

PERFORMANCE SPECIFICATION

POWDER COATING, CAMOUFLAGE CHEMICAL AGENT RESISTANT SYSTEMS

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers powder coatings for use on metallic substrates. Included are chemical agent resistant powder coatings for use as a finish coat and powder coatings meant for use as primers with chemical agent resistant camouflage finish coats on all military tactical equipment, which includes ground, aviation and related support assets. The materials are free of volatile organic compounds (VOCs), volatile organic hazardous air pollutants (VOHAPs) and inorganic hazardous air pollutants (HAPs), other than cobalt and non-hexavalent chromium.

1.2 Classification. The powder coating covered by this specification will be furnished in the following types and classes as specified (see 6.1, 6.1.1 and 6.2).

1.2.1 Types. The coatings will be furnished in the following types. If one of the following coating types is not cited in a relevant contractual document or drawing, select type I when a primer coat is required, type III when a finish coat is required and type IV when an ammunition coating is required.

- Type I - For use as a primer with chemical agent resistant finish coatings.
- Type II - For use as a primer with no finish coating. For interior use only.
- Type III - For use as a camouflage, chemical agent resistant finish coating.
- Type IV - For use as an ammunition container, chemical agent resistant finish coating.

1.2.2 Classes. The coatings will be furnished in the following classes. If one of the following coating classes is not cited in a relevant contractual document or drawing, select class I.

- Class I - No limitation on maximum temperature reached by substrate during coating cure.
- Class II - Maximum temperature of 350 °F (177 °C) reached by substrate during coating cure.

Comments, suggestions, or questions on this document should be addressed to: Director, U.S. Army Research Laboratory, Weapons and Materials Research Directorate, Materials Manufacturing Technology Branch, Specification and Standards Office, ATTN: RDRL-WMM-D, Aberdeen Proving Ground, MD 21005-5069 or emailed to rsquilla@arl.army.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at <https://assist.daps.dla.mil/>.

1.3 Part or identifying number (PIN). Use the following example to create the PINs to be used for coatings acquired to this specification:

<u>M32348</u>	-	<u>XX</u>	-	<u>XX</u>	-	<u>XXXX</u>	-	<u>XXXXX</u>
Specification identifier		Type designator		Class designator		Container size designator		Color designator
		Type I = 01		Class I = 01		50 pound = 050P		FED-STD-595 color chip number
		Type II = 02		Class II = 02		100 pound = 100P		
		Type III = 03				150 pound = 150P		
		Type IV = 04						

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

FEDERAL STANDARDS

- FED-STD-313 - Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities.
- FED-STD-595 - Colors Used in Government Procurement.
- FED-STD-595/17925 - Miscellaneous, Gloss.
- FED-STD-595/24533 - Green, Semigloss.
- FED-STD-595/26622 - Gray, Semigloss.
- FED-STD-595/27875 - Miscellaneous, Semigloss.
- FED-STD-595/Color - Green 808.
- Description
- FED-STD-595/Color - 30051, 31136, 33105, 33245, 33303, 33446, 33510, 33531, 33538, Chip Numbers for 34031, 34079, 34082, 34088, 34094, 34160, 34201, 35044, 35237, Type III 36231, 36300, 36375, 37030, 37031, 37038, 37875. All colors are flat or lusterless.

DEPARTMENT OF DEFENSE SPECIFICATIONS

- MIL-DTL-12468 - Decontaminating Agent, STB.
- MIL-PRF-23377 - Primer Coatings: Epoxy, High-Solids.
- MIL-PRF-23699 - Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number O-156.
- MIL-DTL-53022 - Primer, Epoxy Coating, Corrosion Inhibiting Lead and Chromate Free.
- MIL-DTL-53030 - Primer Coating, Epoxy, Water Based, Lead and Chromate Free.

- MIL-DTL-53039 - Coating, Aliphatic Polyurethane, Single Component, Chemical Agent Resistant.
- MIL-DTL-64159 - Camouflage Coating, Water Dispersible Aliphatic Polyurethane, Chemical Agent Resistant.
- MIL-PRF-83282 - Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Metric, NATO Code Number H-537.
- MIL-PRF-85582 - Primer Coatings: Epoxy, Waterborne.

(Copies of these documents are available online at <https://assist.daps.dla.mil/quicksearch/> or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (EPA)
EPA Method 311 - HAPS in Paints & Coatings.

(Copies of this document are available online at <http://www.epa.gov/ttn/emc/> or from the Environmental Protection Agency, Ariel Rios Building, 1200 Pennsylvania Avenue, N.W., Washington, DC 20460.)

ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
Specification Control - Coatings, High Performance (For Ammunition Coatings.)
Drawing Part No.
12998172

(Copies of this document are available at U.S. Army ARDEC, RDAR-EIL-P, B455, Picatinny, New Jersey, 07806-5000.)

TOP 8-2-111 - Chemical, Biological, and Radiological (CBR) Contamination Survivability, Small Items of Equipment.

(Copies of this document are available online at <http://www.dtic.mil/dtic/> or from the Chemical, Biological, Radiological & Nuclear Defense Information Analysis Center, Battelle Eastern Science and Technology Center, ATTN: CBRNIAC, 1204 Technology Drive, Aberdeen, MD 21001.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

ASTM INTERNATIONAL
ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.
(DoD adopted)

