



CHO-SHIELD® 200X Series
Formulation Change and Qualification Report

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Objective

CHO-SHIELD 200X series paints are being reformulated without a fluorinated component. The objective of this work is to ensure the reformulated CHO-SHIELD 200X series coatings have equivalent performance to the current 200X series coatings.

Test Plan

Manufacturing batches of CHO-SHIELD 2001 and CHO-SHIELD 2002 with both the new and baseline formulations were made using the same manufacturing processes. Since CHO-SHIELD 2003 is chemically the same as CHO-SHIELD 2001 with a pigment added for color, the CHO-SHIELD 2001 data was used as a basis to qualify the CHO-SHIELD 2003 coating. In addition, a manufacturing batch of the re-formulated CHO-SHIELD 2003 was manufactured and evaluated for sprayability and conformance testing.

Test panels were sprayed with the manufactured CS 200X series coatings on aluminum and fiberglass epoxy (G10) substrates under the same spray conditions. Quality conformance tests were performed on these samples. Qualification tests including mechanical, fluid immersion and environmental tests conducted on coatings made with both new and control batches. All tests were repeated on three panels and the averaged values are reported.

1. Conformance Tests

- I. Viscosity (ASTM D4212)
- II. Adhesion (ASTM D3359)
- III. Tack free time
- IV. Surface Resistivity (CEPS-0002, on Aluminum and G10)

2. Qualification Tests

- I. Cure Condition: all samples are cured at room temperature for 7 days
- II. Test Panels
 - a. 6061-T6 aluminum with MIL-DTL-5541 Type I, Class III conversion coating, 4"x 4"x 0.032".
 - b. G10 fiberglass epoxy, 4"x 2" x 0.032".
- III. Tests
 - a. Surface Resistance (CEPS-0002)
 - b. Fluid Resistance (72-hr Immersion)
 - c. Environmental Exposure (Heat, Heat and Humidity, and Cold)
 - d. Mechanical Testing (Taber Abrasion D4060, Conical Bend ASTM D522, Mandrel Bend D522, Impact Resistance ASTM D2794)
 - e. Salt Fog Corrosion (ASTM B117)

3. Sample Preparation

All panels were cleaned with isopropanol alcohol and air dried. CHO-SHIELD 1091 primer was applied to all panels and air dried for 1-2 hours before applying 200X series coatings. It is recommended that the 200X series coatings are applied with a thickness of at least 0.003”.

Material	Batch	Substrates	Primer
CHO-SHIELD 2001	QC2001	Aluminum	CHO-SHIELD 1091
CHO-SHIELD 2001 (Control)	22CH7060, 22CF6909	Aluminum	CHO-SHIELD 1091
CHO-SHIELD 2002	QC22-016	Aluminum and G10 fiberglass epoxy	CHO-SHIELD 1091
CHO-SHIELD 2002 (Control)	22CH7080, 22CB6520, 22CF6871	Aluminum and G10 fiberglass epoxy	CHO-SHIELD 1091

Three test panels were prepared for each test conditions. The results in this report are the averaged values.

Test Methods

1. Surface Resistance

Initial and post environmental exposure surface resistivity of the coatings were measured per CEPS-0002, with a 1 inch² CHO-PROBE using 2kg of force.

2. Adhesion

Cross hatch adhesion tests were conducted per ASTM D3359 Method B.

3. Fluid Resistance

The following fluids and dwell conditions were evaluated:

Immersion Fluid	Dwell Temperature (°C/°F)	Dwell Time (hours)
Jet Fuel Type JP-8	21 °C /70°F	72
Hydraulic Fluid MIL-H-5606	21 °C /70°F	72
Lubricating Oil MIL-L-7808	21 °C /70°F	72

Initial surface resistivity was measured for all test panels. The samples were placed in a container and fully submerged in fluids. The containers were sealed and stored at testing conditions. Following the dwell samples were removed from the fluids and physically dried using an absorbent cloth. The dried samples were then evaluated for:

1. **Surface Resistance** –Test Method CEPS-0002
2. **Visual Inspection** – Evaluate the presence of any flaking, cracking, surface irregularities, blistering and wrinkling.

