NEW DEVELOPMENTS IN POWDER PRIMING OF SMC

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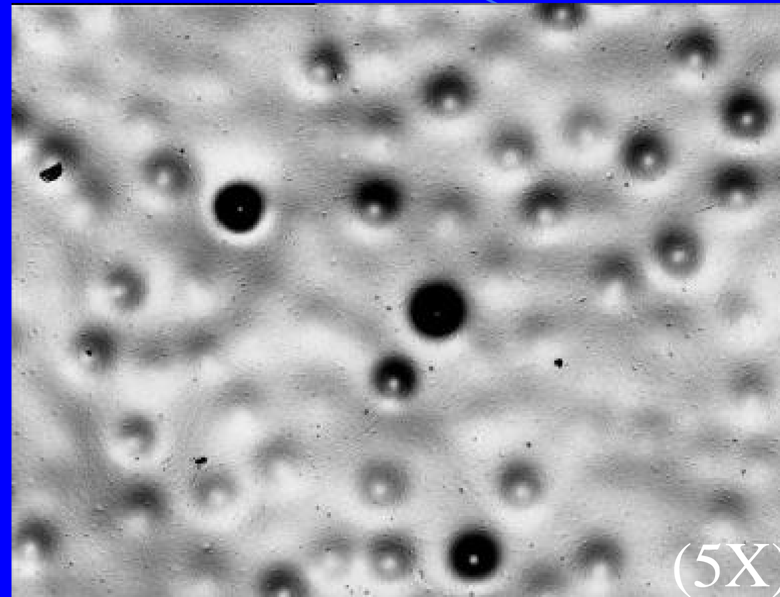
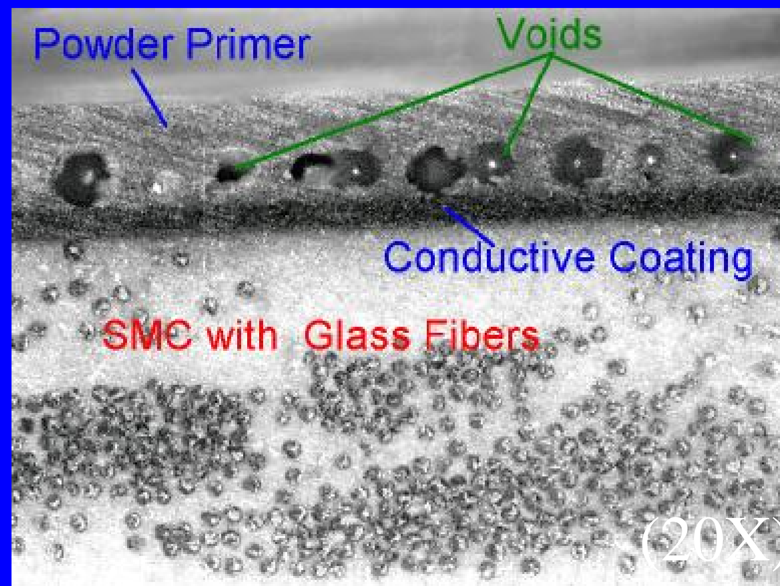
Powder Popping Defect





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Popping on Wet Class A SMC Panels With Varied Moisture Content

Primer \ SMC	SMC-1				SMC-2				SMC-3			
	Dry	15% RH	30% RH	90% RH	Dry	15% RH	30% RH	90% RH	Dry	15% RH	30% RH	90% RH
PRIMER-1	0	0.0377	0.1618	0.7279	0				0	0.0478	0.1353	0.4349
PRIMER-2	0	0.0392	0.1303	0.7063	0	0.0411	0.1293	0.7013	0	0.0266	0.1122	0.4040
PRIMER-3	0	0.0357	0.1094	0.7195	0	0.0234	0.0768	0.6614	0	0.0167	0.0735	0.4180
PRIMER-4	0	0.0274	0.1027	0.6794	0	0.0239	0.0836	0.6520	0	0.0276	0.1061	0.4206
PRIMER-5	0	0.0047	0.1126	0.6857	0	0.0006	0.0779	0.6503	0	0.0030	0.0692	0.3987
PRIMER-6	0	0.0042	0.0843	0.6761	0	0.0064	0.0757	0.6537	0	0.0056	0.0625	0.4170

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Observations

- All existing Class A SMC's after exposure to high humidity fail in the bake oven of the powder primer and show popping
- The moisture content threshold for initiating popping varies from one SMC to another due to variation in diffusivity.
- Moisture is not the only cause of failure because some SMC panels even after complete drying prior to powder primer application fail in the bake oven and show popping.

