

Development of the M2A1 Container Coatings ECP

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Introduction

- Container Coatings - use low cost Alkyd based technologies with significant rework and are high in volatile organic compounds (VOC's)
- Current Packaging interests – improved corrosion resistance, reduced environmental impact and reduced life cycle costs

Packaging Program Background



- Modular Artillery Container System (MACS) investigates the use of powder coatings for PA103A2 and PA161 applications around FY02
- Coating Goals (beyond current coating requirements)–
 - Improved Corrosion Resistance
 - Thin uniform Coating
 - Solventless formulation – no VOC's
 - Good chemical resistance

Program Summary



- Polyurethane Powder Coating available from industry meeting lusterless gloss definition (<10 per ASTM D523)
- ASTM B117 Corrosion Resistance over 336 hours possible with lusterless formulations
- Chemical Agent Decontamination Properties Acceptable on Specific Powder Formulations
- Spot Weld and Recesses in Container Designs presented Faraday Effects limiting areas of Coating Application
- E-coat Primer potential solution to Faraday Effect Issue at Increased Coating Costs
- Powder plus E-coat coating system for MACS containers was in excess of program budget
- MACS continued with alkyd coating system

FY06 Developments



- Future Concepts Division of ARDEC funded a “Reassessment” of Powder Coatings for Conventional Ammunition Containers Applications
- The Coating for Munitions Modernization Program receives Congressional Funding

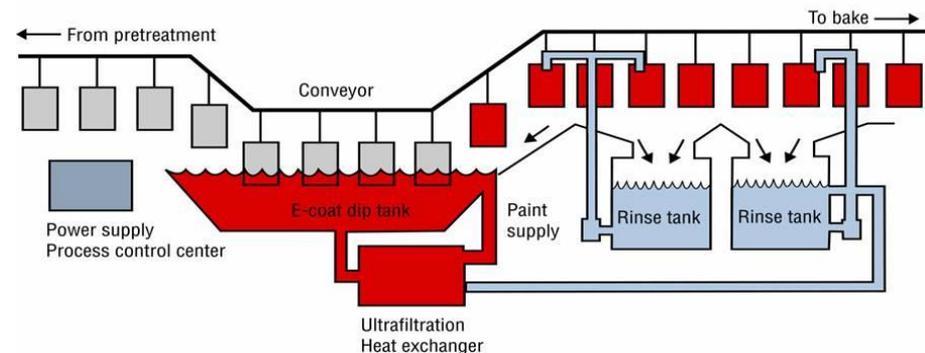
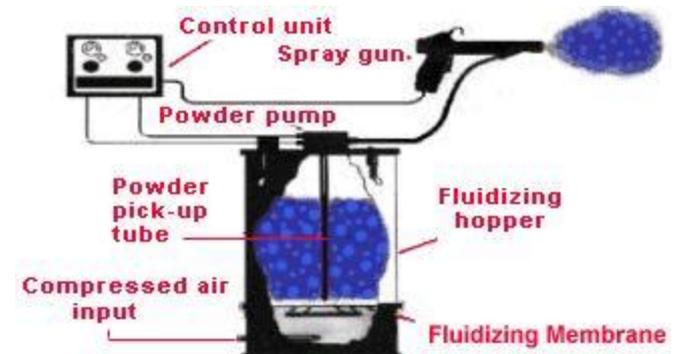
FY06 M2A1 Coating Process Assessment

- Alkyd Enamels Technology (Mil-E-52891, Mil-DTL-11195)
- Applied by spray or dip processes and adapted for container configurations
- Salt Spray resistance 150 hrs
- Poor Aesthetics
- Runs, Drips, Sags increase costs due to rework



FY06/07 Preliminary Research Results

- Powder formulations had improved since FY02.
- New Powder Coating Application Processes with improved “throw” into recesses exist.
- Cationic Acrylic E-coat Products could meet the established corrosion protection and UV durability requirements in the existing coating specification.
- Exterior lusterless gloss E-Coat applications did not exist for commercial market.