ASTM D476	- Standard Classification for Dry Pigmentary Titanium Dioxide Products. (DoD adopted)
ASTM D522	- Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings. (DoD adopted)
ASTM D523	- Standard Test Method for Specular Gloss. (DoD adopted)
ASTM D1654	- Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments. (DoD adopted)
ASTM D1849	- Standard Test Method for Package Stability of Paint. (DoD adopted)
ASTM D2805	- Standard Test Method for Hiding Power of Paints by Reflectometry. (DoD adopted)
ASTM D3271	- Standard Practice for Direct Injection of Solvent-Reducible Paints Into a Gas Chromatograph for Solvent Analysis. (DoD adopted)
ASTM D3335	- Standard Test Method for Low Concentrations of Lead, Cadmium, and Cobalt in Paint by Atomic Absorption Spectroscopy. (DoD adopted)
ASTM D3359	- Standard Test Methods for Measuring Adhesion by Tape Test.
ASTM D3363	- Standard Test Method for Film Hardness by Pencil Test. (DoD adopted)
ASTM D3723	- Standard Test Method for Pigment Content of Water-Emulsion Paints by Low-Temperature Ashing.
ASTM D4214	- Standard Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films. (DoD adopted)
ASTM E308	- Standard Practice for Computing the Colors of Objects by Using the CIE System. (DoD adopted)
ASTM E1331	- Standard Test Method for Reflectance Factor and Color by Spectrophotometry Using Hemispherical Geometry.
ASTM G90	- Standard Practice for Performing Accelerated Outdoor Weathering of Nonmetallic Materials Using Concentrated Natural Sunlight.
ASTM G154	- Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials.

(Copies of these documents are available from www.astm.org or ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959.)

GENERAL MOTORS ENGINEERING STANDARDS

GMW 14872 - Cyclic Corrosion Laboratory Test.

(Copies of this document are available from www.ihs.com or General Motors International, General Motors Technical Center, Warren, MI 48092.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Qualification. The coating furnished under this specification shall be a product authorized by

the qualifying activity for listing in the Qualified Products Database (QPD) before contract award (see 4.2 and 6.4). Any change in the formulation or processing of a qualified product shall necessitate its requalification. The material supplied under contract shall be identical, within manufacturing tolerances, to the product receiving qualification.

3.1.1 Type IV qualification. The ammunition coatings shall conform to Specification Control Drawing Part No. 12998172. The drawing requirements take priority over inconsistencies between the technical drawing and specification. The drawing ensures proper interface between the powder coating and the ammunition containers (see 4.2 and 6.4)

3.2 Materials. The materials used in the coating shall be as specified herein. Materials not specified shall be selected by the contractor and shall be subject to all provisions of this specification.

3.2.1 Color characteristics. The color of a type I powder coat primer shall be characteristic of titanium dioxide pigments or light beige or gray not darker than color number 26622 of FED-STD-595. There are no gloss requirements or limitations for this type. Type I primers conforming to the color requirements of color numbers 17925 and 27875 can also be used as a type II primer when those color numbers are cited in a relevant contractual document or drawing. The type II powder coat primer is available in a wide variety of colors for interior applications. The color and gloss of the type II powder coat primer shall be consistent with the requirements of FED-STD-595 for each different color. Color number 24533 shall be used as a type II primer only.

3.2.2 Finish coat. For type III coatings, the required finish color shall be one of the following FED-STD-595 colors listed in table I. Where Aircraft Black, 37038 is specified for use, Black, 37030 is authorized to be used in its place. The Army's primary camouflage colors are Aircraft Green, 34031, Aircraft Gray, 36300, Black, 37030, Brown 383, 30051, IRR Foliage Green 504, 34160, Green 383, 34094, Green 808, Tan 686A, 33446, and Woodland Desert Sage, 34201.

TABLE I. FED-STD-595 colors.

Color Number	Color Description	Color Number	Color Description
37038	Aircraft Black	33105	Field Drab
36300	Aircraft Gray	34094	Green 383
34031	Aircraft Green	-	Green 808
35044	Aircraft Insignia Blue	37031	Interior Aircraft Black
31136	Aircraft Red	36231	Interior Aircraft Gray
37875	Aircraft White	34160	IRR Foliage Green 504
33538	Aircraft Yellow	36375	Medium Gray
37030	Black	34088	Olive Drab
35237	Blue Gray	33303	Sand
30051	Brown 383	33531	Tan
34082	Dark Green	33446	Tan 686A
33510	Dark Sandstone	34201	Woodland Desert Sage
33245	Earth Yellow		

3.2.3 Ammunition Desert Tan, 33446 and Ammunition Forest Green, 34079. These colors are not camouflage coatings. These colors are specific to type IV ammunition container coatings.

3.3 Color and spectral reflectance. For type III coatings, the camouflage colors listed in table II shall impart to the substrate the required spectral reflectance properties in the visible (400-700 nanometers) and near infrared (700-900 nanometers) spectrums. Some camouflage colors shall have numerical requirements and some shall have visual match(es) (VM) for chromaticity as listed in table II. Interior Aircraft Black, 37031, Aircraft Gray, 36300, Ammunition Forest Green, 34079, Ammunition Tan, 33446, Tan 33531 and Dark Sandstone, 33510 shall visually match the appropriate chips from FED-STD-595. Aircraft Green, 34031 shall visually match color chips furnished by the U.S. Army Research Laboratory (ARL), ATTN: RDRL-WMM-C, Organic Coatings Team, Building 4600, Deer Creek Loop, Aberdeen Proving Ground, MD 21005-5066. All other colors listed in table I shall visually match the appropriate chip from FED-STD-595. The camouflage colors listed in table II, except the aircraft colors and Dark Sandstone, 33510, shall meet the infrared reflectance requirements of table II when tested as in 4.6.2. The aircraft colors and Dark Sandstone, 33510 shall meet the infrared reflectance requirements of table II when tested as in 4.6.9. The color Dark Green, 34082 and Green 383, 34094 shall meet the spectral reflectance limits specified in table IV. The color IRR Foliage Green 504, 34160 shall meet the spectral reflectance limits specified in table V. The color Green 808 shall meet the spectral reflectance limits in table VI. Colors not listed in table II are only visual match(es) (VM) to the required color chip, as specified in FED-STD-595.

