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National Technical Systems - Baltimore
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Date In: October 19, 2022

Customer:
Lackwerke Peters Gmbh+Co Kg
Hooghe Weg 13
47906 Kempen
DE

Purchase Order Number: Wire

A. TEST OBJECTIVE:
Qualification of Conformal Coating for “SL 1307 FLZ/4”

B. TEST ITEM(S):
Conformal Coating Applied to Applicable Test Coupons

C. SPECIFICATIONS / METHODS / TECHNIQUES:
1. IPC-CC-830C

D. RESULTS:
Coating **meets** the requirements of the specification. See page 3 for results summary.

TESTING PERFORMED BY:

Ronald Roden, Jr., PCB Technical Specialist	Dan Phillips, Department Manager FA/Analytical	Katherine Higgs Department Manager Special Projects	Dave Hillis, Materials Tech II

TECHNICAL/QUALITY APPROVALS:

Elizabeth A. Allison
Department Manager PCB / PCA

TEST ITEM IDENTIFICATION

COATING IDENTIFICATION / MATERIAL NAME:	SL 1307 FLZ/4
MATERIAL TYPE:	AR - Acrylic
DATE OF MANUFACTURE:	01.10.2022 18.09.2021 for shelf life
LOT NUMBER:	201911724 201911722 for shelf life
COATING MANUFACTURER PLANT LOCATION:	Same as location noted on page 1
SAMPLE DISPOSITION:	Samples returned to Lackwerke Peters Gmbh+Co Kg

BREAKDOWN OF TEST COUPONS*

(Reference Table 4-1 IPC-CC-830C)

Test Sample(s)	Quantity	Testing	Specification Paragraph
Glass Plate	4 coated, 1 uncoated	FTIR	3.4.1
Glass Plate		Appearance	3.5.2
Glass Plate		Fluorescence	3.5.3
Glass Plate		Thickness	4.6.4
Glass Plate	4 coated	Fungus Resistance	3.5.4
Tin Panel	4 coated	Flexibility	3.5.5
UL94 Test Strip	6 coated	Flammability	3.5.6
IPC-B-25A, Pattern C	5 coated	Dielectric Withstanding Voltage	3.6.1
IPC-B-25A, Pattern D & C	4 coated, 1 uncoated	Moisture and Insulation Resistance	3.7.1
IPC-B-25A, Pattern C	5 coated	Thermal Shock	3.7.2
Y-Shape Test Assembly	5 coated, with resistors	Temperature and Humidity Aging (Hydrolytic Stability)	3.7.3
Liquid Conformal Coating	1 sample	Viscosity	3.5.1
IPC-B-25A, Pattern D & C	5 coated	Shelf Life (IR and DWV Test)	3.3.2
Witness Coupon (i.e. Glass Plate)	4 coated	Coating Thickness	4.6.4

Note: Prepared sample substrates were coated by the customer prior to submission to NTS. No coating application was performed at NTS Baltimore.

TEST SUMMARY

Test, paragraph	Results	Comments
Materials, 3.3.1	Pass	
Shelf Life, 3.3.2	Pass	
Cure, 3.3.3	Pass	
Fourier Transform Infrared Spectroscopy (FTIR), 3.4.1	See scan on page 8	Spectrum to be retained for future reference
Viscosity, 3.5.1	See Viscosity Results	Measurement to be recorded for future reference
Appearance, 3.5.2	Pass	
Fluorescence, 3.5.3	Fluorescent under UV	
Fungus Resistance, 3.5.4	Pass	
Flexibility, 3.5.5	Pass	
Flammability, 3.5.6	Pass	
Dielectric Withstanding Voltage, 3.6.1	Pass	
Moisture and Insulation Resistance, 3.7.1	Pass	
Thermal Shock, 3.7.2	Pass	
Temperature Humidity Aging, (Hydrolytic Stability), 3.7.3	Pass	
Coating Thickness, 4.6.4	Pass	

MATERIALS

REFERENCE	IPC-CC-830C, paragraph 3.3.1
TEST SPECIMENS	All samples
REQUIREMENT	The conformal coating shall be free of foreign objects/materials which degrade performance. A visual examination should be conducted.
SUMMARY	**Meets requirements.**
TEST MODIFICATIONS	None
TEST CONDITIONS	N/A
EVALUATION PERFORMED BY	RR
EVALUATION DATE	January 18, 2023
EQUIPMENT USED	WC051719

SHELF LIFE

REFERENCE	IPC-CC-830C, paragraph 3.3.2
TEST SPECIMENS	Five coated IPC-B-25A boards
REQUIREMENT	The conformal coating **shall** meet all requirements of this standard within the shelf life and storage conditions specified by the conformal coating manufacturer. Shelf life of coating with two or more components shall be that of the component with the shortest shelf life. Tests to verify shelf life shall consist of Insulation Resistance (IR) and Dielectric Withstanding Voltage (DWV). Insulation Resistance: • Minimum 500 MΩ for type ER (5.0E+02 MΩ) • Minimum 5000 MΩ (5.0E+03 MΩ) for all other types Dielectric withstanding voltage: • There **shall** be no disruptive discharge evidenced by flashover (surface discharge), sparkover (air discharge), or breakdown (puncture discharge). • The leakage rate shall not exceed 10 microamperes.
SUMMARY	**Meets requirements for Type AR coating.**
TEST MODIFICATIONS	None
TEST CONDITIONS	N/A
EVALUATION PERFORMED BY	RR
EVALUATION DATE	April 10, 2023
EQUIPMENT USED	WC051508, WC052060

RESULTS:

Sample	Insulation Resistance		Dielectric Withstanding Voltage Results (Pattern C)
	Pattern D Test Point	Resistance Reported In Megohms	
1	1-2	7.29E+05	Pass
	3-2	3.52E+05	
	3-4	3.49E+05	
	5-4	2.31E+05	
2	1-2	2.21E+05	Pass
	3-2	1.24E+06	
	3-4	4.06E+05	
	5-4	4.06E+06	
3	1-2	4.11E+06	Pass
	3-2	1.00E+06	
	3-4	3.03E+06	
	5-4	3.29E+05	
4	1-2	9.07E+05	Pass
	3-2	1.03E+06	
	3-4	2.24E+05	
	5-4	1.37E+06	
5	1-2	2.82E+05	Pass
	3-2	1.06E+06	
	3-4	2.86E+05	
	5-4	1.56E+06	

CURE

REFERENCE	IPC-CC-830C, paragraph 3.3.3
TEST SPECIMENS	All coated samples.
REQUIREMENT	The conformal coating when applied and cured per the manufacturers recommended parameters **shall** meet the requirements of this specification.
SUMMARY	**The coating on the submitted samples appears to be fully cured. The cure time stated by the supplier matches that stated on the technical data sheet.**
TEST MODIFICATIONS	None
TEST CONDITIONS	N/A
EVALUATION PERFORMED BY	RR
EVALUATION DATE	January 18, 2023
EQUIPMENT USED	Technical Data Sheet and supplied information

RESULTS:

The received samples coated with cured conformal coating appear to have exhibited the desired hardness after the customer's application and curing process.

