An Enhanced Corrosion Protection Mechanism for Rubber-to-Metal Bonding

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Outline

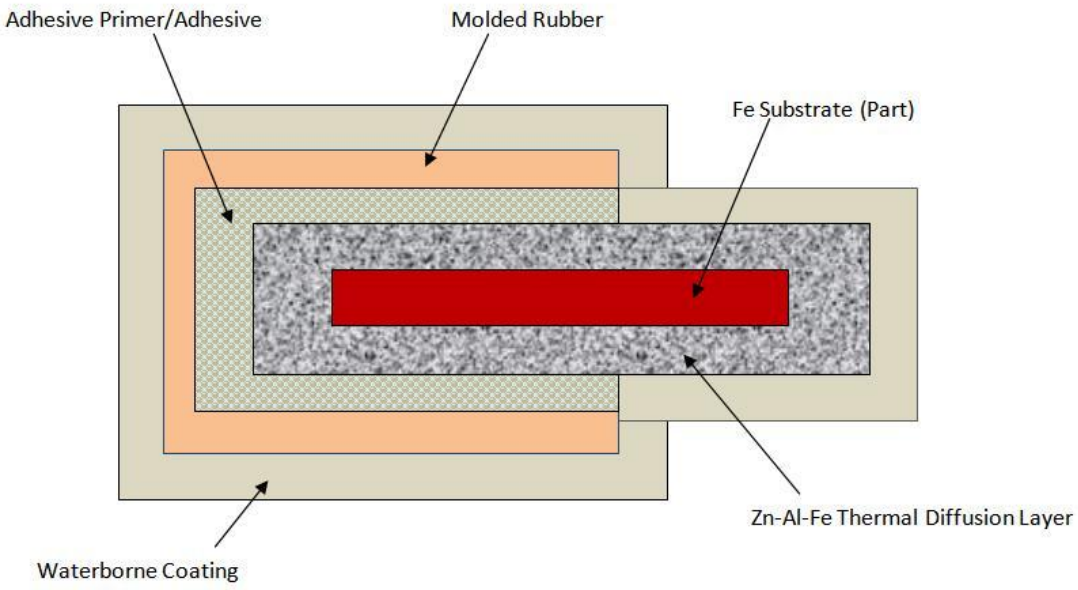
1. Motivation
2. Solution
3. The TCSM Coating Process
4. The Waterborne Coating Process
5. Test Results
6. Conclusions & Future Direction

1. Motivation

- Standards are becoming more stringent
  - Corrosion protection to 1,000 + hours
  - “Cosmetic Corrosion” is unacceptable
  - Dynamic properties demand improved bond performance
- Process variability within conventional processes
- Flexible processes for cost containment opportunities
- Compliance to environmental standards
- Thermal-Diffusion plus Waterborne coating provides functional and cosmetic properties

2. Proposed Solution

- Two-Stage Process
  - Thermo-Chemical Surface Modification (TCSM)
  - Waterborne high corrosion paint



2. Proposed Solution

- Better Corrosion Resistance:
  - > 1500 hours of salt spray corrosion resistance
  - Long Term under bond corrosion protection
  - Inhibits Galvanic Cell Activity
- Better Bond Performance:
  - Initial Bond Strength
  - Bond Strength Retention
  - Compatible with industry recognized adhesive coatings
- Better Environment, Health & Safety:
  - No Chrome III or Chrome VI
  - Eco-Friendly processes configured to customer requirements

TCSM Applications

Substrates

- Stampings
- Fasteners
- Sintered Metal & MIM Shapes
- Forgings
- Ductile Iron Castings
- Formed Tubes
- Bars & Pipe

