60.0%	0.0%	Poor, Dewet, Pinholes, Non-Wet
Au 51	0.0%	100.0%	0.0%	40.0%	60.0%	0.0%	Poor, Dewet, Pinholes, Non-Wet
Au 52	80.0%	0.0%	20.0%	50.0%	50.0%	0.0%	Poor, Dewet, Pinholes, Non-Wet
Au 53	16.7%	50.0%	33.3%	0.0%	83.3%	16.7%	Poor, Dewet, Pinholes, Non-Wet

TABLE 1 (CONTINUED)

80%
AFTER BURN-IN & AGING

	230°C			260°C			
	%P	%F	%M	%P	%F	%M	VISUAL
Au 54	0.0%	83.3%	16.7%	60.0%	40.0%	0.0%	Poor, Dewet, Pinholes, Non-Wet
Au 55	100.0%	0.0%	0.0%	66.7%	33.3%	0.0%	Poor, Dewet, Rough, Pinholes
Au 56	16.7%	83.3%	0.0%	0.0%	100.0%	0.0%	Poor, Dewet, Rough, Pinholes, Non-Wet
Au 57	83.3%	16.7%	0.0%	50.0%	50.0%	0.0%	Poor, Dewet, Rough, Non-Wet
Au 69	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	Poor, Dewet, Non-Wet
Au 70	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	Poor, Non-Wet
Au 71	50.0%	25.0%	25.0%	50.0%	50.0%	0.0%	Poor, Dewet, Rough
Au 40A	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	4 Good, 11 Dewet
Au 41A	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	7 Good, 8 Dewet
Au 42A	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	3 Good, 12 Dewet
Au 43A	100.0%	0.0%	0.0%	------	------	------	13 Good, 2 Dewet
Au 44A	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	2 Good, 13 Dewet
Au 45A	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	4 Good, 11 Dewet
Au 46A	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	2 Good, 13 Dewet
Au 47A	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	9 Good, 6 Dewet
Au 48A	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	Poor
Au 49A	50.0%	50.0%	0.0%	100.0%	0.0%	0.0%	14 Good, 1 Dewet
Au 50A	60.0%	40.0%	0.0%	100.0%	0.0%	0.0%	14 Good, 1 Dewet
Au 51A	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	15 Good

TABLE 1 (CONTINUED)

80%
AFTER BURN-IN & AGING

	230°C			260°C			
	%P	%F	%M	%P	%F	%M	VISUAL
Au 52A	66.7%	33.3%	0.0%	50.0%	25.0%	25.0%	9 Good, 6 Dewet
Au 53A	100.0%	0.0%	0.0%	75.0%	25.0%	0.0%	Poor
Au 54A	75.0%	25.0%	0.0%	66.7%	33.3%	0.0%	Poor
Au 55A	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	9 Good, 6 Dewet
Au 56A	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	Poor
Au 57A	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	4 Good, 11 Dewet
Au 72A	50.0%	50.0%	0.0%	0.0%	0.0%	100.0%	4 Good, 1 Dewet
Au 73A	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	1 Good, 4 Dewet
Au 74A	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	4 Good, 1 Dewet
Au 75A	------	------	------	100.0%	0.0%	0.0%	2 Good, 3 Dewet
Au 69A	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	12 Good, 3 Dewet
Au 70A	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	15 Good
Au 71A	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	12 Good, 3 Dewet
Sn 1	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	3 Good, 12 Poor, Rough, Pinholes
Sn 2	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	11 Good, 2 Pinholes, 2 Dewet
Sn 3	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	9 Good, 3 Pinholes, 3 Dewet
Sn 4	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	Good
Sn 5	0.0%	100.0%	0.0%	33.3%	66.7%	0.0%	Good
Sn 6	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	Good
Sn 7	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good

TABLE 1 (CONTINUED)

80%
AFTER BURN-IN & AGING

	230°C			260°C			
	%P	%F	%M	%P	%F	%M	VISUAL
Sn 8	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 9	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 10	0 0%	100.0%	0.0%	33.3%	33.3%	33.3%	Good
Sn 11	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 12	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 13	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	Good
Sn 14	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	7 Good, 5 Dewet, 3 Pinholes
Sn 15	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	8 Good, 7 Dewet, Pinholes
Sn 16	0.0%	100.0%	0.0%	33.3%	66.7%	0.0%	11 Good, 4 Dewet
Sn 17	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	13 Good, 2 Dewet, Pinholes
Sn 18	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 19	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	4 Good, 11 Dewet
Sn 20	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 21	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 22	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	11 Good, 4 Dewet
Sn 23	0.0%	100.0%	0.0%	33.3%	66.7%	0.0%	3 Good, 12 Dewet
Sn 24	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	4 Good, 11 Dewet
Sn 25	0.0%	100.0%	0.0%	66.7%	33.3%	0.0%	Good, Pinholes
Sn 26	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 27	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 28	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good

TABLE 1 (CONTINUED)

80%
AFTER BURN-IN & AGING

	230°C			260°C			
	%P	%F	%M	%P	%F	%M	VISUAL
Sn 29	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good, Pinholes
Sn 30	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good, Pinholes
Sn 31	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 32	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 33	0.0%	100.0%	0.0%	16.7%	66.7%	16.7%	Good
Sn 34	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 35	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	13 Good, 2 Pinholes
Sn 36	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 37	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	13 Good, 2 Pinholes
Sn 38	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 39	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good, Some Rough
Sn 76	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 77	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 78	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 79	50.0%	50.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 80	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 2A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	14 Good, 1 Poor, Pinholes
Sn 3A	0.0%	50.0%	50.0%	100.0%	0.0%	0.0%	9 Good, 6 Poor, Rough, Pinholes
Sn 4A	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	Good, Some Pinholes
Sn 6A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	12 Good, 3 Poor, Dewet

TABLE 1 (CONTINUED)

80%
AFTER BURN-IN & AGING

	230°C			260°C			
	%P	%F	%M	%P	%F	%M	VISUAL
Sn 7A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good, Some Pinholes
Sn 9A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good, Some Pinholes
Sn 10A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	13 Good, 2 Poor, Pinholes
Sn 11A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 12A	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	Good
Sn 14A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	12 Good, 3 Pinholes
Sn 15A	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	3 Good, 12 Dewet, Non-Wet, Pinholes
Sn 16A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	13 Good, 2 Dewet, Pinholes
Sn 17A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	11 Good, 2 Dewet, 2 Pinholes
Sn 19A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	2 Good, 13 Dewet, Pinholes
Sn 20A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	12 Good, 3 Dewet, Pinholes
Sn 21A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good
Sn 22A	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	1 Good, 14 Poor, Dewet
Sn 23A	0.0%	100.0%	0.0%	50.0%	50.0%	0.0%	2 Good, 13 Poor, Dewet
Sn 24A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	3 Good, 12 Poor, Dewet

TABLE 1 (CONTINUED)

80%
AFTER BURN-IN & AGING

	230°C			260°C			
	%P	%F	%M	%P	%F	%M	VISUAL
Sn 25A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	11 Good, 4 Poor, Dewet
Sn 27A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	13 Good, 2 Poor, Pinholes
Sn 28A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good, Some Pinholes
Sn 30A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	Good, Some Pinholes
Sn 31A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	14 Good, 1 Poor, Dewet
Sn 33A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	9 Good, 6 Poor, Dewet
Sn 34A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	13 Good, 2 Poor, Dewet
Sn 37A	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	13 Good, 2 Poor, Pinholes
SnPb 58	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	12 Good, 3 Dewet
SnPb 59	50.0%	50.0%	0.0%	100.0%	0.0%	0.0%	13 Good, 2 Dewet
SnPb 61	------	------	------	100.0%	0.0%	0.0%	Good
SnPb 63	66.7%	33.3%	0.0%	100.0%	0.0%	0.0%	7 Good, 8 Poor, Dewet, Pinholes
SnPb 64	0.0%	100.0%	0.0%	33.3%	66.7%	0.0%	9 Good, 6 Poor, Dewet
SnPb 66	0.0%	66.7%	33.3%	0.0%	100.0%	0.0%	14 Good, 1 Poor, Dewet, Pinholes
SnPb 67	0.0%	100.0%	0.0%	33.3%	33.3%	33.3%	Good
SnPb 88	------	------	------	------	------	------	11 Good, 4 Dewet

with the visual examination results. Dewet phenomena was observed in the gold and in a few tin samples. Some samples also exhibited either total or partial non-wetting characteristics. Also, the tin samples, on the whole, passed well on both the visual, and 260°C meniscograph tests. The differences arise in the 230°C meniscograph tests. The tin samples did not do very well here, but the 99.9% gold-plated samples seemed to deviate little from the 260°C results. Based on these statements, the 260°C meniscograph test and MIL-STD-883B, Method 2003.2 are fairly compatible, but meniscograph tests run at 230°C on tin specimens show big differences.

As to rewriting MIL-STD-883B, Method 2022, a recommendation should be made to include either a 230°C test, or one between 230°C, and 260°C to give more accurate results as to the true solderability of the specimens being tested. Also, thought should be given to lowering the force pass/fail criteria, or changing it, since relatively few of the samples used were able to reach 300 dynes within one second.

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APPENDIX 1

METHOD 2022

MENISCOGRAPH SOLDERABILITY

1. PURPOSE. The purpose of this test method is to determine the solderability of all ribbon leads up to 0.050 inches (1.27 mm) in width and up to 0.025 inches (0.64 mm) in thickness which are normally joined by a soldering operation and used on microelectronic devices. This determination is made on the basis of the wetting time and wetting force curve produced by the specimen while under test.

