

Hexavalent Chromium (Cr^{+6}) Reduction at U.S. Air Force Plant 44 in Tucson, Arizona

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ABSTRACT

As part of the U.S. Air Force Plant (AFP) 44 Pollution Prevention (P2) Program at Raytheon Missile Systems in Tucson, Arizona, a project was commissioned to reduce the use of hexavalent chromium (Cr^{+6}) in missile manufacturing and depot level repair operations.

The main sources of Cr^{+6} were from the conversion coating of aluminum alloys per MIL-DTL-5541. The secondary source was from Cr^{+6} containing paint primers per MIL-PRF-85582 (waterborne) and MIL-PRF-23377 (high solids) that are utilized in solvent based painting of components per MIL-PRF-85285. This paper summarizes the Cr^{+6} alternatives that were identified and how they performed in qualification testing.

INTRODUCTION

Air Force Plant (AFP) 44 is a Government Owned and Contractor Operated (GOCO) facility and forms a portion of the Tucson operations of Raytheon Missile Systems where a wide variety of missile and space defense systems are manufactured.

AFP 44 has a highly successful Pollution Prevention (P2) Program, whose charter is to reduce the use of hazardous materials on site. As part of this program a project was initiated to identify and qualify alternative materials or processes that would eliminate the use of hexavalent chromium (Cr^{+6}) in missile manufacturing and depot level processes. This effort aligns with the gradual shift to Cr^{+6} alternatives that are underway at a number of facilities within the Department of Defense (DoD). Additionally, the European Union has taken an even more aggressive stand via their restriction of the use of certain hazardous substances (RoHS) initiative. Military equipment has been exempted from RoHS, but due to the increasing availability of suitable alternatives for Cr^{+6} containing materials, it cannot be assumed that this exemption will last beyond 2009.

One additional driver to eliminate Cr^{+6} at AFP 44 surfaced after the project was underway via OSHA Rule 1910.1026. This rule, which went into effect 27 Nov 06, lowered the Permissible Exposure Limit (PEL) for Cr^{+6} from 52 micrograms per cubic meter (ug/m^3) to $5 \text{ ug}/\text{m}^3$. In addition, the action level was set at $2.5 \text{ ug}/\text{m}^3$ with medical surveillance and Industrial Health (IH) monitoring triggered at the action level. Still other requirements are triggered at the PEL. It was immediately realized that spraying of Cr^{+6}

based paint primers and sanding operations where Cr^{+6} primer coatings were made airborne placed the manufacturing and depot level repair areas well above the PEL.

ALTERNATIVES REPORT

As a starting point for this Cr^{+6} elimination effort, Raytheon commissioned a survey of the Cr^{+6} alternatives that were commercially available and currently being utilized, or approved for use, within the DoD.

Concurrent Technologies Corporation (*CTC*) was selected by Raytheon to perform this survey. *CTC* issued a Chromium Alternatives Report on 28 Feb 06 identifying the Cr^{+6} free alternative products that were currently used or approved for use in the DoD for conversion coating and paint primer applications. This report detailed the product background, application procedures, and current applications for each identified alternative. The report is available on request from Raytheon or *CTC*.

QUALIFICATION TEST PLAN

The next step was to write a qualification test plan for the alternative products that were identified. The EFI Group was put on contract for this task and delivered to Raytheon a Statement of Work (SOW) titled Chromium Qualification Test Plan on 19 Jun 06. This document identified the various tests that were required as well as the products that would be tested. The test plan is available on request from Raytheon or *CTC*.