Cure process used per manufacturer:

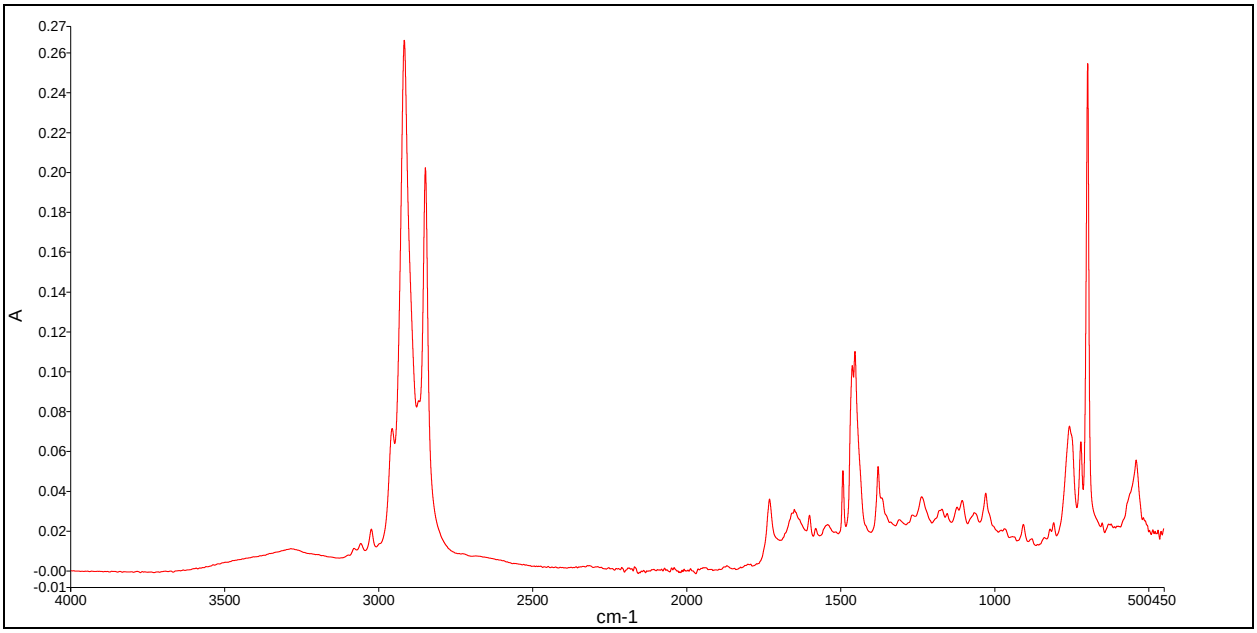
30 min@ 80°C

FOURIER TRANSFORM INFRARED SPECTROSCOPY (FTIR)

REFERENCE	IPC-CC-830C, paragraph 3.4.1
TEST SPECIMENS	Coated Glass Panel(s)
REQUIREMENT	The FTIR test **shall** be performed as part of the coating qualification. The methodology is chosen by the coating manufacturer. When used in qualification retention inspection, FTIR spectra **shall** be compared to those obtained during qualification inspection.
SUMMARY	**No pass/fail criteria. See below for spectra.**
TEST MODIFICATIONS	None
TEST CONDITIONS	N/A
EVALUATION PERFORMED BY	DP
EVALUATION DATE	June 13, 2023
EQUIPMENT USED	WC051803

RESULTS:

The FTIR Scan for the applied coating is found below:



VISCOSITY

REFERENCE	IPC-CC-830C, paragraph 3.5.1 • ASTM D1084
TEST SPECIMENS	Uncured liquid conformal coating material(s) • Note: Test is N/A for XY coatings.
REQUIREMENT	Viscosity **shall** be measured as part of data gathering for the conformal coating during qualification inspection. This viscosity data **shall** be used by the manufacturer to pre-determine an acceptable viscosity range for quality conformance inspection.
SUMMARY	**See results below.**
TEST MODIFICATIONS	None
TEST CONDITIONS	N/A
EVALUATION PERFORMED BY	RR
EVALUATION DATE	June 1, 2023
EQUIPMENT USED	WC051723

RESULTS:

Readings	cps
1	135.6
2	136.0
3	136.2
4	137.4
5	137.6

APPEARANCE

REFERENCE	IPC-CC-830C, paragraph 3.5.2
TEST SPECIMENS	Four coated glass plates
REQUIREMENT	The applied cured conformal coating **shall** be smooth and tack-free when observed at ambient conditions. In addition, the conformal coating on the test vehicles **shall** have no bubbles, pinholes, blisters, cracking, crazing, peeling, wrinkles, mealing or evidence of reversion, or cause corrosion. For UT coatings, visual appearance shall be inspected per vendor's recommendation.
SUMMARY	**Meets requirements.**
TEST MODIFICATIONS	None
TEST CONDITIONS	N/A
EVALUATION PERFORMED BY	RR
EVALUATION DATE	January 18, 2023
EQUIPMENT USED	WC051719

RESULTS:

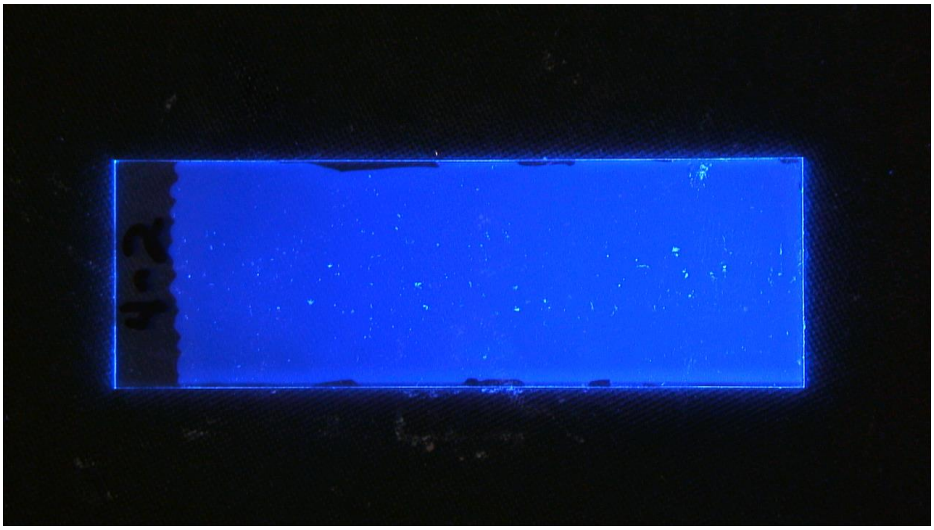
The conformal coating was smooth and tack-free.

The coating did not exhibit any bubbles, pinholes, blisters, cracking, crazing, peeling, wrinkles, mealing or evidence of reversion, or cause corrosion on the applicable test vehicles.

FLUORESCENCE

REFERENCE	IPC-CC-830C, paragraph 3.5.3
TEST SPECIMENS	Four coated glass plates
REQUIREMENT	Conformal coating materials which incorporate a fluorescent marker **shall** be fluorescent by UV illumination. Those materials which do not incorporate a fluorescing agent are not required to fluoresce under black light illumination.
SUMMARY	**The coating exhibited fluorescence.**
TEST MODIFICATIONS	None
TEST CONDITIONS	N/A
EVALUATION PERFORMED BY	N/A
EVALUATION DATE	June 12, 2023
EQUIPMENT USED	WC062012

RESULT:



Representative photo of glass slide under black light/UV illumination.

FUNGUS RESISTANCE

REFERENCE	IPC-TM-650, Method 2.6.1.1; Requirements per IPC-CC-830
TEST SPECIMENS	Four (4)
REQUIREMENT	The cured conformal coating shall not contribute or be attacked by biological growth
SUMMARY	**Meets requirement.**
SAMPLE PREPARATION DETAILS	See Test Method section for details
SAMPLE PREPARATION PERFORMED BY	DH/KH
PREPARATION DATE	January 23 - February 7, 2023
CONTROL GROWTH VERIFICATION PERFORMED BY	DH/KH
CONTROL GROWTH VERIFICATION DATE	February 14, 2023
TEST MODIFICATIONS	• *A. pullulans* ATCC #15233 used instead of ATCC #9348 • *T. pinophilus* ATCC #11797 used instead of ATCC #9644
TEST CONDITIONS	29 ± 1°C and minimum 85% RH
TEST PERFORMED BY	DH/KH
TEST DATE	February 7 - March 9, 2023
EQUIPMENT USED	WC051523, WC051524, WC051625, WC051626, WC051668, WC051692, WC051740, WC051863, WC051928, WC051957, WC051961, WC051962, WC052068, WC052072, WC052073, WC052090, WC052113, WC058804, WC059253, WC059408, WC059409, WC059411, WC061951

RESULTS:

The samples were evaluated with guidance from ASTM G21, which assigns a fungal growth rating based on visual observations after fungal exposure. A summary of the rating system is provided below.