These processes will verify that the treatment used in the manufacturing process to facilitate soldering is satisfactory and that it has been applied to the required portion of the part which is designated to accommodate a solder connection.

2. APPARATUS.

2.1 Solder meniscus force measuring device (Meniscograph). A solder meniscus force measuring device (Meniscograph) which includes a temperature-controlled solder pot containing approximately 750 grams of solder shall be used. This apparatus shall be capable of maintaining the solder at the temperature specified in 3.4. The Meniscograph apparatus also includes a strip chart recorder which records the force curve for the device tested.

2.2 Dipping device. A mechanical dipping device is incorporated in the Meniscograph, and is preset to produce an immersion and emersion rate as specified in 3.4. The specimen dwell time is operator controlled to the time specified in 3.4.

2.3 Container and cover. A nonmetallic container of sufficient size to allow the suspension of the specimens 1-1/2 inches (38.10 mm) above the boiling distilled water shall be used. (A 2,000 ml beaker is one size that has been used satisfactorily for smaller components.) The cover shall be of one or more stainless steel plates and shall be capable of covering approximately 7/8 of the open area of the container so that a more constant temperature may be obtained. A suitable method of suspending the specimens shall be improvised. Perforations or slots in the plates are permitted for this purpose.

2.4 Materials.

2.4.1 Flux. The flux shall conform to type RMA or R, as applicable, of MIL-F-14256, "Flux, Soldering, Liquid (Rosin Base)."

2.4.2 Solder. The solder shall conform to type S, composition Sn60, of QQ-S-571, "Solder; Tin Alloy; Lead-Tin Alloy; and Lead Alloy."

3. PROCEDURE. The test procedure shall be performed on the number of terminations specified in the applicable procurement document. During handling, care shall be exercised to prevent the surface to be tested from being abraided or contaminated by grease, perspirants, etc. The test procedure shall consist of the following operations:

a. Proper preparation of the terminations (see 3.1), if applicable.
b. Aging of all specimens (see 3.2).
c. Application of flux and immersion of the terminations into molten solder (see 3.3 and 3.4).
d. Examination and evaluation of the recordings upon completion of the solder-dip process (see 3.5).

3.1 Preparation of terminations. No wiping, cleaning, scraping, or abrasive cleaning of the terminations shall be performed. Any special preparation of the terminations, such as bending or reorientation prior to the test, shall be specified in the applicable procurement document.

3.2 Aging. Prior to the application of the flux and subsequent solder dips, all specimens assigned to this test shall be subjected to aging by exposure of the surfaces to be tested to steam in the container specified in 2.3. The specimens shall be suspended so that no portion of the specimen is less than 1-1/2 inches

(38.10 mm) above the boiling distilled water with the cover specified in 2.3 in place for 60 minutes minimum. Means of suspension shall be a nonmetallic holder. If necessary, additional hot distilled water may be gradually added in small quantities so that the water will continue to boil and the temperature will remain essentially constant.

3.3 Application of flux. Flux, type RMA or R, shall be used (see 2.4.1). Terminations shall be immersed in the flux, which is at room ambient temperature, to the minimum depth necessary to cover the surface to be tested. Unless otherwise specified in the applicable procurement document, terminations shall be immersed to 0.16 inch (4 mm) from end of lead. The surface to be tested shall be immersed in the flux for a period of from 5 to 10 seconds.

3.4 Solder dip. The dross and burned flux shall be skimmed from the surface of the molten solder specified in 2.4.2. The molten solder shall be maintained at a uniform temperature of 260 ±10°C. The surface of the molten solder shall be skimmed again just prior to immersing the terminations in the solder. The part shall be attached to a dipping device (see 2.2) and the flux-covered terminations immersed once in the molten solder to the same depth specified in 3.3. The immersion and emersion rates shall be 1 ±1/4 inch (25.40 ±6.35 mm) per second and the dwell time in the solder bath shall be 5 ±1/2 seconds, unless otherwise specified.

3.5 Evaluation of resultant Meniscograph curves from testing of microelectronic leads. The criteria for acceptable solderability during the evaluation of the recordings are:

a. That the recorded signal trace crosses the zero balance point at or before 0.59 seconds of test time.
b. That the recorded signal trace crosses the positive 300 dynes per centimeter meniscus force point at or before 1 second of test time.

4. SUMMARY. The following details must be specified in the applicable procurement document:

a. The number of terminations of each part to be tested (see 3).
b. Special preparation of the terminations, if applicable (see 3.1).
c. Depth of immersion if other than 0.16 inch (4 mm) (see 3.3).
d. Solder dip if other than specified in 3.4.
e. Evaluation of Meniscograph curves if other than specified in 3.5.
f. Solder composition, flux, and temperature if other than those specified in 2.4 and 3.4.
g. Number of cycles, if other than one. Where more than one cycle is specified to test the resistance of the device to heat as encountered in multiple solderings, the examinations and measurements required shall be made at the end of the first cycle and again at the end of the total number of cycles applied. Failure of the device on any examination and measurement at either the one-cycle or the end-point shall constitute failure to meet this requirement.

APPENDIX 2

TABLE 22. MIL-M-38510 COMPONENT FINISHING

Lot Number Identification		Specified Finish System	Primary Finish							Undercoat						
		Primary/Undercoat	Thickness, μin		Plating Conditions				Bath Composition	Thickness, μin		Plating Conditions				Bath Composition
			Avg	Range	Time (min)	Temp (°C)	Voltage	ASF		Avg	Range	Time (min)	Temp (°C)	Voltage	ASF	
	Sn4	Sn(100)/Ni(10)	94	55-100					10.0 oz/gal Sn	43	30-56					
115	A			55-100	2	34	0.7	25	21.8 oz/gal BF_4		33-56	1	36	3.4		9.7 oz/gal Ni
	B			60-130	2	36	0.7	25	Add: 90 ml		30-55	1	38	3.4		2.8 oz/gal H_3BO_4
	C			60-80	2	38	0.7	25	TWSR		38-50	1	38	3.4		pH 4.2
	Sn5	Sn(100)/Ni(50)	110	60-140						54	45-80					
116	A			80-115	2	38	0.7	25			50-75	4	38	3.4		
	B			100-135	2	38	0.7	25			50-80	4	38	3.4		
	C			108-140	2	38	0.7	25			48-75	4	38	3.4		
	Sn6	Sn(100)/Ni(100)	138	100-190						78	50-110					
117	A			100-175	2	38	0.7	25			50-110	8	38	3.4		
	B			123-190	2	38	0.7	25			65-100	8	38	3.4		
	C			115-145	2	38	0.7	25			55-110	8	38	3.4		
	Sn7	Sn(300)/Ni(10)	276	250-300					9.8 oz/gal Sn	30	20-40					8.9 oz/gal Ni
118	A			255-285	6	38	0.7	25	20.4 oz/gal BF_4		20-40	1	38	3.4		2.4 oz/gal H_3BO_4
	B			270-300	6	38	0.7	25	Add: 480 ml		28-40	1	38	3.4		pH 4.15
	C			250-285	6	38	0.6	25	$SnBF_4$		25-33	1	38	3.4		Add: 1 liter Ni sulfamate; 139 gm H_3BO_4
	Sn8	Sn(300)/Ni(50)	295	245-320						65	42-95					
119	A			270-290	6	38	0.6	25			43-80	4	38	3.4		
	B			255-315	6	38	0.7	25			50-97	4	38	3.4		
	C			255-300	6	38	0.7	25			64-95	4	38	3.4		
	Sn9	Sn(300)/Ni(100)	209	85-295					10.0 oz/gal Sn	65	40-85					8.9 oz/gal Ni
120	A			100-295	6	38	0.9	25	21.1 oz/gal BF_4		40-85	6	38	3.5		3.3 oz/gal H_3BO_4
	B			85-275	6	38	0.8	25	Add: 90 ml		65-80	6	38	3.5		pH 3.7
	C			225-270	6	38	0.9	25	TWSR		85-75	6	38	3.5		Add: 1 liter Ni sulfamate
	Sn10	Sn(500)/Ni(10)	380	350-420						20	<20-30					
121	A			350-390	10	38	0.8	25			20-25	0.5	38	3.4		
	B			370-400	10	38	0.8	25			<20-30	0.5	38	3.5		
	C			375-420	10	38	0.8	25			20-25	0.5	38	3.5		
	Sn11	Sn(500)/Ni(50)	416	400-445					7.6 oz/gal Sn	62	50-85					8.5 oz/gal Ni
122	A			400-445	10	38	0.9	25	18.2 oz/gal BF_4		60-85	3	38	3.5		2.9 oz/gal H_3BO_4
	B			400-445	10	38	0.9	25	Add: 1.55 liters		50-75	3	38	3.4		pH 3.7
	C			405-435	10	38	0.9	25	$SnBF_4$		55-65	3	38	3.4		Add: 2 liters Ni sulfamate

TABLE 22. MIL-M-38510 COMPONENT FINISHING (CONTINUED)

