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TEST REPORT FOR:

LACKWERKE PETERS
Postfach 10 05 20, D-47882 Kempen
Hooghe WEG 13, D-47906 Kempen

Attn: Geraldine Roskothen

DATE IN: April 17, 2013

DATE COMPLETED: July 15, 2013

QUOTE REFERENCE: PetersResearch120720

P/O #: PR 13-2203-0176


SUBMISSION IDENTIFICATION:

One lot of specimens conformally coated with material originally identified as ELPEGUARD® SL 1307 FLZ/234 but later changed to ELPEGUARD® SL 1307 FLZ/&4 (colorless) were submitted for qualification testing in accordance with Lackwerke Peters GmbH & Co. KG's statement of work and IEC 61086-2, Class 2. The testing was conducted on four sets of conformally coated test specimens identified as A – D.

SUMMARY:

See page 2 for summary of the test results.

APPROVED:



John M. Radman
Senior Technical Director



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SUMMARY OF TEST RESULTS

Test	Sample	Stage	Results
Specimens A			
Cleanliness	1 - 20	Before coating	Met the requirements
Coating, Thickness	1 - 10	Before coating	Measurements taken on pads 1 - 8
Coating	20		
• Visual Inspection	1 - 20	After coating	Met the requirements
• Thickness	1 - 10	After coating	Met the requirements
• Fluorescence	1 - 20	After coating	Met the requirements
Thermal Cycling Exposure	1 - 20		
• Visual Inspection	1 - 20	After exposure	Met the requirements
Thermal Shock Exposure	1 - 20		
• Visual Inspection	1 - 20	After exposure	Met the requirements
Damp Heat (Moisture Resistance)	1 - 5		
• Insulation Resistance	1 - 5	During exposure	Arithmetic Mean Range: 8.6×10^{10} – $1.7 \times 10^{12} \Omega$. Lowest Value: $3.2 \times 10^8 \Omega$
• Breakdown Voltage	1 - 5	After exposure	Lowest breakdown voltage 8.2 kilovolts
Thermal Aging	11 - 15		
• Visual Inspection	11 - 15	After exposure	Met the requirements
• Insulation Resistance	11 - 15	During exposure	Arithmetic Mean Range: 1.1×10^{12} – $1.5 \times 10^{12} \Omega$. Lowest Value: $3.3 \times 10^{11} \Omega$
Salt Mist	16 - 20		
• Insulation Resistance	16 - 20	During exposure	Arithmetic Mean Range: 3.4×10^{11} – $8.6 \times 10^{11} \Omega$. Lowest Value: $1.4 \times 10^9 \Omega$
• Breakdown Voltage	16 - 20	After exposure	Lowest breakdown voltage 10.1 kilovolts





Test	Sample	Stage	Results
Specimens B			
Cleanliness	1 - 15		Met the requirements
Coating	15		
• Visual	1 - 5	After coating	Met the requirements
• Tackiness	1 - 5	After coating	Met the requirements
• Flexibility	1 - 5	After coating	Met the requirements
Thermal Shock	6 - 10		
• Visual Inspection	6 - 10	After exposure	Met the requirements
• Flexibility	6 - 10	After exposure	Met the requirements
Thermal Aging	11 - 15		
• Visual Inspection	11 - 15	After exposure	Met the requirements
• Flexibility	11 - 15	After exposure	Met the requirements
Specimens C			
Cleanliness	1 - 5	Before coating	Met the requirements
Coating	5		
• Visual Inspection	1 - 5	After coating	Met the requirements
Mould Growth, Visual Inspection	1 - 5	After coating	Met the requirements
Specimens D			
Cleanliness	1 - 5	Before coating	Met the requirements
Coating	5		
• Visual Inspection	1 - 5	After coating	Met the requirements
Flammability	1 - 5	After coating	Met V-0 rating



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TEST SPECIMENS A

CLEANING

TEST SPECIMENS:

Twenty IEC 61086-2 boards, identified as 1 – 20, conformally coated with ELPEGUARD ® SL 1307 FLZ/&4 , colorless.

REFERENCE:

IEC 61086-2, Table A.1, paragraphs 3 – 3.1.2.3

REQUIREMENT:

The conductivity extract shall not be greater than 50 μSm^{-1}

METHOD:

The conductivity of a 4L solution consisting of 75% 2-propanol and 25% deionized water insuring that the solvent was not greater than 5.0 μSm^{-1} . Each individual sample was spray rinsed with 320 ml of the 75% 2-propanol and 25% deionized water solution making sure that both sides of the sample were rinsed over a time period of 300 seconds. The conductivity of the extract was then measured using an Omega conductivity bridge. The final measurements were recorded for each board.

RESULTS:

Board	μScm^{-1}	Board	μSm^{-1}
1	0.13	11	0.10
2	0.11	12	0.10
3	0.10	13	0.09
4	0.11	14	0.10
5	0.11	15	0.10
6	0.11	16	0.11
7	0.11	17	0.11
8	0.11	18	0.11
9	0.10	19	0.12
10	0.10	20	0.11



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COATING

TEST SPECIMENS:

Twenty IEC 61086-2 boards, identified as 1 – 20, conformally coated with ELPEGUARD ® SL 1307 FLZ/&4 , colorless.