3.3.1 Camouflage system colors. For type III coatings, the colors of the camouflage system shall fall within 2.0 National Bureau of Standards (NBS) units of the values listed in table II using tristimulus color coordinates. Obtain brightness (Y) and chromaticity (x, y) values under standard illuminant C, and the 2-degree standard observer angle in accordance with paragraph 4.6.2.

TABLE II. Color and reflectance requirements using tristimulus color coordinates.

Color	Brightness (Y)	Chromaticity		Average Near Infrared ^{1/}		Allowable Ratio ^{2/} (Min.)
		x	y	Min.	Max.	
Dark Green, 34082	0.071 – 0.091	0.339	0.390	-	60.0	5.2
Green 383, 34094	0.063 – 0.083	0.328	0.365	-	60.0	5.2
Green 808	33.10 ^{3/}	-4.70 ^{3/}	8.70 ^{3/}	-	60.0	5.0
IRR Foliage Green 504, 34160	0.125 – 0.153	0.3155	0.3314	23.0	33.0	-
Field Drab, 33105	0.093 – 0.117	0.390	0.383	25.0	35.0	-
Earth Yellow, 33245	0.228 – 0.263	0.420	0.395	30.0	40.0	-
Sand, 33303	0.284 – 0.323	0.360	0.366	55.0	65.0	-
Brown 383, 30051	0.060 – 0.080	0.357	0.342	8.0	20.0	-
Black, 37030	0.030 – 0.041	0.310	0.315	0.0	15.0	-
Tan 686A, 33446	0.360 – 0.400	0.368	0.364	62.0	72.0	-
Tan, 33531	VM ^{4/}	VM ^{4/}		62.0	72.0	-
Woodland Desert Sage, 34201	0.187 – 0.220	0.347	0.360	15.0	25.0	-
Aircraft Green, 34031	VM ^{4/}	VM ^{4/}		-	7.0	-
Interior Aircraft Black, 37031	VM ^{4/}	VM ^{4/}		-	7.0	-
Aircraft Gray, 36300	VM ^{4/}	VM ^{4/}		-	15.0	-
Dark Sandstone, 33510	VM ^{4/}	VM ^{4/}		-	45.0	-

^{1/} See table III or 4.6.2 or 4.6.9.

^{2/} Allowable ratio is calculated by dividing the average infrared value by the average red

value determined by using the selected wavelengths in table III. This is only applicable for Dark Green, 34082 and Green 383, 34094.

3/ For Green 808 CIELAB units (L^* , a^* , b^*) shall be used in lieu of the tristimulus values (Y , x , y). The color difference Delta (Δ)E shall not be greater than 2.0 CIELAB units of the values listed in table I for Green 808. Obtain L^* , a^* , b^* values using the standard illuminant D65 and the 10-degree standard observer angle.

4/ VM as stated in 3.3 are to be used for Aircraft Green, 34031, Interior Aircraft Black, 37031, Aircraft Gray, 36300, Dark Sandstone, 33510, and Tan, 33531.

TABLE III. Selected wavelengths for determining red and infrared values from reflectance data.

Red Region ^{1/} (Nanometers)	Infrared region ^{2/} (Nanometers)
620.0	720.0
630.0	740.0
640.0	760.0
640.0	770.0
650.0	780.0
650.0	800.0
650.0	810.0
660.0	830.0
660.0	840.0
660.0	860.0

1/ The red value is the average reflectance for the ten wavelengths listed.

2/ The infrared value is the average reflectance for the ten wavelengths listed.

TABLE IV. Spectral reflectance limits for Woodland Desert Sage, 34201, Dark Green, 34082 and Green 383, 34094.

Wavelength Nanometers	% Reflectance		Wavelength Nanometers	% Reflectance	
	Max.	Min.		Max.	Min.
600	10.2	-	760	59.5	40.0
610	9.8	-	770	61.5	42.0
620	9.8	-	780	-	42.0
630	9.8	-	790	-	42.0
640	9.5	-	800	-	42.0
650	9.5	-	810	-	42.0
660	10.0	-	820	-	42.0
670	10.5	4.0	830	-	42.0
680	13.0	5.8	840	-	42.0
690	21.5	8.5	850	-	42.0
700	28.0	11.0	860	-	42.0
710	35.8	15.0	870	-	42.0
720	41.0	19.0	880	-	42.0
730	48.5	25.0	890	-	42.0
740	51.8	30.0	900	-	42.0
750	56.0	36.3			

TABLE V. Spectral reflectance limits for IRR Foliage Green 504, 34160.

Wavelength Nanometers	% Reflectance		Wavelength Nanometers	% Reflectance	
	Max.	Min.		Max.	Min.
600	18.0	8.0	760	32.0	18.0
620	18.0	8.0	780	34.0	18.0
640	20.0	8.0	800	36.0	20.0
660	26.0	10.0	820	38.0	22.0
680	26.0	10.0	840	40.0	24.0
700	28.0	12.0	860	42.0	26.0
720	30.0	16.0			
740	30.0	16.0			

TABLE VI. Spectral reflectance limits for Green 808.

Wavelength Nanometers	% Reflectance		Wavelength Nanometers	% Reflectance	
	Max.	Min.		Max.	Min.
600	11.0	-	800	-	47.0
610	11.0	-	810	-	48.0
620	11.0	-	820	-	49.0
630	11.0	-	830	-	50.0
640	12.0	-	840	-	51.0
650	13.0	-	850	-	52.0
660	14.0	-	860	-	52.5
670	15.5	6.0	870	-	53.0
680	17.5	7.0	880	-	53.5
690	20.0	9.0	890	-	54.0
700	23.0	11.0	900-1000	-	54.0
710	27.0	13.0	1000-1100	-	54.0
720	33.0	15.0	1100-1200	-	54.0
730	39.0	18.0	1200-1300	-	54.0
740	45.0	22.0	1300-1400	-	54.0
750	51.0	27.0	1400-1500	-	54.0
760	57.0	33.0			
770	61.0	39.0			
780	-	43.0			
790	-	45.0			

3.4 Composition. The material shall be a finely ground free flowing powder with a resin and curing agent, catalysts, fillers, colorants, and flow control agents to form a powder formulation capable of being applied electrostatically and conforming to the requirements of this specification. The powder shall be devoid of compounds of antimony, arsenic, beryllium, cadmium, cyanide, hexavalent chromium, lead, manganese, mercury, nickel and selenium.