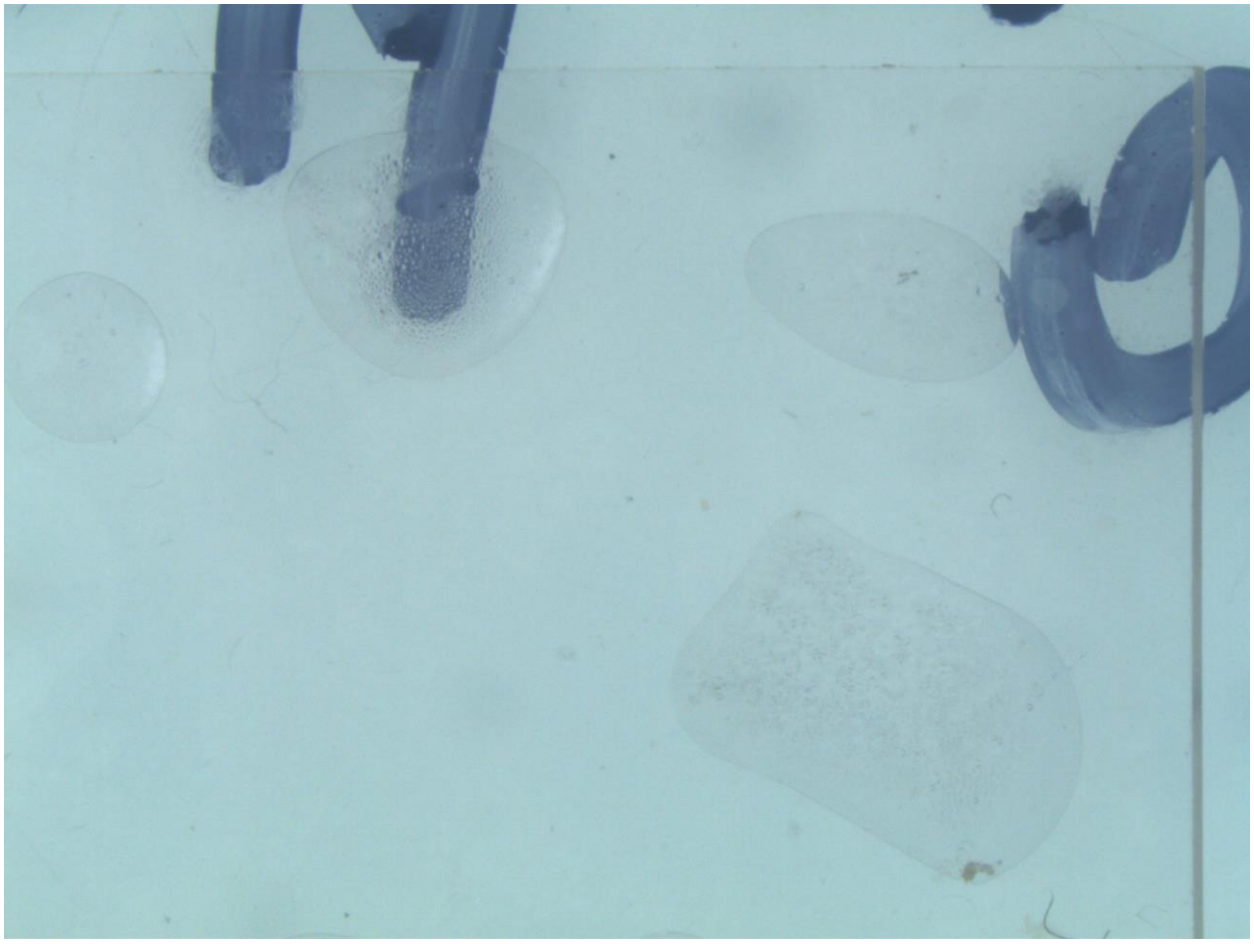
Growth Amount	Rating
None	0
Trace (less than 10%)	1
Light (10-30%)	2
Medium (30-60%)	3
Heavy (60-100%)	4

The following table summarizes the growth ratings for each material after 28 days:

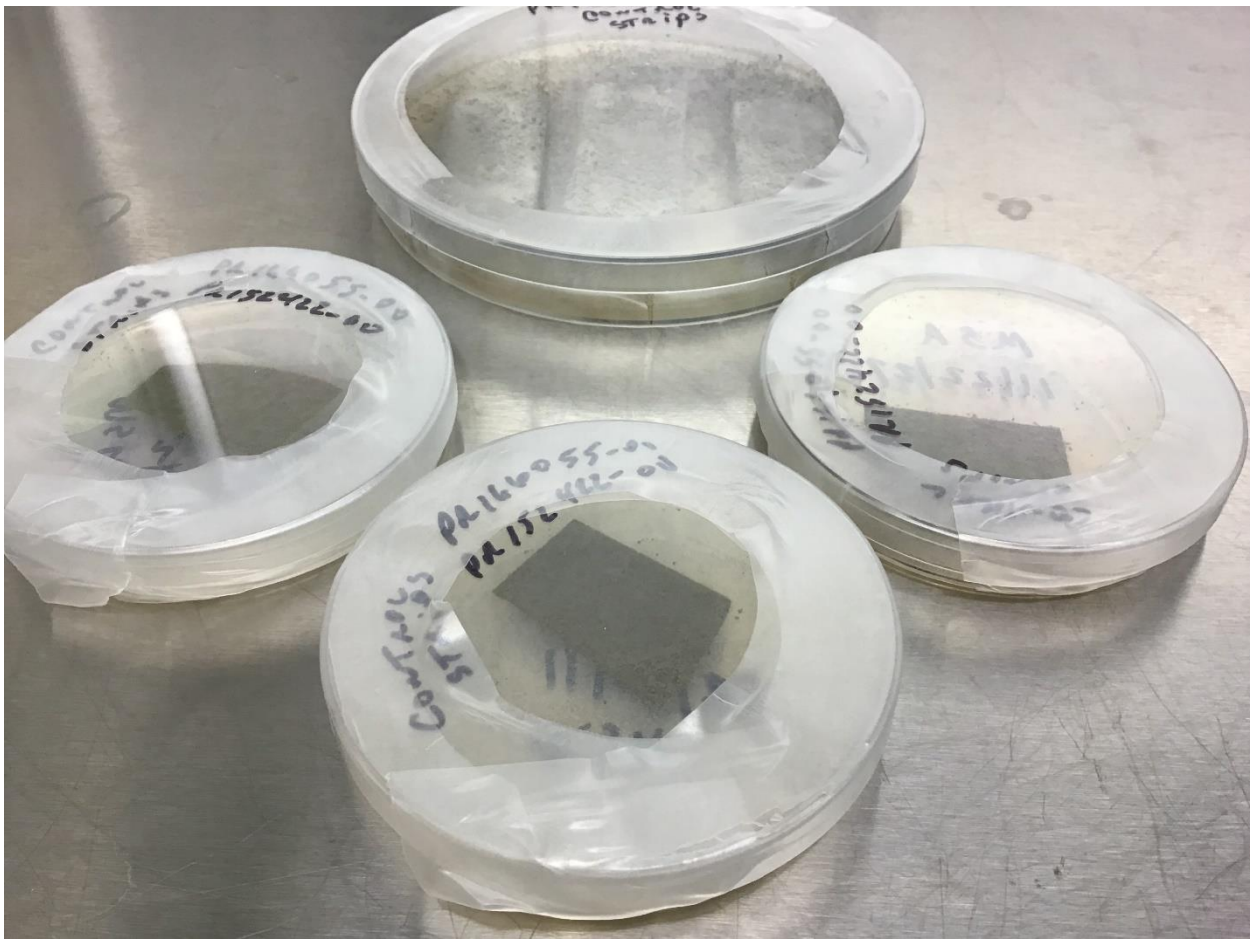
Group	Specimen	Visual Results	
		Rating	Observations
4	4-1	0	No active growth observed.
	4-2	0	No active growth observed.
	4-3	0	No active growth observed.
	4-4	0	No active growth observed.

Representative test images are provided on the following pages.

IMAGES:



Representative Overview of Group 4 at 7x Magnification
(No Fungal Growth Observed)



Overview of the Control Samples

The white control cloths and white control filter paper were inoculated with fungal spores and allowed to incubate for 28 days adjacent to the submitted samples. Heavy growth observed without aid of microscopy.