Lot Number Identification	Specified Finish System	Primary Finish							Undercoat						
	Primary/Undercoat	Thickness, μin		Plating Conditions				Bath Composition	Thickness, μin		Plating Conditions				Bath Composition
		Avg	Range	Time (min)	Temp (^{0}C)	Voltage	ASF		Avg	Range	Time (min)	Temp (^{0}C)	Voltage	ASF	
Sn12	Sn(500)/Ni(100)	379	365-420						71	50-110					
123 A			355-405	10	38	0.9				50-75	6	38	3.4		10.5 oz/gal Ni
B			365-395	10	38	0.9				65-85	6	38	3.4		3.2 oz/gal H_3BO_4
C			355-420	10	38	0.9				70-110	6	38	3.4		pH 3.6
Sn1	Sn(100)	80	60-90												
124 A			60-85	2	38	1.0						NA			
B			75-90	2	38	1.0									
C			75-90	2	38	1.0									
Sn2	Sn(300)	293	250-340					9.8 oz/gal Sn				NA			
125 A			265-290	7	38	1.0-1.5		19.9 oz/gal BF_4							
B			250-330	7	38	1.0-1.5		Add: 440 ml							
C			300-340	11	38	0.8	17	$SnBF_4$							
Sn2	Sn(300)	230	160-295												
125 A			160-232	12	36	1.0						NA			
Repeat B			205-295	12	38	1.3									
C			168-238	12	39	1.0									
Sn3	Sn(500)	Uneven, spotty plate		NEW BATH				9.9 oz/gal Sn				NA			
126 A				20	40	0.8		18.7 oz/gal BF_4							
B				20	41	1.1									
C				20	41	1.0									
SnPb60	SnPb(200)/Ni(100)	550	315-790	HOT DIP				NA	118	100-140					
127 A										105-130	6	38	3.4		
B										100-140	6	38	3.4		
C										105-140	6	38	3.4		
SnPb61	SnPb(200)/Ni(150)	445	295-655	HOT DIP				NA	163	160-175					
128 A										140-180	9	38	3.4		
B										160-175	9	38	3.4		
C										160-165	9	38	3.4		
SnPb62	SnPb(200)/Ni(200)	670	460-1555	HOT DIP				NA	136	100-170	12	38	3.4		10.8 oz/gal Ni
129 A										100-145	12	38	3.4		3.2 oz/gal H_3BO_4
B										120-170	12	38	3.4		pH 3.4
C															
Sn13	Sn(100)/Cu(10)	191	155-225					2.8 oz/gal Sn	Not Detected						10.8 oz/gal Ni
130 A			155-210	4	42	1.1		23.2 oz/gal BF_4			0.5	RT	1.0		3.0 oz/gal H_3BO_4
B			180-225	4	42	1.1	15.7	Add: 1.32 liters			0.5	RT	1.1	15.7	pH 3.4
C			170-205	4	42	1.0		$SnBF_4$			0.5	RT	2.2	30.9	5.8 oz/gal Cu
															7.0 oz/gal H_2BO_4

TABLE 22. MIL-M-38510 COMPONENT FINISHING (CONTINUED)

Lot Number Identification		Specified Finish System	Primary Finish							Undercoat						
		Primary/Undercoat	Thickness, μin		Plating Conditions				Bath Composition	Thickness, μin		Plating Conditions				Bath Composition
			Avg	Range	Time (min)	Temp (°C)	Voltage	ASF		Avg	Range	Time (min)	Temp (°C)	Voltage	ASF	
	Sn14	Sn(100)/Cu(50)	156	140-175					6.2 oz/gal Sn	56	60-60					6.1 oz/gal Cu
131	A			140-165	4	42	1.2		24.9 oz/gal BF_4		60-60	3	RT	1.0		6.9 oz/gal H_2SO_4
	B			150-195	4	40	1.6				55-60	3	RT	1.6		
	C			130-160	4	40	1.2				50-55	3	RT	1.6		
	Sn15	Sn(100)/Cu(100)	156	125-190						131	110-165					
132	A			140-180	4	40	1.2				135-165	7	RT	1.5		
	B			140-190	4	40	1.2				110-140	7	RT	1.6		
	C			125-190	4	40	1.1				110-135	7	RT	1.4		
	Sn16	Sn(300)/Cu(10)	356	290-470						Detected						
133	A			290-370	12	39	1.1					0.5	RT	1.6		
	B			310-470	12	40	1.4					0.5	RT	1.6		
	C			310-340	12	40	1.1					0.5	RT	1.6		
	Sn17	Sn(300)/Cu(50)	415	345-500						63	40-110					
134	A			360-500	12	40	1.1				45-60	3	RT	1.5		
	B			345-480	12	40	1.4				50-110	3	RT	1.7		
	C			390-420	12	40	1.1				46-60	3	RT	1.4		
	Sn18	Sn(300)/Cu(100)	357	265-500					6.1 oz/gal Sn	110	100-135					8.0 oz/gal Cu
135	A			295-395	12	40	1.1		24.9 oz/gal BF_4		110-135	7	RT	1.8		7.1 oz/gal H_2SO_4
	B			360-500	12	40	1.6				100-130	7	RT	1.7		
	C			265-325	12	40	1.0				105-135	7	RT	1.5		
	Sn19	Sn(500)/Cu(10)	637	545-850						23	~10-40					
136	A			590-670	20	41	1.1				30-35	0.5	RT	1.6		
	B			613-850	20	40	1.6				~10, detected	0.5	RT	1.7		
	C			545-585	20	40	1.1				25-40	0.5	RT	1.5		
	Sn20	Sn(500)/Cu(50)	687	585-775					Ag decrease to 8 ft/min from 12 ft/min	76	60-95					
137	A			680-775	20	40	1.1				60-95	3	RT	1.6		
	B			585-690	20	40	1.1				60-80	3	RT	1.6		
	C			660-770	20	40	1.1				80-90	3	RT	1.6		
	Sn21	Sn(500)/Cu(100)	651	595-745					6.4 oz/gal Sn	100	80-125					
138	A			505-630	20	40	1.1		25 oz/gal BF_4		85-100	7	RT	1.5		
	B			650-745	20	40	1.5				100-125	7	RT	1.7		
	C			610-655	20	40	1.1				80-95	7	RT	1.6		

TABLE 22. MIL-M-38510 COMPONENT FINISHING (CONTINUED)

Lot Number Identification		Specified Finish System	Primary Finish							Undercoat						
		Primary/Undercoat	Thickness, μin		Plating Conditions				Bath Composition	Thickness, μin		Plating Conditions				Bath Composition
			Avg	Range	Time (min)	Temp (°C)	Voltage	ASF		Avg	Range	Time (min)	Temp (°C)	Voltage	ASF	
	SnPb63	SnPb(200)/NiB(100)	800	160-1660	HOT DIP				NA	187	185-220					7.2 oz/gal Cu
139	A										180-220	30	68			7.4 oz/gal H_3BO_4
	B										165-195	30	68-70			96.6% Ni act (NiB)
	C										185-195	30	70			pH 7.2
	SnPb64	SnPb(200)/NiB(150)	629	360-1330	HOT DIP				NA	223	185-265					
140	A										225	45	68			
	B										185-265	45	67-68			
	C										205-230	45	68-67			
	SnPb65	SnPb(200)/NiB(200)	504	320-670	HOT DIP				NA	287	230-350					81.5% Ni act
141	A										300-350	60	66-68			61.2% DMAB act
	B										245-300	60	68-65			pH 7.17
	C										230-245	60	64-66			Add: 246 ml 468A, 516 ml 468B
	Sn22	Sn(100)/NiB(10)	110	55-135						Not detected						
142	A			120-135	3	40	1.0					2	66			
	B			55-130	3	39	1.1					2	66			
	C			75-125	3	38	1.0					2	66			
	Sn23	Sn(100)/NiB(50)	132	115-150						49	40-60					
143	A			115-140	3	38	0.9				50-60	10	66-68			
	B			120-150	3	39	1.2				40-45	10	67-68			
	C			120-150	3	39	0.9				50-55	10	68			
	Sn24	Sn(100)/NiB(100)	138	95-170					6.2 oz/gal Sn	73	55-95					89% Ni act
144	A			95-160	3	51	0.8		24.8 oz/gal BF_4		75-95	20	70			pH 6.9
	B			145-170	3	50	0.9				50-55	20	70-68			Add: 145 ml 468A,
	C			100-130	3	47	0.9				55-75	20	62-63			145 ml 468B
	Sn25	Sn(300)/NiB(10)	178	155-200						Not detected						
145	A			175-200	9	46	0.9					2	63			
	B			155-175	9	44	1.1					2	65			
	C			170-175	9	43	1.1					2	66			
	Sn26	Sn(300)/NiB(50)	330	295-360						38	30-50					
146	A			295-360	9	44	1.1				30-50	10	65-66			
	B			325-360	9	42	1.2				30-35	10	66			
	C			300-320	9	42	1.1				40-50	10	66			

TABLE 22. MIL-M-38510 COMPONENT FINISHING (CONTINUED)

Lot Number Identification		Specified Finish System	Primary Finish							Undercoat						
		Primary/Undercoat	Thickness, μin		Plating Conditions				Bath Composition	Thickness, μin		Plating Conditions				Bath Composition
			Avg	Range	Time (min)	Temp (°C)	Voltage	ASF		Avg	Range	Time (min)	Temp (°C)	Voltage	ASF	
	Sn27	Sn(300)/NiB(100)	306	300-355					5.7 oz/gal Sn	60	45-75					101.5% Ni act
147	A			300-325	9	40	1.0		25.2 oz/gal BF_4		55-75	20	65			pH 6.8
	B			300-330	9	41	1.1				45-65	20	64-63			
	C			330-355	9	42	0.9				55-70	20	66-65			
	Sn28	Sn(500)/NiB(10)	631	500-970						Not detected						
148	A			500-970	15	41	1.1					2	65			
	B			500-654	15	41	1.1					2	66			
	C			725	15	41	1.2					2	60			
	Sn29	Sn(500)/NiB(50)	503	420-630						47	30-70					
149	A			450-630	15	41	1.1				40-70	10	66			
	B			420-500	15	41	1.1				30-50	10	65			
	C			500-550	15	41	1.0				40-50	10	66			
	Sn30	Sn(500)/NiB(100)	837	675-1100					5.4 oz/gal Sn	60	50-75					
150	A			675-880	15	41	0.9		24.5 oz/gal BF_4		55-65	20	66			
	B			752-1100	15	41	1.0		NEW RACKS		50-75	20	66			
	C			720-930	15	41	1.4				50	20	66			
	SnPb66	SnPb(200)/NiP(100)	670	300-1325	HOT DIP				NA	127	105-145					94.7% Ni act (NiB)
151	A										110-125	10	77			pH 6.5
	B										105-135	10	83-81			0.75 oz/gal Ni(NiP)
	C										130-145	10	80			pH 4.9
	SnPb67	SnPb(200)/NiP(150)	458	135-748	HOT DIP				NA	158	120-180					
152	A										165-180	15	79			
	B										120-160	15	77			
	C										155-180	15	77-78			
	SnPb68	SnPb(200)/NiP(200)	496	245-1050	HOT DIP				NA	195	170-225					0.68 oz/gal Ni
153	A										195-225	20	79-78			pH 4.7
	B										170-185	20	76-77			Add: 20 ml 418A,
	C										190-220	20	80			20 ml 418C
	Sn31	Sn(100)/NiP(10)	110	70-140						55	25-80					
154	A			70-125	3	42	0.6				60-80	1	83-82			
	B			110-140	3	42	1.0				25-50	1	82-81			
	C			90-120	3	42	0.9				60-75	1	78			