REFERENCE:

IEC 61086-2, Table A.1, paragraphs 3.1.3, 7.1, 7.2, and 7.3

REQUIREMENT:

Paragraph 3.1.3: The entire board surface, including sides and edges, shall be completely covered with the conformal coating.

Paragraph 7.1: Any voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion, or discoloration of the copper conductors shall be reported. Any legends shall be clearly visible through the coating.

Paragraph 7.2: The coating thickness shall be 25 – 75 µm (0.000984 – 0.002953") according to @'s specified instructions. The coating thickness shall be reported as the arithmetic mean of all the pad readings for each individual specimen.

Paragraph 7.3: The result shall be reported as positive if fluorescence is apparent on visual examination. The specimens shall be examined with ultraviolet light in a dark room.

METHOD:

Prior to coating the eight pads from the boards identified as 1 - 10 were measured and recorded. The specimens were sent to Lackwerke Peters GmbH & Co. KG to coat the specimens with ELPENGUARD® SL 1307 GLZ&4 , colorless conformal coating. They were returned to Trace Laboratories in order to obtain the thickness of the coating. Once cured the specimens were visually examined, thickness values assessed, and fluorescence determined.

Visual Inspection:

All of the boards were visually inspected with 10X magnification for voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion, or discoloration of the copper conductors. All legends were examined for legibility through the coating.



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Thickness of the Coating:

The eight pads of each of the boards identified as 1 – 10 were again measured, calculated to insure that the difference between the measurements were within the specified requirements of 25 – 75 μm (0.000984 – 0.002953"), and arithmetic mean was recorded for each specimen.

Fluorescence of the Coating:

The specimens were examined with an ultraviolet light in a dark room for coating fluorescence.

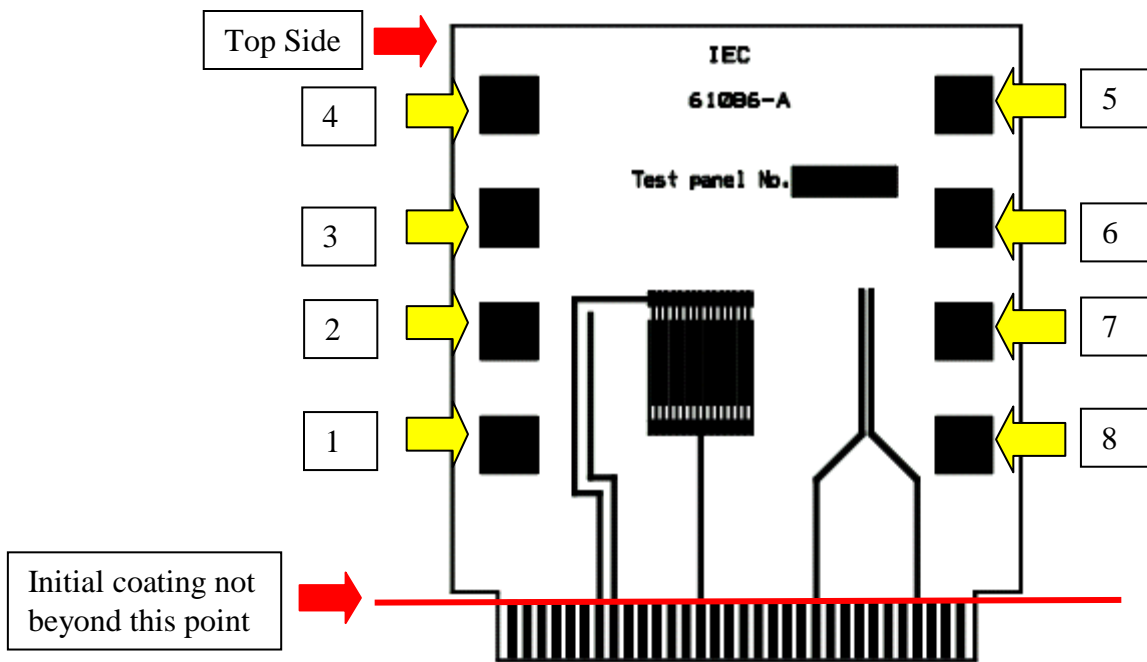


Figure 1



RESULTS:

Visual Inspection:

There was no evidence of voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion, or discoloration of the copper conductors.

All legends were clearly visible through the coating.

Thickness of the Coating:

Lackwerke Peters GmbH & Co. KG's specified requirements of 25 – 75 µm (0.000984 – 0.002953")

Board	Coating Thickness (µm)							
	Pad 1	Pad 2	Pad 3	Pad 4	Pad 5	Pad 6	Pad 7	Pad 8
1	37	39	36	40	38	34	35	39
2	40	39	32	38	30	30	37	38
3	40	43	39	36	34	39	47	49
4	41	39	36	36	34	38	42	40
5	55	50	56	58	44	66	69	67
6	47	45	41	36	37	37	57	57
7	47	53	42	49	48	43	35	35
8	55	43	49	51	39	44	47	48
9	53	48	49	46	44	50	56	45
10	53	51	50	44	42	44	57	53

Fluorescence of the Coating:

The specimens did fluoresce when examined with an ultraviolet light.





THERMAL CYCLE

TEST SPECIMENS:

Twenty IEC 61086-2 boards, identified as 1 – 20, conformally coated with ELPEGUARD ® SL 1307 FLZ/&4 , colorless.