4. Environmental Exposure

Initial surface resistivity measurements were conducted for all test panels. The samples were then exposed to different environment. Upon removal from the testing environments the samples were tested for surface resistivity and visual inspection. The following environmental exposure conditions were tested:

Tests	Conditions	Time (days)
High Temperature Dwell	85°C/185°F	10
Low Temperature Dwell	-40°C/-40°F	10
Heat and Humidity	85°C/185°F and 85% RH	10

5. Mechanical Tests

Taber Abrasion – CHO-SHIELD 200X series coatings were sprayed on round G10 fiberglass epoxy substrates. Samples were subject to Taber Abrasion per ASTM D 4060. The weight of the samples was recorded before and after 1000 cycles on the Taber abrader with 500 grams CS-10 wheels.

Conical Bend – CHO-SHIELD 200X coatings on aluminum panels were bent over a cone and examined for cracking per ASTM D522 Test Method A.

Mandrel Bend – CHO-SHIELD 200X coatings on aluminum panels were bent over 1/4” mandrel and examined for cracking per ASTM D522 Test Method B.

Impact tests – CHO-SHIELD 200X coatings on aluminum panels were tested for impact resistance per ASTM D2794-93 Method.

6. Salt Fog Corrosion

CHO-SHIELD 2001 coatings were applied on aluminum substrates; CHO-SHIELD 2002 coatings were applied on both aluminum and G10 fiberglass epoxy substrates. Samples were cured at room temperature for 7 days. The edges of the panels were coated with wax to minimize corrosion initiating from the edges. Samples were tested both with and without scratches (1” scratch through the coatings before testing). Three panels were tested for each condition.

Cured sample panels were then placed in a neutral salt fog environment per ASTM B117. After 500 hours of exposure, samples were visually inspected for the presence of any blistering or peeling and tested for surface resistivity. The sample panels were rinsed with water to remove salt on surface before testing.

Results

All results in this report are the averaged value of three tests.

1. Conformance Tests

All CHO-SHIELD 200X test panels passed the conformance tests listed below.

CHO-SHIELD 2001

Test	Procedure	Specification	New (QC2001)	Control (22CH7060)
Viscosity (Zahn #2, seconds)	ASTM D4212	14-18 seconds	15	17
Adhesion	ASTM D3359 Method B	5B	5B	5B
Tack Free Time	ASTM D1650	Less than 4 hours	Pass	Pass
Pencil Hardness	ASTM D3363	4H	5H	5H
MEK Rub	ASTM D4060	50 Double Rub	Pass	Pass
Surface Resistivity on Al (ohms/square)	CEPS-0002	<0.100	0.044	0.034

CHO-SHIELD 2002

Test	Procedure	Specification	New (QC22-016)	Control (22CH7080, 22CB6520)
Viscosity (Zahn #2, seconds)	ASTM D4212	14-18 seconds	17	17
Adhesion	ASTM D3359 Method B	5B	5B	5B
Tack Free Time	ASTM D1650	Less than 4 hours	Pass	Pass
Pencil Hardness	ASTM D3363	4H	5H	5H
MEK Rub	ASTM D4060	50 Double Rub	Pass	Pass
Surface Resistivity on Al (ohms/square)	CEPS-0002	<0.100	0.059	0.029
Surface Resistivity on G10 (ohms/square)	CEPS-0002	<0.100	0.055	0.060

2. Qualification Tests

A series of fluid immersion, environmental, mechanical and corrosion tests were conducted on coatings sprayed with 200X series paints (New and Control), on aluminum (CHO-SHEILD 2001 and 2002) and G10 fiberglass epoxy (CHO-SHEILD 2002) substrates. Surface resistivity were measured on each sample after test. The averaged results of three test panels are summarized below.

Fluid Resistance

Fluid resistance of new CHO-SHIELD 200X series coatings is comparable to the control 200X series coatings in Chomerics' internal qualification. All coatings passed visual inspections after immersion tests, showed no signs of blisters, wrinkling or other defects.

CHO-SHIELD 2001

Mil-H-5606 Hydraulic Fluid Immersion Room Temperature for 72 Hours						
Coating	Test	Substrate	Specification	Cure	Initial	Post Test
CS2001 New	Hydraulic Fluid	Al 4"x4"	< 0.1 ohm/sq.	RT	0.047	0.049
CS2001 Control	Hydraulic Fluid	Al 4"x4"		RT	0.040	0.038

Mil-L-7808 Lubricant Oil Immersion Room Temperature for 72 Hours						
Coating	Test	Substrate	Specification	Cure	Initial	Post Test
CS2001 New	Lubricant Oil	Al 4"x4"	< 0.1 ohm/sq.	RT	0.047	0.044
CS2001 Control	Lubricant Oil	Al 4"x4"		RT	0.043	0.044