TABLE 22. MIL-M-38510 COMPONENT FINISHING (CONTINUED)

Lot Number Identification		Specified Finish System	Primary Finish							Undercoat						
		Primary/Undercoat	Thickness, μin		Plating Conditions				Bath Composition	Thickness, μin		Plating Conditions				Bath Composition
			Avg	Range	Time (min)	Temp (°C)	Voltage	ASF		Avg	Range	Time (min)	Temp (°C)	Voltage	ASF	
	Sn32	Sn(100)/NiP(50)	145	100-215						46	30-60					
155	A			100-215	3	42	0.9				40-60	5	78			
	B			125-160	3	42	1.0				30-50	5	76			
	C			140-170	3	42	1.0				45-50	5	76			
	Sn33	Sn(100)/NiP(100)	245	145-450						100	80-120					
156	A			145-450	3	42	1.0				95-105	10	77-76			
	B			170-245	3	42	1.1				80-110	10	77-76			
	C			190-450	3	42	1.0				100-120	10	77			
	Sn34	Sn(300)/NiP(10)	330	250-415					5.3 oz/gal Sn 24 oz/gal BF_4 Add: 420 ml HBF_4	45	20-60					0.72 oz/gal Ni pH 4.65
157	A			250-310	9	41	0.9				50-60	1	81			
	B			255-290	9	41	1.0				20-50	0.5	80			
	C			390-415	9	41	0.8				45-50	0.5	80			
	Sn35	Sn(300)/NiP(50)	335	275-420						55	45-65					
158	A			275-315	9	41	1.0				50-60	5	79			
	B			380-420	9	41	1.1				45-55	5	80-79			
	C			290-325	9	42	0.8				50-65	5	80-79			
	Sn36	Sn(300)/NiP(100)	365	305-470						100	75-120					
159	A			315-340	9	42	0.8				100-120	10	79			
	B			385-470	9	42	1.0				75-105	10	80-79			
	C			305-345	9	42	0.8				100-105	10	79-78			
	Sn37	Sn(500)/NiP(10)	504	430-800					4.5 oz/gal Sn 23.7 oz/gal BF_4 Add: 300 ml Sn BF_4	35	5-50					0.70 oz/gal Ni pH 4.65
160	A			430-500	15	40	0.8				25-40	0.5	74			
	B			630-800	15	40	1.0				5-50	0.5	74			
	C			430-455	15	42	0.8				30-45	0.25	78			
	Sn38	Sn(500)/NiP(50)	565	450-750						58	50-70					
161	A			450-500	15	42	0.8				50-65	5	78-77			
	B			470-550	15	42	1.0				50-70	5	82-81			
	C			600-750	15	41	0.8				60-65	5	79			
	Sn39	Sn(500)/NiP(100)	565	400-795						95	55-115					
162	A			400-500	15	41	0.9				85-105	10	78			
	B			670-795	15	41	1.1				55-95	10	78			0.62 oz/gal Ni(NiP) pH 4.7
	C			415-460	15	42	0.8				95-115	10	78			

TABLE 22. MIL-M-38510 COMPONENT FINISHING (CONTINUED)

Lot Number Identification		Specified Finish System	Primary Finish							Undercoat						
		Primary/Undercoat	Thickness, μin		Plating Conditions				Bath Composition	Thickness, μin		Plating Conditions				Bath Composition
			Avg	Range	Time (min)	Temp (°C)	Voltage	ASF		Avg	Range	Time (min)	Temp (°C)	Voltage	ASF	
	Au69	Au(50)	67	40-106					5.3 oz/gal Sn				NA			
163	A			60-106	3	36	2.7	10	26.5 oz/gal BF_4							
	B			40-90	3	35	3.4	10	Au-pH 4.23							
	C			55-75	3	35	3.2	10	Baumé-15°							
									1.08 oz/gal Au				NA			
	Au70	Au(125)	115	100-130												
164	A			100-120	8	34	3.5	10								
	B			100-130	8	33	3.6	10								
	C			110-115	8	33	3.4	10								
	Au71	Au(225)	170	145-200									NA			
165	A			145-185	14	32	3.5	10								
	B			150-200	14	33	3.7	10								
	C			150-170	14	33	3.4	10								
	Au40	Au(50)/Ni(50)	50	25-65					0.91 oz/gal Au	45	35-50					9.3 oz/gal Ni (Sulfamate)
166	A			25-55	3	30	3.2	10	pH 4.2		35-50	3	36	2.9		2.6 oz/gal H_3BO_4
	B			50-65	3	32	4.3	10	Baumé-14°		40-45	3	37	3.8		pH 3.2
	C			45-60	3	33	3.7	10	Add: 30 gm		40-50	3	38	3.1		Add: 910 ml Ni
									KAuCN(20							Sulfamate, 120
	Au41	Au(50)/Ni(100)	55	40-75					gm Au)	90	65-115					gm H_3BO_4
167	A			40-60	3	34	2.9	10			85-100	6	38	2.9		
	B			45-75	3	34	3.5	10			65-90	6	38	3.9		
	C			40-55	3	34	3.0	10			90-115	6	38	3.0		
	Au42	Au(50)/Ni(150)	50	40-65						140	106-190					
168	A			40-65	3	33	3.5	10			106-135	12	38	3.2		
	B			40-60	3	33	3.4	10			130-190	12	38	4.0		
	C			45-65	3	33	3.8	10			120-135	12	38	3.3		
	Au43	Au(125)/Ni(50)	95	70-180					0.94 oz/gal Au	55	40-70					9.4 oz/gal Ni
169	A			70-180	8	30	3.8	10			45-70	3	39	3.2		3.0 oz/gal H_3BO_4
	B			95-110	8	30	3.5	10			45-70	3	39	3.9		pH 2.9
	C			75-100	8	31	3.2	10			40-45	3	39	2.8		Add: 780 ml Ni
	Au44	Au(125)/Ni(100)	100	75-130						90	65-120					Sulfamate; pH adj 4.16 w/
170	A			75-100	8	33	3.0	10			65-115	8	38	3.0		$NiCO_3$
	B			80-130	8	33	3.6	10			70-100	8	38	3.8		
	C			90-105	8	33	3.1	10			85-120	8	38	3.1		

TABLE 22. MIL-M-38510 COMPONENT FINISHING (CONTINUED)

Lot Number Identification		Specified Finish System	Primary Finish							Undercoat						
		Primary/Undercoat	Thickness, μin		Plating Conditions				Bath Composition	Thickness, μin		Plating Conditions				Bath Composition
			Avg	Range	Time (min)	Temp (^oC)	Voltage	ASF		Avg	Range	Time (min)	Temp (^oC)	Voltage	ASF	
	Au45	Au(125)/Ni(150)	95	60-160					Add: 30 gm	155	90-210					
171	A			60-100	8	33	3.1	10	KAuCN		105-210	12	38	3.0		
	B			105-160	8	33	4.3	10	(20 gm Au)		90-130	12	38	3.8		
	C			80-90	8	33	3.5	10	Baumé-13°		130-200	12	38	3.1		
									pH 4.3							
	Au46	Au(225)/Ni(50)	170	105-225					pH adj to	50	35-65					
172	A			150-190	18	33	3.4	10	4.05		35-65	3	38	3.2		
	B			160-225	18	33	4.3	10			45-65	3	38	4.0		
	C			105-140	18	33	3.5	10			45-50	3	38	3.1		
	Au47	Au(225)/Ni(100)	180	135-245					0.92 oz/gal Au	110	75-170					10.5 oz/gal Ni
173	A			135-200	18	32	3.5	10	890 mg/l CO		75-170	8	38	2.9		3.1 oz/gal H_3BO_4
	B			180-245	18	32	4.0	10			85-160	8	38	3.6		96.6% Ni act (NiB)
	C			145-185	18	32	3.3	10			100-125	8	38	3.0		pH 6.35
																Add: 45 ml 468A,
	Au48	Au(225)/Ni(150)	190	150-230					Add: 43 gm	160	135-195					45 ml 468B
174	A			150-180	18	32	3.8	10	KAuCN(29		150-180	12	38	3.2		
	B			200-230	18	32	3.9	10	gm Au)		155-195	12	38	4.0		
	C			150-175	18	33	3.4	10	pH 3.5 adj		135-160	12	39	3.1		
									to 4.0							
	Au49	Au(50)/NiB(50)	50	20-70					Baumé 13.5°	45	30-50					
175	A			20-50	3	32	3.6	10			40-50	12	66-68			
	B			35-70	3	32	3.6	10			30-50	12	66-67			
	C			50	3	33	3.5	10			45-50	12	66-67			
	Au50	Au(50)/NiB(100)	55	45-70						60	35-75					
176	A			45-70	3	33	3.5	10			60-75	24	66-67			
	B			50-65	3	33	3.8	10			35-60	24	64			
	C			45	3	33	3.3	10			45-75	24	65			
	Au51	Au(50)/NiB(150)	65	45-90						75	50-100					
177	A			50-60	3	33	3.7	10			60-80	36	64-67			
	B			45-95	4	34	3.9	10			50-100	36	68			
	C			55-60	4	34	3.5	10			50-80	36	69			
	Au52	Au(125)/NiB(50)	90	50-125					0.96 oz/gal Au	40	25-60					97.0% Ni act
178	A			70-100	8	32	3.3	10	pH 4.18 adj		40-60	12	70			pH 6.25
	B			85-125	8	32	3.8	10	to 4.02		25-40	12	66-68			Add: 40 ml 468A,
	C			50-90	8	33	3.7	10	Baumé-13.7°		50	12	68			40 ml 468B