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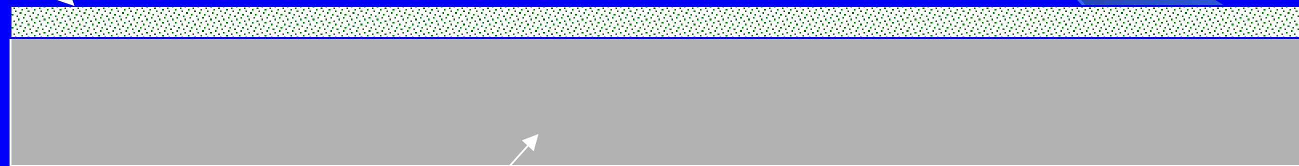
Failure Mechanism

Powder



Conductive coated SMC

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Potential Failure Mechanisms

Powder initiated:

- Chemical incompatibility at the interface of the powder and the conductive coating
- Skin formation on the liquid film
- Substrate static charges

SMC initiated:

- Residual unreacted volatiles
- Decomposition of the substrate
- Volatiles that have been absorbed by the substrate

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The Effect of Storage Condition After Drying

SMC	Vacuum Seal	Regular seal
Dry SMC-4		

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Failure Mechanism

Powder initiated:

- Chemical incompatibility at the interface of the powder and the conductive coating
- Skin formation on the liquid film
- Substrate static charges

SMC initiated:

- Residual unreacted volatiles
- Decomposition of the substrate
- Volatiles that have been absorbed by the substrate
    - Vapors: water
    - Gases : nitrogen, oxygen

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The effect of Air Moisture

Exposure Environment	Exposure Time (minutes)					
	0	5	7	10	12	20
Air						
Water	-	-		-		-

Air penetrates into SMC panels faster than water

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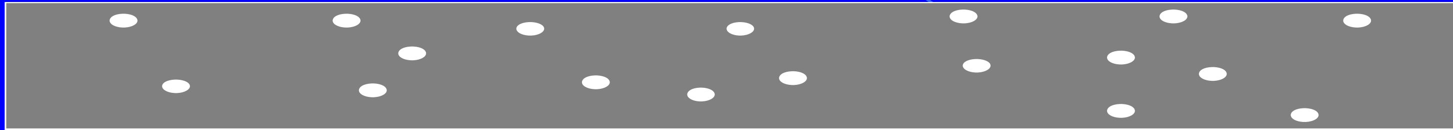
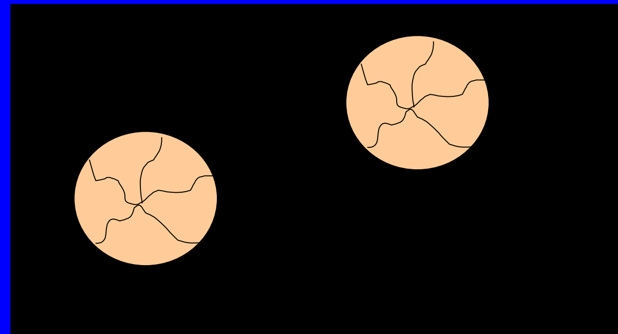
SMC Voids

Processing voids



Low profile micro voids



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MR5 SMC Formulation

Component	S.G.	Parts
Ashland MR13006	1.120	52.00
Neulon T-Plus	1.100	40.00
Styrene monomer (J.T. Baker)	0.907	6.00
Byk W-9010	1.010	1.50
Mod E (5% PBQ)	1.100	0.20
Trigonox BPIC	0.900	1.50
Zinc Stearate (Norac COAD 27)	1.100	4.00
CaCO3 (Huber W-4)	2.710	150.00
Carbon black (CM-2015)	1.800	0.03
MgO (AM-9033, 32.5%)	1.393	1.75
Glass Fiber (OCF-973)	2.540	97.46

