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ISO 9001:2000 Registered Firm

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PERRY JOHNSON REGISTRARS, INC.

Cert No. C2005-01504

TEST REPORT FOR:

PETERS RESEARCH GMBH & CO KG
Hooghe Weg 13
47906 Kempen, Germany

Attn: Geraldine Roskothen

DATE IN:

October 2, 2006

P/O #:

Wire Transfer (PRO6-2909-0657)

SUBMISSION IDENTIFICATION:

Six solder mask coated specimens, identified $2469 SM-HF, were tested in accordance with IPC-SM-840C, Amendment 1, Class T (Telecommunications) and Class H (High Reliability), for Visual, Hydrolytic Stability, and Dielectric Strength.

SUMMARY:

The solder mask, identified as $2469 SM-HF, has met the specified requirements of IPC-SM-840C, Amendment 1, Class T (Telecommunications) and Class H (High Reliability), for Visual, Hydrolytic Stability, and Dielectric Strength.

APPROVED:

Renee J. Michalkiewicz
Laboratory Director

SAMPLE DISPOSITION:

Samples returned to the customer

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VISUAL

TEST SPECIMENS:

Fourteen samples coated with solder mask.

REFERENCE:

IPC-SM-840C, Amendment 1, paragraph 3.4.8.

REQUIREMENT:

The solder mask appearance shall be observed visually in all stages of evaluation, qualification, and conformance inspection with the aid of a magnifying lens rated between 1.75 and 10X magnification unless otherwise specified.

The material shall be uniform in appearance and free of foreign materials, cracks, inclusions, peeling, and roughness that would interfere with the assembly or operation of the printed board. Discoloration of metallic surfaces under the cured solder mask shall be acceptable.

METHOD:

The samples were visually examined using a magnification of 10X. Any defects observed were recorded.

RESULTS:

There was no evidence of cracks, inclusions, peeling, or roughness. The solder mask was uniform in appearance and free of foreign materials.

HYDROLYTIC STABILITY/AGING

TEST SPECIMENS:

Three 4" x 4" copper or copper clad laminates, coated with solder mask.

REFERENCE:

IPC-SM-840C, Amendment 1, paragraph 3.6.2.

REQUIREMENT:

The cured solder mask shall be designated as being able to withstand 97 $\pm 2^{o}$C, 90-98% RH for a duration of 28 days, without an irreversible change of state. Resistance to reversion shall be determined by examining the appearance and surface tackiness in accordance with TM 2.6.11C of IPC-TM-650.

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METHOD:

A saturated solution of distilled water and potassium sulfate (35 grams per 100 cc) was prepared and heated to 97 ±2°C. The solution was poured into a desiccator to a level just below the ceramic plate. Crystals of potassium sulfate remained visible in the saturated solution. The ceramic plate was placed in the desiccator and a rack was placed in the center of the plate. The specimens were placed in the rack, vertically (the samples did not touch one another). The desiccator lid was sealed with a high temperature silicone grease. The desiccator, containing the samples, was placed in a Blue-M oven which had been preset to 97 ±2°C. The test was run for twenty-eight (28) days. After the required time exposure, the specimens were removed from the desiccator. The appearance of each sample was visually examined and any defects were recorded. The surface tackiness was performed by touching the solder mask with a swab of absorbent cotton. The solder mask was then examined for cotton particles adhering to the coating.

RESULTS:

There was no evidence of reversion. There was no evidence of cotton particles adhering to the solder mask surface.

(Meets the specified requirement)

DIELECTRIC STRENGTH

TEST SPECIMENS:

Three 4" x 4" copper or copper clad (one side) laminates containing a 3" x 3" square of the solder mask in the center of each sample.

REFERENCE:

IPC-SM-840C, Amendment 1, paragraph 3.8.1.

REQUIREMENT:

When tested in accordance with TM 2.5.6.1A of IPC-TM-650, the solder mask material shall meet or exceed the minimum value of 500 VDC per 0.025 mm (0.001") of thickness. Thickness of solder mask less than 0.025 mm (0.001") shall meet an absolute minimum breakdown voltage of 500 volts DC.

METHOD:

A ground terminal of a Hi-Pot Tester was clipped over the thickness of the copper cladding and substrate, being careful not to let the clip extend inward to the polymer coating. A positive electrode was placed on top of the test panel at the center making certain the electrode and clip were electrically isolated by the test polymer film. A

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voltage of direct current was applied in 500 volt increments per second until failure occurred.

RESULTS:

Specimens	Solder Mask Thickness (mils)	Voltage Breakdown (VDC)	Volts/Mil
1	1.8	2,500	1,389
2	1.7	2,000	1,176
3	1.6	2,500	1,563

Trace Laboratories-East certifies that the test equipment used complies with the calibration test purposes of ISO 10012-1, ANSI/NCSL Z540-1-1994, and MIL-STD-45662A and that the data contained in this report is accurate within the tolerance limitation of this equipment.

All test procedures detailed within this report are complete. The results in this report relate only to those items tested. If any additional information or clarification of this report is required, please contact us. This test report shall not be reproduced except in full, without the written approval of Trace Laboratories-East.

See attached certificates to determine if testing performed within this report is covered under our A2LA Scope of Accreditation.

Thank you for selecting Trace Laboratories-East for your testing requirements.