TABLE 22. MIL-M-38510 COMPONENT FINISHING (CONTINUED)

Lot Number Identification		Specified Finish System Primary/Undercoat	Primary Finish Thickness, μin Avg	Primary Finish Thickness, μin Range	Primary Finish Plating Conditions Time (min)	Primary Finish Plating Conditions Temp (°C)	Primary Finish Plating Conditions Voltage	Primary Finish Plating Conditions ASF	Primary Finish Bath Composition	Undercoat Thickness, μin Avg	Undercoat Thickness, μin Range	Undercoat Plating Conditions Time (min)	Undercoat Plating Conditions Temp (°C)	Undercoat Plating Conditions Voltage	Undercoat Plating Conditions ASF	Undercoat Bath Composition
	Au53	Au(125)/NiB(100)	95	55-125						65	40-85					
179	A			90-120	8	33	3.7	10			60-85	30	66			
	B			55-125	8	34	3.8	10			40-80	30	67-68			
	C			80-85	8	34	3.4	10			60-80	30	67-68			
	Au54	Au(125)/NiB(150)	100	60-140						100	75-130					
180	A			60-85	8	32	3.6	10			75-120	60	68			
	B			110-140	8	33	3.9	10			85-100	60	67-68			
	C			75	8	33	3.4	10			75-130	60	68			
	Au55	Au(225)/NiB(50)	225	195-290	(NEW RACKS)				0.94 oz/gal Au	100	80-120					88.3% Ni act
181	A			200-290	21	34	3.4	10	Add: 28 gm		95-120	10	66			40.5% DMAB act
	B			195-235	21	34	4.1	10	K AuCN(19		80-100	10	66			pH 6.2
	C			200-245	21	34	3.5	10	gm Au)		85-100	10	64-63			Add: 155 ml 468A,
									0.99 oz/gal Au							790 ml 468B,
	Au56	Au(225)/NiB(100)	215	195-250					pH 4.01 (before	165	135-185					adj pH to 7.1
182	A			195-215	21	33	4.0	10	& after add)		155-185	20	65-64			w/NH_4OH
	B			200-250	21	34	4.0	10	Baumé-13.5°		155-185	20	68-66			
	C			200-225	21	34	4.5	10	before &		135-175	20	66			
									after add.							
	Au57	Au(225)/NiB(150)	220	200-250					Add: 23.5 gm	210	155-240					
183	A			200-225	21	33	3.9	10	K AuCN(15.9		200-240	30	66-65			
	B			215-250	21	34	4.4	10	gm Au)		190-225	30	67-66			
	C			210-230	21	34	4.5	10			155-215	30	66-65			
									0.93 oz/gal Au 920 mg/l CO pH - Baumé -							86.4 Ni act 34.3 DMAB act pH 7.0
																91.3% Ni Act (NiB) 58.4% DMAB Act pH 7.0 Add: 120 ml 468A, 550 ml 468B
	Sn2A	Sn(300)	270	235-300					5.4 oz/gal Sn			NA				
125A	A			265-285	7	42	1.1	25	27.4 oz/gal BF_4							
	B			240-300	9	41	1.3	20								
	C			235-260	15	40	1.0	10								
	Sn27	Sn(300)/NiB(100)	278	204-365						145	125-180					
147A	A			221-365	9	36	1.1	20			135-160	20	63-64			
	B			275-340	9	37	1.2	20			125-155	20	65-66			
	C			204-241	9	38	1.1	20			125-160	20	66-65			

TABLE 22. MIL-M-38510 COMPONENT FINISHING (CONTINUED)

Lot Number Identification	Specified Finish System	Primary Finish							Undercoat						
	Primary/Undercoat	Thickness, μin		Plating Conditions				Bath Composition	Thickness, μin		Plating Conditions				Bath Composition
		Avg	Range	Time (min)	Temp (°C)	Voltage	ASF		Avg	Range	Time (min)	Temp (°C)	Voltage	ASF	
Sn3A	Sn(500)	458	415-500									NA			
136A A			425-485	25	38	0.8	10								
B			415-500	12	38	0.9	25	4.8 oz/gal Sn							
C			430-500	12	38	1.5	25	25.9 oz/gal BF_4							
SnPb63A	NIB(100)	355	116-612		HOT DIP			NA	100	90-125					
139A A										90-110	20	65-65			
B										90-105	20	65-65			
C										95-125	20	65-65			
SnPb64A	NIB(150)	458	300-750		HOT DIP			NA	130	115-140					87.1% Ni Act(NIB)
140A A										125-140	30	66-66			100% DMAB Act
B										120-135	30	66-66			pH 7.0
C										115-125	30	66-66			Add - 170 ml 468A
Sn22A	Sn(100)/NIB(10)	104	90-125						ND						
142A A			90-100	3	39	0.6	20				3	66-66			
B			100-125	3	39	1.1	20				3	66-66			
C			100-120	3	39	1.0	20				3	66-66			
Sn23A	Sn(100)/NIB(50)	105	75-120						48	45-55					
143A A			75-115	3	39	1.1	20			45-55	10	66-66			
B			90-120	3	39	1.1	20			43-50	10	66-66			
C			105-120	3	39	1.2	20			45-50	10	66-66			
Sn24A	Sn(100)/NIB(100)	120	70-170						70	65-80					
144A A			90-140	3	39	1.0	20			65-80	20	66-66			
B			70-150	3	38	1.1	20			70-80	20	65-66			
C			75-170	3	39	1.1	20			55-80	20	66-66			
Sn25A	Sn(100)/NIB(100)	120	70-170						70	55-80					
144A A			90-140	3	39	1.0	20			65-80	20	66-66			
B			70-150	3	38	1.1	20			70-80	20	65-66			
C			75-170	3	39	1.1	20			55-80	20	66-66			
Sn25A	Sn(1[illegible])/NIB(10)	388	305-455					4.8 oz/gal Sn	53	10-70					88.4% Ni Act(NIB)
145A A			305-430	10	38	1.4	20	25.8 oz/gal BF_4		50-70	3	66-66			108% DMAB Act
B			320-455	10	38	1.1	20			50-70	3	67-67			pH 6.4
C			380-435	10	39	1.2	20			10-50	3	67-67			Add - 155 ml 468A Adj. pH to 7.1
Sn28A	Sn(500)/NIB(10)	553	425-700					Add - 30 ml	40	10-60					
146A A			550-700	16	40	1.2	20	TWSR		10-60	3*	66-66			
B			425-585	16	40	1.2	20			10-50	3	66-67			
C			465-625	16	39	1.1	20			25-55	3	67-67			

TABLE 22. MIL-M-38510 COMPONENT FINISHING (CONTINUED)

Lot Number Identification		Specified Finish System	Primary Finish							Undercoat						
		Primary/Undercoat	Thickness, μin		Plating Conditions				Bath Composition	Thickness, μin		Plating Conditions				Bath Composition
			Avg	Range	Time (min)	Temp (°C)	Voltage	ASF		Avg	Range	Time (min)	Temp (°C)	Voltage	ASF	
	Sn30A	Sn(500)/NiB(100)	610	500-740						235	190-290					
150A	A			500-600	16	38	1.2	20			225-290	25	68-69			
	B			500-740	16	39	1.2	20	4.7 oz/gal Sn		195-230	25	66-66			
	C			560-615	16	39	1.4	20	25.2 oz/gal BF_4		190-245	25	65-66			
	SnPb66A	NiP(100)	710	390-1200		HOT DIP			NA	92	85-105					0.89 oz/gal Ni(NiP)
151A	A										85-95	9	79-79			pH 4.7
	B										90-105	9	79-78			Add-17 ml 418A
	C										90-90	9	78-78			17 ml 418C
	Sn31A	Sn(100)/NiP(10)	100	75-135						22	10-40					91.3% Ni Act(NiB)
154A	A			75-110	3	40	1.1	20			10-40	5 sec	78			103% DMAB Act
	B			80-120	3	39	1.1	20			10-35	5 sec	85			pH 7.3
	C			80-135	3	39	1.2	20			10-30	5 sec	83			11.5 oz/gal Ni (Ni Sulfamate) 3.3 oz/gal H_3BO_4
	Sn33A	Sn(100)/NiP(100)	150	105-230						80	60-95					pH 3.7
156A	A			105-160	3	38	1.1	20			65-85	9	80-79			
	B			110-205	3	38	1.1	20			80-95	9	79-79			
	C			105-230	3	38	1.1	20			60-90	9	78-78			
	Sn34A	Sn(300)/NiP(10)	280	220-355						18	10-35					
157A	A			250-350	9	37	1.1	20			10-35	5 sec	79			
	B			240-335	9	37	1.1	20			10-10	5 sec	78			
	C			220-355	9	38	1.1	20			20-35	15 sec	76			
	Sn37A	Sn(500)/NiP(10)	554	380-940						23	10-55					
160A	A			380-940	15	38	1.0	20			10-55	15 sec	76			
	B			440-850	15	38	1.0	20	5.0 oz/gal Sn		10-30	10 sec	78			
	C			575-615	15	38	1.1	20	23.7 oz/gal BF_4		10-25	10 sec	78			
	SnPb62A	Ni(200)	410	230-570		HOT DIP			5.0 oz/gal Sn	175	115-225					
129A	A								23.7 oz/gal BF_4		115-195	13	36	4.0		
	B										195-225	13	38	4.5		
	C										140-167	13	40	4.4		
	Sn4A	Sn(100)/Ni(10)	90	70-115						25	10-35					
115A	A			75-115	3	38	1.3	20			10-30	15 sec	44	4.3		
	B			80-105	3	38	0.9	20			10-35	15 sec	44	4.0		
	C			70-110	3	38	1.1	20			20-30	15 sec	43	4.0		