JP-8 Immersion Room Temperature for 72 Hours (After 6 Days + 2-hr @ 80°C)						
Coating	Test	Substrate	Specification	Cure	Initial	Post Test
CS2001 New	JP-8	Al 4"x4"	< 0.5 ohm/sq.*	RT	0.044	0.382
CS2001 Control	JP-8	Al 4"x4"		RT	0.039	0.171

CHO-SHIELD 2002

Mil-H-5606 Hydraulic Fluid Immersion Room Temperature for 72 Hours						
Coating	Test	Substrate	Specification	Cure	Initial	Post Test
CS2002 New	Hydraulic Fluid	G10 4"x2"	< 0.1 ohm/sq.	RT	0.062	0.059
CS2002 Control	Hydraulic Fluid	G10 4"x2"		RT	0.059	0.055

Mil-L-7808 Lubricant Oil Immersion Room Temperature for 72 Hours						
Coating	Test	Substrate	Specification	Cure	Initial	Post Test
CS2002 New	Lubricant Oil	G10 4"x2"	< 0.1 ohm/sq.	RT	0.062	0.059
CS2002 Control	Lubricant Oil	G10 4"x2"		RT	0.059	0.055

JP-8 Immersion Room Temperature for 72 Hours (After 6 Days + 2-hr @ 80°C)						
Coating	Test	Substrate	Specification	Cure	Initial	Post Test
CS2002 New	JP-8	G10 4"x2"	< 0.5 ohm/sq.*	RT	0.066	0.356
CS2002 Control	JP-8	G10 4"x2"		RT	0.062	0.164

*Measurements on JP-8 immersed samples were conducted after 6 days and 2-hour at 80°C.

Environmental Tests

The environmental test results show that new CHO-SHIELD 200X series coatings perform equivalent to the control 200X series coatings after most of the tests. Some coatings made with new 200X paints showed slight decrease of heat and humidity resistance. As a fluorinated component was replaced in the new 200X formulations, this decrease may be attributable to a slight decrease of hydrophobicity of the coatings. All coatings passed visual inspections after immersion tests, showed no signs of blisters, wrinkling or other defects.

CHO-SHIELD 2001

85° C/85% RH for 10 Days						
Coating	Test	Substrate	Specification	Cure	Initial	Post Test
CS2001 New	Heat and Humidity	Al 4"x4"	N/A	RT	0.044	0.752
CS2001 Control	Heat and Humidity	Al 4"x4"		RT	0.032	0.349

85° C for 10 Days						
Coating	Test	Substrate	Specification	Cure	Initial	Post Test
CS2001 New	High Temp Dwell	Al 4"x4"	N/A	RT	0.042	0.087
CS2001 Control	High Temp Dwell	Al 4"x4"		RT	0.034	0.073

-40° C for 10 Days						
Coating	Test	Substrate	Specification	Cure	Initial	Post Test
CS2001 New	Low Temp Dwell	Al 4"x4"	N/A	RT	0.045	0.066
CS2001 Control	Low Temp Dwell	Al 4"x4"		RT	0.032	0.048

CHO-SHIELD 2002

85° C/85% RH for 10 Days						
Coating	Test	Substrate	Specification	Cure	Initial	Post Test
CS2002 New	Heat and Humidity	G10 4"x2"	N/A	RT	0.061	0.122
CS2002 Control	Heat and Humidity	G10 4"x2"		RT	0.053	0.094

85° C for 10 Days						
Coating	Test	Substrate	Specification	Cure	Initial	Post Test
CS2002 New	High Temp Dwell	G10 4"x2"	N/A	RT	0.063	0.098
CS2002 Control	High Temp Dwell	G10 4"x2"		RT	0.058	0.086

-40° C for 10 Days						
Coating	Test	Substrate	Specification	Cure	Initial	Post Test
CS2002 New	Low Temp Dwell	G10 4"x2"	N/A	RT	0.074	0.087
CS2002 Control	Low Temp Dwell	G10 4"x2"		RT	0.060	0.068

Mechanical Tests

CHO-SHIELD 200X series New and Control samples showed same performance for all mechanical tests conducted.