Debora L. Obitz
Senior Engineer

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TEST REPORT FOR:

PETERS RESEARCH GMBH & CO KG
Hooghe Weg 13
47906 Kempen, Germany

Attn: Geraldine Roskothen

DATE IN:

October 2, 2006

P/O #:

Wire Transfer (PRO6-2909-0657)

SUBMISSION IDENTIFICATION:

Twenty-four solder mask coated test samples, identified as $2469 SM-HF, on FR-4 laminate with copper patterns, were tested in accordance with IPC-SM-840C, Amendment 1, Column B, Classes T (Telecommunications) and H (High Reliability).

SUMMARY:

The solder mask, identified as $2469 SM-HF, has met the specified requirements of IPC-SM-840C, Amendment 1, Column B, Classes T (Telecommunications) and H (High Reliability).

APPROVED:

Renee J. Michalkiewicz
Laboratory Director

SAMPLE DISPOSITION:

Samples returned to the customer

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VISUAL

TEST SPECIMENS:

Twenty-four IPC-B-25A boards coated with solder mask.

REFERENCE:

IPC-SM-840C, Amendment 1, paragraph 3.4.8.

REQUIREMENT:

The solder mask appearance shall be observed visually in all stages of evaluation, qualification, and conformance inspection with the aid of a magnifying lens rated between 1.75 and 10X magnification unless otherwise specified.

The material shall be uniform in appearance and free of foreign materials, cracks, inclusions, peeling, and roughness that would interfere with the assembly or operation of the printed board. Discoloration of metallic surfaces under the cured solder mask shall be acceptable.

METHOD:

The samples were visually examined using a magnification of 10X. Any defects observed were recorded.

RESULTS:

There was no evidence of cracks, inclusions, peeling, or roughness. The solder mask was uniform in appearance and free of foreign materials.

MACHINABILITY

TEST SPECIMENS:

Three IPC-B-25A boards coated with solder mask.

REFERENCE:

IPC-SM-840C, Amendment 1, paragraph 3.5.3.

REQUIREMENT:

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The cured solder mask applied over the base laminate shall not be cracked or torn more than that observed on the substrate used when subjected to drilling, routing, sawing or punching that is normally associated with the printed board manufacturing process when visually examined with 20/20 corrected vision without magnification.

METHOD:

The boards were subjected to drilling, routing, sawing and punching. They were then visually examined with 20/20 corrected vision for cracked or torn solder mask.

RESULTS:

The solder mask was not cracked, or torn more than that observed on the substrate.

CURE

TEST SPECIMENS:

Three IPC-B-25A boards coated with solder mask.

REFERENCE:

IPC-SM-840C, Amendment 1, paragraph 3.4.5.

REQUIREMENT:

The cure of solder masks covered by this specification may be functionally determined by meeting the requirements of solvent and cleaning agent resistance (3.6.1.1), solderability (3.7.1), and solder resistance (3.7.2).

Note: Other test methods for monitoring level of cure or control of the curing process are sometimes used. For further information on several of the methods see paragraph 6.3 of IPC-SM-840C.

METHOD:

The test methods, solvent and cleaning agent resistance (3.6.1.1), solderability (3.7.1) and solder resistance (3.7.2) were used to determine cure, and are found elsewhere in the body of this report.

RESULTS:

The solder mask met the requirements of solvent and cleaning agent resistance, solderability, and solder resistance. The solder mask was properly cured.

PENCIL HARDNESS

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TEST SPECIMENS:

Three IPC-B-25A boards coated with solder mask.

REFERENCE:

IPC-SM-840C, Amendment 1, paragraph 3.5.1.

REQUIREMENT:

When tested in accordance with IPC-TM-650, method 2.4.27.2A, the cured solder mask shall not be scratched by a pencil, which is softer than an "F" hardness.

METHOD:

Each board, tested individually, was placed on a firm horizontal surface. Starting with the hardest (6H) pencil, it was pressed firmly against the solder mask at a 45° angle away from the operator in a downward and forward motion. With the next softest pencil, the test was repeated until a pencil was found that did not cut or gouge the solder mask. The pencil hardness was recorded.

The specimens were then baked at 105°C for one hour. They were then placed in a desiccator to cool to room temperature. After cooling the specimens were immersed in flux for 10 seconds. The flux used was a standard activated rosin flux (Type ROL1 per J-STD-004) having a composition of 25% ±0.05% by weight of colophony and 0.15% ±0.01% by weight diethylammonium Hydrochloride (CAS 660-68-4), in 74.85% ±0.5% by weight of isopropyl alcohol. The specimens were placed in a rack in the vertical position for 30 seconds to drain the excess flux. The dross and residual flux was removed from the surface of the molten solder prior to testing. The specimens, tested individually, were slid onto the surface of molten solder. The specimens were floated on the solder for 5 seconds. The molten solder was maintained at a temperature of 452°F. After floating, the specimens were cooled and the residual flux was removed with isopropyl alcohol. The pencil test was repeated using the above. The pencil hardness was recorded.

RESULTS:

The pencil hardness that did not cut or gouge the solder mask before solder exposure was 6H.

The pencil hardness that did not cut or gouge the solder mask after solder exposure was 6H.

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ADHESION – RIGID

TEST SPECIMENS:

Three IPC-B-25A boards coated with solder mask.

REFERENCE:

IPC-SM-840C, Amendment 1, paragraph 3.5.2 and 3.5.2.1.