REFERENCE:

IEC 61086-2, Table A.1, paragraphs 4.1 and 7.1, and IEC 60068-2-14, test Nb

REQUIREMENT:

After thermal cycling exposure the specimens shall be visually inspected in accordance with paragraph 7.1.

Paragraph 7.1: Any voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion, or discoloration of the copper conductors shall be reported. Any legends shall be clearly visible through the coating.

METHOD:

Twenty test boards were placed in Thermal Cycling Test Chamber. The cold chamber was set at $-55^{\circ}\text{C} \pm 5^{\circ}\text{C}$, and the hot portion of the chamber was set at $125^{\circ}\text{C} \pm 5^{\circ}\text{C}$. The dwell time was set at 25 ± 2 minutes. The transfer to temperature extremes was set for $12^{\circ}\text{C}/\text{minute}$.

The chamber was set for 100 cycles. Upon completion of the 100 cycles, the twenty test boards were removed from the chamber and visually inspected with 10X magnification for voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating. Evidence of adhesion loss or discoloration of the copper conductors shall be reported. All legends were examined and clarity of the legends through the coating was determined utilizing 10X magnification.

RESULTS:

Visual Inspection after Exposure:

There was no evidence of voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion, or discoloration of the copper conductors.

All legends were clearly visible through the coating.



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THERMAL SHOCK

TEST SPECIMENS:

Twenty IEC 61086-2 boards, identified as 1 – 20, conformally coated with ELPEGUARD ® SL 1307 FLZ/&4 , colorless.

REFERENCE:

IEC 61086-2, Table A.1, paragraphs 4.2 and 7.1, and IEC 60068-2-14, test Na

REQUIREMENT:

After thermal shock exposure the specimens shall be visually inspected in accordance with paragraph 7.1.

Paragraph 7.1: Any voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion, or discoloration of the copper conductors shall be reported. Any legends shall be clearly visible through the coating.

METHOD:

Twenty test boards were placed in Thermal Shock Test Chamber. The cold chamber was set at $-55^{\circ}\text{C} \pm 5^{\circ}\text{C}$, and the hot portion of the chamber was set at $125^{\circ}\text{C} \pm 5^{\circ}\text{C}$. The dwell time was set at 25 ± 2 minutes. The transfer to temperature extremes was less than 2 minutes*.

The chamber was set for 100 cycles. Upon completion of the 100 cycles, the twenty test boards were removed from the chamber and visually inspected with 10X magnification for voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating. Evidence of adhesion loss or discoloration of the copper conductors shall be reported. All legends were examined and clarity of the legends through the coating was determined utilizing 10X magnification.

*Note: In the case of automatic two-chamber test equipment, a change-over period of less than 30 seconds is allowed per paragraph 1.6.5 of IEC 60068-2-14, test Na.

RESULTS:

Visual Inspection after Exposure:

There was no evidence of voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion, or discoloration of the copper conductors.

All legends were clearly visible through the coating.



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SPECIMEN A - SUBGROUPS

After exposure to Thermal Cycling and Thermal Shock testing, the specimens were broken into groups of 5 boards per group.

The first group identified as boards 1 – 5 were utilized for the Damp Heat testing.

The second group identified as boards 6 – 10 were utilized for Salt Mist testing.

The third group identified as boards 11 – 15 were utilized for Thermal Aging testing.

Teflon insulated wires, in the form of cables, were attached to the “y” pattern and the comb pattern of the IEC 61086-2 boards. The wire cables were long enough so that they would extend to the outside of the test chambers so that measurements could be obtained during chamber exposure.

For the Salt Mist test boards the leads were cleaned and then coated with conformal coating so as to cover all exposed metal surfaces; this being necessary so as not to introduce “false failures” that would be attributed to corroded finger tabs during the salt chamber exposure. The exposed copper finger tabs naturally corrode within a salt environment.



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DAMP HEAT

TEST SPECIMENS:

Five IEC 61086-2 boards, identified as 1 – 5, conformally coated with ELPEGUARD ® SL 1307 FLZ/&4, colorless.

REFERENCE:

IEC 61086-2, Table A.1, paragraphs 4.4, 6.3, and 6.1, IEC 60068-2-78, and IEC 60243-1 (rapid rise method).

REQUIREMENT:

Paragraph 4.4: The exposure of IEC 60068-2-78 shall be used for a duration of 96 hours.

Paragraph 6.3 (during exposure): The measurements shall be made using the electrodes of the comb pattern. See Figure 1 on page 4 of this report. Measurements are to be made at intervals of 20 ± 1 minutes during exposure duration.

The result shall be the arithmetic mean of the measured values; the lowest value of apparent resistance recorded shall also be reported.

Paragraph 6.1 (after exposure): The test voltage shall be in accordance with IEC 60243-1 (rapid rise method) and shall be conducted on the “Y” pattern. The voltage breakdown shall be reported in kilovolts.

METHOD:

The five boards were placed in the center of a temperature and humidity test chamber. The wire cables which were attached to the boards were dressed through a port in the side of the chamber in order to obtain measurements during exposure. The cable ends were connected to an automated measuring device in order to obtain measurements at 20 minute intervals during chamber exposure (96 hours). The Initial measurements were obtained with 50 volts to insure that the test boards were sufficient for testing. A measurement voltage of 50 volts was utilized during chamber exposure. The test boards were exposed to 96 hours at 40°C , $\pm 2^{\circ}\text{C}$, with 90% relative humidity.