FLEXIBILITY

REFERENCE	IPC-CC-830C, paragraph 3.5.5 • IPC-TM-650, Method 2.4.5.1
TEST SPECIMENS	Four coated tin panels
REQUIREMENT	There **shall** be no evidence of cracking or crazing on the cured conformal coating.
SUMMARY	**Meets requirements**
TEST MODIFICATIONS	None
TEST CONDITIONS	N/A
EVALUATION PERFORMED BY	RR
EVALUATION DATE	April 12, 2023
EQUIPMENT USED	WC051964 (F-5 (0.12” Diameter mandrel))

RESULTS:

No cracks or crazing were observed in the conformal coating on any of the test samples.

FLAMMABILITY

REFERENCE	IPC-CC-830C, paragraph 3.5.6
TEST SPECIMENS	Six (6) 13 mm X 130 mm long laminate strips, coated.
REQUIREMENT	The cured conformal coating shall meet UL 94, HB (Horizontal Burning Test) requirements as a minimum: a. Not have a burning rate exceeding 40mm (1.75") per minute over a 75 mm (2.95") span for specimens having a thickness of 3.0 – 13 mm (0.118 – 0.512"), or b. Not have a burning rate exceeding 75 mm (2.95") per minute over a 75 mm (2.95") span for specimens having a thickness less than 3.0 mm (0.118"), or c. Cease to burn before the 100 mm (3.937") reference mark.
SUMMARY	**See results below.**
TEST MODIFICATIONS	N/A
TEST CONDITIONS	N/A
EVALUATION PERFORMED BY	RR
EVALUATION DATE	June 2, 2023
EQUIPMENT USED	WC051635, WC059288, WC052081,

RESULTS:

Specimen	Burning beyond 25 mm		See Note	Burning Rate $V = 60\frac{L}{t}$ (mm/min)
	Time, *t* (seconds)	Damaged Length, *L* (mm)		
1	N/A	N/A	2	N/A
2	N/A	N/A	2	N/A
3	N/A	N/A	2	N/A

(1) Ceased to burn before the 100 mm reference mark and rate is determined.
(2) Ceased to burn before the 25 mm reference mark and rate is not determined.

DIELECTRIC WITHSTANDING VOLTAGE

REFERENCE	IPC-CC-830C, paragraph 3.6.1 • IPC-TM-650, Method 2.5.7.1
TEST SPECIMENS	Five coated IPC-B-25A boards • Pattern C
REQUIREMENT	Dielectric withstanding voltage of the cured conformal coating **shall** be measured in accordance with IPC-TM-650, test method 2.5.7.1 using pattern C. • There **shall** be no disruptive discharge evidenced by flashover (surface discharge), sparkover (air discharge), or breakdown (puncture discharge). • The leakage rate **shall** not exceed 10 microamperes.
SUMMARY	**Meets requirements**
TEST MODIFICATIONS	None
TEST CONDITIONS	N/A
EVALUATION PERFORMED BY	RR
EVALUATION DATE	April 12, 2023
EQUIPMENT USED	WC052060

RESULTS:

There was no disruptive discharge evidenced by flashover (surface discharge), sparkover (air discharge), or breakdown (puncture discharge).

The leakage rate did not exceed 10 microamperes.

MOISTURE AND INSULATION RESISTANCE

REFERENCE	IPC-CC-830C, paragraph 3.7.1 • IPC-TM-650, Method 2.6.3.4
TEST SPECIMENS	Four coated IPC-B-25A boards One uncoated IPC-B-25A board
REQUIREMENT	The minimum insulation resistance shall be • 500 MΩ (5.00E+02 MΩ) or (5.00E+08Ω) for type ER and • 5000 MΩ (5.00E+03 MΩ) or (5.00E+09Ω) for all other types • Requirement applicable during humidity, after humidity, and one to two hours at reference conditions, and after 24 hours at reference conditions. The uncoated board is representative of the cleaning process therefore not subject to pass/fail criteria. Appearance shall be assessed and dielectric withstanding voltage shall be tested and meet the requirements as specified in 3.5.2 and 3.6.1 respectively; after 24 hours at the reference conditions. Uncoated boards are not tested for DWV after MIR Testing.
SUMMARY	**Meets requirements for Type AR coating.**
TEST MODIFICATIONS	None
TEST CONDITIONS	N/A
EVALUATION PERFORMED BY	RR
EVALUATION DATE	April 10-18, 2023
EQUIPMENT USED	WC051621, WC051634, WC051633, WC051719, WC052060

RESULTS:

All results are reported in Ohms, using scientific notation format.

The minimum insulation resistance value noted: 7.24E+10

Moisture and Insulation Resistance Readings (Ω)

Sample	Test Point	Initial (Ambient)	First Cycle	Fourth Cycle	Seventh Cycle	Tenth Cycle	After 1-2 Hours (Ambient)	After 24 Hours (Ambient)
1	1-2	1.07E+13	4.07E+11	3.02E+11	4.07E+11	5.62E+11	1.05E+13	7.76E+12
	3-2	1.07E+13	2.51E+11	2.19E+11	3.09E+11	3.89E+11	1.05E+13	8.32E+12
	3-4	1.07E+13	2.51E+11	2.09E+11	3.24E+11	3.89E+11	1.07E+13	1.00E+13
	5-4	1.07E+13	3.39E+11	2.75E+11	4.07E+11	5.01E+11	1.02E+13	1.02E+13
2	1-2	1.07E+13	7.24E+10	7.94E+10	1.29E+11	3.09E+11	9.77E+12	8.71E+11
	3-2	1.07E+13	3.02E+11	2.40E+11	3.09E+11	4.07E+11	1.00E+13	3.39E+12
	3-4	1.07E+13	3.39E+11	2.29E+11	3.31E+11	4.47E+11	1.05E+13	1.05E+13
	5-4	1.07E+13	3.98E+11	3.39E+11	3.98E+11	5.25E+11	1.05E+13	1.00E+13
3	1-2	1.07E+13	2.04E+12	1.55E+12	1.62E+12	1.58E+12	9.77E+12	4.07E+12
	3-2	1.07E+13	2.24E+12	1.15E+12	9.12E+11	1.23E+12	1.02E+13	5.75E+12
	3-4	1.07E+13	2.09E+12	1.45E+12	1.02E+12	1.05E+12	1.07E+13	1.00E+13
	5-4	1.10E+13	2.40E+12	1.66E+12	1.58E+12	1.48E+12	1.07E+13	1.00E+13
4	1-2	1.07E+13	2.95E+12	1.48E+12	1.48E+12	1.70E+12	9.55E+12	6.76E+12
	3-2	1.07E+13	1.82E+12	1.29E+12	1.12E+12	1.07E+12	9.55E+12	5.75E+12
	3-4	1.07E+13	2.04E+12	1.62E+12	1.00E+12	1.02E+12	1.05E+13	1.02E+13
	5-4	1.07E+13	2.63E+12	1.78E+12	1.35E+12	1.17E+12	1.07E+13	1.05E+13
Uncoated	1-2	1.05E+13	3.89E+11	3.24E+11	3.63E+11	5.25E+11	9.12E+12	8.32E+12
	3-2	1.05E+13	2.57E+11	2.00E+11	2.45E+11	3.63E+11	9.12E+12	7.94E+12
	3-4	1.05E+13	2.69E+11	2.00E+11	2.45E+11	3.63E+11	9.77E+12	7.24E+12
	5-4	1.05E+13	3.63E+11	3.09E+11	4.07E+11	5.89E+11	1.02E+13	7.76E+12
Lab Control	1-2	1.07E+13	9.33E+11	9.12E+11	8.13E+11	9.12E+11	9.77E+12	5.25E+12
	3-2	1.07E+13	8.13E+11	5.13E+11	6.92E+11	7.41E+11	1.05E+13	5.25E+12
	3-4	1.07E+13	7.94E+11	6.61E+11	5.62E+11	3.89E+11	1.07E+13	1.05E+13
	5-4	1.10E+13	1.02E+11	2.00E+11	8.32E+11	5.13E+11	1.07E+13	1.05E+13

Appearance

The coating did not have bubbles, pinholes, blisters, cracking, crazing, peeling, wrinkles, mealing or evidence of reversion, or cause corrosion after moisture and insulation resistance exposure.