Components

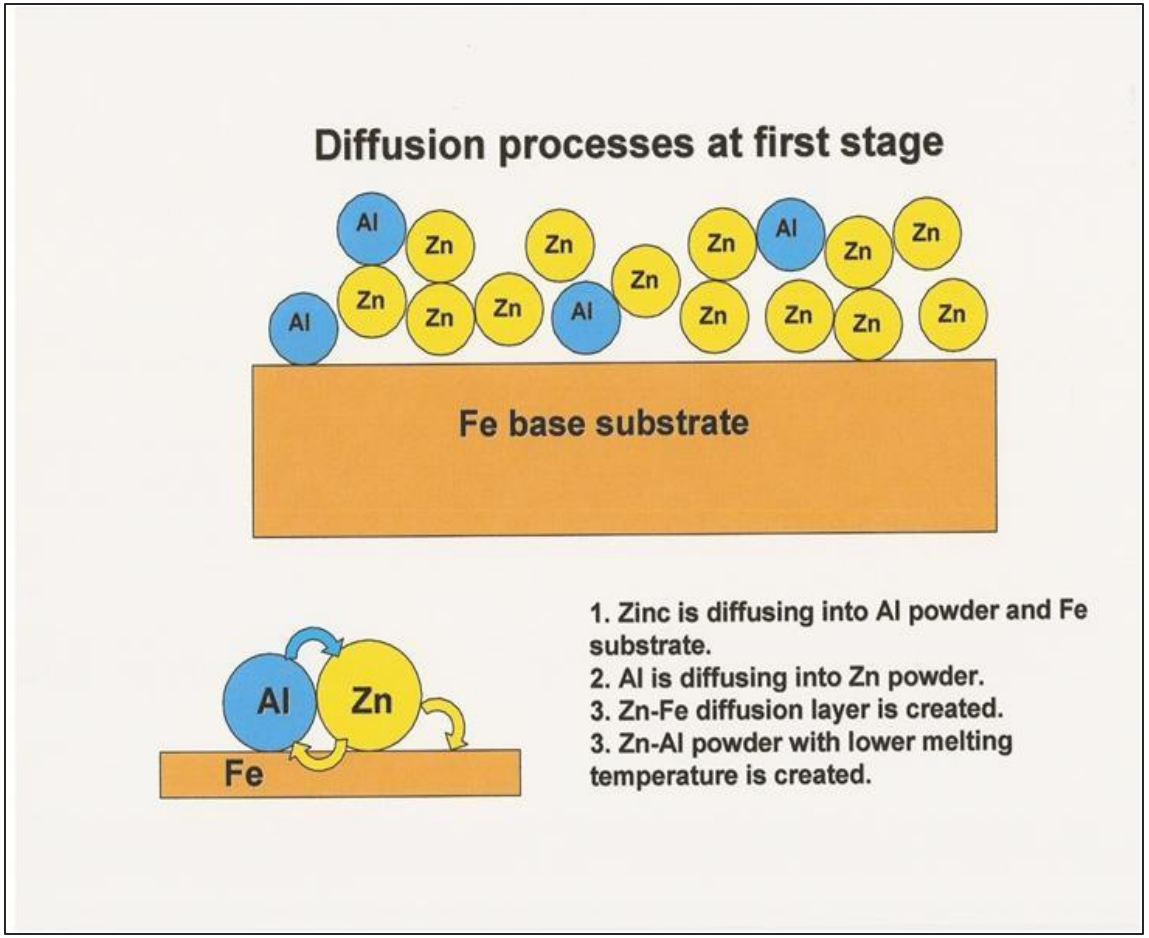
- Suspension Bushings
- Engine Mounts
- Exhaust Hangers
- Chassis Mounts
- Mass Dampers
- Strut Mounts
- Seals

3. Thermo Diffusion Coatings

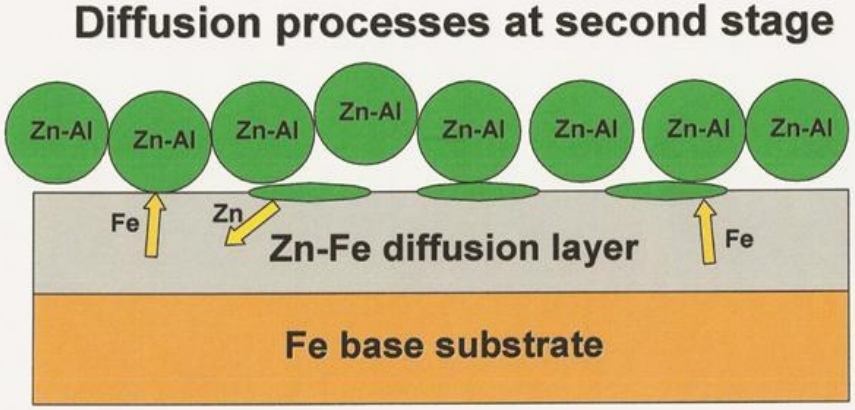
Patented zinc/aluminum protective formulations used as a base coat for automotive and industrial Duplex Coatings.