A variety of non Cr^{+6} conversion coating products were identified by *CTC* in the Alternatives Report and included, among others, the U.S. Navy (NAVAIR) developed and commercially licensed and available TCP (Trivalent Chromium Cr^{+3} Pretreatment). Four TCPs were selected for testing and are designated as TCP1 through TCP4 in this paper. Even though these products still contained chromium, their Cr^{+3} formulations met all of the environmental and industrial health related goals associated with eliminating Cr^{+6} at AFP 44. Additionally, two completely non chrome conversion coating products, designated NCCC1 and NCCC2, were evaluated. A number of other promising products were identified but not evaluated as they were not being utilized beyond a pilot production phase within the DoD. Just one chromate conversion coating, designated CCC, was selected as the baseline comparison conversion coating for aluminum. This product is a widely utilized chromate conversion coating chemistry per MIL-DTL-5541, Type I, Class 1A and is on the QPL-81706. It is widely utilized within Raytheon and its suppliers. It is also exclusively utilized for in-house touch up work.

The Qualification Test Plan identified screening tests that were to be performed on pretreated-only panels to eliminate any products that could not meet minimum performance requirements prior to advancing to a more elaborate and higher cost test matrix involving solvent based (wet) paint processes applied per MIL-PRF-85285 and powder paint processes applied per an in-house controlled specification. The screening tests used for evaluation were 168 hour salt spray corrosion resistance, tape adhesion, and appearance tests. The screening test matrix is shown in Table I.

Table I. Screening Test Matrix

Test	Test Method	Requirement
Appearance	MIL-DTL-5541, Section 3.5	Uniform, continuous, free from powdery or loose coating, voids, flaws, etc.
Corrosion Resistance	MIL-DTL-5541, Section 3.6 and Section 4.5.1 (ASTM B117)	5% Salt Spray for 168 Hours; No more than 5 isolated spots or pits, none larger than 0.031 inch in diameter. No more than 15 pits, none larger than 0.031 inch in diameter on the combined surface area of all 5 specimens (150 square inches).
Tape Adhesion	ASTM D 3359, Method A	No coating separation from base metal substrate.

During the writing of the test plan in early 2006, none of the selected alternatives to chromate conversion coating were certified for use with the MIL-DTL-5541 specification. Additionally, the non chrome paint primers were not certified for use with MIL-PRF-85582 (waterborne) or MIL-PRF-QPL-23377 (solvent borne). As a result, it was necessary to qualify the chrome based and non chrome based paint primer candidates with both the baseline chromate conversion coating (CCC) as well as with the alternatives to chromate conversion coat to assure maximum compatibility.

The waterborne paint primer selected for baseline testing was in daily use at AFP 44 and is listed on QPL-85582, which is the Qualified Products List (QPL) for MIL-PRF-85582, Type I, Class C1 (Barium Chromate) primers. The waterborne, non chromated primer candidate selected for testing was expected to soon be on the QPL-85582 for use as a MIL-PRF-85582, Type I, Class "N" (Non-Chromate) primer.

The high solids (solvent) primer selected for baseline testing was in daily use at AFP 44 and listed on the QPL-23377 for MIL-PRF-23377, Type I, Class "C" (Strontium Chromate) primers. The non chromated candidate primer selected for testing was expected to soon be on the QPL-23377 for use as a MIL-PRF-23377, Type I, Class "N" (Non-Chromate) primer.

It was lastly decided to paint with a topcoat that was already being utilized in daily production at AFP 44. The topcoat selected was qualified to MIL-PRF-85285C, Type I, Color White per FED-STD-595, Color #17925. Table II summarizes the coatings applied.

Table II. Wet Spray Coating Systems for Evaluation

Name	Description
MIL-PRF-23377H, Type I, Class C	Cr ⁺⁶ -containing solvent-borne primer
MIL-PRF-23377H, Type I, Class N	Non-chromated solvent-borne primer
MIL-PRF-85582, Type I, Class C1	Cr ⁺⁶ -containing waterborne primer
MIL-PRF-85582, Type I, Class N	Non-chromated waterborne primer
MIL-PRF-85285C, Type I	FED-STD-595 white topcoat

Table III lists the primer and topcoat test matrix, which includes wet tape adhesion, 2000 hour corrosion resistance, water resistance and filiform corrosion.