3.4.1 Pigment. The pigments listed in table VII, or any combination thereof, shall make up the primary hiding pigmentation for the colors specified for types III and IV. Iron oxides used as hiding pigments shall be of synthetic origin and not naturally occurring. The titanium dioxide

shall be a rutile, chalk resistant type conforming to ASTM D476, type III or IV. If other tinting pigments are used to match the spectral characteristics, these additional pigments shall have good color stability. When tested in accordance with 4.6.4 and 4.6.5, no component of the coating shall contain lead, cadmium, cadmium compounds, and hexavalent chromium. Antimony sulfide shall be absent.

3.4.1.1 Lead content. The lead content shall not exceed 0.05 percent by weight of total nonvolatile content upon analysis as specified in 4.6.5.

3.4.2 VOC content. Because powder coatings do not require solvents, the coatings shall be VOC-free when tested in accordance with EPA method 311 as specified in 4.6.6.

TABLE VII. Pigmentation.

Color	Description
Green 383, 34094 Dark Green, 34082 IRR Foliage Green 504, 34160	Acid insoluble green pigment predominately composed of cobalt, zinc, and chromium oxides with other oxides permitted; carbazole dioxazine violet, iron oxides, light stable organic yellow and orange, zinc/magnesium ferrite or other mixed metal oxides.
Green 808	Complex inorganic acid insoluble green pigment (non-cobalt), chromium oxide, light stable organic yellow or orange, carbazole violet, iron oxides, zinc/magnesium ferrite or other mixed oxides.
Field Drab, 33105 Brown 383, 30051 Earth Yellow, 33245 Sand, 33303 Tan 686A, 33446 Woodland Desert Sage, 34201 Dark Sandstone, 33510	Chromium oxide, titanium dioxide, carbon black, carbazole dioxazine violet, iron oxides, zinc/magnesium ferrite or other mixed metal oxides.
Aircraft Green, 34031 Olive Drab, 34088	Iron oxides, carbon black, zinc/magnesium ferrites, titanium dioxide, chromium oxide or other mixed metal oxides.
Ammunition Forest Green, 34079 Ammunition Tan, 33446	Copper phthalocyanine green, iron oxides, carbon black, zinc/magnesium ferrites, titanium dioxide, chromium oxide or other mixed metal oxides.
Black, 37030 Aircraft Black, 37038 Interior Aircraft Black, 37031	Carbon black, iron oxides.
Aircraft White, 37875	Titanium dioxide.
Aircraft Red, 31136	Titanium dioxide, light stable organic red.
Aircraft Gray, 36300 Interior Aircraft Gray, 36231	Titanium dioxide, carbon black, iron oxides.
Aircraft Insignia Blue, 35044	Copper phthalocyanine blue, carbon or lampblack, black iron oxide, titanium dioxide.

Note: Chromium oxides exclude the use of hexavalent chromium. Copper phthalocyanine blue and green does not contain cyanide compounds.

3.4.3 VOHAP content. Coatings shall be VOHAP-free when tested in accordance with 4.6.6.1.

3.5 Quantitative requirements. The coating shall conform to the quantitative requirements of table VIII when tested as specified in 4.6.

TABLE VIII. Coating requirements.

Characteristic	Min.	Max.
Composition		
Pigment, hexavalent chromium, cadmium, cadmium compounds	Absent	-
Lead content, percent of total solids	-	0.0
Inorganic HAP compounds	Absent	-
VOC content	Absent	-
VOHAP compounds	Absent	-
Hiding power (contrast ratio)		
Aircraft Red, 31136	.94	-
Aircraft White, 37875	.92	-
Other colors	.98	-
Specular gloss for Dark Sandstone, 33510; Sand, 33303; Earth Yellow, 33245; Tan 686A, 33446		
60 degree	-	1.6
85 degree	-	4.0
Specular gloss for Green 383, 34094; Black, 37030; Brown 383, 30051, Green 808		
60 degree	-	1.0
85 degree	-	3.5
Specular gloss for IRR Foliage Green 504, 34160		
60 degree	-	3.0
85 degree	-	3.0
Specular gloss for Aircraft Green, 34031; Interior Aircraft Black, 37031		
60 degree	-	0.6
85 degree	-	1.0
Specular gloss for Woodland Desert Sage, 34201		
60 degree	-	1.8
85 degree	-	4.0
Specular gloss for Ammunition Forest Green, 34079 and Ammunition Tan, 33446		
60 degree	-	10.0
Specular gloss for Other colors in type III		
60 degree	-	3.0
85 degree	-	8.0
Specular gloss for type II primer, Lusterless colors	60 degree	5.0
Specular gloss for type II primer, Semigloss colors	60 degree	15.0 30.0
Specular gloss for type II primer, Gloss colors	60 degree	90.0 -

3.6 Qualitative requirements.

3.6.1 Storage stability. When stored under ambient conditions with a temperature not exceeding 80°F (26.7 °C) and a relative humidity between 50 and 60%, powder shall remain readily useable for at least one year.

3.6.2 Coating appearance. The cured coating shall be uniform and smooth when visually examined with no magnification in accordance with 4.6.11.

3.6.3 Flexibility. A film of the coating tested as specified in 4.6.12 shall withstand bending without cracking or flaking.