REQUIREMENT:

The adhesion of the cured solder to melting (e.g. tin-lead or bright acid tin when exposed above its melting point) or to non-melting (e.g. copper, nickel, etc.) metals shall be determined in accordance with IPC-TM-650, method 2.4.28.1D.

The maximum percentage of cured solder mask lifted from the surface of the rigid base material or conductive material of the checker board pattern prior to and subsequent to exposure to solder per 3.7.1 shall be in accordance with Table 2.

Table 2 Adhesion to Rigid Boards
(IPC-B-25A Board and/or Production Board)

Surface	Maximum Percentage Loss Allowed Class T and H
Bare copper	0
Gold or Nickel	5
Base Laminate	0
Melting Metals, (Tin-Lead Plating, Fused Tin-Lead, and Bright Acid Tin)	10

Note: While it is recognized that solder mask has little adherence to tin/lead after is reflows, the solder mask should have sufficient integrity to remain intact during tape testing to meet the requirements of Table 2. See paragraph 6.4 of IPC-SM-840C, Amendment 1.

METHOD:

A strip of pressure sensitive tape (3M Brand 600) ½" X 2" long was pressed firmly across the checker board pattern eliminating the air bubbles. The tape fully covered the area being tested. The tape was pulled with a rapid snap pull approximately 90° to the pattern. An unused strip of tape was used for each specimen.

The specimens were then baked at 105°C for one hour. They were then placed in a desiccator to cool to room temperature. After cooling the specimens were

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immersed in flux for 10 seconds. The flux used was a standard activated rosin flux (Type ROL1 per J-STD-004) having a composition of 25% ±0.05% by weight of colophony and 0.15% ±0.01% by weight diethylammonium Hydrochloride (CAS 660-68-4), in 74.85% ±0.5% by weight of isopropyl alcohol. The specimens were placed in a rack in the vertical position for 30 seconds to drain the excess flux. The dross and residual flux was removed from the surface of the molten solder prior to testing. The specimens, tested individually, were slid onto the surface of molten solder. The specimens were floated on the solder for 5 seconds. The molten solder was maintained at a temperature of 452°F. After floating, the specimens were cooled and the residual flux was removed with isopropyl alcohol. The adhesion test was repeated using the above.

RESULTS:

There was no solder mask removed from the laminate or conductive surfaces before solder exposure.

There was no solder mask removed from the laminate or conductive surfaces after solder exposure.

RESISTANCE TO SOLVENTS AND CLEANING AGENTS

TEST SPECIMENS:

Six IPC-B-25A boards coated with solder mask.

REFERENCE:

IPC-SM-840C, Amendment 1, paragraph 3.6.1.1.

REQUIREMENT:

The cured solder mask coating should be tested by the printed board fabricator and/or his user for resistance to those solvents, cleaning agents, fluxes, or other chemicals which are encountered in the intended manufacturing, repair, and maintenance processes and to the end use environment to which the production board system will or may be subjected, and are not specified herein.

The cured solder mask coating shall not exhibit a degradation in surface characteristics, such as surface roughness, swelling, tackiness, blistering, or color change, as shall be determined by exposing the specimens to the conditions listed in Table 3. Resistance to each agent shall be tested separately. New specimens shall be used for each agent. After immersion, specimens shall be hung to dry for ten minutes at ambient laboratory conditions, after which they are to be visually examined with 20/20 corrected vision without magnification for surface degradation such as roughness, blisters, delamination, cracking, swelling, and color change.

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METHOD:

Each of the boards was exposed ton one of the solvents/cleaning agents listed in Table 3.

Table 3 Resistance to Solvents and Cleaning Agents

Solvent/ Cleaning Agent	Test Conditions	
	Temperature	Time (minutes)
Isopropanol	Standard Laboratory, Room	2
75% Isopropanol/25% Water	46 ± 2°C	15
D-Limonene	Standard Laboratory, Room	2
10% Alkaline detergent (for example, ≤40% alkanolamine, ≤20% 2-butoxyethanol, ≤20% glycol ether and the remaining 90% water, pH ≤13	57 ± 2°C	2
Monoethanolamine	57 ±2°C	2
Deionized Water	60 ±2°C	5

After exposure, the samples were hung to dry for 10 minutes at ambient laboratory conditions. After drying, the specimens were examined with 20/20 corrected vision for surface degradation such as roughness, blisters, delamination, cracking, swelling, and color change.

RESULTS:

The solder mask did not exhibit any roughness, blisters, delamination, cracking, swelling, and color change after exposure to the solvents/cleaning agents listed in Table 3.

SOLDERABILITY

TEST SPECIMENS:

Three IPC-B-25A boards coated with solder mask.

REFERENCE:

IPC-SM-840C, Amendment 1, paragraph 3.7.1.

REQUIREMENT:

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The solder mask coating shall not adversely affect the solderability of the are as which were intended to be soldered when tested as specified in accordance with ANSI/J-STD-003.

METHOD:

The specimens were baked at 105°C for one hour. They were then placed in a desiccator to cool to room temperature. After cooling the specimens were immersed in flux for 10 seconds. The flux used was a standard activated rosin flux (Type ROL1 per J-STD-004) having a composition of 25% ±0.05% by weight of colophony and 0.15% ±0.01% by weight diethylammonium Hydrochloride (CAS 660-68-4), in 74.85% ±0.5% by weight of isopropyl alcohol. The specimens were placed in a rack in the vertical position for 30 seconds to drain the excess flux. The dross and residual flux was removed from the surface of the molten solder prior to testing. The specimens, tested individually, were slid onto the surface of molten solder. The specimens were floated on the solder for 5 seconds. The molten solder was maintained at a temperature of 452°F. After floating, the specimens were cooled and the residual flux was removed with isopropyl alcohol. The samples were examined to ensure that the solder mask did not adversely affect the solderability of the areas intending to be soldered.