Once completion of the 96 hour exposure, the results were recorded as the arithmetic mean of the measured values and the lowest value was reported.

The boards were removed from the test chamber and tested for breakdown voltage in accordance with IEC 60243-1, Rapid Rise Method. The voltage was applied to the wires attached to the “Y” pattern in 500v/second intervals until breakdown occurred. The breakdown was recorded in kilovolts.



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RESULTS:

Insulation Resistance in Ohms:

Board	Arithmetic Mean	Lowest Value
1	8.62 X10 ¹⁰	3.24 X10 ⁸
2	9.19 X10 ¹¹	2.19 X10 ¹¹
3	5.57 X10 ¹¹	3.09 X10 ¹⁰
4	1.67 X10 ¹²	6.61 X10 ¹¹
5	4.84 X10 ¹¹	1.51 X10 ¹⁰

Voltage Breakdown:

Board	Kilovolts
1	8.4
2	10.3
3	10.6
4	11.0
5	10.5



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THERMAL AGING

TEST SPECIMENS:

Five IEC 61086-2 boards, identified as 11 – 15, conformally coated with ELPEGUARD ® SL 1307 FLZ/&4 , colorless.

REFERENCE:

IEC 61086-2, Table A.1, paragraphs 4.3, 7.1, and 6.3

REQUIREMENT:

Paragraph 6.3 (during exposure): The measurements shall be made using the electrodes of the comb pattern. See Figure 1 on page 4 of this report. Measurements are to be made at intervals of 20 ± 1 minutes during exposure duration.

The result shall be the arithmetic mean of the measured values; the lowest value of apparent resistance recorded shall also be reported.

After exposure the specimens shall be visually examined (see 7.1) for loss of adhesion.

Paragraph 7.1 (after exposure): Any voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion, or discoloration of the copper conductors shall be reported. Any legends shall be clearly visible through the coating.

METHOD:

The five boards were placed in the center of a forced air circulation oven. The wire cables which were attached to the boards were dressed through a port in the side of the oven in order to obtain measurements during exposure. The cable ends were connected to an automated measuring device in order to obtain measurements at 20 minute intervals during chamber exposure (500 hours). The Initial measurements were obtained with 50 volts to insure that the test boards were sufficient for testing. A measurement voltage of 50 volts was utilized during chamber exposure. The test boards were exposed to 500 hours at 125°C , $\pm 2^{\circ}\text{C}$.

Once completion of the 500 hour exposure, the results were recorded as the arithmetic mean of the measured values and the lowest value was reported.



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Upon completion of the 500 hours, the five test boards were removed from the oven and visually inspected with 10X magnification for voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating. Evidence of adhesion loss or discoloration of the copper conductors shall be reported. All legends were examined and clarity of the legends through the coating was determined utilizing 10X magnification.

RESULTS:

Insulation Resistance in Ohms:

Board	Arithmetic Mean	Lowest Value
11	1.38 X10 ¹²	3.31 X10 ¹¹
12	1.35 X10 ¹²	1.35 X10 ¹²
13	1.33 X10 ¹²	1.33 X10 ¹²
14	1.07 X10 ¹²	1.07 X10 ¹²
15	1.49 X10 ¹²	1.49 X10 ¹²

Visual Inspection after Exposure:

There was no evidence of voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion, or discoloration of the copper conductors.

All legends were clearly visible through the coating.





SALT MIST

TEST SPECIMENS:

Five IEC 61086-2 boards, identified as 6 – 10, conformally coated with ELPEGUARD ® SL 1307 FLZ/&4 , colorless.

REFERENCE:

IEC 61086-2, Table A.1, paragraphs 4.5, 6.3, and 6.1.

REQUIREMENT:

The procedure of IEC 60068-2-11 shall be used.

Paragraph 6.3 (during exposure): The measurements shall be made using the electrodes of the comb pattern. See Figure 1 on page 4 of this report. Measurements are to be made at intervals of 20 ± 1 minutes during exposure duration.

The result shall be the arithmetic mean of the measured values; the lowest value of apparent resistance recorded shall also be reported.

Paragraph 6.1 (after exposure): The test voltage shall be in accordance with IEC 60243-1 (rapid rise method) and shall be conducted on the “Y” pattern. The voltage breakdown shall be reported in kilovolts.

METHOD:

The five boards were placed in the center of a salt mist test chamber. The wire cables which were attached to the boards were dressed through a port in the side of the chamber in order to obtain measurements during exposure. The cable ends were connected to an automated measuring device in order to obtain measurements at 20 minute intervals during chamber exposure (96 hours). The Initial measurements were obtained with 50 volts to insure that the test boards were sufficient for testing. A measurement voltage of 50 volts was utilized during chamber exposure. The test boards were exposed to 96 hours of a salt concentration of $5 \pm 1\%$ by weight of salt to 95 parts by weight of demineralized water.

Once completion of the 96 hour exposure, the boards were removed from the test chamber and rinsed with running tap water for 5 minutes, then rinsed with demineralized water followed by air blasting to remove the water droplets from the boards. The results were recorded as the arithmetic mean of the measured values and the lowest value was reported.



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Once cleaned of salt, the boards were tested for breakdown voltage in accordance with IEC 60243-1, Rapid Rise Method. The voltage was applied to the wires attached to the “Y” pattern in 500v/second intervals until breakdown occurred. The breakdown was recorded in kilovolts.