Coating Properties Data – Dec 07

	MIL-E-52891	Acrylic E-Coat	Urethane Powder	Results
APPLICATION	Low End One-Coat Dip Enamel	High End One-Coat Electrocoat	High End One-Coat Top Coat	
Cure (Double Acetone Rubs)	25-50	100+	TBD 100+ Expected	Significantly Exceed
60° Gloss	Maximum 8	< 5	< 6	Pass
VOC	High - Solvent Based (~5 lbs/gal)	Low - Water Based < 2.5 lbs/gal	No VOC's	Significantly Exceed
Adhesion	knife-tape 1/16"	Crosshatch 95-100%	ASTM D3359 4B min	Pass
Flexibility	1/4" Mandrel	1/4" Mandrel	1/4" Mandrel	Pass
Water Resistance	168 hours	168 hours	_____	Pass
Salt Spray	5% Salt Fog 150 hours 1/8" scribe creep Trace rust / < 5 blisters	5% Salt Fog 700 hours 1/8" scribe creep No blistering or surface corrosion	5% Salt Fog 750 hours 1/8" scribe creep No blistering or surface corrosion	Significantly Exceed
Touch Up Adhesion	dip enamel 5 sec. No blisters/lift/ or bleeding	Will develop a touch-up product if necessary	Will develop a touch-up product if necessary	Development Need
Weather Resistance	168 hours WOM ΔL less than 4	168 hours WOM ΔL less than 4	168 hours WOM ΔL less than 4 expected	Pass
Dugway Testing	_____	GD, HD, VX Decontamination	GD, HD, VX Decontamination	Pass

Program Results Jan 2008

- Single coat military Powder and E-coat is technically a viable option for exterior applications
- Acrylic e-coat meets current performance requirements for gloss, flexibility, water resistance
- Acrylic e-coat exceeds current performance requirements of alkyd coatings in salt spray resistance, and **weather resistance**
- Additional benefits include low VOC water based formula and Decontaminability

Hawaiian Exposure –Aug 07-Jun 08

Coconut Island, Oahu, Hawaii



Aug 07



Jan 08



Jun 08

E-Coat Reformulation Effort (Feb 08-Dec 09)



- Organic Color Additives degraded with UV exposure
- Container Weather Resistance requirement inadequate
- Baseline Container Weather Resistance determined
- Inorganic Color Additives used in revised formulation
- New Packaging Container Coating Requirements Established



Development of the M2A1 Container Coatings ECP



FY09 Coating Properties Data

	MIL-E-52891	Acrylic E-Coat	Urethane Powder	Results
APPLICATION	Low End One-Coat Dip Enamel	High End One-Coat Electrocoat	High End One-Coat Top Coat	
Cure (Double Acetone Rubs)	25-50	100+	100+	Significantly Exceed
60° Gloss	Maximum 8	< 6	< 6	Pass
VOC	High - Solvent Based (~5 lbs/gal)	Low - Water Based < 2.5 lbs/gal	No VOC's	Significantly Exceed
Adhesion	knife-tape 1/16"	Crosshatch 95-100%	ASTM D3359, 4B min	Pass
Flexibility	1/4" Mandrel	1/4" Mandrel	1/4" Mandrel	Pass
Water Resistance	168 hours	168 hours	168 hours	Pass
Salt Spray	5% Salt Fog 150 hours 1/8" scribe creep Trace rust / < 5 blisters	5% Salt Fog 500 hours 1/8" scribe creep No blistering or surface corrosion	5% Salt Fog 700 hours 1/8" scribe creep No blistering or surface corrosion	Significantly Exceed
Touch Up Adhesion	dip enamel 5 sec. No blisters/lift/ or bleeding	Touch-up product identified	Touch-up product identified	Pass
Weather Resistance	168 hours WOM ΔL less than 4	700 hours WOM ΔL less than 4	700 hours WOM ΔL less than 4 expected	Significantly Exceed
Dugway Testing	_____	GD, HD, VX Decontamination	GD, HD, VX Decontamination	Significantly Exceed

Outdoor Exposure of Existing M2A1 Powder Coating

ARDEC Test Site - NJ



Apr 2009



Jul 09



Sep 09



Coating System Process Study for Container Applications

Purpose of the Study

To complete a finishing cost analysis for painting ammunition containers.

Compare equipment, layout and operating costs for

Electrocoat and powder finishing versus current systems.

Evaluate the impact of increasing line capacity.

Evaluate the impact of adding a second color.

Obtain an outside consultant to provide unbiased data and processing line cost estimates.

Coating System Study Assumptions

A mix of small and large, square and round containers.

Largest parts chosen were PA171 and PA154

Smallest parts chosen were M19A1 container and all lids

Pretreatment requirements and performance are equal.

Zinc phosphate with non chrome sealer

Paint cure requirements are equal.

375 degrees F metal temperature for 20 minutes

All interior surfaces must have paint coverage.

E-coat film build = 1.0 mils.

Powder film build = 2.5 mils.

One and two color system capability.

Annual production sizes:

2, 10, 20 & 30 million square feet per year.