RESULTS:

The solder mask coating did not adversely affect the solderability of the areas, which were intended to be soldered.

RESISTANCE TO SOLDER

TEST SPECIMENS:

Three IPC-B-25A boards coated with solder mask.

REFERENCE:

IPC-SM-840C, Amendment 1, paragraph 3.7.2.

REQUIREMENT:

Immediately after exposure to solder, inspect visually in accordance with paragraph 3.4.8 (Visual Requirements) for the resistance of solder mask to accept solder. This is also an indication of acceptable cure.

METHOD:

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The specimen shall completely resist the adherence of solder when tested as follows:

The specimens were coated with a Type "M" flux per J-STD-004. A Type "M" flux is moderate flux/flux residue activity. The specimens were held at ambient temperature for five minutes. Each specimen tested individually, was placed on molten solder maintained at 260°C for 10 seconds. The above procedure was repeated until all of the specimens were exposed to solder. After solder exposure the specimens were visually examined using between 1.75X - 10X magnification for the ability of the solder mask to resist the adherence of solder.

RESULTS:

There was no solder adhering to the surface of the solder mask.

INSULATION RESISTANCE

TEST SPECIMENS:

One bare and two IPC-B-25A boards coated with solder mask.

REFERENCE:

IPC-SM-840C, Amendment 1, paragraph 3.8.2.

REQUIREMENT:

The solder mask coated sample shall have a minimum insulation resistance, in either standard or production board systems, before and after performing the resistance to solder test of 3.7.2. The insulation resistance of the production board system shall be determined in accordance with the initial ambient temperature insulation resistance measurement of IPC-TM-650, method 2.6.3.1.

A minimum insulation resistance of 500 (5.0×10^8 ohms) shall be acceptable when measured on a comb or "Y" pattern with a minimum spacing greater than or equal to 0.125mm (0.005").

METHOD:

Teflon insulated wires were soldered on the finger tabs, of the D-comb pattern for Class H and the E and F – comb patterns for Class T, of the bare and before solder exposure boards. The flux was not removed.

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The remaining board was baked at 105°C for one hour. It was then placed in a desiccator to cool to room temperature. After cooling the specimen was immersed in flux for 10 seconds. The flux used was a standard activated rosin flux (Type ROL1 per J-STD-004) having a composition of 25% ±0.05% by weight of colophony and 0.15% ±0.01% by weight diethylammonium Hydrochloride (CAS 660-68-4), in 74.85% ±0.5% by weight of isopropyl alcohol. The specimen was placed in a rack in the vertical position for 30 seconds to drain the excess flux. The dross and residual flux was removed from the surface of the molten solder prior to testing. The specimen was slid onto the surface of molten solder. The specimen was floated on the solder for 5 seconds. The molten solder was maintained at a temperature of 452°F. After floating, the specimen was cooled and the residual flux was removed with isopropyl alcohol. Teflon insulated wires were soldered on the finger tabs, of the D-comb pattern for Class H and the E and F – comb patterns for Class T.

The insulation resistance was obtained with a high resistance meter using a test voltage of 100VDC which was applied to the individual test points for one minute prior to obtaining each measurement. The measurements were recorded.

RESULTS:

Class T

Specimen	Comb Pattern	Insulation Resistance (megohms)
Bare Board	E	5.9×10^7
	F	6.0×10^7
Before Solder	E	3.9×10^7
	F	2.8×10^7
After Solder	E	1.4×10^7
	F	3.6×10^7

Class H

Specimen	Initial Insulation Resistance Measurements (megohms)			
	1 – 2	2 - 3	3 - 4	4 - 5
Bare Board	2.5×10^7	1.6×10^7	3.0×10^7	3.5×10^7
Before Solder	4.6×10^7	3.2×10^7	5.2×10^7	2.6×10^7
After Solder	3.7×10^7	4.8×10^7	3.8×10^7	3.9×10^7

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MOISTURE AND INSULATION RESISTANCE
Class T

TEST SPECIMENS:

One bare and two IPC-B-25A boards coated with solder mask.

REFERENCE:

IPC-SM-840C, Amendment 1, paragraph 3.9.1.

REQUIREMENT:

The solder mask coated board shall withstand the conditions listed in Table 4 without exhibiting blistering or separation.

Table 4 Moisture and Insulation Resistance

Class	Test Temperature	Test Humidity	Bias Voltage VDC	Test Voltage VDC	Duration	Test Pattern	Requirements
T	65° ±2°C	90 ±3%	0	100	24 hours	E and F, C	500
H	25° to 65° ±2°C	90, -5, +3%	50	100	6 2/3 days	D, C	500

The average insulation resistance shall exceed 500 megohms (5.0×10^8 ohms).

No individual insulation resistance value may be less than 0.1 X IR_{min}. Two measurements may be excluded from calculating the average (see Note 6.3) if there is an assignable cause of low insulation resistance that can be attributable to the laminate itself or to the process used to produce the board. Such assignable causes include:

- Contamination on the insulating surface of the board such as lint, solder splines, or waterdroplets from the conditioning chamber.
- Incompletely etched patterns that decrease the insulating space between conductors by more than amount allowed in the appropriate design the requirements drawing.
- Scratched, cracked, or obviously damaged insulation between conductors.