RESULTS:

Insulation Resistance in Ohms:

Board	Arithmetic Mean	Lowest Value
16	3.38 X10 ¹¹	1.23 X10 ¹⁰
17	6.88 X10 ¹¹	1.00 X10 ¹¹
18	7.34 X10 ¹¹	1.12 X10 ¹¹
19	8.67 X10 ¹¹	1.38 X10 ⁹
20	6.52 X10 ¹¹	1.55 X10 ¹¹

Voltage Breakdown:

Board	Kilovolts
16	10.2
17	11.3
18	10.5
19	11.1
20	10.1



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TEST SPECIMENS B

CLEANING

TEST SPECIMENS:

Fifteen soft copper samples approximately 100 mm x 50 mm and 0.125 mm thick, identified as 1 – 15.

REFERENCE:

IEC 61086-2, Table A.2, paragraphs 3 – 3.1.2.3

REQUIREMENT:

The conductivity extract shall not be greater than 50 μSm^{-1}

METHOD:

The conductivity of a 4L solution consisting of 75% 2-propanol and 25% deionized water insuring that the solvent was not greater than 5.0 μSm^{-1} . Each individual sample was spray rinsed with 320 ml of the 75% 2-propanol and 25% deionized water solution making sure that both sides of the sample were rinsed over a time period of 300 seconds. The conductivity of the extract was then measured using an Omega conductivity bridge. The final measurements were recorded for each specimen.

RESULTS:

Copper Specimen	μSm^{-1}	Copper Specimen	μSm^{-1}
1	0.14	11	0.09
2	0.15	12	0.10
3	0.20	13	0.37
4	0.17	14	0.09
5	0.14	15	0.25
6	0.13		
7	0.22		
8	0.14		
9	0.17		
10	0.15		





COATING

TEST SPECIMENS:

Fifteen soft copper samples approximately 100 mm x 50 mm and 0.125 mm thick, identified as 1 – 15, conformally coated with ELPEGUARD ® SL 1307 FLZ/&4 , colorless.

REFERENCE:

IEC 61086-2, Table A.2, paragraphs 3.1.3, 7.1, 7.4, and 7.5, and ISO 1519.

REQUIREMENT:

Paragraph 3.1.3: The entire board surface, including sides and edges, shall be completely covered with the conformal coating.

Paragraph 7.1: Any voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion, or discoloration of the copper conductors shall be reported. Any legends shall be clearly visible through the coating.

Paragraph 7.4: The coating shall be reported as non-tacky if the paper can be removed by method a) slight vibration or b) lightly touching the paper without any paper fibers being left on the coating of any specimen.

If the filter paper cannot be removed by method a) or b) and it has to be forcibly detached, or if there is significant amount of paper fibers left on the specimen, the coating shall be reported as being tacky.

Paragraph 7.5: Any evidence of cracking or crazing of the coating of any specimen shall be reported.

METHOD:

The fifteen copper specimens were sent to Lackwerke Peters GmbH & Co KG to be coated with ELPEGUARD ® SL 1307 FLZ/&4 , colorless, conformal coating. Once cured the specimens were returned to Trace Laboratories for testing. The five of the specimens, identified as 1 – 5, were visually examined, tackiness assessed, and coating flexibility tested.

Visual Inspection:

Five of the specimens were visually inspected with 10X magnification for voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion, or discoloration of the copper conductors.



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Tackiness:

Five specimens were selected for testing and identified as 1 - 5. Each was tested individually as follows: The test was conducted at room temperature. A piece of filter paper was placed on the specimen in such a manner that there was a space approximately 10 mm wide at one end which was not covered by the paper. A soft rubber disc, 20 mm in diameter and a thickness of 5 mm, was placed on top of the filter paper. A cylindrical weight with a mass of 500 g and 20 mm in diameter was placed on the rubber disc. The pressure was maintained for 1 minute and then the rubber disc and weight was removed. The specimen with the paper attached was held in the vertical position. The specimen was a) slightly vibrated, or b) the paper was lightly touched, or c) had to be forcibly removed in an attempt to remove the filter paper. The results were recorded as a, b, or c for removal. The specimens were then visually examined for evidence of filter paper fibers left on the coating surface.

Flexibility:

Five specimens were selected for testing and identified as 1 - 5. Each was tested individually as follows: A 3 mm diameter mandrel was placed in the center of the coated copper specimen. The specimens were bent over the mandrel at a steady rate without jerking over a period of 1 second bending the specimen 180° over the mandrel. The specimens were examined for cracking or crazing of the coating.

RESULTS:

Visual Inspection:

There was no evidence of voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion, or discoloration of the copper conductors.

Tackiness:

There was no evidence of filter paper fibers on any of the specimens tested. The filter paper was loosened by slightly vibrating the specimens therefore receiving a non-tacky rating.

Flexibility:

None of the specimens exhibited cracking or crazing of the coating.



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THERMAL SHOCK

TEST SPECIMENS:

Five soft copper samples approximately 100 mm x 50 mm and 0.125 mm thick, identified as 6 – 10, conformally coated with ELPEGUARD ® SL 1307 FLZ/&4 , colorless.

REFERENCE:

IEC 61086-2, Table A.2, paragraphs 4.2, 7.1, and 7.5, 60068-2-14, test Na, and ISO 1519.