- Dry bulk powder
- No VOC's or out gassing bi-products
- Do not contain Chrome III or Chrome VI
- Does not cause Hydrogen Embrittlement
- Complies with RoHS and ELV Directive (2000/53EC)

First Stage TCSM

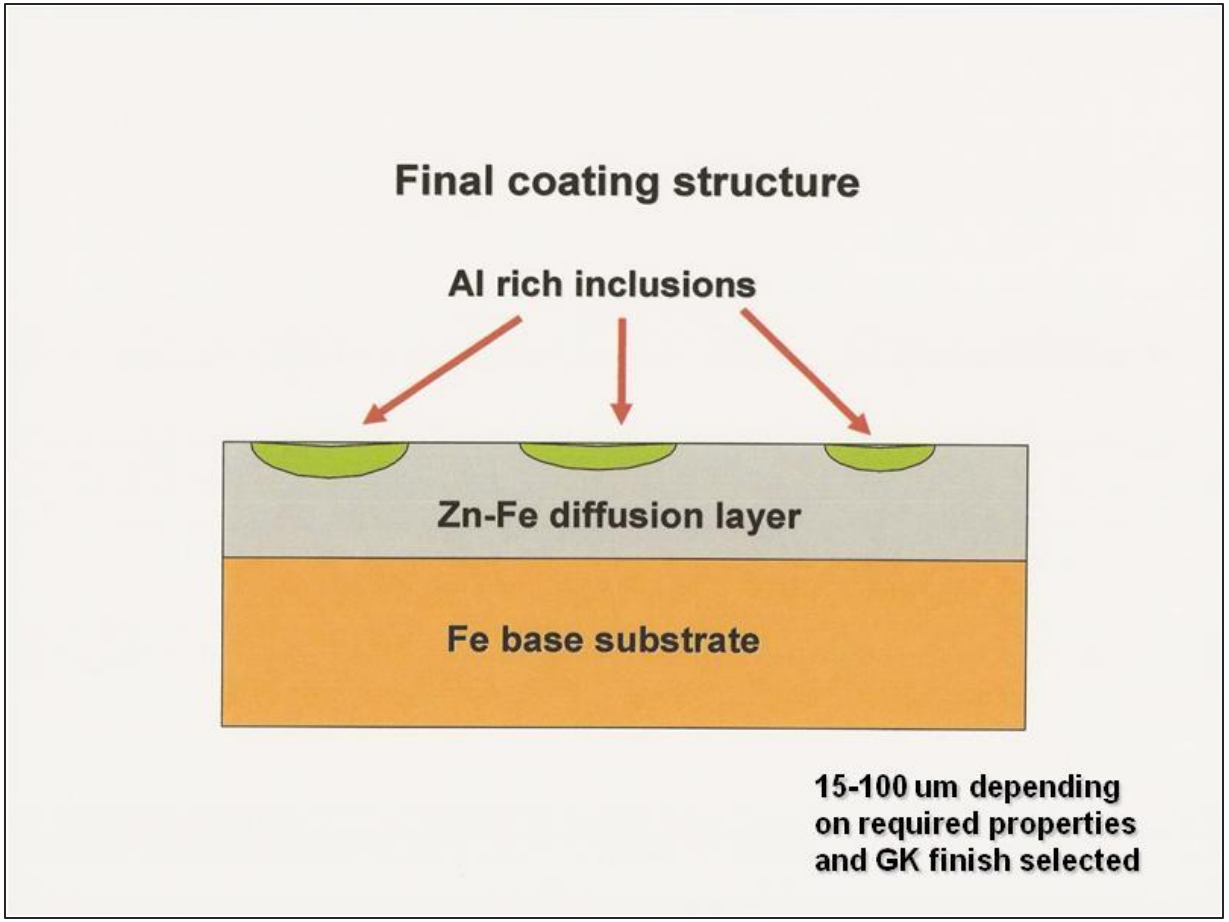


Second Stage TCSM

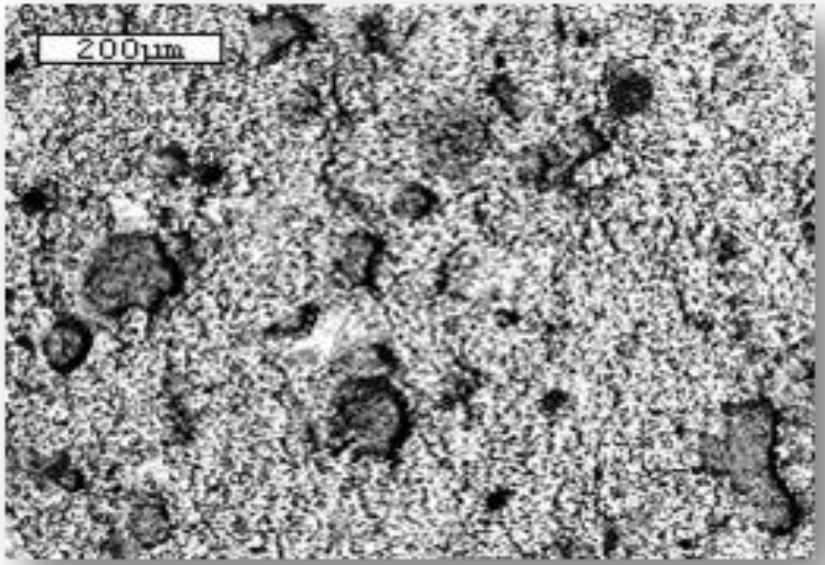


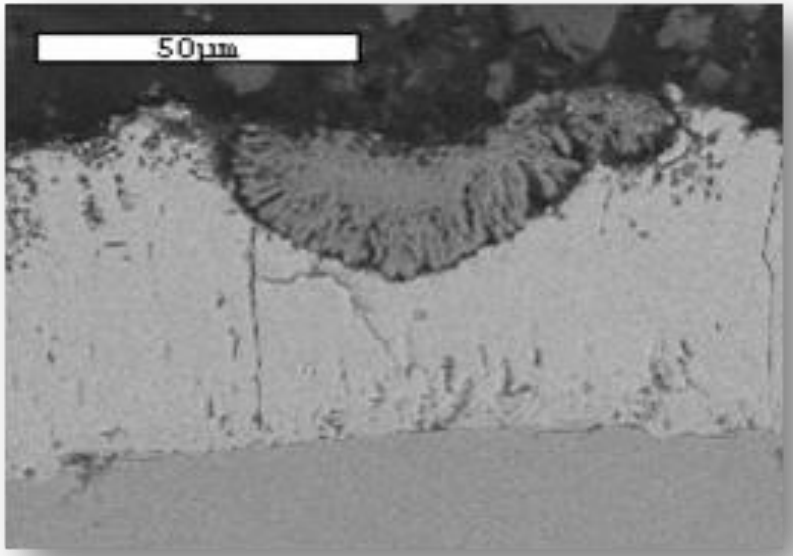
1. Zn-Al powder melted grains are absorbed on the Zn-Fe diffusion layer.
2. Zn from those grains is diffusing into Zn-Fe diffusion layer.
3. Fe is diffusing into the absorbed grains, trial Al-Fe-Zn system is creating, melting temperature is increasing, absorbed grains are "frizzing" and Al rich areas are created.
4. Fe is diffusing into the Zn-Al powder grains, trial Al-Fe-Zn system is creating, melting temperature is increasing, powder grains are "frizzing" absorbtion process is finished.