TABLE 22. MIL-M-38510 COMPONENT FINISHING (CONTINUED)

Lot Number Identification		Specified Finish System Primary/Undercoat	Primary Finish Thickness, μin Avg	Primary Finish Thickness, μin Range	Primary Finish Plating Conditions Time (min)	Primary Finish Plating Conditions Temp (^oC)	Primary Finish Plating Conditions Voltage	Primary Finish Plating Conditions ASF	Primary Finish Bath Composition	Undercoat Thickness, μin Avg	Undercoat Thickness, μin Range	Undercoat Plating Conditions Time (min)	Undercoat Plating Conditions Temp (^oC)	Undercoat Plating Conditions Voltage	Undercoat Plating Conditions ASF	Undercoat Bath Composition
	Sn6A	Sn(100)/Ni(100)	105	85-130						100	80-115					
117A	A			85-120	3	38	1.2	20			86-115	7	43	4.0	20	
	B			90-130	3	38	1.1	20			80-105	7	42	3.9	20	
	C			100-110	3	38	1.0	20			80-100	7	42	4.0	20	
	Sn7A	Sn(300)/Ni(10)	299	265-340					4.7 oz/gal Sn	40	30-48					0.63 oz/gal Ni(NiP)
118A	A			265-319	9	38	1.3	20	23.8 oz/gal BF_4		30-40	15 sec	38	3.6	20	pH 4.7
	B			289-340	9	38	1.0	20	Add-210 ml		30-40	15 sec	38	3.7	20	10.6 oz/gal Ni
																(Ni Sulfamate)
	C			272-323	9	38	1.1	20	$Sn(BF_4)$,		35-45	15 sec	38	3.8	20	3.0 oz/gal H_3BO_4
									1.7 liters							pH 2.5
	Sn9A	Sn(300)/Ni(100)	360	280-440					HBF_4	130	116-140					Add-adj pH to
120A	A			350-440	9	38	1.1	20			120-140	7	39	3.8	20	3.4 w/$NiCO_3$
	B			290-400	9	38	1.1	20			115-135	7	38	3.8	20	
	C			280-360	9	38	1.1	20			125-125	7	38	3.8	20	
	Sn10A	Sn(500)/Ni(10)	408	340-504					4.7 oz/gal Sn	30	25-40					10.3 oz/gal Ni
																(Ni Sulfamate)
121A	A			391-504	15	42	1.0	20	29.5 oz/gal BF_4		30-40	5 sec	40	4.0	20	2.9 oz/gal H_3BO_4
	B			377-445	15	42	1.0	20	Add-180 ml		25-30	5 sec	40	3.9	20	pH 3.85
	C			340-415	15	42	1.1	20	$Sn(BF_4)_2$		25-40	5 sec	38	4.0	20	Add-65 gm H_3BO_4
																5.5 oz/gal Cu($CuSO_4$)
	Sn11A	Sn(500)/Ni(50)	387	340-523						48	34-65					6.8 oz/gal H_2SO_4
122A	A			340-468	15	41	1.0	20			34-65	2	38	4.0	20	Add-280 gm $CuSO_4$
	B			340-377	15	41	1.0	20			41-54	2	38	3.6	20	23 ml H_2SO_4
	C			340-523	15	41	0.9	20			37-54	2	38	3.8	20	
	Sn12A	Sn(500)/Ni(100)	405	323-493						122	102-150					
123A	A			323-439	15	40	1.0	20			102-150	7	38	3.9	20	
	B			340-442	15	39	0.9	20			102-136	7	38	3.8	20	
	C			445-493	15	39	0.8	20			112-133	7	38	3.8	20	
	Sn18A	Sn(300)/Cu(100)	483	360-612					5.3 oz/gal Sn	194	133-235					
135A	A (TD FP 2nd lot)			445-592	12	39	1.3	25	29.6 oz/gal BF_4		201-235	7	RT	1.5	25	10.5 oz/gal Ni
																(Ni Sulfamate)
	B (Tekform FP)			360-612	12	40	1.3	25	Add-1 liter		133-235	7	RT	2.0	25	3.4 oz/gal H_3BO_4
	C (Same as A)			469-510	12	40	1.3	25	TWSR		187-197	7	RT	1.9	25	pH 3.5
	Sn13A	Sn(100)/Cu(10)	156	116-255						34	27-41					
136A	A			116-255	3	40	1.4	25			31-41	30 sec	RT	2.1	25	
	B			119-170	3	40	1.3	25			27-41	30 sec	RT	1.9	25	
	C			150-180	3	40	1.2	25			27-41	30 sec	RT	2.0	25	

TABLE 22. MIL-M-38510 COMPONENT FINISHING (CONTINUED)

Lot Number Identification		Specified Finish System	Primary Finish							Undercoat						
		Primary/Undercoat	Thickness, μin		Plating Conditions				Bath Composition	Thickness, μin		Plating Conditions				Bath Composition
			Avg	Range	Time (min)	Temp (°C)	Voltage	ASF		Avg	Range	Time (min)	Temp (°C)	Voltage	ASF	
	Sn14A	Sn(100)/Cu(50)	185	160-230						60	40-66					
131A	A			168-228	3	38	1.4	25			40-66	2	RT	1.7	25	
	B			150-230	3	39	1.3	25			40-60	2	RT	2.1	25	
	C			150-170	3	39	1.0	25			40-50	2	RT	2.3	25	
	Sn15A	Sn(100)/Cu(100)	175	155-200						95	80-115					
132A	A			155-175	3	39	1.1	25			85-95	4	RT	2.2	25	
	B			160-200	3	39	1.2	25			95-115	4	RT	1.7	25	
	C			170-200	3	40	1.0	25			80-100	4	RT	1.8	25	
	Sn16A	Sn(300)/Cu(10)	299	255-340						30	10-45					
133A	A			289-320	9	40	1.1	25			20-40	30sec	RT	2.1	25	
	B			265-340	9	40	1.2	25			10-45	30sec	RT	2.0	25	
	C			255-279	9	40	1.0	25			10-30	30sec	RT	1.7	25	
	Sn17A	Sn(300)/Cu(50)	395	350-435					5.1 oz/gal Sn 31.1 oz/gal BF_4	60	45-100					6.0 oz/gal Cu 6.8 oz/gal H_2SO_4
134A	A			350-415	8	40	1.0	25			50-100	2	RT	2.0	25	
	B			385-435	8	40	1.0	25			45-55	2	RT	2.0	25	
	C			360-425	8	40	1.1	25			50-70	2	RT	2.0	25	
	Sn19A	Sn(500)/Cu(10)	520	270-740						ND						
136A	A			270-455	12	40	1.0	25				30sec	RT	2.0	25	
	B			545-740	12	40	1.2	25				30sec	RT	2.0	25	
	C			500-625	12	40	1.2	25				30sec	RT	2.2	25	
	Sn20A	Sn(500)/Cu(50)	580	500-675						65	50-90					
137A	A			545-625	12	40	1.0	25			55-75	2	RT	2.1	25	
	B			500-675	12	40	1.1	25			50-80	2	RT	2.0	25	
	C			570-605	12	40	1.2	25			65-90	2	RT	2.1	25	
	Sn21A	Sn(500)/Cu(100)	585	500-685						90	60-125					
138A	A			500-590	12	40	1.1	25			60-120	4	RT	2.1	25	
	B			500-685	12	40	1.2	25			90-125	4	RT	2.1	25	
	C			565-575	12	40	1.0	25			70-100	4	RT	2.1	25	

TABLE 22. MIL-M-38510 COMPONENT FINISHING (CONTINUED)