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Requirements Drawing #12998172 Summary

Requirement	MIL-E-52891	Acrylic E-Coat	Urethane Powder
Cured thickness	1.0-2.0 mils	1.0-1.5 mils	2.0-3.0 mils
Impact Resistance ASTM D2794 30 in-lbs int, 10 in-lbs ext	—	Pass	Pass
Specular Gloss ASTM D523 60° Gloss (<10)	Maximum 8	< 6	< 6
Enamel Paint Compatibility ASTM D3359, Method B	Pass	Pass	Pass
Adhesion ASTM D3359, Method B, 4B min	Pass	Pass	Pass
Flexibility ASTM D522, 1/4" Conical Mandrel	Pass	Pass	Pass
Hardness ASTM D3363 (2H)	Pass	Pass	Pass
Salt Spray ASTM B117	150 hours 1/8" scribe creep Trace rust / < 5 blisters	400 hours 1/8" scribe creep No blistering or surface corrosion	400 hours 1/8" scribe creep No blistering or surface corrosion
Touch Up Adhesion	Touch-up product identified	Touch-up product identified	Touch-up product identified
Accelerated Weathering ASTM G26, Method 1, Type BH	168 hours WOM ΔL less than 4	700 hours WOM ΔL less than 4	700 hours WOM ΔL less than 4 expected
Dugway Testing (Not a Formal Requirement)	—	GD, HD, VX Decontamination	GD, HD, VX Decontamination

JMC FY10 M2A1 Contract Solicitation

- Jan 09 Solicitation request asked for container price quotes based on alkyd coating, powder coating and e-coat systems for “Full and Open” and “Small Business Set-Aside” Contract .
- “Full and Open” Contract was awarded with selection of e-coat process based on unit cost in late July 2009.
- “Small Business Set-Aside” Contact was awarded with selection of powder coating process based on unit cost in August 2009 using an ECP powder.
- Polyurethane Powder will be implemented first since contractor had an existing powder coating process.
- E-Coat implementation will be delayed until coating line installation.

Acknowledgments

- Thanks for the assistance of the Acquisition, JMC, PM and ARDEC offices involved in this effort.
- Thanks for the cooperation of ARDEC manufacturing contractors involved in this program including Best Foam Fabricators, Conco Containers, Delfasco Containers and B-Way Containers.
- Special thanks for the effort and work accomplished on this program by the many individuals of PPG, Valspar, Sherwin Williams, Govesan Manufacturing, DuPont, TTX, Inc, and the University of Hawaii – Corrosion Research Center.