Result: TCSM

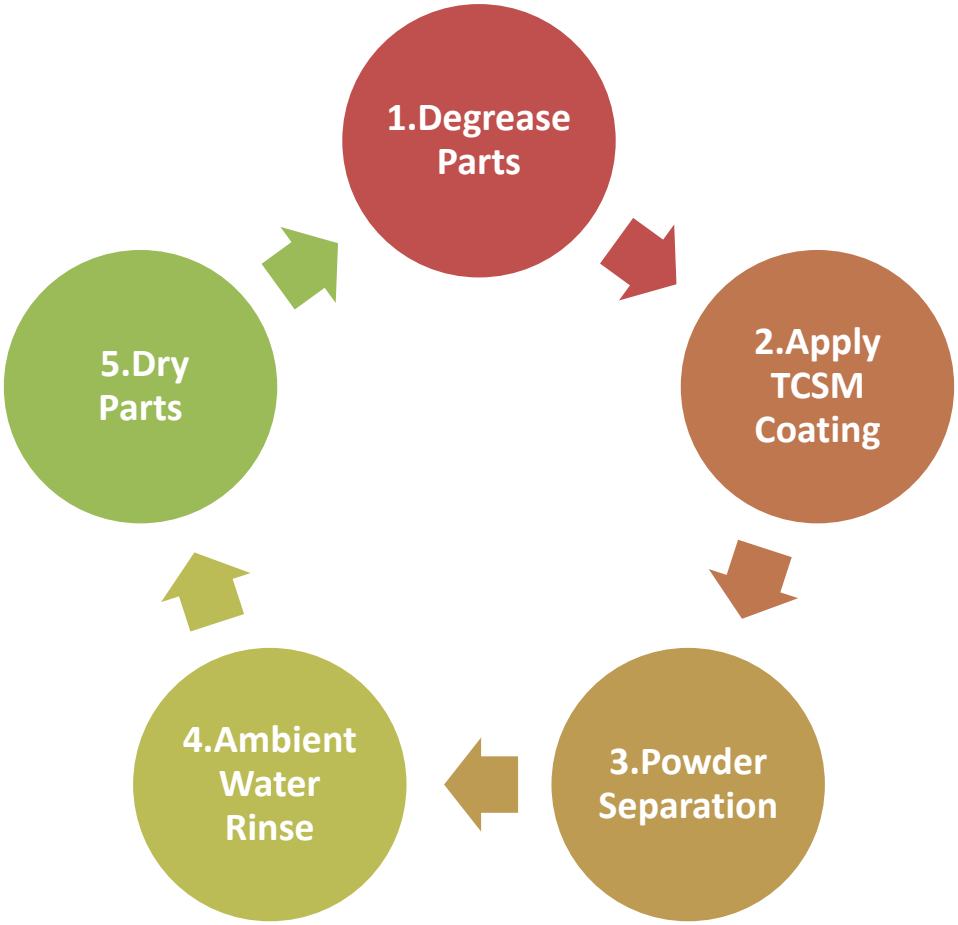

Final coating structure
Al rich inclusions
Zn-Fe diffusion layer
Fe base substrate
15-100 um depending
on required properties
and GK finish selected

TCSM - Micrographs





TCSM Coating Process



4. Waterborne Coating Step

- Low VOC corrosion resistance polymer coating
  - Excellent adhesion to metals and rubber formulations
  - Low moisture and permeability properties
  - Air dry or low bake temperatures for accelerated dry time
  - Variable film thicknesses applied by spray or dip systems
  - Can be formulated for colors with gloss levels up to 35
- Enhanced corrosion performance when used with TCSM
- Cost effective alternative for electro-deposition coatings when applied to RTM components and sub assemblies

Waterborne Paint Application

Dip, or Dip-Spin

Spray Painting

Waterborne Coating Specifications

Product Name	Kalgard 094 – water reducible coating #94-9218JB
Solids	54% ±2% by weight, 37% ±2% by volume
VOC	0.5 lbs/gallon theoretical
Weight/Gallon	11.12 ± 0.2 lbs / gallon
Viscosity	35 ± 2 seconds, #2 Zahn
Flash Point	205°F
Gloss	2 – 8 @60°
pH	5.5 – 6.5
Coverage	303 sq. ft. / gallon @ 2.0 mil DFT
Salt Spray	500+ hours ASTM B117
Humidity	480+ hours ASTM D2247
Gravelometer	Pass, SAE J-400
Chemical Resistance	50/50 Ethylene Glycol, Excellent
	10w30 Engine Oil @275°F @ 1 hour, Excellent
	Gasoline 70°F @ 1 hour, Excellent
	Brake Fluid 70°F @ 1 hour, Excellent
Self Life	6 months maximum @ 70°F
Cure Schedule	30 minutes @ 75°F @ 50% RH to Touch
	45 minutes @ 75°F @ 50% RH to Handle
	4 hours @ 75°F @ 50% RH to Recoat
Application	Spray (air, airless, electrostatic), dip, dip spin, brush touch-up
Clean-up	While plastic: warm detergent water, after cure: MEK

5. Test Results:
Phosphate vs. TCSM with Adhesive Cover Coat

1,000 hours Salt Fog Testing ASTM B117

500 hours vs. 1,000 hours corrosion results

	Scribe Creep (mm)		Blistering		Unscribed Area	
Treatment	500 h	1000 h	500 h	1000 h	500 h	1000 h
Greenkote PM-1	0	0	none	none	No failure	No failure
Greenkote PM-10	0	0	none	none	No failure	No failure
Zinc Phosphate	0.1 mm	> 16 mm	none	several	No failure	5% Failure