Table III. Primer and Topcoat Test Matrix

Test	Test Method	Requirement
Wet Tape Adhesion	MIL-DTL-5541, Section 4.3.3.1.1 and MIL-PRF-85582, Section 3.6.4 IAW Section 4.5.42 (FED Test STD 141 Method 6301)	No loss of adhesion.
Water Resistance	MIL-PRF-85582, Section 3.7.1 IAW Section 4.5.7; 4-day Water Immersion Test	No wrinkling, blistering, or any coating deficiency.
Corrosion Resistance	MIL-PRF-85582, Section 3.7.2.1 IAW Section 4.5.8.1; 5% Salt Spray for 2000 hours, Test with scribe marks	No blistering, lifting or either coating, or substrate pitting.
Filiform Corrosion	MIL-PRF-85582, Section 3.7.2.2 IAW Section 4.5.8.2; Exposure to 12 N HCl followed by 1000 hrs in humidity cabinet	No filiform corrosion extending beyond 0.25 inch from scribe, majority of filaments shall be less than 0.125 inch.

Finally, testing was required to qualify the alternative conversion coatings for use with powder coating. The powder coat selected was per an in-house specification but commercially available, Color Gray per FED-STD-595, Color #36375.

Table IV summarizes the tests performed, which includes wet tape adhesion, dry tape adhesion, humidity, accelerated weathering, heat resistance, thermal shock resistance and 2000 hour sulfur dioxide (SO₂) corrosion resistance.

Table IV. Powder Coat Test Matrix

Test	Test Method	Requirement
Wet Tape Adhesion	FED-STD-141A, Method 6301.3	No loss of adhesion.
Dry Tape Adhesion	ASTM D 3359, Method A	No coating removal, cracking, or flaking.
Humidity	FTMS No. 141A, Method 6201	400 hrs hum. @ 100° F ±5° F, no loss adhesion, blistering, film softening, discoloration.
Accelerated Weathering	ASTM-D-5894	Pass 2000 hrs.
Heat Resistance	FED-STD-141, Method 6051	Pass 24 hrs @ 300° F ±10° F, no blistering, loss of adhesion.
Thermal Shock Resistance	SCD 6500168, 4.4.2.7; 24 ±1 hrs @ 300° F ±10° F & immersion in ice water @ 34° F ±2° F	No loss of adhesion.
Corrosion Resistance	SCD 6500168, 4.4.2.10; 5% salt spray per ASTM B117 except sulfur dioxide (SO ₂) shall be injected at a flow rate of 1.0±0.2 cm ³ /min/ft ³ , 6° angle from vertical.	Corrosion within 3mm from scribe shall not be considered a failure.

This test plan was used to prepare a competitive solicitation for testing services. *CTC* was again put on contract to apply the baseline and alternative coatings, to perform the lab testing, and to evaluate the test results. All of this work was conducted at the *CTC* facility in Johnstown, Pennsylvania.

RESULTS and DISCUSSION

Table V shows the results for the screening testing of the baseline chromate conversion coating (CCC) and the alternatives to chromate conversion coatings. Note that this testing was performed on unpainted panels only. As expected, the baseline CCC was exceptional. Only the TCP1 product met the corrosion resistance requirements associated

with MIL-DTL-5541, but, because three of the TCP products had already been added to the Qualified Products List (QPL-81706) for MIL-DTL-5541 by the time this testing was completed, it was decided that all TCP products should continue to full testing. The qualifying agency, U.S. Navy (NAVAIR), suggested that the excessive pitting on our panels may have been due to the fact that the TCP chemistries, unlike the hexavalent chromium based conversion coatings, were more sensitive to the cleaning and deoxidizing steps as well as the actual operating parameters of the TCP solution.

Both of the non-chromate conversion coatings (NCCC1, NCCC2) failed salt spray and were eliminated from further testing. This does not imply that these two coatings would not be effective as pretreatments on aluminum prior to painting but the project requirements were only to consider non Cr⁺⁶ systems that could pass both on their own and with subsequent chromated and non chromated paint primers or with direct powder coat.