REQUIREMENT:

After thermal shock exposure the specimens shall be visually inspected in accordance with paragraphs 7.1 and 7.5.

Paragraph 7.1: Any voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion, or discoloration of the copper conductors shall be reported. Any legends shall be clearly visible through the coating.

Paragraph 7.5: Any evidence of cracking or crazing of the coating of any specimen shall be reported.

METHOD:

Five copper specimens were placed in Thermal Shock Test Chamber. The cold chamber was set at - 55°C ±5°C, and the hot portion of the chamber was set at 125°C ±5°C. The dwell time was set at 25 ± 2 minutes. The transfer to temperature extremes was less than 2 minutes*.

The chamber was set for 100 cycles. Upon completion of the 100 cycles, the copper specimens were removed from the chamber and visually inspected with 10X magnification for voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating. Evidence of adhesion loss or discoloration of the copper conductors shall be reported. The specimens were examined utilizing 10X magnification.

*Note: In the case of automatic two-chamber test equipment, a change-over period of less than 30 seconds is allowed per paragraph 1.6.5 of IEC 60068-2-14, test Na.

At the conclusion of the visual inspection each of the specimens were tested for flexibility. A 3 mm diameter mandrel was placed in the center of the coated copper specimen. The specimens were bent over the mandrel at a steady rate without jerking over a period of 1 second bending the specimen 180° over the mandrel. The specimens were examined for cracking or crazing of the coating.



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RESULTS:

Visual Inspection after Exposure:

There was no evidence of voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion, or discoloration of the copper conductors.

Flexibility:

None of the specimens exhibited cracking or crazing of the coating.



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THERMAL AGING

TEST SPECIMENS:

Five soft copper samples approximately 100 mm x 50 mm and 0.125 mm thick, identified as 11 – 15, conformally coated with ELPEGUARD ® SL 1307 FLZ/&4 , colorless.

REFERENCE:

IEC 61086-2, Table A.2, paragraphs 4.3, 7.1, and 7.5, and ISO 1519.

REQUIREMENT:

After thermal shock exposure the specimens shall be visually inspected in accordance with paragraphs 7.1 and 7.5.

Paragraph 7.1: Any voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion, or discoloration of the copper conductors shall be reported. Any legends shall be clearly visible through the coating.

Paragraph 7.5: Any evidence of cracking or crazing of the coating of any specimen shall be reported.

METHOD:

The five copper specimens were placed in the center of a forced air circulation oven. The copper test specimens were exposed to 500 hours at 125°C, ±2°C.

Once completion of the 500 hour exposure, the specimens were visually examined for voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion, or discoloration of the copper conductors utilizing 10X magnification.

Upon completion of the visual examination each of the specimens were tested for flexibility. A 3 mm diameter mandrel was placed in the center of the coated copper specimen. The specimens were bent over the mandrel at a steady rate without jerking over a period of 1 second bending the specimen 180° over the mandrel. The specimens were examined for cracking or crazing of the coating.



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RESULTS:

Visual Inspection after Exposure:

There was no evidence of voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion, or discoloration of the copper conductors.

Flexibility:

None of the specimens exhibited cracking or crazing of the coating.



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TEST SPECIMENS C

CLEANING

TEST SPECIMENS:

Five standard microscope slides

REFERENCE:

IEC 61086-2, Table A.3, paragraphs 3 – 3.1.2.3

REQUIREMENT:

The conductivity extract shall not be greater than $50 \mu\text{Sm}^{-1}$

METHOD:

The conductivity of a 4L solution consisting of 75% 2-propanol and 25% deionized water insuring that the solvent was not greater than $5.0 \mu\text{Sm}^{-1}$. Each individual sample was spray rinsed with 320 ml of the 75% 2-propanol and 25% deionized water solution making sure that both sides of the sample were rinsed over a time period of 300 seconds. The conductivity of the extract was then measured using an Omega conductivity bridge. The final measurements were recorded for each board.

RESULTS:

Slides	μSm^{-1}
1	0.14
2	0.16
3	0.16
4	0.13
5	0.16



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COATING

TEST SPECIMENS:

Five standard microscope slides conformally coated with ELPEGUARD ® SL 1307 FLZ/&4 , colorless.

REFERENCE:

IEC 61086-2, Table A.3, paragraphs 3.1.3 and 7.1.

REQUIREMENT:

Paragraph 3.1.3: The entire board surface, including sides and edges, shall be completely covered with the conformal coating.

Paragraph 7.1: Any voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion, or discoloration of the copper conductors shall be reported. Any legends shall be clearly visible through the coating.

METHOD:

The five glass slides were sent to Lackwerke Peters GmbH & Co KG to be coated with ELPEGUARD ® SL 1307 FLZ/&4 , colorless, conformal coating. Once cured the specimens were returned to Trace Laboratories for testing. The five of the specimens, identified as 1 – 5, were visually examined with 10X magnification for evidence of voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion.

RESULTS:

Visual Inspection:

There was no evidence of voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion.



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MOULD GROWTH

TEST SPECIMENS:

Five standard microscope slides conformally coated with ELPEGUARD® SL 1307 FLZ/&4 , colorless.

REFERENCE:

IEC 61086-2, Table A.3, paragraphs 3.1.3 and 7.7, and IEC 60068-2-10.