3.6.4 Recoatability. When tested as specified in 4.6.13, recoating of a dried film shall produce no lifting, softening, or other film irregularity.

3.6.5 Adhesion. The assessment of the adhesion of the coating film shall be determined by its ability to not peel from the substrate when tested in accordance with ASTM D3359 as specified in 4.6.14. The resultant test rating shall be classified as scale 4B or better.

3.6.6 Water resistance. When tested as specified in 4.6.15, a film of the coating shall show no blistering or wrinkling, and no more than a slight whitening or softening immediately upon removal from the water. Film softening shall not exceed a 2 pencil hardness difference (see ASTM D3363) from an unexposed film with identical cure history prior to water exposure. After 2 hours of air drying, the immersed portion of the panel shall be almost indistinguishable with regard to adhesion, hardness, color, and gloss from an unexposed film with identical cure history prior to water exposure.

3.6.7 Fluid resistance. When tested as specified in 4.6.16, a film of the coating shall show no blistering or wrinkling when examined immediately after removal from the test fluid. When examined 2 hours after removal, there shall be no excessive softening, whitening, or dulling. Film softening shall not exceed a 2 pencil hardness difference (see ASTM D3363) from an unexposed film with identical cure history prior to hydrocarbon exposure. After 24 hours drying the immersed portion of the panel shall be almost indistinguishable with regard to hardness, adhesion, and general appearance from a panel prepared at the same time but not immersed and shall have no more than a 0.5 gloss unit increase over the original 60 and 85 degree gloss values. Slight staining of the coating is acceptable.

3.6.8 Acid resistance. For Dark Green, 34082, Green 383, 34094, Green 808, Woodland Desert Sage, 34201, and IRR Foliage Green 504, 34160, a film of the coating tested as specified in 4.6.17 shall have no blistering and show no change from the original color upon visual inspection.

3.6.9 Super Tropical Bleach (STB) resistance. When tested as specified in 4.6.18, a film of the coating shall show no blistering, wrinkling, or film softening when examined immediately after washing with water. Film softening shall not exceed a 2 pencil hardness difference (see ASTM D3363) from an unexposed film with identical cure history prior to STB exposure. After drying, there shall be a maximum color change of 2.5 NBS units when comparing a portion of the untested panel to that of the tested area using tristimulus color coordinates. The STB composition shall be in accordance with MIL-DTL-12468.

3.6.10 Chemical agent resistance. A film of the coating tested as specified in 4.6.19 shall desorb a maximum of 180 micrograms of agent HD, a vesicant agent, and a maximum of 40 micrograms of agent GD, a toxic nerve agent. Type IV coating, tested as specified in 4.6.19.6, shall have acceptable negligible risk levels for vapor threshold limits. Acceptable negligible risk levels

following decontamination of the ammunition container powder top coatings shall be 50 mg min/meter³ for distilled mustard (HD) vapor, 2.5 mg min/meter³ for soman (HD) vapor and 0.25 mg min/meter³ for persistent nerve agent (VX) vapor.

3.6.11 Accelerated weathering. For type III coatings, samples of aircraft colors and Olive Drab, 34088 tested as specified in 4.6.20 for 800 hours shall show no cracking, chalking, or loss of adhesion, and shall meet the color, infrared reflectance, 60 and 85 degree gloss requirements of the specification. Camouflage colors tested as specified in 4.6.20 for 800 hours shall show no cracking, chalking, loss of adhesion, or increase in the 60 and 85 degree glosses to exceed maximum values in table VII. Color change shall be less than 2.5 NBS units when compared to an unexposed sample of the same batch using tristimulus color coordinates. In addition, after accelerated weathering the color change shall remain within 2.5 NBS units of the value specified in table II (difference from nominal values or center of color ellipse). The infrared reflectance and allowable ratio shall remain within those limits originally specified. For type IV coatings the ammunition colors Forest Green, 34079 and Tan, 33446, shall be exposed for 700 hours. The cured film shall show no cracking, color change exceeding a ΔE of ± 4.0 , blistering, wrinkling, or loss of adhesion of the coating, nor evidence of substrate corrosion.

3.6.12 Weather resistance. For type III, films of the coating tested as specified in 4.6.21 shall show no checking, cracking, or appreciable film deterioration. There shall be no more than light chalking (see ASTM D4214). The color shall not exceed 2.5 NBS units at 560 MJ/m² of total UV irradiance when compared to an unexposed sample of the same batch using tristimulus color coordinates. The approximate equivalence of one year of total UV irradiance in southern Florida is 280 MJ/m².

3.6.13 Corrosion resistance.

3.6.13.1 Salt spray. For type I and II primer coatings and type IV ammunition coatings, a film of the powder coating tested as specified in 4.6.22.1 and examined immediately after removal from the salt spray test shall show no more than a trace of rusting (ASTM D610, table I, rust grade 9) or corrosion, and no more than five scattered blisters, none larger than one (1) mm in diameter for unscribed regions. Scribed areas shall have ratings in accordance with ASTM D1654 method A of not less than six (6) for steel or eight (8) for aluminum panels. Upon removal of the primer, there shall be no more than a trace of rusting, pitting, or corrosion on the panels.

3.6.13.2 Cyclic corrosion test. For type I and II primer coatings, a film of the powder coating tested as specified in 4.6.22.2 and evaluated using ASTM D1654 method A shall have a rating of not less than seven (7). There shall be no more than five (5) scattered blisters in the unscribed area.

3.7 User instruction marking and precaution sheet. All containers shall include a printed precaution sheet with the following information:

CAUTION: The Surgeon General requires airline respirators to be used unless air sampling shows exposure to be below standards. Then, either chemical cartridge respirators or airline respirators are required. Avoid contact with skin and eyes. Use with adequate ventilation. For other safety recommendations, refer to the Material Safety Data Sheet (MSDS). Keep containers closed.