The coating did not mask or obliterate the identification markings, conductors, and base materials greater than the discoloration caused by conditioning when uncoated after moisture and insulation resistance exposure.

Dielectric Withstanding Voltage (Pattern C – not performed on uncoated board)

There was no disruptive discharge evidenced by flashover (surface discharge), sparkover (air discharge), or breakdown (puncture discharge) after moisture and insulation resistance exposure.

The leakage rate did not exceed 10 microamperes after moisture and insulation resistance exposure.

THERMAL SHOCK

REFERENCE	IPC-CC-830C, paragraph 3.7.2 • IPC-TM-650, Method 2.6.7.1
TEST SPECIMENS	Five coated IPC-B-25A boards.
REQUIREMENT	Conformal coating products shall be tested in accordance with IPC-TM-650, method 2.6.7.1, with test conditions of -65°C (-85°F) to 125°C (257°F), 100 cycles. After the temperature cycles are completed, the coated test vehicles shall be maintained at the reference conditions at a temperature of 25 ±5°C (77 ±9°F) and a relative humidity of 50 ±5% for a period of 24 hours; after which appearance shall be assessed and dielectric withstanding voltage shall be tested and meet the requirements as specified in 3.5.2 and 3.6.1 respectively.
SUMMARY	**Meets Requirements**
TEST MODIFICATIONS	None
TEST CONDITIONS	-65°C to +125°C, 100 cycles, 15 minute dwells
EVALUATION PERFORMED BY	RR
CHAMBER EXPOSURE DATES	April 8-10, 2023
EVALUATION DATE	April 10-12, 2023
EQUIPMENT USED	WC051664, WC051719, WC052060

RESULTS:

Appearance

The coating did not have bubbles, pinholes, blisters, cracking, crazing, peeling, wrinkles, mealing or evidence of reversion, or cause corrosion after thermal shock exposure.

The coating did not mask or obliterate the identification markings, conductors, and base materials greater than the discoloration caused by conditioning when uncoated after thermal shock exposure.

Dielectric Withstanding Voltage (Pattern C)

There was no disruptive discharge evidenced by flashover (surface discharge), sparkover (air discharge), or breakdown (puncture discharge) after thermal shock exposure.

The leakage rate did not exceed 10 microamperes after thermal shock exposure.

TEMPERATURE AND HUMIDITY AGING (Hydrolytic Stability)

REFERENCE	IPC-CC-830C, paragraph 3.7.3 • IPC-TM-650, Method 2.6.11.1 (Desiccator technique used)
TEST SPECIMENS	Four coated HASL Finish Y-pattern coupons, with resistors to be tested. One coated HASL Finish Y-pattern coupon, with resistors to be used as a control sample
REQUIREMENT	The control specimen **shall** be maintained at the reference conditions at 25 ±5°C and 50 ±5% relative humidity. The aged conformal coating **shall** be tack free to touch. There **shall** be no evidence of softening, chalking, blistering, surface tack, cracking, loss of adhesion or reversion to the liquid state.
SUMMARY	**The samples meet requirements.**
TEST MODIFICATIONS	None
TEST CONDITIONS	N/A
EVALUATION PERFORMED BY	RR
EVALUATION DATE	January 30, 2023, to June 6, 2023
EQUIPMENT USED	WC051696, WC051719

RESULTS:

Tackiness

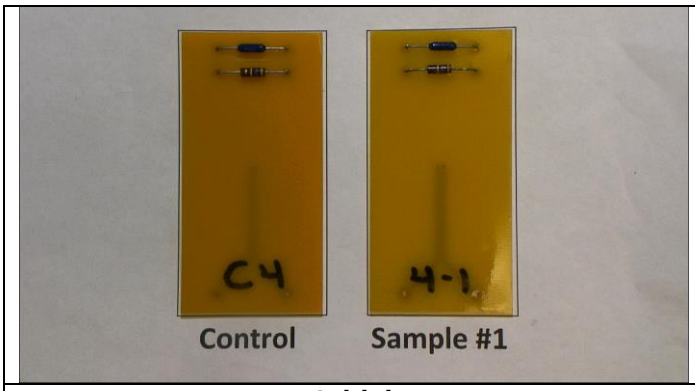
There was no evidence of loosening, detachment, wrinkling, or other distortion of the conformal coating.

Visual Examination

There was no evidence of blistering of the conformal coating. There was no evidence of softening, chalking, surface tack, cracking, loss of adhesion or reversion to the liquid state.

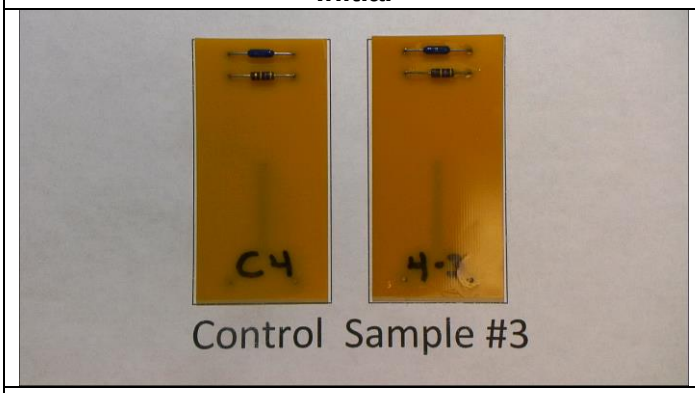
Visual Exam Interval		Test Specimen			
	1 (Control)	2	3	4	5
Initial	Clear	Clear	Clear	Clear	Clear
After 28 days	No Change	Slightly Darker	Slightly Darker	Slightly Darker	Slightly Darker
After 56 days	No Change	Slightly Darker	Slightly Darker	Slightly Darker	Slightly Darker
After 84 days	No Change	Slightly Darker	Slightly Darker	Slightly Darker	Slightly Darker
After 120 days	No Change	Slightly Darker	Slightly Darker	Slightly Darker	Slightly Darker
After 127 days	No Change	Slightly Darker	Slightly Darker	Slightly Darker	Slightly Darker

Representative photos at each interval are shown below.

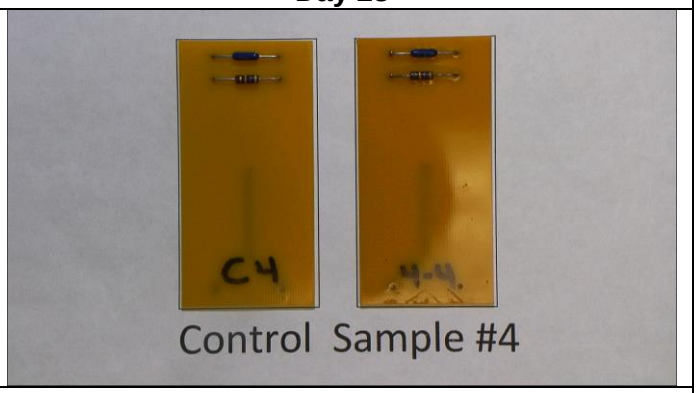


Initial

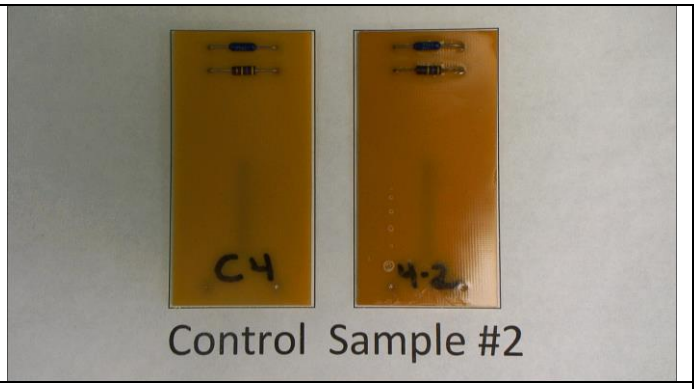
Day 28



Day 56



Day 84

	
Day 120	**Day 127**

COATING THICKNESS

REFERENCE	IPC-CC-830C, paragraph 4.6.4
TEST SPECIMENS	Four coated tin panels and one uncoated tin panel
REQUIREMENT	The thickness **shall** be measured accurately to a minimum to ± 0.1 mil. Thickness measurement and accuracy for Type UT coating **shall** be performed by the manufacturer's recommended methods. The reported thickness of the coating for each test may be taken from a witness coupon. The cured conformal coating on the test vehicle **shall** have a thickness as specified below.