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MR3 SMC Formulation

Component	S.G.	Parts
Ashland MR13006	1.120	52.00
Reichhold X4399-05	1.100	40.00
Styrene monomer (J.T. Baker)	0.907	6.00
Byk W-9010	1.010	1.50
Mod E (5% PBQ)	1.100	0.20
Trigonox BPIC	0.900	1.50
Zinc Stearate (Norac COAD 27)	1.100	4.00
CaCO3 (Huber W-4)	2.710	150.00
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MgO (AM-9033, 32.5%)	1.393	1.75
Glass Fiber (OCF-973)	2.540	97.46

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CONCLUSIONS

- Polyvinyl acetate low profile additives, can cause micro cracking and promote primer popping in absence of moisture
- The popping issue in the dry condition can be eliminated by using an alternative low profile additive.
- In the wet condition, a modified conductive coating is needed to slow down moisture penetration to the surface.

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Issues

- **The molded SMC panels did not have a smooth surface finish.**
- **The experimental coating**
  - **Passed the initial adhesion test**
  - **Failed the 10-day humidity test**

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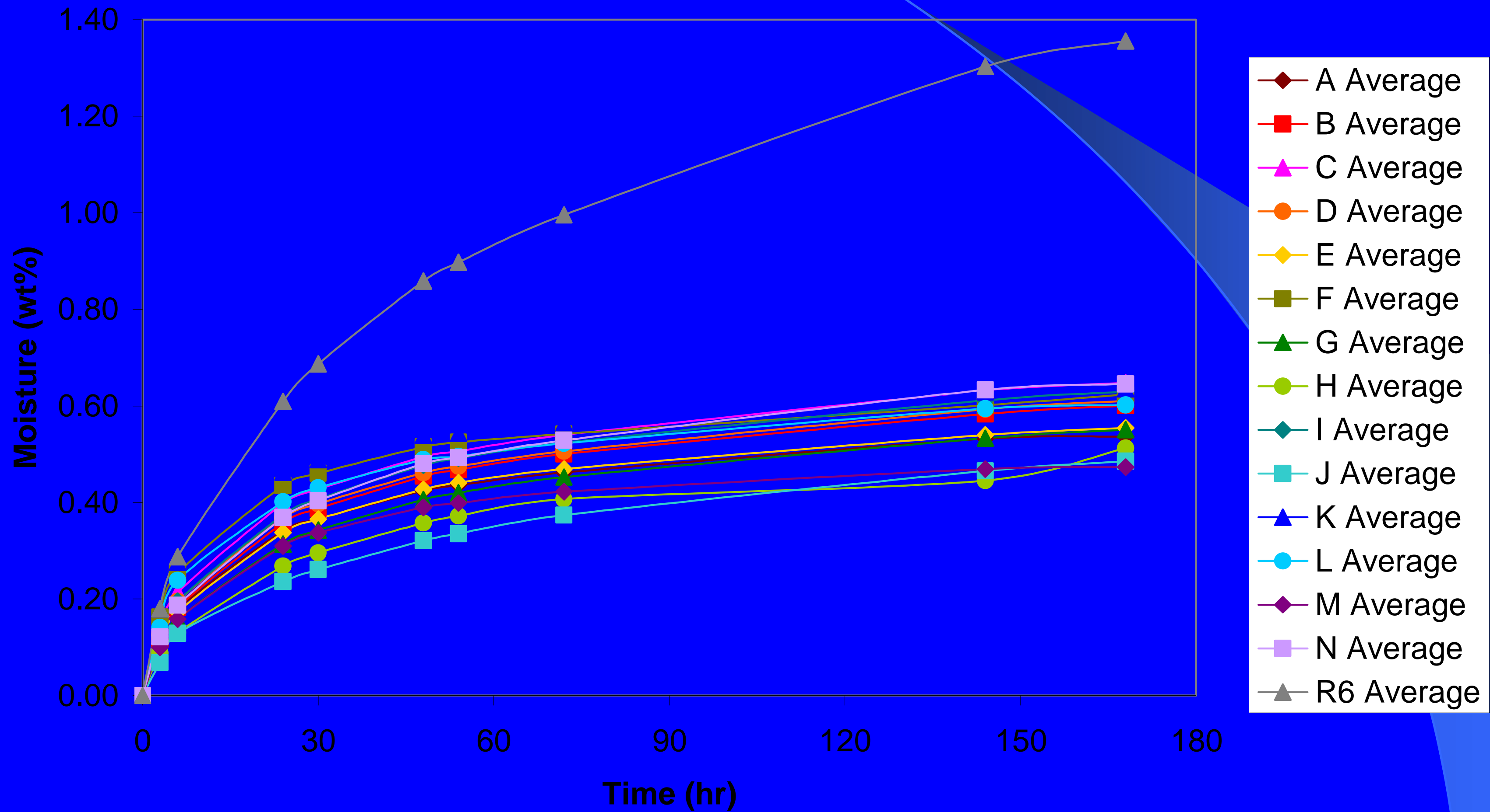
SMC Development