REQUIREMENT:

Paragraph 3.1.3: The entire board surface, including sides and edges, shall be completely covered with the conformal coating.

Paragraph 7.7: The extent of mold growth shall be reported.

REQUIREMENT:

Extent of Growth

Table with 2 columns: Observation and Rating. Rows describe growth levels from 0 (No growth) to 3 (Growth covers more than 25% of the test surface).

Note: where specimens comprising an assembly show varying degrees of growth they should be assessed separately.

METHOD:

The cultures of each microorganism were maintained separately on the agar for optimal growth. A spore suspension was prepared two weeks after inoculation and incubation of the microorganisms by pouring into one subculture of each fungus, a 10-ml portion of a sterile solution containing 0.05 g per liter of a non-toxic wetting agent such as sodium dioctyl sulfosuccinate. The test fungi used are: Aspergillus niger, Aspergillus terreus, Aureobasidium pullulans, Poecilomyces variotii, Penicillium funiculosum, Penicillium ochrochloron, Scopulariopsis brevicaulis, and Trichoderma viride

Using a sterile inoculating loop the surface growth of each culture was gently scraped to remove it from the agar. The spore charge was poured into a sterile 125 ml glass-stopped Erlenmeyer flask containing 45 ml of sterile water and 10 - 15 solid glass beads (5 mm in diameter). The flask was vigorously shaken in





order to liberate the spores from the fruiting bodies and to break up the spore clumps. The dispersed fungal spore suspension was filtered through a 6 mm layer of glass wool contained in a glass funnel, into a sterile test tube.

This process removed large mycelial fragments and clumps of agar, which could interfere with the spraying process.

The test tubes containing the filtered spore suspensions were placed in a centrifuge for 20 minutes. The supernatant liquid was discarded. The residue was resuspended with sterile water and again placed in the centrifuge. The spores were washed in this manner three times. The final washed residue was resuspended with sterile mineral salts solution.

The spore suspension may be prepared fresh each day or may be held at 3 to 10°C for not more than 4 days.

Viability of Inoculum Control

With each test specimen group, three pieces of sterilized filter paper, one inch square, were placed on hardened mineral salts agar in separate Petri dishes. They were inoculated with the spore suspension by spraying from a sterilized atomizer until initiation of droplet coalescence. The strips were incubated at 30°C (86°F) at a relative humidity of 90%. They were examined after fourteen days of incubation. If the cultures did not show growth, the procedure was repeated.

In addition to the viability of inoculum control, a known susceptible substrate (a sterile cotton strip) was inoculated along with the test item to ensure that proper conditions were present in the incubation chamber to promote fungus growth. The control strip was dipped in a solution containing 30.0g Sucrose, 0.7g potassium dihydrogen orthophosphate, 0.3g Potassium monohydrogen orthophosphate, 0.5g magnesium sulfate, 2.0g Sodium Nitrate, and 0.01g Ferrous sulphate. The excess liquid was removed prior to inoculation.

Inoculation of Test and Control Item

The test and control items were suspended on suitable fixtures. No cleaning of the test specimen took place for at least 72 hours prior to inoculation. The chamber was preconditioned at 30°C and 90% minimum relative humidity.

The test samples and the control were sprayed with the spore suspension and incubation period began. The test specimens were exposed to a static temperature of 30°C with a minimum humidity of 90%. Note: covered dishes containing nutrient agar are considered to have the desired humidity. Covers on large dishes may be sealed with masking tape.



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After 14 days, the growth on the control items was inspected to be assured that the environmental conditions were suitable for growth. (If inspection revealed that the environmental conditions are unsuitable for growth, the entire test was repeated.)

If the control items showed satisfactory fungus growth, the test was continued for a period of 28 days from the time of inoculation, or as specified.

After 28 days, the samples were visually examined for evidence of fungal growth.

RESULTS:

The specimens received a rating of "0".



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TEST SPECIMENS D

CLEANING

TEST SPECIMENS:

Five laminate strips measuring 0.125 mm x 13 mm and 0.75 mm thick

REFERENCE:

IEC 61086-2, Table A.4, paragraphs 3 – 3.1.2.3

REQUIREMENT:

The conductivity extract shall not be greater than 50 μSm^{-1}

METHOD:

The conductivity of a 4L solution consisting of 75% 2-propanol and 25% deionized water insuring that the solvent was not greater than 5.0 μSm^{-1} . Each individual sample was spray rinsed with 320 ml of the 75% 2-propanol and 25% deionized water solution making sure that both sides of the sample were rinsed over a time period of 300 seconds. The conductivity of the extract was then measured using an Omega conductivity bridge. The final measurements were recorded for each board.

RESULTS:

Laminate Strips	μSm^{-1}
1	0.21
2	0.22
3	0.20
4	0.24
5	0.17



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COATING

TEST SPECIMENS:

Five laminate strips measuring 0.125 mm x 13 mm and 0.75 mm thick conformally coated with ELPEGUARD ® SL 1307 FLZ/&4 , colorless.

REFERENCE:

IEC 61086-2, Table A.4, paragraphs 3.1.3 and 7.1.

REQUIREMENT:

Paragraph 3.1.3: The entire board surface, including sides and edges, shall be completely covered with the conformal coating.

Paragraph 7.1: Any voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion, or discoloration of the copper conductors shall be reported. Any legends shall be clearly visible through the coating.