Lot Number Identification		Specified Finish System	Primary Finish							Undercoat						
		Primary/Undercoat	Thickness, μin		Plating Conditions				Bath Composition	Thickness, μin		Plating Conditions				Bath Composition
			Avg	Range	Time (min)	Temp (°C)	Voltage	ASF		Avg	Range	Time (min)	Temp (°C)	Voltage	ASF	
	Au44A	Au(125)/Ni(100)	160	135-190						130	100-165					
170A	A			150-190	16	48	1.8	3	1.68 oz/gal Au		100-145	8	39	3.8	20	10.4 oz/gal Ni
	B			145-180	16	52	1.7	3	pH 9.5		115-145	8	42	3.2	20	3.4 oz/gal H_3BO_4
	C			135-150	16	51	1.7	3			115-165	8	42	3.6	20	pH 3.5
	Au41A	Au(50)/Ni(100)	55	35-95						105	90-120					
167A	A			35-40	5	50	1.8	3	1.73 oz/gal Au		90-110	7	40	3.7	20	10.4 oz/gal Ni
	B			45-60	5	50	1.8	3	pH 8.8 adj to		100-120	7	40	3.6	20	4.0 oz/gal H_3BO_4
	C			55-95	5	51	1.8	3	10.0		100-115	7	40	3.7	20	pH 3.5
	Au42A	Au(50)/Ni(150)	45	30-65						140	105-180					
168A	A			35-55	5	50	1.8	3			105-155	10	40	3.5	20	
	B			30-45	5	51	2.0	3			105-155	10	40	3.8	20	
	C			50-65	5	51	1.8	3			160-180	10	40	3.5	20	
	Au43A	Au(125)/Ni(50)	132	120-145						76	60-85					
169A	A			130-145	13	50	2.0	3			60-85	3	40	3.5	20	
	B			120-140	13	51	1.9	3			65-85	3	40	3.5	20	
	C			120-135	13	51	1.9	3			70-80	3	40	3.5	20	
	Au45A	Au(125)/Ni(150)	125	110-140						149	130-190					
171A	A			110-135	13	51	1.8	3			140-160	10	40	3.6	20	
	B			115-140	13	51	1.8	3			130-190	10	40	3.4	20	
	C			115-140	13	50	1.8	3			130-155	10	39	3.4	20	
	Au46A	Au(225)/Ni(50)	211	200-230					~1 tr. oz of	64	55-80					
172A	A			2[illegible]0-230	22	50	1.7	3	Au + 20 ml		65-80	3	40	4.0	20	
	B			200-220	22	50	1.8	3	Brightener		55-75	3	40	3.6	20	
	C			210-215	22	50	1.7	3	replenished		65-75	3	40	3.6	20	
	Au47A	Au(225)/Ni(100)	207	180-235						145	125-180					10.2 oz/gal Ni
173A	A			180-230	22	50	1.8	3	pH 9.3 adj		135-180	7	40	3.2	20	3.5 oz/gal H_3BO_4
	B			180-220	22	51	1.8	3	to 9.7		125-165	7	40	3.3	20	pH 3.4
	C			210-235	22	52	1.9	3			125-145	7	40	3.3	20	
	Au40A	Au(50)/Ni(50)	61	45-75					~1 tr. oz of	62	50-75					
166A	A			45-75	5	51	1.8	3	Au replenished		50-75	3	40	3.5	20	
	B			50-70	5	51	1.7	3			55-65	3	40	3.5	20	
	C			50-60	5	50	1.6	3			50-75	3	40	3.5	20	

TABLE 22. MIL-M-38510 COMPONENT FINISHING (CONTINUED)

Lot Number Identification	Specified Finish System	Primary Finish							Undercoat						
	Primary/Undercoat	Thickness, uin		Plating Conditions				Bath Composition	Thickness, μin		Plating Conditions				Bath Composition
		Avg	Range	Time (min)	Temp (°C)	Voltage	CD		Avg	Range	Time (min)	Temp (°C)	Voltage	CD	
Au69A	Au(50) None	53	40-70									NA			
163A A			45-70	5	50	1.8	3								
B			40-65	5	50	1.8	3								
C			40-65	5	50	1.8	3								
Au70A	Au(125) None	125	100-150									NA			
164A A			115-140	13	50	1.8	3								
B			100-135	13	50	1.8	3								
C			120-150	13	51	1.8	3								
Au71A	Au(225) None	200	175-230									NA			
165A A			175-215	22	51	1.7	3								
B			200-225	22	51	1.7	3								
C			206-230	22	51	1.8	3								
Au48A	Au(225)/Ni(150)	194	155-250					~1 tr. oz of	150	120-185					
174A A			155-250	22	50	1.7	3	Au + 10 ml		120-180					
B			160-200	22	51	1.6	3	brightener		120-170					
C			195-215	22	51	1.6	3	replenished		150-185					
Au49A	Au(50)/NiB(50)	55	45-65					1.73 oz/gal Au	100	85-120					10.2 oz/gal Ni
175A A			45-60	5	51	1.6	3	pH 9.5		90-110	10	65			3.1 oz/gal H_3BO_4
B			45-60	5	51	1.6	3			85-105	10	64-65			pH 2.9
C			50-65	5	51	1.6	3			100-120	10	67-68			82.6% Ni Act 92% DMAB Act
Au50A	Au(50)/NiB(100)	59	45-70						194	165-215					pH 7.5
176A A			45-70	5	50	1.6	3			175-215	20	68			230 ml 468A
B			55-65	5	50	1.6	3			165-210	20	68			+ 106 ml 468B
C			60-70	5	50	1.6	3			190-210	20	68			replenished
Au51A	Au(50)/NiB(150)	56	40-80						231	185-260					93% Ni Act
177A A			40-65	5	50	1.6	3			230-260	30	68			89% DMAB Act
B			40-80	5	50	1.6	3			210-260	30	67			pH 7.1
C			50-65	5	50	1.6	3			185-200	30	68-69			90 ml 468A + 142 ml 468B Before Sublot B
Au52A	Au(125)/NiB(50)	115	100-135						66	40-90					replenished
178A A			100-135	13	50	1.6	3			50-85	10	69			
B			105-130	13	50	1.6	3			40-90	10	66			
C			105-120	13	50	1.6	3			50-80	10	66			

TABLE 22. MIL-M-38510 COMPONENT FINISHING (CONTINUED)

Lot Number Identification		Specified Finish System	Primary Finish							Undercoat						
		Primary/Undercoat	Thickness, μin		Plating Conditions				Bath Composition	Thickness, μin		Plating Conditions				Bath Composition
			Avg	Range	Time (min)	Temp (°C)	Voltage	CD		Avg	Range	Time (min)	Temp (°C)	Voltage	CD	
	Au53A	Au(125)/NIB(100)	115	90-130						55	10-100					
179A	A			110-125	13	51	1.6	3	1.53 oz/gal Au		10-85	20	69-70			New NIB Bath
	B			90-125	13	51	1.7	3	pH 9.1 adj to		80-100	20	69-68			93.6% Ni Act
	C			110-130	13	51	1.8	3	9.9		10-10	20	68-67			96% DMAB Act
									Replenish ~1							pH 7.3
	Au54A	Au(125)/NIB(150)	127	115-145					tr. oz Au + 10	117	100-135					
180A	A			120-130	13	51	1.8	3	ml brightener		100-135	30	67-66			95.6% Ni Act
	B			115-145	13	51	1.8	3			100-130	30	65-66			pH 7.1
	C			130-140	13	51	1.8	3			115-120	30	66			
	Au55A	Au(225)/NIB(50)	153	136-190						51	44-65					
181A	A			136-190	22	50	1.6	3			44-58	10	65			Replenish
	B			143-167	22	50	1.6	3			44-65	10	64-65			46 ml 468A
	C			150-160	22	50	1.6	3			44-51	10	66			& 468B
																91.5% Ni Act
	Au56A	Au(225)/NIB(100)	177	156-197					Replenish	89	75-99					pH 7.1 AFTER
182A	A			173-197	22	48	1.6	3	~1 tr. oz Au		75-99	20	65-66			Au 55A
	B			156-197	22	48	1.6	3	+ 10 ml		78-96	20	66			Sublot A
	C			167-180	22	48	1.6	3	brightener		88-99	20	66			Replenish
																50 ml 468A
	Au57A	Au(225)/NIB(100)	170	150-185						150	135-185					& 468B
183A	A			150-185	22	50	1.6	3			135-155	30	65-66			BEFORE lot
	B			150-185	22	50	1.6	3			150-185	30	66			Au56A
	C			165-185	22	50	1.6	3			140-160	30	66			Replenish
																60 ml 468A
	Au72A	Au(100)/NIP(50)	58	45-65					1.65 tr. oz/gal	62	45-90					& 468B
184A					10	49	1.5	3	Au, pH 9.1			5	80			After lot
									adj to 9.8							Au 56A
	Au73A	Au(200)/NIP(50)	151	120-170					Replenish	45	30-70					97.4% Ni Act
185A					20+	49	1.6	3	~1 tr. oz Au			5	80			88.3% DMAB Act
									+10 ml							pH 7.1
	Au74A	Au(100)/NIP(150)	87	80-100					brightener	111	100-125					0.59 oz/gal
186A					10	50	1.5	3				15	80			Ni, pH 4.6
																Replenish
	Au75A	Au(200)/NIP(150)	155	85-170						125	30-135					38 ml 418A
187A					20	50	1.6	3				15	79-80			& 418C
									1.59 tr. oz/gal							0.58 oz/gal Ni
									Au, pH 10.0							pH 4.5

TABLE 22. MIL-M-38510 COMPONENT FINISHING (CONTINUED)