Table V. Screening Test (pretreatment only) Results

Sample Name	Appearance	Adhesion	Corrosion Resistance – 168 hours
CCC, 2024-T3 Al	Shiny, gold around edges & iridescent in center	Pass, 5A	10 rating, No corrosion
CCC, 6061-T6 Al	Shiny, yellow-brown coating; uneven coating – heavier along the edges	Pass, 5A	9 rating, 1-5 pits
NCCC1	Shiny, slightly iridescent coating	Pass, 5A	3 rating, 21-30% of area contains pitting and/or white corrosion product (WCP)
NCCC2	Scuffed aluminum appearance	Pass, 5A	0 rating, Pitting, WCP and black corrosion product (BCP) – removed after 24 hours
TCP1	Shiny, matte, yellow/brown coating; some scratches; uneven coating – heavier near bottom of panels	Pass, 5A	9 rating, 0-6 pits, 0-1% WCP
TCP2	Shiny, slightly iridescent, even coating; a few scratches	Pass, 5A	8 rating, 12 – 30 pits, 2-3% WCP
TCP3	Shiny, matte, iridescent coating	Pass, 5A	9 rating, 8-27 pits, 0-1% WCP
TCP4	Shiny, iridescent coating	Pass, 5A	8 rating, 42-100 pits, 2-3% WCP

Table VI shows the results of the wet (solvent) spray paint testing. The baseline CCC and the TCPs did very well with the chromated and non chromated paint primers. Table VII shows the results of the powder paint testing. Again, the baseline CCC and the TCPs did very well.

As of this writing, all four of the TCPs tested have been added, via certification letters, to the QPL for MIL-DTL-5541 (QPL-81706) and designated as Type II (compositions containing no Cr⁺⁶) chemical conversion materials.

Regarding the paint primers, the waterborne, non-chromated primer performed very well and was added to QPL-85582 for MIL-PRF-85582, Type I, Class "N" (Non-Chromate) on 19 Dec 06. However, to date, the high solids, non-chromated primer, while passing all of the tests, has not been added to the QPL for MIL-PRF-23377 due to an induction (mixing) time issue. In short, if the two part mixture is not permitted to cure for the required 30-45 minutes, adhesion to the topcoat could be adversely affected. This induction time would not be a concern at AFP 44 but has kept the primer from receiving full certification. Because Raytheon at AFP 44 would only want to use primers listed on the QPLs, testing has begun on another high solids, non-chromated product, which has actually been on QPL-23377 via letter since 27 Jan 05. Our team did not originally select this product because it's brochure identified it as being for touch up applications. However, it has been tested, certified and added to the QPL for full scale use.

Table VI. Wet Spray Paint Evaluation Results

Pretreatment	Coating System	Test Methods – Wet Spray Coatings			
		Wet tape adhesion	Water resistance – 4 day	Corrosion resistance – 2000 hr	Filiform corrosion – 1000 hr
Baseline CCC	MIL-PRF-23377H, Type I, Class C Primer Only	Pass – Rating of 5A	Color change – coating is more green in color	NA	NA
	MIL-PRF-23377H, Type I, Class N Primer Only	Pass – Rating of 5A	Color change – 2 panels were olive green with mint green spots; 1 panel was olive; 2 panels were mint green	NA	NA
	MIL-PRF-85582, Type I, Class C1 Primer Only	Pass – Rating of 5A	Color change – darker	NA	NA
	MIL-PRF-85582, Type I, Class N Primer Only	Pass – Rating of 5A	Color change – dulling	NA	NA
	MIL-PRF-23377H, Type I, Class C Primer + MIL-PRF-85285C, Type I Topcoat	Pass – Rating of 5A	No change	Rating = 10, Scribed area Rating = 8, Unscribed area (blisters)	4 panels – no filaments; 1 panel w/ 4 filaments, from 1/16” to 1/32”
	MIL-PRF-23377H, Type I, Class N Primer + MIL-PRF-85285C, Type I Topcoat	Pass – Rating of 5A	No change	Rating = 10, Scribed area Rating = 10, Unscribed area	Average of 110 filaments, from 1/32” to 1/8” in length
	MIL-PRF-85582, Type I, Class C1 Primer + MIL-PRF-85285C, Type I Topcoat	Pass – Rating of 5A	No change	Rating = 10, Scribed area Rating = 10, Unscribed area	TNTC filaments, from 1/32” to 1/8” in length
	MIL-PRF-85582, Type I, Class N Primer + MIL-PRF-85285C, Type I Topcoat	Pass – Rating of 5A	No change	Rating = 9, Scribed area (WCP) Rating = 10, Unscribed area	Average of 80 filaments, from 1/32” to 1/8” in length