3.8 Toxicity clearance. All new chemicals and materials being added to the Army supply system shall have a toxicity clearance. A toxicity clearance involves a toxicological evaluation of materials prior to introduction into the Army supply system. The Army program manager shall be responsible for identifying technically feasible materials and requesting a toxicity clearance for use of that material within their program (see 6.4.4).

3.9 MSDS. An MSDS shall be prepared for the coating in accordance with FED-STD-313 and forwarded to the qualifying activity (see 6.4.2). The MSDS for the material covered by this specification shall be included with each shipment, and submitted to pertinent Government agencies as stated in FED-STD-313.

4. VERIFICATION

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

- a. Qualification inspection (see 4.2).
- b. Extension of qualification inspection (see 4.3).
- c. Conformance inspection (see 4.4).

4.2 Qualification inspection. Qualification shall be conducted by the qualifying activity (see 6.4). The qualification test sample shall be as specified by the qualifying activity. The samples shall be legibly identified (see 6.4.3). Qualification inspection shall consist of tests for all requirements in section 3 and table IX. Qualification inspection shall examine for user instruction marking (see 3.7). The results of each test shall be compared with the applicable requirement in section 3. Failure to conform to any requirement shall be counted as a defect, and paint represented by the sample test shall not be approved for inclusion in the QPD under this specification. See 3.1.1 for qualification and testing requirements for type IV powder primer.

4.3 Extension of qualification inspection. Qualification inspection (see 4.2) shall be performed on all type I and II coatings. For type III coatings, qualification inspection shall be performed on the colors listed in the left column of table X. These ten primary colors shall require full qualification testing. These colors shall be approved for inclusion in the QPD. The extension test program shall test for color, infrared reflectance, accelerated weathering (Aircraft Yellow, 33538 and Aircraft Red, 31136), 60 and 85 degree gloss, STB resistance, acid resistance, accelerated storage stability, chemical agent resistance for approval under this specification. The extension test program can include limited extension testing. Limited extension testing for only color, gloss, and STB resistance shall be determined on a case by case basis and formalized prior to testing through test service agreements. Colors in the right column shall be listed in the QPD if they satisfy the requirements of the extension test program. The qualification test sample shall consist of a one quart sample of the paint. The sample and the necessary paperwork (see 6.4.3) shall be sent to the qualifying activity (see 6.4).

4.4 Conformance inspection. The contracting officer shall require, for type III coatings, that an appropriate applied and cured sample from each production lot (see 4.4.1) be forwarded to ARL, ATTN: RDRL-WMM-C, Organic Coatings Team, Building 4600, Deer Creek Loop, Aberdeen Proving Ground, MD 21005-5066. Conformance inspection shall consist of testing spectral reflectance characteristics to include color, STB resistance, and gloss at 60 and 85 degrees. There shall be no failures (see 6.5). For type I and II coatings, the manufacturer shall forward from each

production lot (see 4.4.1) a batch validation letter detailing the batch number, manufacturer's code, specification and type number, QPL number and batch volume to ARL, ATTN: RDRL-WMM-C, Organic Coatings Team, Building 4600, Deer Creek Loop, Aberdeen Proving Ground, MD 21005-5066. The manufacturer shall perform conformance inspection testing on each production lot and have these test results on file when requested by the contracting officer. Conformance inspection for individual lots shall test for color, gloss, spraying properties, coating appearance and spectral reflectance.

TABLE IX. Index of tests.

Item	ASTM Method	Test Paragraph	Requirement Paragraph or Table
Color and spectral reflectance	E308 & E1331	4.6.2	3.3 & 3.3.1
Pigment analysis	D3723	4.6.3	3.4.1; Table VII & VIII
Titanium dioxide	D476, type III or IV	4.6.3	3.4.1
Hexavalent chromium	-	4.6.4	Table VIII
Lead content	D3335	4.6.5	3.4.1.1; Table VIII
Cadmium content	D3335	4.6.3	Table VIII
Nonvolatile vehicle	-	4.6.6	3.4.2
VOC content ^{1/}	-	4.6.6	3.4.2
VOHAP content ^{1/}	D3271	4.6.6.1	3.4.3
Hiding-power (contrast ratio)	D2805	4.6.7	Table VIII
Specular gloss	D523	4.6.8	Table VIII
<u>Infrared reflectance</u> Camouflage colors ^{2/} Other colors Aircraft colors ^{3/} Dark Sandstone, 33510	E308 & E1331	4.6.2 4.6.2 4.6.9 4.6.9	3.3 & 3.3.1; Table II & III
<u>Spectral reflectance limits</u> Dark Green, 34082 Green 383, 34094 IRR Foliage Green 504, 34160 Woodland Desert Sage, 34201 Green 808	E308 & E1331	4.6.2 4.6.2 4.6.2 4.6.2 4.6.2	Table IV, V & VI
Storage stability	D1849	4.6.10	3.6.1
Coating appearance	-	4.6.11	3.6.2
Flexibility	D522	4.6.12	3.6.3
Recoatibility	-	4.6.13	3.6.4
Adhesion	D3359	4.6.14	3.6.5
Water resistance	-	4.6.15	3.6.6
Fluid resistance	-	4.6.16	3.6.7
Acid resistance	-	4.6.17	3.6.8
STB resistance	-	4.6.18	3.6.9

TABLE IX. Index of tests - Continued.

Item	ASTM Method	Test Paragraph	Requirement Paragraph or Table
Chemical agent resistance	-	4.6.19	3.6.10
Accelerated weathering	G154	4.6.20	3.6.11
Weather resistance	G90	4.6.21	3.6.12
Salt spray corrosion resistance	B117	4.6.22.1	3.6.13.1
Cyclic corrosion resistance ^{4/}	-	4.6.22.2	3.6.13.2

1/ EPA Method 311.