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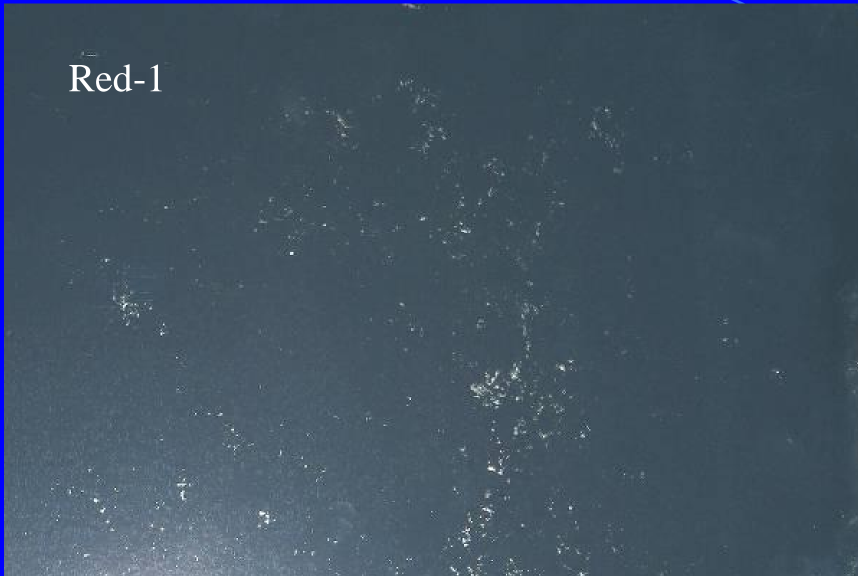
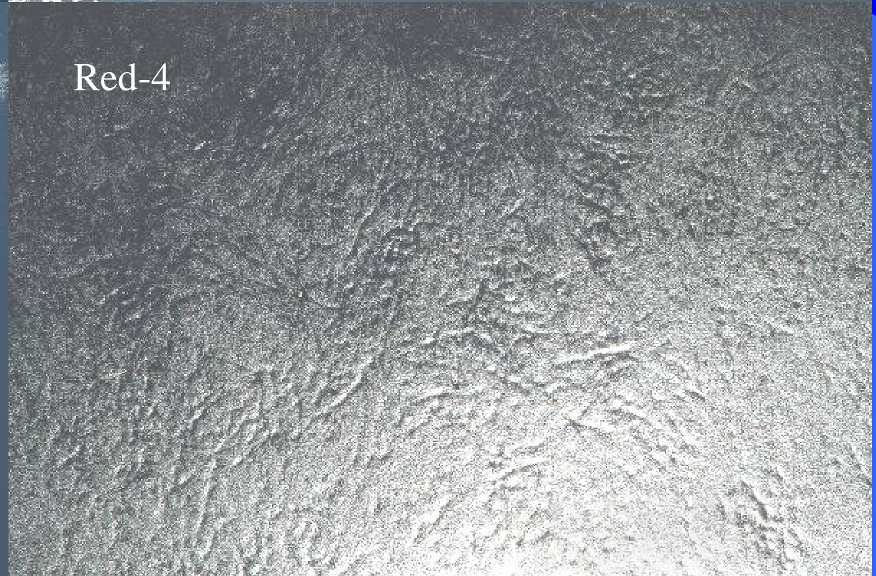
Ranking of severe popping on powder coated SMC panels