Table VI. Wet Spray Paint Evaluation Results (cont.)

Pretreatment	Coating System	Test Methods – Wet Spray Coatings			
		Wet tape adhesion	Water resistance – 4 day	Corrosion resistance – 2000 hr	Filiform corrosion – 1000 hr
TCP1	MIL-PRF-23377H, Type I, Class C Primer Only	Rating of 5 – 4 panels Rating of 4 – 1 panel	Slight color change – dulling	NA	NA
	MIL-PRF-23377H, Type I, Class N Primer Only	Pass – Rating of 5A	Slight color change – dulling	NA	NA
	MIL-PRF-85582, Type I, Class C1 Primer Only	Pass – Rating of 5A	Color change – darker	NA	NA
	MIL-PRF-85582, Type I, Class N Primer Only	Pass – Rating of 5A	Slight color change – dulling	NA	NA
	MIL-PRF-23377H, Type I, Class C Primer + MIL-PRF-85285C, Type I Topcoat	Pass – Rating of 5A	No change	Rating = 10, Scribed area Rating = 10, Unscribed area	Average of 36 filaments, from 1/32” to 5/16” in length
	MIL-PRF-23377H, Type I, Class N Primer + MIL-PRF-85285C, Type I Topcoat	Pass – Rating of 5A	No change	Rating = 9, Scribed area (WCP) Rating = 10, Unscribed area	Average of 99 filaments, from 1/32” to 3/32” in length
	MIL-PRF-85582, Type I, Class C1 Primer + MIL-PRF-85285C, Type I Topcoat	Pass – Rating of 5A	No change	Rating = 10, Scribed area Rating = 10, Unscribed area	TNTC filaments, from 1/32” to 1/4”
	MIL-PRF-85582, Type I, Class N Primer + MIL-PRF-85285C, Type I Topcoat	Pass – Rating of 5A	No change	Rating = 8, Scribed area (WCP) Rating = 10, Unscribed area	Average of 110 filaments, from 1/32” to 5/32” in length

Table VI. Wet Spray Paint Evaluation Results (cont.)

Pretreatment	Coating System	Test Methods – Wet Spray Coatings			
		Wet tape adhesion	Water resistance – 4 day	Corrosion resistance – 2000 hr	Filiform corrosion – 1000 hr
TCP2	MIL-PRF-23377H, Type I, Class C Primer Only	Pass – Rating of 5A	Slight color change – dulling	NA	NA
	MIL-PRF-23377H, Type I, Class N Primer Only	Pass – Rating of 5A	Slight color change – dulling	NA	NA
	MIL-PRF-85582, Type I, Class C1 Primer Only	Pass – Rating of 5A	Color change – darker	NA	NA
	MIL-PRF-85582, Type I, Class N Primer Only	Pass – Rating of 5A	Slight color change – dulling	NA	NA
	MIL-PRF-23377H, Type I, Class C Primer + MIL-PRF-85285C, Type I Topcoat	Rating of 5 – 1 panel Rating of 4 – 3 panels Rating of 3 – 1 panel	No change	Rating = 10, Scribed area Rating = 10, Unscribed area	Average of 25 filaments, from 1/32” to 3/16” in length
	MIL-PRF-23377H, Type I, Class N Primer + MIL-PRF-85285C, Type I Topcoat	Pass – Rating of 5A	No change	Rating = 9, Scribed area (WCP) Rating = 10, Unscribed area	Average of 119 filaments, from 1/32” to 1/8” in length
	MIL-PRF-85582, Type I, Class C1 Primer + MIL-PRF-85285C, Type I Topcoat	Rating of 5 – 4 panels Rating of 4 – 1 panel	No change	Rating = 10, Scribed area Rating = 10, Unscribed area	TNTC filaments, from 1/32” to 5/32” in length
	MIL-PRF-85582, Type I, Class N Primer + MIL-PRF-85285C, Type I Topcoat	Pass – Rating of 5A	No change	Rating = 8, Scribed area (WCP) Rating = 10, Unscribed area	Average of 132 filaments, from 1/32” to 1/8” in length