2/ Exclude from this category Aircraft Green, 34031 and Aircraft Gray, 36300.

3/ Include the camouflage colors Aircraft Green, 34031 and Aircraft Gray, 36300 in this category.

4/ General Motors Standard: GMW 14872.

TABLE X. Qualification and extension colors.

Full QPD Testing/Color Qualified	QPD Extension Test Program/Additional Colors to which Approval is Extended
Green 383, 34094	Dark Green, 34082; Olive Drab, 34088; Field Drab, 33105
Green 808	-
IRR Foliage Green 504, 34160	-
Tan 686A, 33446	Earth Yellow, 33245; Dark Sandstone, 33510; Sand, 33303
Woodland Desert Sage, 34201	-
Brown 383, 30051	-
Black, 37030	Aircraft Black, 37038; Interior Aircraft Black, 37031
Aircraft Green, 34031	-
Aircraft White, 37875	Aircraft Red, 31136; Aircraft Yellow, 33538; Aircraft Insignia Blue, 35044
Aircraft Gray, 36300	Interior Aircraft Gray, 36231 Blue Gray, 35237 Medium Gray, 36375

4.4.1 Lot and batch formation. For purposes of conformance inspection, a lot shall consist of all coatings of the same type, composition and color, from a single uniform batch, produced and offered for delivery at one time (see 6.4.1). A batch shall consist of all coating material (in U.S. pounds) manufactured during one continuous operation and forming part of one contract or order for delivery (see 6.4.1). When required, the manufacturer shall furnish with each lot and/or batch a certified test report showing that the material has passed the conformance inspection, and there has been no formulation or process change that resulted in the production of the qualification

inspection sample. The addition of any substance to a batch shall constitute a new lot.

4.5 Inspection conditions. Unless otherwise specified, all inspections shall be performed in accordance with the test conditions of a temperature of 23 ± 1 °C (73 ± 2 °F) and a relative humidity of 50 ± 4 percent. A dry film thickness of 2 ± 0.2 mils (50 ± 5 microns) shall be used whenever film thickness is requested in any test, unless otherwise required by the test.

4.6 Test methods.

4.6.1 Test conditions. Except as otherwise specified herein, the routine testing conditions shall be conducted in accordance with the test conditions of a temperature of 23 ± 1 °C (73 ± 2 °F) and a relative humidity of 50 ± 4 percent, or the appropriate ASTM method. Failure of any test result to fall within the ranges specified in section 3 as applicable, shall constitute failure of the applicable test.

4.6.1.1 Test procedures. The following tests shall be conducted in accordance with table IX. The right is reserved to conduct any additional tests deemed necessary to determine that the coating meets the requirements of this specification.

4.6.1.2 Test panels. Unless otherwise specified, metal panels used for test purposes shall be of four types:

- a. Steel, cold rolled 1020, pretreated with zinc phosphate coating, 0.032 inches (0.8128 mm) thick, for all tests except flexibility.
- b. Steel, tinplated, 0.010 inches (0.254 mm) thick, for flexibility only.
- c. Aluminum, 6061 T6 treated with MIL-DTL-5541, type II.
- d. Aluminum, 2024-T-3 treated with MIL-DTL-5541, type II.

4.6.1.3 Epoxy primer. For type III coatings, test panels in 4.6.1.2 shall be solvent wiped and cleaned prior to applying epoxy primer. Apply epoxy primer conforming to the latest revision of MIL-DTL-53022, MIL-DTL-53030 or the type I primer of this specification. For aviation system application evaluation, use MIL-PRF-23377 or MIL-PRF-85582 epoxy primers.

4.6.1.4 Polyurethane topcoat. For type I coatings, when a topcoat is required by the test method, mix polyurethane coating conforming to MIL-DTL-64159 and MIL-DTL-53039, Green 383, conforming to FED-STD-595, color number 34094. Apply the coating to a total dry film thickness of 1.7 to 2.3 mils (43 to 58 microns). If applied in two coats, allow the first coat to air dry for 60 minutes prior to application of the second coat. After application of the topcoat to the required thickness and prior to testing, allow the coating to air dry for not less than seven (7) days or allow the coating to air dry for one hour followed by 24 hours at 65.5 ± 3 °C (150 ± 5 °F).

4.6.2 Color and spectral reflectance. Prepare two samples of the coating on leneta black and white metopac metal panels to a dry film thickness of 2 ± 0.2 mils (50 ± 5 microns). Cure according to manufacturers' specifications. Determine the color and infrared reflectance from the spectral curves using the recording spectrophotometer method in accordance with ASTM E308 and ASTM E1331. Measurements shall be made over the black portion of the hiding chart. For aircraft colors and Dark Sandstone, 33510 (see 4.6.9), compare the color as specified in 3.3 and 3.3.1. Visually match the other colors listed in table I to the appropriate color chip from FED-

STD-595 for compliance with 3.3 and table II. Spectral reflectance limits are outlined in tables IV, V and VI. Noncompliance to 3.3 and 3.3.1 shall constitute failure of this test.

4.6.3 Pigment analysis. Determine the pigment content of the coating in accordance with ASTM D3723. The pigment generated by this method shall be used for the screening tests of the coating's heavy metal content. Check for compliance with 3.4.1.

4.6.4 Hexavalent chromium. Determine the presence or absence of hexavalent chromium by either of the following chemical reagent screening techniques:

(a) Weigh approximately 250 mg of pigment into a small glass test tube. Add 5 ml of 25 percent aqueous KOH and shake vigorously for 1-2 minutes. Decant a 1 ml aliquot into a plastic micro-centrifuge tube and centrifuge for five (5) minutes at 17000 rpm, balancing the centrifuge with a tube containing 1 ml of the KOH solution. The resulting supernatant liquid shall be nearly colorless. Use the tube containing the KOH solution as a reference. A distinct yellow color indicates the presence of hexavalent chromium, and, therefore, shall constitute failure of the test requirement.