The average insulation resistance (IR_{avg}) was calculated from:

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$$IR_{avg} = 10^{\left\{\frac{1}{N}\sum_{1}^{N}\log IR_i\right\}}$$

Where: *N = Number of test points*
IR_i = Individual insulation resistance measurements.

METHOD:

Teflon insulated wires were soldered on the finger tabs of the E and F – comb patterns of the bare and before solder exposure boards. The flux was not removed. The remaining board was baked at 105°C for one hour. It was then placed in a desiccator to cool to room temperature. After cooling the specimen was immersed in flux for 10 seconds. The flux used was a standard activated rosin flux (Type ROL1 per J-STD-004) having a composition of 25% ±0.05% by weight of colophony and 0.15% ±0.01% by weight diethylammonium Hydrochloride (CAS 660-68-4), in 74.85% ±0.5% by weight of isopropyl alcohol. The specimen was placed in a rack in the vertical position for 30 seconds to drain the excess flux. The dross and residual flux was removed from the surface of the molten solder prior to testing. The specimen was slid onto the surface of molten solder. The specimen was floated on the solder for 5 seconds. The molten solder was maintained at a temperature of 452°F. After floating, the specimen was cooled and the residual flux was removed with isopropyl alcohol.

The specimens were placed in an oven maintained at 50 ± 2°C for 24 hours. The specimens were cooled. The initial insulation resistance measurements were obtained with an applied test voltage of 100 VDC (which had been applied for 1 minute prior to taking the measurements). The specimens were placed in a chamber in the vertical position. The wires were dressed to the outside of the chamber through a port. The doors and port were closed and the chamber was brought to a temperature of 65°C and 90% RH. The specimens were stabilized at these test conditions for 24 hours. After 24 hours, the insulation resistance was again obtained with an applied test voltage of 100 VDC, for one minute. The insulation resistance readings were averaged. After completion of all electrical testing, the test specimens were examined for mealing, blisters, delamination or other forms of degradation following 24-hour stabilization at ambient laboratory conditions.

RESULTS:

The average insulation resistance measurement is 1.32×10^4 megohms.

There was no evidence of mealing, blistering, delamination or other forms of degradation of the solder mask.

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Specimen	Comb Pattern	Insulation Resistance (megohms)
Bare Board	E	2.5×10^4
	F	3.2×10^4
Before Solder	E	1.6×10^3
	F	5.0×10^4
After Solder	E	3.0×10^3
	F	2.8×10^3

MOISTURE AND INSULATION RESISTANCE
Class H

TEST SPECIMENS:

One bare and two IPC-B-25A boards coated with solder mask.

REFERENCE:

IPC-SM-840C, Amendment 1, paragraph 3.9.1.

REQUIREMENT:

The solder mask coated board shall withstand the conditions listed in Table 4 without exhibiting blistering or separation.

Table 4 Moisture and Insulation Resistance

Class	Test Temperature	Test Humidity	Bias Voltage VDC	Test Voltage VDC	Duration	Test Pattern	Requirements
H	25° to 65° ±2°C	90, -5, +3%	50	100	6 2/3 days	D, C	500

METHOD:

Teflon insulated wires were soldered on the finger tabs of the E and F – comb patterns of the bare and before solder exposure boards. The flux was not removed. The remaining board was baked at 105°C for one hour. It was then placed in a desiccator to cool to room temperature. After cooling the specimen was immersed in flux for 10 seconds. The flux used was a standard activated rosin flux (Type ROL1 per J-STD-004) having a composition of 25% ±0.05% by weight of colophony and 0.15% ±0.01% by weight diethylammonium Hydrochloride (CAS 660-68-4), in 74.85% ±0.5% by weight of isopropyl alcohol. The specimen was placed in a rack in the vertical position for 30 seconds to drain the excess flux. The dross and residual flux was removed from the surface of the molten solder prior to testing. The specimen was slid onto the surface of molten solder. The specimen was floated on the solder for 5 seconds. The molten solder was maintained at a

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temperature of 452°F. After floating, the specimen was cooled and the residual flux was removed with isopropyl alcohol.

The specimens were placed in an oven maintained at 50 ± 2°C for 24 hours. The specimens were cooled. The initial insulation resistance measurements were obtained with an applied test voltage of 100 VDC (which had been applied for 1 minute prior to taking the measurements). The specimens were then placed in a humidity chamber. A polarizing voltage of 50 VDC was applied using a power supply, for the duration of the chamber time. The 1, 3, and 5 test points were connected to the positive terminal and the 2 and 4 test points were connected to the negative terminal. The test specimens were exposed to 20 cycles of temperature and humidity. Polarizing voltage was maintained throughout the entire 20-cycle period. Humidity was maintained at 85% minimum through the cycles, except at the low temperature, step (c), the humidity was maintained at 80% minimum.

One cycle is as follows:

a) Start test at 25°C and raise temperature to 65°C over a time span of 1.75 ± 0.75 hours.

b) Maintain temperature at 65°C for 3, ± 0.5, -0 hours.

c) Lower temperature from 65 to 25°C over 1.75 ± 0.5 hours.

Note: There shall be no delay between cycles.