Table VI. Wet Spray Paint Evaluation Results (cont.)

Pretreatment	Coating System	Test Methods – Wet Spray Coatings			
		Wet tape adhesion	Water resistance – 4 day	Corrosion resistance – 2000 hr	Filiform corrosion – 1000 hr
TCP3	MIL-PRF-23377H, Type I, Class C Primer Only	Pass – Rating of 5A	Slight color change – dulling	NA	NA
	MIL-PRF-23377H, Type I, Class N Primer Only	Pass – Rating of 5A	Slight color change – dulling	NA	NA
	MIL-PRF-85582, Type I, Class C1 Primer Only	Pass – Rating of 5A	Color change – darker	NA	NA
	MIL-PRF-85582, Type I, Class N Primer Only	Pass – Rating of 5A	Slight color change – dulling	NA	NA
	MIL-PRF-23377H, Type I, Class C Primer + MIL-PRF-85285C, Type I Topcoat	Rating of 5 – 2 panels Rating of 4 – 3 panels	No change	Rating = 10, Scribed area Rating = 10, Unscribed area	Average of 10 filaments, from 1/32” to 1/8” in length
	MIL-PRF-23377H, Type I, Class N Primer + MIL-PRF-85285C, Type I Topcoat	Rating of 5 – 3 panels Rating of 4 – 2 panels	No change	Rating = 9, Scribed area (WCP) Rating = 10, Unscribed area	Average of 95 filaments, from 1/32” to 1/8” in length
	MIL-PRF-85582, Type I, Class C1 Primer + MIL-PRF-85285C, Type I Topcoat	Rating of 5 – 3 panels Rating of 4 – 1 panel Rating of 3 – 1 panel	No change	Rating = 10, Scribed area Rating = 10, Unscribed area	TNTC filaments, from 1/32” to 5/32” in length
	MIL-PRF-85582, Type I, Class N Primer + MIL-PRF-85285C, Type I Topcoat	Pass – Rating of 5A	No change	Rating = 8, Scribed area (WCP) Rating = 10, Unscribed area	Average of 64 filaments, from 1/32” to 1/8” in length

Table VI. Wet Spray Paint Evaluation Results (cont.)