Development of the M2A1 Container Coatings ECP



Information (Backup) Slides



Development of the M2A1 Container Coatings ECP



Requirements Comparison

	MIL-P-53022B	MIL-P-53030A	MIL-DTL-53084		MIL-DTL-11195G	MIL-E-52891	MIL-DTL-64159	MIL-C-53039		URETHANE POWDER DRAWING 1298172	PPG THRESHOLD PROPERTIES
APPLICATION	Low end primer	Low end primer	High end primer (e-coat)		VOC Compliant 1coat	Low end 1 coat	CARC Topcoat	CARC Topcoat		Medium spec 1 coat for ammo boxes	Low end 1 coat
60° Gloss	min 10 / max 30	max 25	30-70		max 8	max 8	max 1.0	max 1.0		max 10	max 8
85° Gloss							3.5	3.5			
VOC					3.5 #/gal.						max. 3.5# / gal.
Adhesion	knife-tape 1/16"	knife-tape 1/16"	primer 5B / primer+tpct 4B ASTM D3359		knife-tape 1/8"	knife-tape 1/16"	4B over primer ASTM D3359	4B over primer ASTM D3359		4B ASTM D3359	knife-tape 1/16"
Knife test	Method 6304	Method 6304	Method 6304		Method 6304	Method 6304					Method 6304
Impact Resistance										50 inch-pounds (reverse & forward)	30 inch-pounds (to be confirmed)
Flexibility	Method 6221 (1/4" mandrel)	Method 6221 (1/4" mandrel)	ASTM D522 (1/4" mandrel) aluminum panel		ASTM 522 1/4" mandrel	Method 6221 (1/4" mandrel)	ASTM D522 (1/4" mandrel)	Method 6221 (1/4" mandrel)		ASTM D522 (1/4" mandrel)	Method 6221 (1/4" mandrel)
Water Resistance	ASTM D1308 168 hours 24 hr.recovery	ASTM D1308 168 hours 24 hr.recovery			18 hours 2 and 24 hour recovery	ASTM D1308 168 hours 24 hr. recovery	ASTM D1308 168 hours 2H Δpencil little change gloss/color	168 hours 2 hr. recovery 2H Δpencil			168 hours 2 hr. recovery 2H Δpencil
Salt Spray	ASTM B117 unscored 336 hours trace rust/< 5 blis. Strip and eval.	ASTM B117 unscored 336 hours trace rust/< 5 blis. Strip and eval.	ASTM B117 'X' scribe 1000hours 1/8" scribe creep 3 B adhesion trace rust strip and eval.		ASTM D1654 TYPE I - 120 hr TYPE 2 - 240 hr min 7 rating	METHOD 6061 150 hours 1/8" scribe creep trace rust / < 5 blis. Strip and eval.				ASTM B117 240 hours 1/4" scribe creep no blistering or surface corrosion	ASTM B117 240 hours 1/4" scribe creep no blistering or surface corrosion
Hardness										2H	2H
Touch Up Adhesion	green 383,34084 urethane; knife blade test	green 383; knife test	see adhesion			dip enamel 5 sec. No blisters/lift/ or bleeding	self	self		Brushed on enamel adhesion test	Brushed on enamel adhesion test
Weather Resistance	Topcoated w/ 383; 18 mths Wash DC; trace rust	Topcoated/ w/ 383; 24 mths Wash DC; strip	Topcoated w/ 383/34094 (64159) ASTM G90 (560 mJ/m2 total) chalking (ASTM D4214); ΔE less than		24 mths Aberdeen MD, ASTM 610, rust rating 9	168 hours WOM (Method 6152) ΔL less than 4; also 18 months (scored) Wash DC	1000 hours ASTM G154, color change less than 2.5 NBS, no increase in gloss, chalking or adhesion loss	800 hours (ASTM G154) UV 340A; ΔE , 2.5		240 hours WOM (ASTM G26 method 1) ΔE less than 4	168 hours WOM (ASTM G26 method 1) ΔE less than 4
Hydrocarbon Fluid	ASTM D1308 TT S-735; 168 hour 2 hour recovery	ASTM D1308 TT S-735; 168 hour 2 hour recovery			70:30 isooctane/toluene 4 hrs immed/2 & 24 hr recovery		JP-8 168 hours 2 hours less than 2 H pencil; 24 hours no change hdns, adsn, app, no more than 0.5 gloss increase	ASTM D1308 TT S-735; 168 hour 2 hour recovery/24 hour recovery			70:30 isooctane/toluene 4 hrs immed/2 & 24 hr recovery
DS2	30 min 1/2 ml DS2; no softening or color change (ΔE <2.5)	30 min 1/2 ml DS2; little softening or color change					30 min 1 ml DS2; less than 2H softening, color change < 2.5 NBS units				
Acid Resistance							5 ml. 10% acetic / 1hour, no blister or color change				
Chemical and Live Agent							with primer/ desorb max 40 micrograms GD, 180 micrograms HD				
IR reflectance							FED STD 141 method 6241				
Super Tropical Bleach (STB) resistance			1 ml. STB; 30 min less than 2 pencil hdns, max. color change 2.5 NBS				1 ml. STB; 30 min less than 2 pencil hdns, max. color change 2.5 NBS				
Cure time			ASTM D1153 30 strokes MIBK								ASTM D1153 30 strokes MIBK
Throw power			10 inches								10 inches

Dip Coating

- High cost (rework, transfer efficiency)
- Low performance (corrosion, aesthetics)
- High VOC / Need for incineration



The “True” Cost



Material Usage

The amount of paint that is coated onto a part.

Labor

Manual handling

Re-work

Line operators

Loader/unloader

Painter

Supervisors

Process Efficiency

Square feet painted

Line speed (line of sight)

Ability to rack parts



**Applied Cost
per Square Foot**

Capital Investment

Justified by square footage

Investigation Summary (Dec 08)

	MIL-E-52891	ACRYLIC E-COAT	Results
APPLICATION	Low End One-Coat Dip Enamel	High End One-Coat Electrocoat	_____
Cure (Double Acetone Rubs)	25-50	100+	Significantly Exceed
60° Gloss	Maximum 8	< 8	Pass
VOC	High - Solvent Based (~3.5 lbs/gal)	Low - Water Based < 2.5 lbs/gal	Significantly Exceed
Adhesion	knife-tape 1/16"	Crosshatch 95-100%	Pass
Flexibility	1/4" Mandrel	1/4" Mandrel	Pass
Water Resistance	168 hours	168 hours	Pass
Salt Spray	5% Salt Fog 150 hours 1/8" scribe creep Trace rust / < 5 blisters	5% Salt Fog 500 hours 1/8" scribe creep No blistering or surface corrosion	Significantly Exceed
Touch Up Adhesion	dip enamel 5 sec. No blisters/lift/ or bleeding	Touch-up product identified	Pass
Weather Resistance	168 hours WOM ΔL less than 4	700 hours WOM ΔL less than 4	Significantly Exceed
Energetic Resistance	_____	Comp B-4, Black Powder, C-4, HMX, PBXN-9	Pass
Decontamination Testing	_____	GD, HD, VX Decontamination	Pass