Type	Minimum		Maximum	
AR	25 µm	0.98 mils	75 µm	2.95 mils
UR	25 µm	0.98 mils	75 µm	2.95 mils
ER	25 µm	0.98 mils	75 µm	2.95 mils
SR	50 µm	1.97 mils	200 µm	7.87 mils
XY	12.5 µm	0.49 mils	50 µm	1.97 mils
UT	-	-	<12.5 µm	<0.49 mils
SC	25 µm	0.98 mils	75 µm	2.95 mils

SUMMARY	**Meets Requirements**
TEST MODIFICATIONS	None
TEST CONDITIONS	N/A
EVALUATION PERFORMED BY	RR
EVALUATION DATE	February 3, 2023
EQUIPMENT USED	WC051815

RESULTS:

Location	Specimen – Coating Thickness (mils)			
	1	2	3	4
Area 1	1.1	1.1	1.3	1.2
Area 2	1.2	1.3	1.2	1.3
Area 3	1.2	1.6	1.0	1.0
Average	*1.2*	*1.3*	*1.2*	*1.2*

EQUIPMENT LIST

Asset Number	Manufacturer	Description	M/N	S/N	Last Calibration	Cal Due
WC051508	Hewlett Packard	HIGH RESISTANCE METER	4339B	JP1KD00570	10/17/2022	10/31/2023
WC051521	Mattson	FOURIER, TRANSFORM, INFRARED with Software Version 7.3 install date 02/28/13	GALAXY SERIES 5000, GL-5020	93O2156	NCR	NCR
WC051523	Olympus	Stereomicroscope with Pax-It2 Version 1.7.3.0 (installed 6/4/2021)	SZX16	0L40214	12/13/2021	06/30/2023
WC051524	Microstar	BINOCULAR MICROSCOPE	AO	BE318023	NCR	NCR
WC051621	Thermotron	ENVIRONMENTAL TEST CHAMBER	S-16-8200	45250	03/22/2023	03/31/2024
WC051625	Espec	ENVIRONMENTAL CHAMBER	ESX-3CA	112232	07/05/2022	07/31/2023
WC051626	Yokogawa	RECORDER	FX106-4-2	S5N308885	07/05/2022	07/31/2023
WC051633	Hewlett Packard	LAB BENCH DC POWER SUPPLY	E3612A	KR83007475	11/13/2022	11/30/2023
WC051634	Concoat Systems	AUTOSIR with software v 7.02 install 03/22/10 and Bellcore 6.1.1b install 01/15/09	256 Channel Rack-Mount	9255102000	11/07/2022	11/30/2023
WC051635		LAB HOOD			04/10/2023	04/30/2024
WC051664	Cincinnati Sub-Zero (CSZ)	TEMPERATURE CHAMBER	VTS-3-6-6-SC/WC	VT1313001	01/19/2023	01/31/2024
WC051668	Thermo Scientific	MULTI-PURPOSE ROTATOR (SHAKER)	2345	1666090807904	NCR	NCR
WC051692	Gallenkamp	incubator	ipr150.xx1.1/ sg93/02/304		NCR	NCR
WC051696	Blue M	Mechanical Convection Oven	ESP-400A-9/C-9-UL	ESP-3379	10/17/2022	10/31/2023
WC051719	Tagarno	Stereomicroscope	620000	28593	NCR	NCR
WC051723	Brookfield Engineering	VISCOMETER	RVDV-II+	RT52119	04/04/2023	04/30/2024
WC051740	Tuttnauer Brinkman	AUTOCLAVE/STEAM STERILIZER	3870EA	14081496	09/13/2022	09/30/2023
WC051815	Mitutoyo	Digimatic Micrometer	389-351-30		05/16/2023	05/16/2024
WC051863	Sartorius	Digital Balance	ENTRIS5201-1S	0035807306	03/22/2023	03/31/2024
WC051928	Hausser Scientific	Counting Chamber	1492	522956	NCR	NCR
WC051957	Esco	BioHood	LA2-4A2-E	2019-141243	04/10/2023	04/30/2024

Asset Number	Manufacturer	Description	M/N	S/N	Last Calibration	Cal Due
WC051961	VWR International	Refrigerator/Freezer Thermometer	EU 620-0919	D182548	05/18/2023	05/18/2024
WC051962	VWR International	Refrigerator/Freezer Thermometer	EU 620-0919	D182543	05/18/2023	05/18/2024
WC051964	Trace Labs (Methode)	Mandrels			NCR	NCR
WC052060	Hipotronics	AC Hipot	60HVT-DI	P2110485	01/19/2023	01/31/2024
WC052068	Control Company	Traceable Digital Bottle	06-664-257	210798733	03/09/2023	03/09/2024
WC052069	DeVilbiss	Glass Atomizer w/Metal Top	163-RD		NCR	NCR
WC052072	DeVilbiss	Glass Atomizer w/Metal Top	163-RD		NCR	NCR
WC052073	Control Company	Traceable Digital Bottle	06-664-257	210421833	03/09/2023	03/09/2024
WC052081	Products Engineering	Rigid Ruler	NN262-012	072210726	07/07/2022	07/31/2025
WC052090	Benchmark Scientific	Hotplate/Stirrer	H4000-HS	202104081602	NCR	NCR
WC052113	Cole-Parmer	Analytical Balance	55000-04	PLBBT9	10/25/2022	10/25/2023
WC058804	Precision Scientific	Incubator	6M	10AZ-7	NCR	NCR
WC059253	Ohaus	Top Loader Balance	AR5120	I0861225031691P	03/22/2023	03/31/2024
WC059288	Empire Industries	Horizontal Metal Fixture	2990		12/13/2022	12/31/2025
WC059408	Fisherbrand Ertco	Glass Thermometer/Incubator Bottle	I-030-1SR	18127	10/13/2021	08/31/2023
WC059409	Fisherbrand Ertco	Glass Thermometer/ Incubator Bottle	i-030-1SR	12880	10/13/2021	08/31/2023
WC059411	Fisherbrand Ertco	Glass Thermometer/Incubator Bottle	1007-3	19721	10/13/2021	08/31/2023
WC061951	Fisher Scientific	CENTRIFUGE	1829		NCR	NCR
WC062012	Ultraviolet Products	ULTRAVIOLET LIGHT	UVL-21		NCR	NCR

TEST METHODS

SHELF LIFE

Insulation Resistance:

Teflon insulated wires were soldered to the finger-tabs of the D comb patterns. The comb patterns were protected with an off-contact shield to insure no splattering of the flux onto the combs. The flux was not removed. 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).

Dielectric Withstanding Voltage:

Insulated wires were soldered to the corresponding finger tabs of the C pattern. The electrodes of the hi-pot tester were connected to the insulated wires. One hundred (100) VAC were applied per second until achieving 1500VAC. Once 1500VAC was achieved, the coupons were held at this voltage for sixty seconds. The results were recorded.

CURE

The specimens were prepared at the customer's facility using the specified application and curing procedures.

FOURIER TRANSFORM INFRARED SPECTROSCOPY (FTIR)

A Fourier Transform Infrared Spectrometer was used to collect and process infrared wavelength absorbance/transmission spectra. Infrared spectra can indicate the chemical composition and/or bonding of organic, polymeric, and many inorganic substances.

The spectrometer radiates a broad band of infrared light through the specimen. Depending on their chemical bonding, individual materials will absorb, transmit, or reflect infrared light of various wavelengths. From the spectrum produced, information about chemical bonding is obtained from the location of group frequency peaks. Most spectra contain additional "fingerprint" peaks that are unique to a particular molecular structure. In addition, the microscope attachment (Micro-FTIR) enables analysis of areas as small as 25 microns in diameter.