500 hours vs. 1,000 hours bond strength

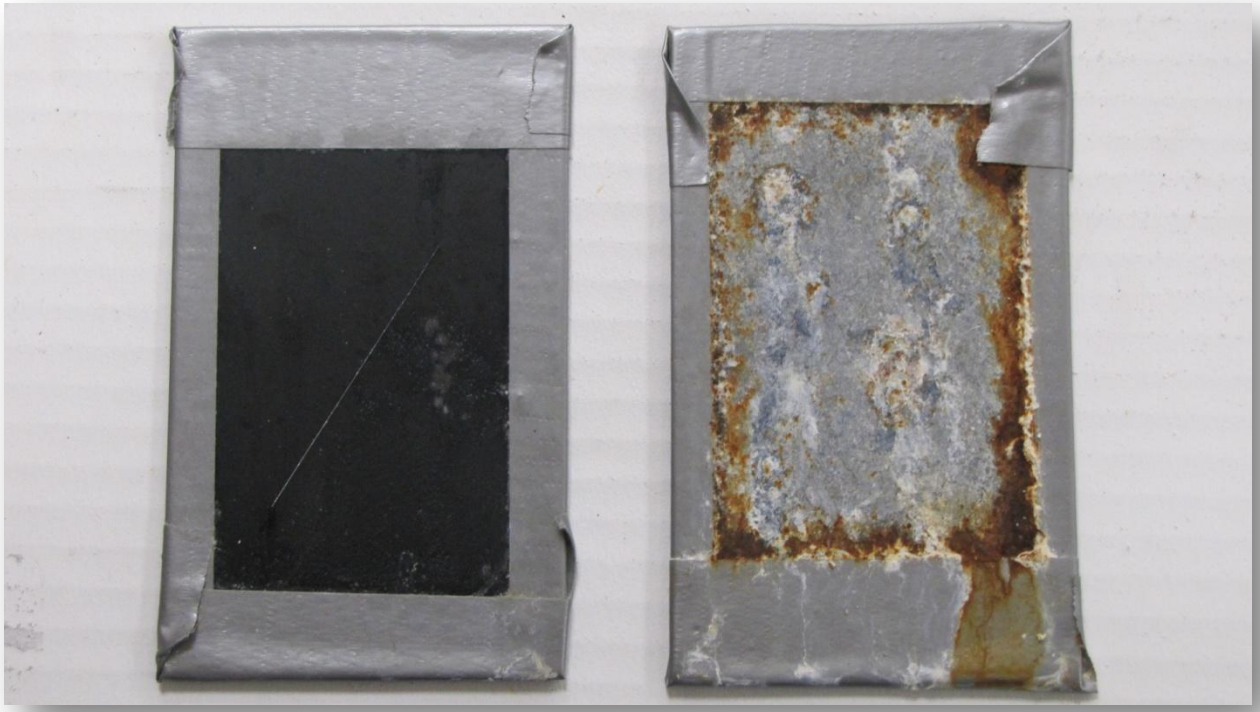
	Initial Bond Strength		1000 Hours Salt Spray		
Treatment	Pounds	Std. Dev.	Pounds	Std. Dev.	% Change
Greenkote PM-1	1150.0	18.9	972.7	25.5	-15.42%
Greenkote PM-10	1193.3	35.3	978.0	72.2	-18.04%
Zinc Phosphate	939.9	104.8	252.3	253.5	-73.16%
Improvement (w/PM-1)	+22.35%		+ 285.5%		

500 hours vs. 1,000 hours bond strength (2)

	Initial Bond Strength		1000 Hours Salt Spray		
Treatment	Newtons	Std. Dev.	Newtons	Std. Dev.	% Change
Greenkote PM-1	6831.5	169.49	6138.0	276.6	-10.15%
Zinc Phosphate	5613.0	1971.0	3165.0	1858.0	-43.61%
Improvement	+ 21.71%		+ 93.93%		

TCSM with and without top coating

1500 + hours Salt Fog Exposure – ASTM B117



TCSM + Waterborne Top Coat

TCSM only

TCSM and Waterborne Coating

2,000 hours Salt Fog Exposure ASTM B117

Process Testing on RTM Bonding Parts

6. Conclusions

- **Improved Bond Performance with TCSM coatings**
  - TCSM provides superior anchor sites for primer and adhesive topcoats.
  - Initial Bond Strength improved 20%-30%
  - Bond Strength retention exceeds 75% of original values after 1000 hours of Salt Fog exposure. No under bond corrosion failures reported.
  - The coating performs well in post forming assembly operations for crimping, swaging, and bending.

6. Conclusions (cont'd)

- **Existing systems are challenged to meet the latest cosmetic, performance and environmental requirements but the proposed process does.**

- **Improved Corrosion Resistance**
  - TCSM + Waterborne coating tested beyond 1,500 hours of Salt Fog Exposure
- **Improved Environmental Compliance**
  - No Chrome III or Chrome VI
  - Minimal process waste stream
- **The new system is more user friendly.**
  - TCSM + Waterborne coating process can be added to manufacturing operations for RTM components and assemblies

Thank You !

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