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Final SMC Formulations

Material Identification	Material Description	
113 A	Resin Type I	LPA Type I
113 B	Resin Type I	LPA Type II
2719	Resin 1,	Low Profile Blend 1
2749	Resin 2,	Low Profile Blend 7,

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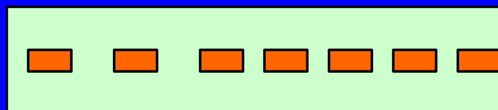
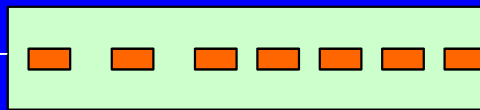
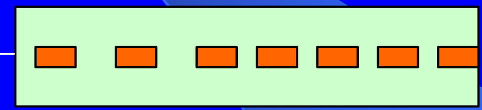
Powder Application

Sealer Application

ELPO







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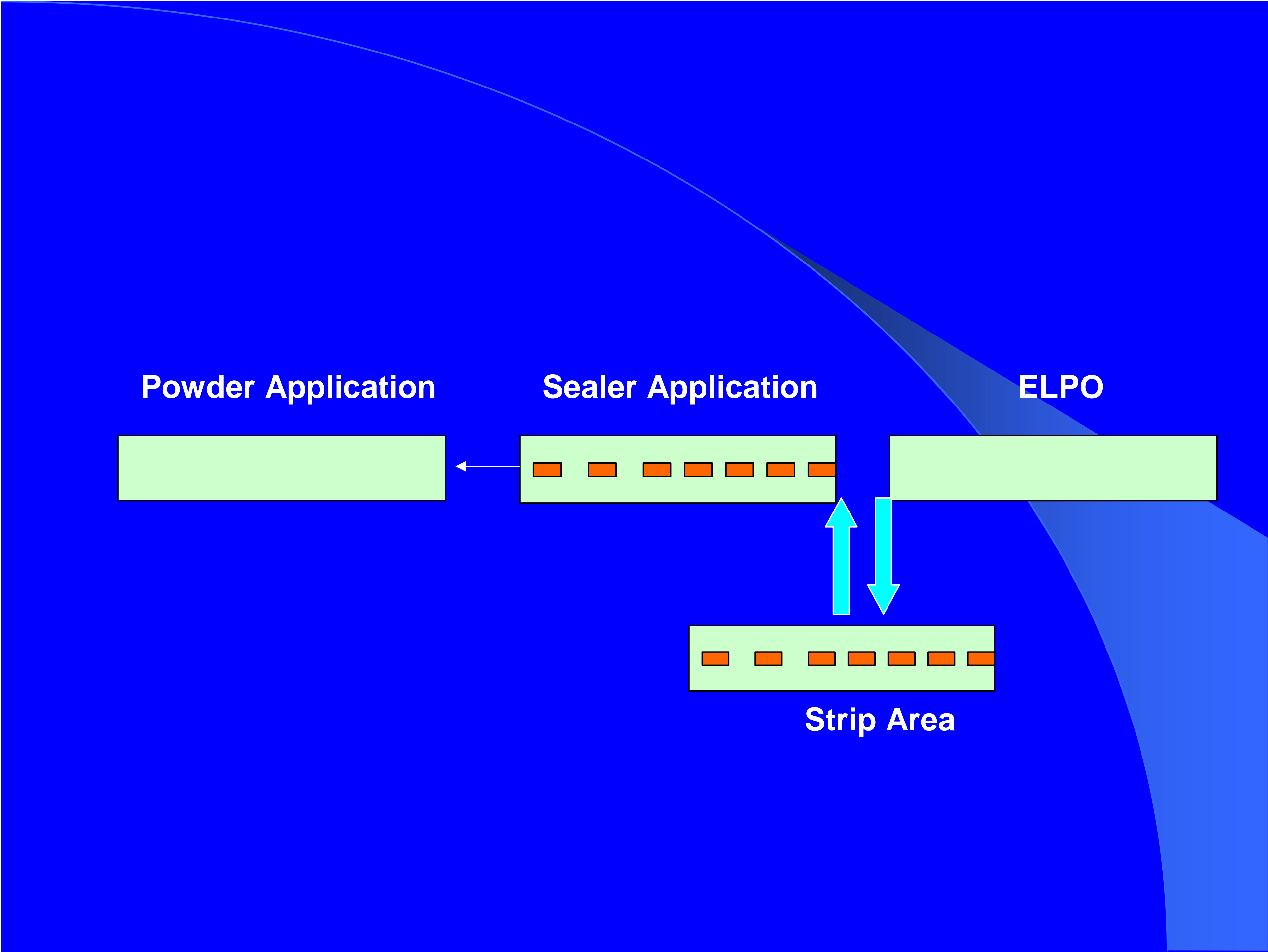