VISCOSITY

The uncured conformal coating container was opened, and a specimen of coating was transferred to a container that was a minimum of 5 cm in diameter and 5 cm deep. The uncured conformal coating was gently stirred for 1 to 2 minutes, taking care to avoid the introduction of air. The container was placed in a water bath maintained per the customer's instructions and was left undisturbed until to reaching thermal and rheological equilibrium.

A T-F (T-bar) spindle was attached to a Brookfield RVDV digital viscometer. The viscometer was leveled and its display zeroed. The T-bar spindle was positioned above the center of the conformal coating and inserted to a depth of one inch. Rotation was begun at 5 rpm. The viscosity was recorded after two revolutions.

APPEARANCE

The conformal coating was examined with 1.75 X magnification with various light sources. Any referee inspection was carried out with 10X magnification.

FLUORESCENCE

Ultra-violet light was placed over each of the test specimens. The light was turned on and it was noted if the conformal coating was fluorescent or not.

FUNGUS RESISTANCE

The fungus test was conducted in accordance with IPC-TM-650 Method 2.6.1.1.

The fungal test samples were pre-conditioned for at least four hours in a chamber at 30°C with a relative humidity of 95±2%. Following the pre-conditioning period the test samples and controls were inoculated with the mixed fungus spore suspension in a mineral salts solution (pH 6.03) by means of a fine mist atomizer.

The following fungi were used:

- *Aspergillus brasiliensis (formerly known as A.niger)*
- *Aureobasidium pullulans*
- *Chaetomium globosum*
- *Talaromyces pinophilus (formerly known as P. pinophilum and P. funiculosum)*
- *Trichoderma virens (formerly known as G. virens)*

The control items were sterile minimal media agar plates with filter paper, sterile potato dextrose agar plates and cotton strips which had been dipped in solution and dried according to IPC-TM-650 Method 2.6.1.1.

Immediately following the inoculation, the fungal test samples and controls were sealed within and incubated at 29±1°C with at least 85% relative humidity. After 7 days, the growth on the control items was inspected to assure that the environmental conditions were suitable for growth. The controls were covered with growth.

After 28 days, the control strips and test samples were removed from the chamber and immediately examined for evidence of fungal growth and/or deterioration. The test items were microscopically examined (up to x63).

The samples were evaluated with guidance from ASTM G21, which assigns a fungal growth rating based on visual observations after fungal exposure. A summary of the rating system is provided below.

Growth Amount	Rating
None	0
Trace (less than 10%)	1
Light (10-30%)	2
Medium (30-60%)	3
Heavy (60-100%)	4

FLEXIBILITY

The conformally coated tin panel was placed on a granite surface plate, to insure a flat and smooth testing surface.

The panel was fixed so that it remained in a stationary position during testing. A 0.3 cm (0.12") diameter mandrel was placed in the center of the coated tin panel. One end of the panel was selected and then bent, within one second, 180° around the mandrel. The specimens were visually examined using 10X magnification for evidence of cracking or crazing of the cured conformal coating.

FLAMMABILITY

Six specimens were tested, the remaining specimens were held for referee purposes. Each specimen was marked with two lines perpendicular to the longitudinal axis of the bar, 25 ± 1 mm and 100 ± 1 mm from the end that is to be ignited. Each test specimen was clamped at the farthest end from the 25 mm mark, with its longitudinal axis horizontal and its transverse axis inclined at 45 ± 2 degrees. A wire gauze was clamped horizontally beneath the specimen, with a distance of 10 ± 1mm between the lowest edge of the specimen and the gauze with the free end of the specimen even with the edge of the gauze.

A 20 ± 1 mm high methane flame was applied to the free end at the lower edge of the specimen. The burner was positioned so that the flame impinges on the free end of the

specimen to a depth of 6 ± 1 mm for 30 ± 1 seconds. After removal of the flame the specimen was allowed to burn to the 25 mm mark. As soon as the flame reached the 25 mm mark, a stopwatch was started, when the flame reached the 100 mm mark the stopwatch was stop and the burn rate was recorded.

Calculation for the linear burn rate, V, in mm per minute, for each specimen:

$$V = 60\frac{L}{t}$$

where:

V is the linear burning rate in mm/minute
L is the damaged length, in mm
t is time, in seconds

DIELECTRIC WITHSTANDING VOLTAGE

Insulated wires were soldered to the corresponding finger tabs of the C pattern. The electrodes of the hi-pot tester were connected to the insulated wires. One hundred (100) VAC were applied per second until achieving 1500VAC. Once 1500VAC was achieved, the specimens were held at this voltage for one minute. The results were recorded.

MOISTURE AND INSULATION RESISTANCE

Teflon insulated wires were soldered to the finger-tabs of the D comb patterns. The comb patterns were protected with an off-contact shield to insure no splattering of the flux onto the combs. The flux was not removed. The specimens were placed in an oven maintained at 50 ± 2ºC for 24 hours. The specimens were cooled to ambient conditions of 25°, +2, -5°C with 40-50% relative humidity prior to obtaining initial insulation resistance measurements. 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 the center of 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 160 hours of temperature and humidity. Polarizing voltage was maintained throughout the entire period. Humidity was maintained at 85% minimum throughout the cycles, except at the low temperature, step (c), the humidity may drop to 80% minimum.

One cycle is as follows:
a) Start test at 25ºC and raise temperature to 65ºC over a time span of 2.5 hours
b) Maintain temperature at 65ºC for 3 hours.
c) Lower temperature from 65 to 25ºC over 2.5 hours.

Note: There shall be no delay between cycles.

The polarizing voltage of 50 VDC was disconnected prior to taking the required insulation resistance measurements. While in the chamber the insulation resistance was measured and recorded at the following intervals: first, fourth, seventh, and tenth cycles. The measurements, during chamber exposure, were taken between hours 2 and 3 of the high temperature phase of each cycle specified.

After completion of the 160 hours, the bias voltage was disconnected, and the specimens were removed from the chamber. The insulation resistance measurements were taken after an hour and before two hours at ambient laboratory conditions of 25°, +2, -5°C with 40-50% relative humidity. The specimens were then stabilized for 24 hours at laboratory conditions of 25°, +2, -5°C with 40-50% relative humidity prior to obtaining the final required insulation resistance measurements.

After completion of all electrical testing, the test specimens were examined for appearance and tested for dielectric withstanding voltage.

Appearance:

The conformal coating was examined with 1.75 X magnification with various light sources. Any referee inspection was carried out with 10X magnification.

Dielectric Withstanding Voltage:

Insulated wires were attached prior to coating to the corresponding finger tabs of the C pattern. The electrodes of the hi-pot tester were connected to the insulated wires. One hundred VAC were applied per second until achieving 1500VAC. Once 1500VAC was achieved, the specimens were held at this voltage for one minute. The results were recorded.

THERMAL SHOCK

The IPC-B-25A boards were placed in Thermal Shock Chamber. The cold chamber was set at -65°C, and the hot portion of the chamber was set at 125°C. The dwell time was set at 15 minutes. The chamber was set for 100 cycles, and cycling commenced.

Upon completion of the 100 cycles, the samples were removed from the chamber. The samples were conditioned at 25 ±5°C and a relative humidity of 50 ±5% for a period of 24 hours, then tested for appearance and dielectric withstanding voltage.

Appearance:
The conformal coating was examined with 1.75 X magnification with various light sources. Any referee inspection was carried out with 10X magnification.

Dielectric Withstanding Voltage:
Insulated wires were attached prior to coating to the corresponding finger tabs of the C pattern. The electrodes of the hi-pot tester were connected to the insulated wires. One hundred VAC were applied per second until achieving 1500VAC. Once 1500VAC was achieved, the specimens were held at this voltage for one minute. The results were recorded.

COATING THICKNESS

A micrometer, accurate to ± 0.0001", was used to measure the thickness of an uncoated tin panel specimen. The micrometer was then used to measure the coated tin panels.

The thickness obtained from the virgin specimen was subtracted from the thickness obtained from the coated specimens.

The three measurements were recorded and averaged for the final coating thickness measurement.