CHO-SHIELD 2001

Conical Bend				
Coating	Test	Substrate Material	Cure	Elongation%
CS2001 New	Conical Bend	Aluminum MIL C5541 Class III 4"x4"x0.032"	RT	> 30%
CS2001 Control	Conical Bend	Aluminum MIL C5541 Class III 4"x4"x0.032"	RT	> 30%

Mandrel Bend				
Coating	Test	Substrate Material	Cure	Mandrel Bar
CS2001 New	Mandrel Bend	Aluminum MIL C5541 Class III 4"x4"x0.032"	RT	1/4" no cracks
CS2001 Control	Mandrel Bend	Aluminum MIL C5541 Class III 4"x4"x0.032"	RT	1/4" no cracks

Taber Abrasion (Spec: < 60 mg after 1000 cycles with 500 mg CS-10 wheels)				
Coating	Test	Substrate Material	Cure	Weight Loss (mg)
CS2001 New	Taber Abrasion	G10 Round	RT	38.8
CS2001 Control	Taber Abrasion	G10 Round	RT	49.2

Impact Resistance					
Coating	Test	Substrate Material	Cure	Concave	Convex
CS2001 New	Impact	Aluminum MIL C5541 Class III 4"x4"x0.032"	RT	60	35
CS2001 Control	Impact	Aluminum MIL C5541 Class III 4"x4"x0.032"	RT	60	30

CHO-SHIELD 2002

Conical Bend				
Coating	Test	Substrate Material	Cure	Elongation%
CS2002 New	Conical Bend	Aluminum MIL C5541 Class III 4"x4"x0.032"	RT	>30%
CS2002 Control	Conical Bend	Aluminum MIL C5541 Class III 4"x4"x0.032"	RT	>30%

Mandrel Bend				
Coating	Test	Substrate Material	Cure	Mandrel Bar
CS2002 New	Mandrel Bend	Aluminum MIL C5541 Class III 4"x4"x0.032"	RT	1/4" no crack
CS2002 Control	Mandrel Bend	Aluminum MIL C5541 Class III 4"x4"x0.032"	RT	1/4" no crack

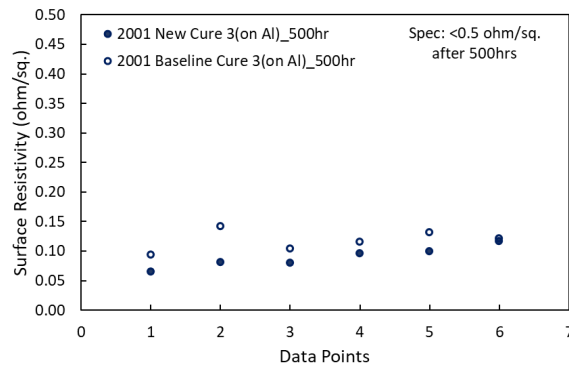
Taber Abrasion (Spec: < 60 mg after 1000 cycles with 500 mg CS-10 wheels)				
Coating	Test	Substrate Material	Cure	Weight Loss (mg)
CS2002 New	Taber Abrasion	G10 Round	RT	39.6
CS2002 Control	Taber Abrasion	G10 Round	RT	43.6

Impact Resistance					
Coating	Test	Substrate Material	Cure	Concave	Convex
CS2002 New	Impact	Aluminum MIL C5541 Class III 4"x4"x0.032"	RT	45	10
CS2002 Control	Impact	Aluminum MIL C5541 Class III 4"x4"x0.032"	RT	40	10

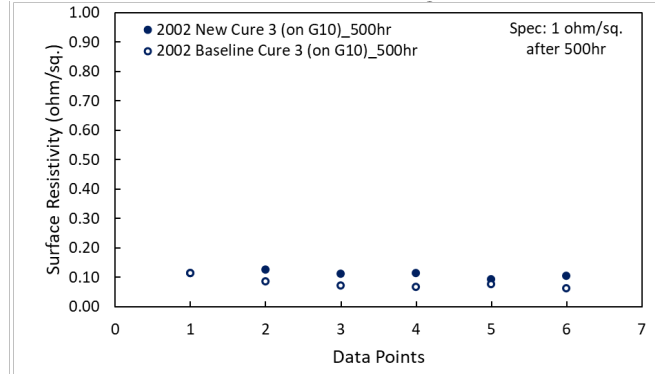
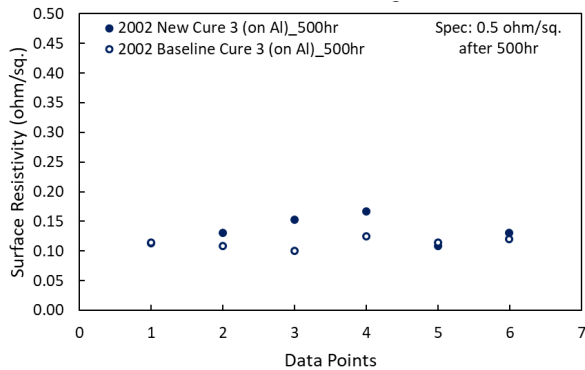
Salt Fog Corrosion