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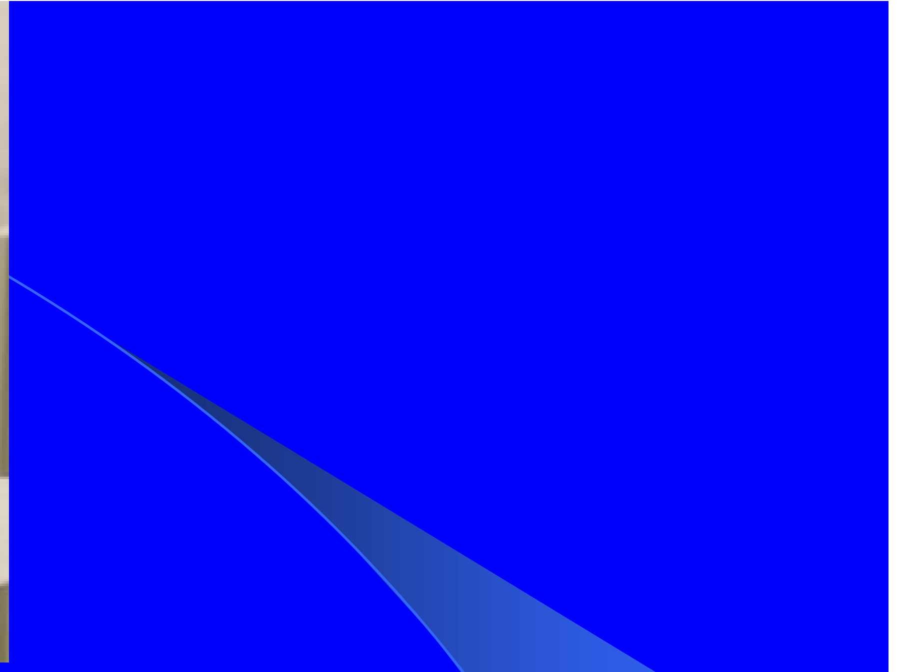
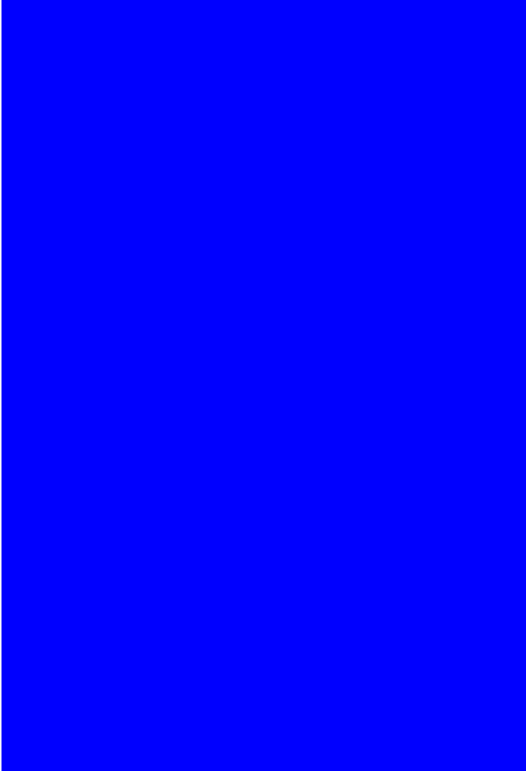

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Conductive Primer	Substrate	Straight Through	4-days in the strip area
Dynaseal	2719		
	2749		
	113-A		
	113-B		
UAE 2560	2719		
	2749		
	113-A		
	113-B		

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- The selected SMC formulations do not show powder primer popping due to air outgassing.
- Their moisture absorption is low enough to allow powder priming when there is no line stoppage.
- In case of extended line stoppage conventional conductive coatings cannot slow down moisture outgassing.
- We need to resolve the conductive coating adhesion issues to accommodate panel storage in weekends and shutdowns.