While in the chamber the insulation resistance was measured and recorded once every 24 hours. The polarizing voltage of 50 VDC was disconnected prior to taking the readings. The measurements, while in the chamber, were taken between hours 2 and 3 of the high temperature phase of each cycle.

After completion of the 20 cycles, the bias voltage was disconnected and the specimens were removed from the chamber. The measurements were taken after an hour and before two hours at ambient laboratory conditions.

Note: Each test specimen shall be evaluated for insulation resistance quality following and/or during the stated conditions. Although several insulation resistance readings are taken during the test only the final readings in the chamber and the reading taken outside the chamber shall be used to determine pass/fail criteria. (Other readings are optional and may be used for diagnostic information of aborting the test).

After completion of all electrical testing, the test specimens were examined for mealing, blisters, delamination or other forms of degradation following 24-hour stabilization at ambient laboratory conditions.

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RESULTS:

The insulation resistance measurements exceed the requirement of 500 megohms (5.0×10^8 ohms).

Specimen	Initial Insulation Resistance Measurements (megohms) 1 – 2	2 - 3	3 - 4	4 - 5
Bare Board	2.5×10^7	1.6×10^7	3.0×10^7	3.5×10^7
Before Solder	4.6×10^7	3.2×10^7	5.2×10^7	2.6×10^7
After Solder	3.7×10^7	4.8×10^7	3.8×10^7	3.9×10^7
Final Inside Chamber				
Bare Board	2.3×10^5	1.2×10^5	3.6×10^5	3.8×10^5
Before Solder	4.5×10^4	3.3×10^4	3.4×10^4	4.3×10^4
After Solder	5.6×10^4	4.9×10^4	4.1×10^4	2.4×10^4
Final Outside Chamber				
Bare Board	1.0×10^7	9.6×10^6	7.8×10^6	1.5×10^7
Before Solder	1.1×10^7	1.2×10^7	9.8×10^6	1.3×10^7
After Solder	1.2×10^7	1.0×10^7	6.9×10^6	7.7×10^6

There was no evidence of blistering, separation, or degradation of the solder mask.

ELECTROCHEMICAL MIGRATION
Class T

TEST SPECIMENS:

Three IPC-B-25A boards coated with solder mask.

REFERENCE:

IPC-SM-840C, Amendment 1, paragraph 3.9.2.

REQUIREMENT:

The solder mask coated board shall not exhibit evidence of electrochemical migration when tested as specified in accordance with Table 5 and IPC-TM-650, method 2.6.14C.

Table 5 Electrochemical Migration

Class	Test Temperature	Test Humidity	Bias Voltage VDC	Test Voltage VDC	Duration	Test Pattern	Requirements
T	85° ±2°C	85% minimum	10	45 – 100	500 hours	D, C	< 1 decade drop in

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							resistance

The average insulation resistance value shall not degrade by more than a decade as a result of the applied bias, i.e.:

$$IR_{final} \geq \frac{IR_{initial}}{10}$$

Where an assignable cause of low insulation resistance, which is properly attributable to the laminate itself or the process used to produce the PWB, can be found, then such a value can be excluded from calculating the average value provided that 15 (of the original 16) test points are included in the average. Such assignable causes include:

- Contamination on the insulating surface of the board such as lint, solder splines, or water droplets from the conditioning chamber.
- Incompletely etched patterns that decrease the insulating space between conductors by more than the amount allowed in the appropriate design requirements drawing.
- Scratched, cracked, or obviously damaged insulation between conductors.

After completion of the electromigration test, the test samples shall be removed from the test chamber and examined, with back-lighting, at 10X magnification.

METHOD:

Teflon insulated wires were soldered to the D pattern of the IPC-B-25A boards. The flux was not removed.

The terminated test patterns were placed in a humidity chamber in a suitable rack that maintained the patterns at least 1/2 inch apart. Airflow was not obstructed by the test patterns.

The rack was placed approximately in the center of the temperature/humidity chamber, oriented to align the test patterns parallel to the chamber airflow. The wires were routed to the outside of the chamber. The wiring was dressed away from the test patterns.

The chamber was closed, and the samples were allowed to stabilize for 96 hours at test conditions of 85^{o}C with 85% minimum relative humidity.

After 96 hours stabilization period, the insulation resistance measurements were made using 50 volts DC. Measurements were made between terminals 1 and 2, 2 and 3, 3 and 4, and 4 and 5. Measurements were made with the patterns under

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test conditions. Terminals 2 and 4 were at one potential, and terminals 1, 3, and 5 at the opposite potential.

The samples were then connected to the power supply with the current limiting resistors in-circuit, and 10 volts DC was applied for the duration of the test. The test polarity was the same as the measurements polarity previously used. After 404 hours (500 hours total test time), the power supply was disconnected and the measurements repeated, as previously stated.

After testing, the average insulation resistance (IR_{avg}) was calculated from the following equation:

$$IR_{avg} = 10^{\left\{ \frac{1}{N} \sum_{1}^{N} \log IR_i \right\}}$$

Where:

N = Number of test points
IR_i = Individual insulation resistance measurements.

RESULTS:

The average insulation resistance did not degrade by more than a decade as a result of the applied bias. The resistance measurements in ohms are as follows:

96 Hours	500 Hours
1.17×10^8	1.75×10^7

There was no evidence of electrochemical migration on the test samples.