Pretreatment	Coating System	Test Methods – Wet Spray Coatings			
		Wet tape adhesion	Water resistance – 4 day	Corrosion resistance – 2000 hr	Filiform corrosion – 1000 hr
TCP4	MIL-PRF-23377H, Type I, Class C Primer Only	Pass – Rating of 5A	Slight color change – dulling	NA	NA
	MIL-PRF-23377H, Type I, Class N Primer Only	Pass – Rating of 5A	4 panels had slight dulling; 1 panel was olive with small mint green spots	NA	NA
	MIL-PRF-85582, Type I, Class C1 Primer Only	Pass – Rating of 5A	No change	NA	NA
	MIL-PRF-85582, Type I, Class N Primer Only	Pass – Rating of 5A	Slight color change – dulling	NA	NA
	MIL-PRF-23377H, Type I, Class C Primer + MIL-PRF-85285C, Type I Topcoat	Rating of 5 – 3 panels Rating of 4 – 2 panels	No change	Rating = 10, Scribed area Rating = 10, Unscribed area	Average of 11 filaments, from 1/32” to 1/16” in length
	MIL-PRF-23377H, Type I, Class N Primer + MIL-PRF-85285C, Type I Topcoat	Pass – Rating of 5A	No change	Rating = 8, Scribed area (WCP) Rating = 10, Unscribed area	Average of 102 filaments, from 1/32” to 1/8” in length
	MIL-PRF-85582, Type I, Class C1 Primer + MIL-PRF-85285C, Type I Topcoat	Rating of 5 – 1 panel Rating of 4 – 4 panels	No change	Rating = 10, Scribed area Rating = 10, Unscribed area	TNTC filaments, from 1/32” to 1/4” in length
	MIL-PRF-85582, Type I, Class N Primer + MIL-PRF-85285C, Type I Topcoat	Rating of 5 – 4 panels Rating of 4 – 1 panel	No change	Rating = 8, Scribed area (WCP) Rating = 10, Unscribed area	Average of 90 filaments, from 1/32” to 3/32” in length

BCP = Black Corrosion Product WCP = White Corrosion Product

Table VII. Powder Coating Evaluation Results

Pretreatment	Test Methods for Powder Coated Panels						
	Wet tape adhesion	Dry Tape Adhesion	Humidity	Accelerated Weathering	Heat resistance	Thermal shock	SO2 corrosion
Baseline CCC	Pass – Rating of 5A	Pass – Rating of 5A	10 Rating – no change	Yellowing with slight chalking; No coating failures	No change	No change	0-1.0 mm avg. creepage from scribe (8-9 rating) – no corrosion
TCP1	Pass – Rating of 5A	Pass – Rating of 5A	10 Rating – no change	Yellowing with slight chalking; No coating failures	No change	No change	1.0-2.0 mm avg. creepage from scribe (7 rating) – no corrosion
TCP2	Pass – Rating of 5A	Pass – Rating of 5A	10 Rating – no change	Yellowing with slight chalking; No coating failures	No change	No change	0.5-1.0 mm avg. creepage from scribe (8 rating) – no corrosion
TCP3	Pass – Rating of 5A	Pass – Rating of 5A	10 Rating – no change	Yellowing with slight chalking; No coating failures	No change	No change – 4 panels; Loss of adhesion along scribe – 1 panel	1.0-2.0 mm avg. creepage from scribe (7 rating) – no corrosion
TCP4	Pass – Rating of 5A	Pass – Rating of 5A	10 Rating – no change	Yellowing with slight chalking; No coating failures	No change	No change	0.5-2.0 mm avg. creepage from scribe (7-8 rating) – no corrosion

SUMMARY

It is now possible to have a Cr^{+6} free conversion coat and paint system (solvent based or powder) for aluminum based missile components that meet the requirements of MIL-DTL-5541, MIL-PRF-85582, MIL-PRF-23377, and MIL-PRF-85285.

All four of the TCP (Trivalent Chromium Cr^{+3} Pretreatment) products tested by CTC have been added, via certification letter, to QPL-81706 for use with MIL-DTL-5541 and designated as Type II (compositions containing no Cr^{+6}) chemical conversion materials.

QPL-85582 now includes our product tested for use with MIL-PRF-85582 as a waterborne, non-chromated paint primer and designated as Class "N" (Non-Chromate).

The high solids, non-chromated paint primer, although successfully passing all of the qualification tests, has not been added to QPL-23377 because of an induction (mixing) time issue. However, a second product from the same supplier is currently on the QPL-23377 for use with MIL-PRF-23377 as a high solids (solvent), non-chromated paint primer and designated as Class "N" (Non-Chromate). Verification testing through the same test matrix listed in Table III is underway for this product with results expected in late Aug 07.

For electronic copies of any of the reports or for additional information, contact Paul Fecsik at PWfecsik@raytheon.com, Jim Arthur at arthurj@ctc.com or Leanne Debias at debiasl@ctc.com.