TEMPERATURE AND HUMIDITY AGING (Hydrolytic Stability)

The specimens were placed in a suitable test vessel in which the appropriate test conditions of 85 ±2°C with a maximum of 98% relative humidity were maintained. The test was run for one hundred and twenty (120) days.

The test samples were examined at the following intervals, using the methods outlined.

After 28, 56, and 84 days, the panels were returned to 25±5°C and 50±5%RH and held for 2 hours. The specimens were compared to the control Y-pattern and results were recorded. After visual examination the specimens were returned to the test vessel for continuing exposure.

After 120 days, the panels were returned to 25±5°C and 50±5%RH. The specimens were compared to the control Y-pattern and results were recorded.

The specimens were held at 25±5°C and 50±5%RH for an additional 7 days.

The specimens were tested for tackiness in accordance with FED-STD-141, method 4061 (Dry Through for Varnish, Lacquers and Enamels).

The boards were visually examined for evidence of softening, chalking, blistering, surface tack, loss of adhesion or reversion to the liquid state. They were compared to the control sample for legibility of the markings of the resistors.

DATASHEETS

Form 313	Customer Name:	Lackwerke Peters
Revision 2	Project #:	PR166055
Page 1 of 1	EQUIPMENT USED:	WC051803

SPECTROSCOPY TEST INFORMATION

SAMPLE IDENTIFICATION:

Coating on glass slides

SCAN / SPECTRUM INFORMATION:

Technique	Date	Initials	File Name(s) *
ATR	6/13/2023	DDP	PR166055*.*

* NOTE: The *.* notation will be used when all files starting with the same **Project** number are performed by the same technician.

NOTES:

Form 36
Revision 0
Page 1 of 1

APPLICABLE TEST METHODS: IPC-TM 650 2.6.1.1

EQUIPMENT USED: See Below

FUNGUS RESISTANCE PREPARATION

MINERAL SALTS SOLUTION PREPARATION: Date Prepared: 1/23/2023 Prepared By: DH

Compounds Used: Date Expires: 4/23/2023

Potassium dihydrogen orthophosphate ID:	13820	Sodium chloride ID:	13587
Potassium monohydrogen orthophosphate ID:	13356	Ferrous sulfate heptahydrate ID:	13838
Magnesium sulfate heptahydrate ID:	13367	Zinc sulfate heptahydrate ID:	13378
Ammonium Nitrate ID:	13353	Manganous sulfate monohydrate ID:	13357

Sterilization: Start Date / Time: 1/23/23 10:30 AM Duration (mins): 30 (20 minimum)

pH: 6.0 (6.0-6.5) Adjusted pH, if needed: N/A

Sodium hydroxide ID: N/A

MINERAL SALTS AGAR PREPARATION: Date Plated: 11/29/2022 Prepared By: DH

Compounds Used: Date Expires: 5/28/2023

Potassium dihydrogen orthophosphate ID:	13820	Sodium chloride ID:	13587
Potassium monohydrogen orthophosphate ID:	13356	Ferrous sulfate heptahydrate ID:	13838
Magnesium sulfate heptahydrate ID:	13367	Zinc sulfate heptahydrate ID:	13378
Ammonium Nitrate ID:	13353	Manganous sulfate monohydrate ID:	13357
Agar ID:	13713		

Sterilization: Start Date / Time: 11/29/22 9:30 AM Duration (mins): 30 (minimum, 20)

pH: 6.0 (6.0-6.5) Adjusted pH, if needed: N/A

Sodium hydroxide ID: N/A

INDIVIDUAL SPORE SUSPENSIONS PREPARATION: Prepared By: DH / KH

**A. brasiliensis* (ATCC #9642) ID:	12830	*A. pullulans* (ATCC #15233) ID:	13234	*icolor* (ATCC #11730) ID:	13231
C. globosum (ATCC #6205) ID:	13227	**T. virens* (ATCC #9645) ID:	13229	*flavus* (ATCC #9643) ID:	13228
**P. funiculosum* (ATCC #11797) ID:	13233				

Wetting agent: Agent used: Lauryl Sulfate ID: 13886

Date Prepared:	Colony Count (within 1 mm^2)		Calculated Count		Date Expires:
1/25/2023	*A. brasiliensis* :	21	1,050,000	(1,000,000 ± 200,000)	2/8/2023
1/31/2023	*C. globosum* :	17	850,000	(1,000,000 ± 200,000)	2/14/2023
1/31/2023	*P. funiculosum* :	22	1,100,000	(1,000,000 ± 200,000)	2/14/2023
1/31/2023	*A. pullulans* :	22	1,100,000	(1,000,000 ± 200,000)	2/14/2023
1/25/2023	*T. virens:*	20	1,000,000	(1,000,000 ± 200,000)	2/8/2023
1/25/2023	*A. veriscolor:*	0	0	(1,000,000 ± 200,000)	2/8/2023
1/25/2023	*A. flavus* :	0	0	(1,000,000 ± 200,000)	2/8/2023

*Previously known as a different species.

NOTES:

WC051523, WC051524, WC051625, WC051626, WC051668, WC051692, WC051740, WC051863, WC051928, WC051957, WC051961, WC051962, WC052068, WC052072, WC052073, WC052090, WC052113, WC058804, WC059253, WC059408, WC059409, WC059411, WC061951

Form 37
Revision 0
Page 1 of 1

CUSTOMER NAME: Lackwerke Peters
PROJECT #: PR166055
EQUIPMENT USED: See Form 36
METHOD/REVISION: 2.6.1.1

TEST INFORMATION - Fungus Resistance, IPC-TM-650, method 2.6.1 / 2.6.1.1

SAMPLE IDENTIFICATION:

Group 4, Slides "1" through "4"

MIXED SPORE SUSPENSION PREPARATION: Date Prepared: 2/7/2023 Prepared By: DH

Spores Used: Date Expires: 2/14/2023

**A. brasiliensis* ID:	12830	*A. pullulans* ID:	13234
C. globosum ID:	13227	**T. virens* ID:	13229
**P. funiculosum* ID:	13233		

*Previously known as a different species. Please see Test Method section for former nomenclature descriptions.

PRECONDITIONING INFORMATION:

Start Date/Time: 2/7/23 2:44 PM
End Date/Time: 2/7/23 6:44 PM
Duration (Hours): 4.0 (4 minimum)

Chamber Conditions: Temperature: 30.0 (30±1°C) Humidity: 95 (95±2%)

EXPOSURE INFORMATION:

Start Date: 2/7/2023
End Date: 3/7/2023
Duration (Days): 28 (28)

Chamber Conditions: Temperature: 29.0 2.6.1 (30±1°C) 2.6.1.1 (29±1°C) Humidity: >85 (85%, min)

CONTROL INFORMATION:

#1 - Viability of Inoculum: Date Prepared: 2/2/2023 Prepared By: DH
#2 - Control Strips: Date Prepared: 2/7/2023 Prepared By: DH

Washing Solution Compound:

Glycerol ID:	13513	Magnesium sulfate ID:	13357
Potassium dihydrogen orthophosphate ID:	13820	Yeast extract ID:	13306
Ammonium nitrate ID:	13353		

#1 - Day 7 Evaluation Rating: 4 (0-4) Performed By: KH/DH OK to Proceed? (Y/N): Y (satisfactory fungus growth must be visible)

#2 - Day 7 Evaluation Rating: 4 (0-4) Performed By: KH/DH OK to Proceed? (Y/N): Y (satisfactory fungus growth must be visible)

VISUAL EXAMINATION RESULTS:

Sample ID	Date	Initials	Observations
4-1	3/9/2023	KH	0 - No active growth observed
4-2	3/9/2023	KH	0 - No active growth observed
4-3	3/9/2023	KH	0 - No active growth observed
4-4	3/9/2023	KH	0 - No active growth observed

CHAMBER DECONTAMINATION:

Before Testing: Date Performed: 1/27/2023 Performed By: DH
After Testing: Date Performed: 3/7/2023 Performed By: DH

NOTES:

Samples were originally inspection on 3/7 by DH and re-inspected by KH on 3/9. The latter results are reported.

REVISION TABLE

Revision	Date	Description
-	16-Jun-2023	• Initial release

END OF REPORT