ELECTROCHEMICAL MIGRATION
Class H

TEST SPECIMENS:

Three IPC-B-25A boards coated with solder mask.

REFERENCE:

IPC-SM-840C, Amendment 1, paragraph 3.9.2.

REQUIREMENT:

The solder mask coated board shall not exhibit evidence of electrochemical migration when tested as specified in accordance with Table 5 and IPC-TM-650, method 2.6.14C.

Table 5 Electrochemical Migration

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Class	Test Temperature	Test Humidity	Bias Voltage VDC	Test Voltage VDC	Duration	Test Pattern	Requirements
T	85° ±2°C	85% minimum	10	45 – 100	500 hours	D, C	< 1 decade drop in resistance
H	85° ±2°C	90%	10	10	168 hours	D, C	Resistance ≥ 2 megohms

METHOD:

Teflon insulated wires were soldered onto the terminals of the test boards. The flux was not removed.

The boards were then placed in a humidity chamber. The temperature was set at 85°C with 90% relative humidity.

The wires were connected to a power supply capable of supplying 10 VDC. A 10 megohm resistor was placed in the appropriate line. The chamber was activated and the test conditions, 85°C with 90%RH, were obtained. The test ran for 168 hours (7 days). At the completion of the 168 hours, the samples were returned to ambient conditions and the resistance measurements were recorded. After obtaining the resistance measurements, the samples were examined for electrochemical migration with backlighting and 10X magnification.

RESULTS:

The minimum insulation resistance measurements in megohms are as follows:

Before Chamber Conditioning	After Chamber Conditioning
2.6×10^8	1.8×10^3

The boards did not exhibit any electrochemical migration.

THERMAL SHOCK

TEST SPECIMENS:

Six IPC-B-25A boards coated with solder mask.

REFERENCE:

IPC-SM-840C, paragraph 3.9.3

REQUIREMENT:

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The solder mask coated board and/or solder masked board conformally coated with a coating per IPC-CC-830 shall be required to pass all visual testing specified in 3.4.8 and shall not exhibit blistering, crazing, or delamination when tested in accordance with IPC-TM-650, method 2.6.7.3, for the conditions shown in Table 6. When conformal coating is used, a crack in the solder mask is not sufficient reason for rejection unless the conformal coating is cracked. Prior to thermal shock testing specimens shall be exposed to solder per paragraph 3.7.1.

Table 6 Thermal Shock Conditions

Class	Temperature	Number of Cycles
T (only when specified)	-65 to +125°C	100
H	-65 to +125°C	100

METHOD:

The boards were baked at 105°C for one hour. They were then placed in a desiccator to cool to room temperature. After cooling the specimens were immersed in flux for 10 seconds. The flux used was a standard activated rosin flux (Type ROL1 per J-STD-004) having a composition of 25% ±0.05% by weight of colophony and 0.15% ±0.01% by weight diethylammonium Hydrochloride (CAS 660-68-4), in 74.85% ±0.5% by weight of isopropyl alcohol. The specimens were placed in a rack in the vertical position for 30 seconds to drain the excess flux. The dross and residual flux was removed from the surface of the molten solder prior to testing. The specimens, tested individually, were slid onto the surface of molten solder. The specimens were floated on the solder for 5 seconds. The molten solder was maintained at a temperature of 452°F. After floating, the specimens were cooled and the residual flux was removed with isopropyl alcohol.

Three samples were coated with conformal coating with a coating complying with IPC-CC-830. The coating was cured per manufacturer's instructions. The six boards were placed in the center of a thermal shock chamber. The cold chamber was set at -65^{o}C, and the hot portion of the chamber was set at 125^{o}C. The dwell time was set at 15 minutes. The transfer time was less than 2 minutes.

The chamber was set for 100 cycles. Upon completion of the 100 cycles, the boards were removed from the chamber and the specimens were visually inspected for blistering, crazing, delamination, and cracking with 10X magnification.

RESULTS:

There was no evidence of blistering, crazing, delamination, or cracking of the solder mask.

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Trace Laboratories-East certifies that the test equipment used complies with the calibration test purposes of ISO 10012-1, ANSI/NCSL Z540-1-1994, and MIL-STD-45662A and that the data contained in this report is accurate within the tolerance limitation of this equipment.

All test procedures detailed within this report are complete. The results in this report relate only to those items tested. If any additional information or clarification of this report is required, please contact us. This test report shall not be reproduced except in full, without the written approval of Trace Laboratories-East.

See attached certificates to determine if testing performed within this report is covered under our A2LA Scope of Accreditation.

Thank you for selecting Trace Laboratories-East for your testing requirements.

ANALYTICAL TEAM:

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Daniel D. Phillips
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Debora L. Obitz
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TEST REPORT FOR:

PETERS RESEARCH
GmbH + Co KG
Postfach 10 05 20, D-47882 Kempen
Hooghe Weg 13, D-47906 Kempen

Attn: Geraldine Roskothen

DATE IN:

May 21, 2008

P/O #:

PR-08-1305-0312

SUBMISSION IDENTIFICATION:

Three separate lots of solder mask coated test samples, identified as *"ELPEMER® $ 24%3 FLEX-HF"*, *"ELPEMER® $ 2469 SM-HF"* and *"ELPEMER® $ 24%7 ##"* on FR-4 laminate with copper patterns, were tested for Adhesion of Layered or Double Coated Solder Mask, Resistance to Lead-Free Solder and Resistance to Lead-Free Reflow in accordance with IPC-SM-840D.