After 500-hour of aging in a neutral salt fog chamber, visual inspection and surface resistivity measurements were conducted on the testing panels. No significant difference was observed for 200X series New and Control samples. Surface resistivity results after 500-hour test are shown below. All coatings passed visual inspections after tests, showed no signs of blisters, wrinkling or other defects. Images of the test panels are in Appendix.

CHO-SHIELD 2001



CHO-SHIELD 2002



Conclusions

Reformulated CHO-SHIELD 200X series paint has the same viscosity, spray performance, and pot life as the current CHO-SHIELD 200X series formulations.

Re-formulated CHO-SHIELD 200X performs similar to current CHO-SHIELD 200X formulations in mechanical, environmental, and fluid testing.

Re-formulated CHO-SHIELD 200X has similar corrosion performance after 500-hr salt fog tests on MIL-DTL-5541-TYPE I, Class 3 conversion coated aluminum (6061) and Fiber glass epoxy (G10) substrates.

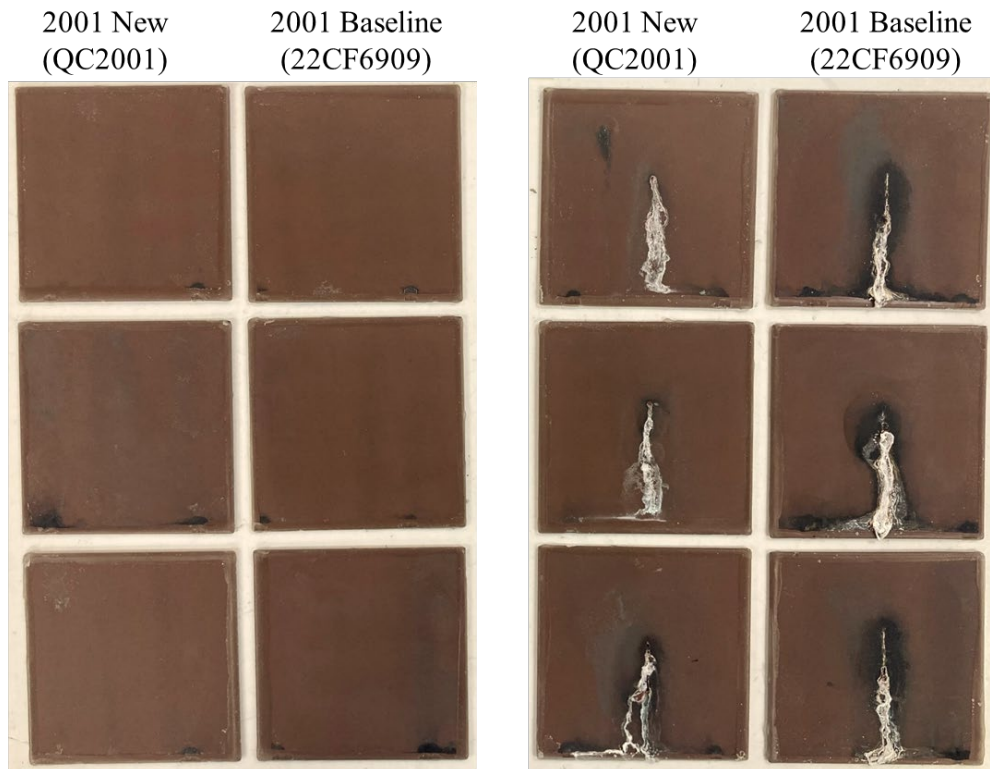
Appendix

Salt Fog Corrosion Panels

Panels after 500-hour neutral salt fog tests are shown in the images below. There is no significant difference between the new and control samples. Some of the corrosion seen around the edge of the panels is initiated from the substrate.

CHO-SHIELD 2001

After 500-hour on aluminum substrates



CHO-SHIELD 2002

On aluminum substrates

2002 New
(QC22-016)

2002 Baseline
(22CF6871)

2002 New
(QC22-016)

2002 Baseline
(22CF6871)



On G10 substrates

2002 New
(QC22-016)

2002 Baseline
(22CF6871)