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ADHESIVE:	PLIOGRIP® 5000A/5020B
SUBSTRATE:	AOC'S 8784 / AOC'S 8784
SURFACE PREP:	DRY WIPE
FIXTURE TIME / TEMP	3' @ 300° /300° F
POSTBAKE TIME / TEMP:	60' @ 400° F

LAP SHEAR REQUIREMENTS TESTED AT 180°F

PSI	FAILURE MODE
561	FIBER TEAR
602	FIBER TEAR
541	FIBER TEAR
510	FIBER TEAR
556	FIBER TEAR
554	**AVERAGE**
33	**STANDARD DEVIATION**

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Development of the Modified Conductive Coating

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Test	Requirements
Cure Test	No softening of films or appearance change after 10 double rubs (0 or 1 rating)
Initial Adhesion	
Cross Hatch + Cross Cut	95% min
Dime Scrape	Fair min
Humidity + Adhesion	No blistering, blushing, color change or softening adhesion requirements: 95% min/Fair min
Cross Hatch + Cross Cut	
Dime Scrape	
Chip Resistance @ -23°C	7 min
Humidity + Chip Resistance	7 min

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Test	Requirements (cont….)
Fuel Resistance	No softening or lifting after 25 dips. Test thumbnail hardness after every fifth dip
Gas dip and immersion	
Gas puddle	
Heat Age	99% paint retention
Moisture And Cold Cycle + Humidity + Adhesion	No loss of adhesion, blistering, color change or other deleterious effects after 15 cycles and humidity tests

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Test	**Requirements** (cont….)
Xenon-1250kJ (SAEJ1960)	No indications of surface tackiness, embrittlement, objectionable color or gloss change, increase in hardness, blooming, loss of adhesion, blistering
Xenon-1250kJ (SAEJ1960) + 96hrs humidity + tape adhesion	
Xenon-2500kJ (SAEJ1960)	For information only
Xenon-4500kJ or failure (SAEJ1960)	
Xenon-4500kJ or failure (SAEJ1960) + 96hrs humidity + tape adhesion	
1 year Florida Appearance	No changes from initial results at the primer interfaces
1 year Florida + humidity + adhesion + chip resistance	Pass chip resistance, humidity and adhesion requirements as above

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Substrate	EXP COATING -1			EXP COATING -2			EXP COATING-3		
	Initial	96 hrs	240 hrs	Initial	96 hrs	240 hrs	Initial	96 hrs	240 hrs
SMC-B-7	100	0	50	100	0	0	100	99	98
SMC-B-7	100	25	97	100	0	0	100	99	99
SMC-B-8	100	0	0	100	0	0	100	99	98
SMC-B-8	100	0	0	100	0	0	100	99	98
SMC-B-3	100	0	0	100	0	0	100	99	99
SMC-B-3	100	0	0	100	0	0	100	99	98
SMC-B-4	100	0	95	100	0	0	99	99	98
SMC-B-4	100	10	80	100	0	0	100	99	99
SMC-B-5	100	97	90	100	95	20	100	99	99
SMC-B-5	100	50	50	99	75	50	99	99	99
SMC-B-6	100	90	98	100	60	90	99	99	98
SMC-B-6	100	99	99	100	99	90	99	95	99
SMC-B-1	100	0	90	100	25	0	98	97	98
SMC-B-1	100	0	0	100	0	0	99	98	98
SMC-B-2	100	25	0	100	0	0	100	99	95
SMC-B-2	100	98	98	100	0	20	100	99	99

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Process Variables	**Low**	**Target**	**High**
Catalyst Ratio (by weight)	8:1	10:1	12:1
Conductive Primer Film Build (mils)	0.5	1.0	1.5
Conductive Primer Bake Temperature (°F)	325	350	375
Conductive Primer Bake Time (Minutes)	20	30	60

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Current Status

- Powder capable class A SMC formulations have been developed
  - Low moisture absorbing
  - No micro-crack outgassing
- A conductive coating has been developed that enables powder priming of the new SMC panels in wet conditions
  - Validation is in progress

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