SUMMARY:

The solder mask, identified as *"ELPEMER® $ 24%3 FLEX-HF"*, *"ELPEMER® $ 2469 SM-HF"* and *"ELPEMER® $ 24%7 ##"*, has **met** the specified requirements of IPC-SM-840D.

APPROVED:

Renee J. Michalkiewicz
Laboratory Director

SAMPLE DISPOSITION: Samples returned to the customer

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RESISTANCE TO LEAD-FREE SOLDER

TEST SPECIMENS:

Three IPC-B-25A boards coated with solder mask.

REFERENCE:

IPC-SM-840D, paragraph 3.7.3.

REQUIREMENT:

Immediately after exposure to solder, inspect visually in accordance with paragraph 3.3 (Visual Requirements) for the resistance of solder mask to accept solder. This is also an indication of acceptable cure.

METHOD:

The specimen shall completely resist the adherence of solder when tested as follows:

The specimens were coated with a ROM0 or ROM1 flux per J-STD-004. A Type "M0" or "M1" flux is moderate flux/flux residue activity. The specimens were held at ambient temperature for five minutes. Each specimen tested individually, was placed on molten solder maintained at 260°C for 10 seconds. The above procedure was repeated until all of the specimens were exposed to solder. After solder exposure the specimens were visually examined using between 1.75X - 10X magnification for the ability of the solder mask to resist the adherence of solder.

RESULTS:

There was no solder adhering to the surface of the solder mask.

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RESISTANCE TO LEAD-FREE REFLOW

TEST SPECIMENS:

Three IPC-B-25A boards that have been tested for resistance to lead-free solder adherence per 3.7.3.

REFERENCE:

IPC-SM-840D, paragraph 3.7.3.1.

REQUIREMENT:

Immediately after the fifth exposure to solder, inspect visually in accordance with paragraph 3.3 (Visual Requirements) for the resistance of solder mask to accept solder. This is also an indication of acceptable cure.

METHOD:

The specimen shall completely resist the adherence of solder when tested as follows:

The three IPC-B-25A boards that have been tested for resistance to lead-free solder adherence per 3.7.3 are to be subjected to five additional solder. The specimens were coated with a ROM0 or ROM1 flux per J-STD-004. A Type "M0" or "M1" flux is moderate flux/flux residue activity. The specimens were held at ambient temperature for five minutes. Each specimen tested individually, was placed on molten solder maintained at 260°C for 10 seconds. The above procedure was repeated until all of the specimens were exposed to solder. After the fifth solder exposure, the specimens were visually examined using between 1.75X - 10X magnification for the ability of the solder mask to resist the adherence of solder.

RESULTS:

There was no solder adhering to the surface of the solder mask.

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ADHESION TO OTHER SOLDER MASK MATERIALS

TEST SPECIMENS:

Three IPC-B-25A boards coated with solder mask.

REFERENCE:

IPC-SM-840D, paragraph 3.5.2.6.

REQUIREMENT:

When multiple layers of solder masks are applied, the adhesion between layers shall be determined in accordance with IPC-TM-650, method 2.4.28.1F.

The maximum percentage of cured solder mask lifted from the surface of the rigid base material or conductive material of the checker board pattern prior to and subsequent to exposure to solder per 3.7.3 shall be in accordance with Table 3-2. These requirements also apply to any touch-up performed.

Table 3-2 Adhesion to Rigid Printed Boards
(IPC-B-25A Board and/or Production Board)

Surface	Maximum Percentage Loss Allowed Class T and H
Bare copper	0
Gold or Nickel	5
Base Laminate	0
Melting Metals, (Tin-Lead Plating, Fused Tin-Lead, and Bright Acid Tin)	10

METHOD:

A strip of pressure sensitive tape (3M Brand 600) ½" X 2" long was pressed firmly across the checkerboard pattern eliminating the air bubbles. The tape fully covered the area being tested. The tape was pulled with a rapid snap pull approximately 90° to the pattern. An unused strip of tape was used for each specimen.

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The specimens were then baked at 135°C for a minimum of six hours. They were then placed in a desiccator to cool to room temperature. After cooling, the specimens were immersed in flux for 10 seconds. The flux used was a standard activated rosin flux (Type ROM0 or ROM1 per J-STD-004). The specimens were placed in a rack in the vertical position for 5 minutes to drain the excess flux. The dross and residual flux was removed from the surface of the molten solder prior to testing. The specimens, tested individually, were slid onto the surface of molten solder. The specimens were floated on the solder for 10 seconds. The molten solder was maintained at a temperature of 500°F. After floating, the specimens were cooled and the residual flux was removed with isopropyl alcohol. The adhesion test was repeated using the above.

RESULTS:

There was no solder mask removed from the laminate or conductive surfaces before solder exposure.

There was no solder mask removed from the laminate or conductive surfaces after solder exposure.

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Trace Laboratories Inc. certifies that the test equipment used complies with the calibration test purposes of ISO 10012-1, ANSI/NCSL Z540-1-1994, and MIL-STD-45662A and that the data contained in this report is accurate within the tolerance limitation of this equipment.

All test procedures detailed within this report are complete. The results in this report relate only to those items tested. If any additional information or clarification of this report is required, please contact us. This test report shall not be reproduced except in full, without the written approval of Trace Laboratories Inc.

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Michael V. Allison
Engineer