METHOD:

The five laminate strips were sent to Lackwerke Peters GmbH & Co KG to be coated with ELPEGUARD ® SL 1307 FLZ/&4 , colorless, conformal coating. Once cured the specimens were returned to Trace Laboratories for testing. The five of the specimens, identified as 1 – 5, were visually examined with 10X magnification for evidence of voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion.

RESULTS:

Visual Inspection:

There was no evidence of voids, holes, wrinkles, streaks, cracking, delamination, blistering, or peeling of the coating or other evidence of loss of adhesion.



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FLAMMABILITY

TEST SPECIMENS:

Five laminate strips measuring 0.125 mm x 13 mm and 1.5 mm thick conformally coated with ELPEGUARD ® SL 1307 FLZ/&4 , colorless.

REFERENCE:

IEC 61086-2, Table A.4, paragraphs 6.6 and 7.6, IEC 60707, and IEC 60695-11-10

MATERIALS CLASSIFICATIONS:

<u>Criteria conditions</u>	<u>V-0</u>	<u>V-1</u>	<u>V-2</u>
Afterflame time for each individual specimen t_1 or t_2	≤ 10s	≤ 30s	≤ 30s
Total afterflame time for any condition set (t_1 plus t_2 for the 5 specimens)	≤ 50s	≤ 250s	≤ 250s
Afterflame plus afterglow time for each individual specimen after the second flame application ($t_2 + t_3$)	≤ 30s	≤ 60s	≤ 60s
Afterflame or afterglow of any specimen up to the holding clamp	No	No	No
Cotton indicator ignited by flaming particles or drops	No	No	Yes

METHOD:

A set of 5 specimens were preconditioned for a minimum of 48 hours at $23 \pm 2^\circ\text{C}$ and 50 ± 5 percent relative humidity.

Each test specimen was supported from the upper 1/4" (with the longitudinal axis vertical) by a clamp on a ring stand so that the lower end of the test specimen was 12 inches above a layer of dry surgical cotton. The test specimen was ignited using a methane flame at a 45° angle for 10 seconds. The flame was then withdrawn from the test specimen at least 6 inches and the duration of flaming (t_1) was noted. When flaming of the test specimen ceased, the methane flame was placed again under the test specimen. After 10 seconds, the test flame was withdrawn, and the duration of the flaming (t_2) and glowing (t_3) was noted.





RESULTS:

Sample Id:	Thickness (mm)	After flame t ₁ (seconds)	After flame t ₂ (seconds)	After glow t ₃ (seconds)	Did specimen burn to holding clamp	Did specimen drip flaming particles that ignited cotton
1	1.52	1	7	7	No	No
2	1.48	1	2	2	No	No
3	1.48	4	1	1	No	No
4	1.47	1	3	3	No	No
5	1.48	1	4	4	No	No

The above material is classified as V-0.





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.

Thank you for selecting Trace Laboratories, Inc. for your testing purposes.

PERFORMED BY:

Erik Buckner
Test Engineer

Ronald Roden, Jr.
Engineer

Diane M. Andercyk
Senior Engineer

Debora L. Obitz
Senior Engineer

SAMPLE DISPOSITION: The samples that were not destroyed in testing were returned to Lackwerke Peters GmbH & Co KG

ATTACHMENT:

Equipment Used





EQUIPMENT USED LIST

Trace ID	Manufacturer	Equipment Name	Serial/Model Number	Calibration Date	Calibration Due Date
D-54	Mitutoyo	Digital Micrometer	05020647/293-831	12-May-11	12-May-12
W-06	Entela	Black Ray Lamp	ULV56	N/A	N/A
T-32	Control Co.	Electronic Stopwatch	72468845/62379-200	20-Jul-2012	20-Jul-2013
E-56	Omega	Conductivity Bridge	1950/CDB-410	23-Jan-2013	23-Jan-2014
S-20	Pace	Soldering Iron Station	02-00-0131/ST40A	3-Oct-2012	3-Oct-2013
O-27	Blue-M	Oven	414217-1/CC09SME	17-Jul-2012	29-Jul-2013
TM-93	Fisher Scientific	Humidity/Temperature Pen	91065698/11-661-14	3-Oct-2012	3-Oct-2013
MS-08	Fisher	Colony Counter	133 - 8002	N/A	N/A
TM-107	Fisher Scientific	Autoclave Thermometer	6488	22-May-2013	22-May-2014
W-08	Tuttnauer	Autoclave	2540EPK/2201398	NA	NA (see TM-107)
M-14	Fisher	Centrifuge	1829	N/A	N/A
O-09	Fisher	Isotemp Incubator	230D	NA	NA (see TM93)
MS-23	Olympus	Microscope and Camera	SZX16	N/A	N/A
T-35	Gralab	Timer	79315/300	23-Jan-2013	23-Jan-2014
CH-23 CH-23R	Espec	Temperature/Humidity Chamber	018338/ESC-3CA	3-Apr-2013	3-Apr-2014
CH-21	Singleton	Salt Fog Chamber	15388/22	19-Jul-2012	19-Jul-2013
E-25	Hipotronics	Hi-Pot Tester	027574-00/750-5	20-Jul-2012	20-Jul-2013
E-52	Concoat	Auto-Sir	91790899/AutoSir 128 Rack	25-Feb-2013	25-Feb-2014
E-54	Concoat	Auto-Sir	12861/256 Channel Rack-mount	25-Feb-2013	25-Feb-2014



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