Lot Number Identification		Specified Finish System	Primary Finish						Undercoat					
		Primary/Undercoat	Thickness, µin		Plating Conditions			Bath Composition	Thickness, µin		Plating Conditions			Bath Composition
			Avg	Range	Time (min)	Temp (°C)	Voltage		Avg	Range	Time (min)	Temp (°C)	Voltage	
	Sn76	Sn(300)/Ni(100)	288	250-360				5.0 oz/gal Sn	94	60-130				10.0 oz/gal Ni
190	A		294	250-360	6	42	0.9	28.7 oz/gal BF_4	90	86-120	6	39	3.7	3.3 oz/gal H_3BO_4
	B		282	270-310	6	42	1.0 25ASF		94	60-125	6	39	3.8 20ASF	pH 4.0
	C		276	250-295	6	41	0.9		88	60-105	6	40	3.8	
	Sn77	Sn(300)/Ni(100)	260	200-300				4.7 oz/gal Sn	94	60-135				10.3 oz/gal Ni
191	A		266	250-300	6	39	1.0	30.2 oz/gal BF_4	81	60-110	6	37	3.8	4.2 oz/gal H_3BO_4
	B		255	200-295	6	40	0.9		102	90-135	6	38	3.9	pH 3.9
	C		258	230-275	6	41	1.0		103	86-120	6	39	3.8	
	SnPb58	Sn(300)/Ni(100)	285	206-595					80	60-110				
180	A		272	210-400	6	41	1.0		76	60-96	6	39	3.8	
	B		340	205-595	6	40	1.0		83	66-110	6	40	3.8	
	C		283	200-350	6	40	1.0		86	70-106	6	40	3.8	
	SnPb58 +	SnPb(200 min)	365	180-685					95	60-135				
	A		315	180-455	6	41	1.0		78	50-110	6	39	3.8	
	B		410	285-580	6	40	1.0		98	80-115	6	40	3.8	
	C		444	250-685	6	40	1.0		115	100-135	6	40	3.8	
	Sn78	Sn(300)/Ni(100)	230	175-350				4.0 oz/gal Sn	120	75-175				10.7 oz/gal Ni
192	A		212	175-265	6	41	1.0	28.9 oz/gal BF_4	103	75-120	6	38	4.0	2.6 oz/gal H_3BO_4
	B		252	190-350	6	41	1.1		123	80-175	6	38	4.0	pH 3.5
	C		233	210-260	6	40	1.0		136	75-175	6	39	3.9	
	Sn79	Sn(300)/Ni(100)	306	270-340				4.7 oz/gal Sn	95	50-120				10.2 oz/gal Ni
193	A		313	290-345	6	40	1.1	29.7 oz/gal BF_4	102	80-120	6	40	3.8	2.7 oz/gal H_3BO_4
	B		300	270-320	6	40	1.1		99	85-110	6	39	3.8	pH 3.9
	C		313	300-330	6	40	1.1		73	50-90	6	40	3.9	
	Sn80	Sn(300)/Ni(100)	286	250-325				4.5 oz/gal Sn	102	80-120				10.3 oz/gal Ni
194	A		290	260-325	6	41	1.0	30.4 oz/gal BF_4	102	80-120	6	40	3.8	2.9 oz/gal H_3BO_4
	B		275	250-300	6	41	1.0		98	80-120	6	40	3.8	pH 3.7
	C		285	265-310	6	41	1.1		109	100-120	6	40	3.9	
	Au61	Au(180)/Ni(180)	150	135-178				4.7 oz/gal Sn	136	100-160				10.1 oz/gal Ni
196	A		151	140-165	19	51	1.6	27.4 oz/gal BF_4	147	125-165	9	39	3.8	3.4 oz/gal H_3BO_4
	B		166	135-178	19	51	1.6 3ASF	1.74Tr.oz/gal Au BDT	124	100-140	9	39	3.8	pH 3.6
	C		135	110-155	19	50	1.6	11.3° Baumé 200	128	100-145	9	41	3.8	
								pH 10.1						
	SnPb59	Au(150)/Ni(150)	155	110-170				1.67 Tr.oz/gal Au	170	130-200				
189	A		139	110-160	19	52	1.5	pH 10.0	177	155-200	13	40	3.0-3.2	9.3 oz/gal Ni
	B		147	115-170	19	50	1.4	(BDT 200)	163	130-195	13	41	3.0-3.2	3.5 oz/gal H_3BO_4
	C		147	150-170	19	50	1.5		163	150-170	13	40	3.0-3.2	pH 4.0
	SnPb59 +	SnPb(200 min)	277	100-385				1.67 Tr.oz/gal Au	176	120-375				
	A		309	225-385	19	52	1.5	pH 10.0	183	140-230	13	40	3.0-3.2	9.3 oz/gal Ni
	B		230	100-320	19	50	1.4	(BDT 200)	191	120-275	13	41	3.0-3.2	3.5 oz/gal H_3BO_4
	C		308	290-330	19	50	1.5		144	120-160	13	40	3.0-3.2	pH 4.0

TABLE 22. MIL-M-38510 COMPONENT FINISHING (CONTINUED)

Lot Number Identification		Specified Finish System	Primary Finish						Undercoat					
		Primary/Undercoat	Thickness, μin		Plating Conditions			Bath Composition	Thickness, μin		Plating Conditions			Bath Composition
			Avg	Range	Time (min)	Temp (°C)	Voltage		Avg	Range	Time (min)	Temp (°C)	Voltage	
	Au82	Au(150)/Ni(150)	135	120-165				1.73 Tr. oz/gal Au	155	140-190				9.4 oz/gal Ni
196	A		140	120-165	10	49	1.5	pH 9.7	165	140-190	13	40	3.8-3.2	3.5 oz/gal H_3BO_4
	B		133	120-140	10	52	1.5	(BDT 200)	155	140-175	13	40	3.8-2.9	pH 4.0
	C		125	120-130	10	52	1.5		145	140-150	13	40	3.6-2.9	
	Au83	Au(150)/Ni(150)	160	115-210				1.59 Tr.oz/gal Au	185	135-260				9.6 oz/gal Ni
197	A		151	130-170	20	51	1.4	pH 9.6	153	135-180	14	40	3.6-2.6	3.4 oz/gal H_3BO_4
	B		185	150-210	20	50	1.2	(BDT 200)	220	190-260	14	40	3.8-2.6	pH 4.0
	C		134	115-140	20	51	1.4		176	160-190	14	40	3.6-2.6	
	SnPb86	SnPb(200 min)/	315	165-500					215	150-315				
500	A	Ni(150)	318	165-500					218	160-270	14	40	3.7-2.6	
	B		317	215-475					227	150-315	14	40	3.6-2.6	
	C		310	280-375					181	165-200	14	40	3.6-2.6	
	Au84	Au(150)	180	150-210				1.47 Tr.oz/gal Au						9.2 oz/gal Ni
198	A		195	175-210	20	52	1.5	pH 9.0 adj to						3.7 oz/gal H_3BO_4
	B		160	150-190	20	52	1.5	9.8 w/NaOH						pH 4.0
	C		163	145-185	20	52	1.5	(BDT 200)						Add - 1.17 liters
														Nickel Sulfamate
	Au01	Au(50)/AuSt(20)	85	75-105										0.19 Tr.oz/gal Au } Aurobond TN
505	A		85	75-105	7	51	1.5				1	55	3.6(10ASF)	15° Baumé
														pH 3.4
	Au85	Au(150)	160	135-180				1.5 Tr.oz/gal Au						9.9 oz/gal Ni
199	A		167	150-180	20	51	1.4	10° Baumé						3.6 oz/gal H_3BO_4
	B		153	135-175	20	50	1.5	pH 9.8						pH 4.0
	C		152	145-165	20	50	1.4	(BDT 200)						0.18 Tr.oz/gal Au } Aurobond TN
														pH 3.4
	SnPb88	SnPb(200 min)/	320	205-560				1.4 Tr.oz/gal Au	177	135-255				9.8 oz/gal Ni
502	A	Ni(150)	361	210-560				pH 9.7	180	135-255	12	40	3.6-2.8	4.0 oz/gal H_3BO_4
	B		291	205-400				(BDT 200)	165	135-190	12	40	3.6-2.7	pH 3.7
	C		288	220-325				1.74 Tr.oz/gal Au	196	175-225	12	40	3.6-2.6	
								pH 11.7						
	SnPb89	SnPb(200 min)/	256	145-360				11.3 oz/gal Free CN^-	207	150-265				10.1 oz/gal Ni
503	A	Ni(150)	280	210-360				(Alautronex 18)	227	200-265				3.9 oz/gal H_3BO_4
	B		243	145-350					211	170-250	12	40	3.6-2.6	pH 3.9
	C		223	175-300					159	150-175	12	40	3.6-2.7	0.52 Tr.oz/gal Au
											12	40	3.6-2.8	pH 8.5 adj to
														5.7 w/HCl
														(Immersion Ni)

TABLE 22. MIL-M-38510 COMPONENT FINISHING (CONTINUED)

Lot Number Identification		Specified Finish System	Primary Finish						Undercoat					
		Primary/Undercoat	Thickness, μin		Plating Conditions			Bath Composition	Thickness, μin		Plating Conditions			Bath Composition
			Avg	Range	Time (min)	Temp (^oC)	Voltage		Avg	Range	Time (min)	Temp (^oC)	Voltage	
	Au82	Au(50)/(Au(20)	120	95-155										
506	A		120	95-155	6	52	1.6				10	64		
	SnPb90	SnPb(200 min)/	290	170-395				1.4 Tr.oz/gal Au	160	120-205				10.2 oz/gal Ni
504	A	Ni(150)	291	170-370				pH 9.6	152	120-175	11	40	3.6-2.8	4.0 oz/gal H_3BO_4
	B		295	170-395				(BDT 200)	161	120-185	11	40	3.6-2.6	pH 3.9
	C		341	275-385					186	165-205	11	40	3.6-2.7	0.51 Tr.oz/gal Au
														pH 5.3
	Au83	Au(150)	210	175-240										(Immersion III)
507	A		210	175-240	9	RT	2.3(6ASF							
	SnPb87	SnPb(200 min)/	270	135-560					175	115-265				
501	A	Ni(150)	261	195-560					173	150-200	13	40	3.6-2.6	
	B		279	185-360					150	115-170	13	40	3.6-2.6	
	C		308	240-380				1.74 Tr.oz/gal Au	228	205-265	13	40	3.6-2.6	9.8 oz/gal Ni
								pH 12.0						3.8 oz/gal H_3BO_4
								11.3 oz/gal Free CN^-						pH 4.0

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