(b) Weigh approximately 50 mg of pigment into a small glass test tube. Add 5ml of 10 percent aqueous H_2SO_4 and shake vigorously for 1-2 minutes. Decant a 1 ml aliquot into a plastic micro-centrifuge tube and centrifuge for five (5) minutes at 17,000 rpm, balancing the centrifuge with a second tube containing one ml of the H_2SO_4 solution. The solution in the second tube shall act as the test "blank". Immerse a chromate ion (CrO_4^{2-}) test strip into the supernatant from each tube. Shake off the excess liquid, and, after approximately one minute, compare the color change in the reaction zone of the strips to the color scale (concentration levels) provided by the manufacturer. The appearance of a purple/violet color from the "sample" strip is indicative of hexavalent chromium, and, therefore, shall constitute failure of the test requirement. If a color change is apparent from the "blank" strip, rerun the test using fresh, chromium-free reagents. The appearance of a pronounced color change is indicative of hexavalent chromium, and, therefore, shall constitute failure of the test requirement.

4.6.5 Lead content. Determine the presence or absence of lead by weighing 50 mg of pigment into a small glass test tube. Add 5 ml of dilute HNO_3 , and shake vigorously for 1-2 minutes. Decant a one ml aliquot into a plastic micro centrifuge tube and centrifuge for five (5) minutes at 17,000 rpm, balancing the centrifuge with a second tube containing 1 ml of the dilute HNO_3 solution. The solution in the second tube shall act as the test "blank". Immerse a lead ion test strip into the supernatant from each tube. Shake off the excess liquid, and, after approximately one minute, compare the color change in the reaction zone of the strips to the color scale (concentration levels) provided by the manufacturer. If a color change is apparent from the "blank" strip rerun the test using fresh, lead-free reagents. Confirmation of the exact lead concentration in the coating's solids shall be quantified using ASTM D3335. Nonconformance to the table VII requirements shall constitute failure of this test.

4.6.6 Solvent analysis for VOC determination. Determine the VOC content in accordance with EPA Method 311. Check for compliance with 3.4.2.

4.6.6.1 VOHAP content of coatings. Hazardous solvent content of each individual coating shall be determined in accordance with EPA Method 311, as applicable. Check for compliance with 3.4.3.

4.6.7 Hiding power (contrast ratio). Using an applied and cured sample from the color determination (see 4.6.2), determine the reflectance using the daylight reflectance factor of ASTM D2805 over the black and white portion of the panel. Record the values as RB/RW and check for compliance with table VIII.

4.6.8 Specular gloss. Spray and cure coating on a metal panel to a dry film thickness of 2 ± 0.2 mils (50 ± 5 microns). Test for 60-degree gloss and 85-degree gloss (sheen) in accordance with ASTM D523. Check for compliance with table VIII.

4.6.9 Infrared reflectance. Determine the infrared reflectance on the black portion of the sprayed sample in 4.6.2. For Aircraft Green, 34031 and Interior Aircraft Black, 37031 determine the infrared reflectance value at 870 nanometers. Determine the infrared reflectance for Aircraft Gray, 36300 and Dark Sandstone, 33510 at 1500 nanometers. In all evaluations, use a spectrophotometer which is capable of measuring the total diffuse reflectance in accordance with ASTM E308 and ASTM E1331. Nonconformance with table II shall constitute failure of this test.

4.6.10 Storage stability. When stored under ambient conditions with a temperature not exceeding 80 °F (27 °C) and a relative humidity between 50 and 60%, powder shall remain readily usable for at least one year.

4.6.11 Coating appearance. Spray the powder coating on a solvent cleaned steel panel to a dry film thickness between 2 ± 0.2 mils (50 ± 5 microns) and cure according to manufacturers' instructions. Observe the coating appearance for compliance with 3.6.2.

4.6.12 Flexibility. Determine flexibility in accordance with ASTM D522, method B using a ¼ inch mandrel. Spray the coating, according to manufacturers' recommendations, on a steel panel, tinplated 0.010 inches (0.254 mm) thick. Cure according to manufacturers' instructions. Bend the coated panels according to ASTM D522, method B. Examine the coating for cracks over the area of the bend for compliance with 3.6.3.

4.6.13 Recoatability. For type I coatings, prepare two (2) test panels as in 4.6.14. Spray a coat of camouflage Green 383, color chip number 34094 polyurethane conforming to MIL-DTL-64159 and MIL-DTL-53039 over the specimens. If necessary, the polyurethane shall be thinned according to the specification, with thinner conforming to the specification or manufacturer and sprayed to a dry film thickness of 2 ± 0.2 mils (50 ± 5 microns). Air dry both panels for 24 hours. Examine panels for lifting, softening, any evidence of other irregularities and for compliance with 3.6.4. Allow the specimens to air dry for a total of 168 hours. Perform adhesion testing as specified in ASTM D3359, method B and examine its ability to not peel. Nonconformance to 3.6.5 constitutes failure of this test.

4.6.14 Adhesion. For type I and II coatings, prepare a pretreated steel and aluminum test panel (see 4.6.1.2). For type IV coatings, prepare a pretreated steel panel (see 4.6.1.2). Spray the coating to a dry film thickness of 2 ± 0.2 mils (50 ± 5 microns) and cure according to manufacturers' instructions. Perform adhesion testing as specified in ASTM D3359, method B, and examine for compliance with 3.6.5.

4.6.15 Water resistance. For type I and II coatings, prepare a pretreated steel test panel (see

4.6.1.2). Spray the coating to a dry film thickness of 2 ± 0.2 mils (50 ± 5 microns) and cure according to manufacturers' instructions. Coat all exposed unpainted metal surfaces with wax or suitable protective coating and immerse in deionized water at 25 ± 1 °C (77 ± 2 °F) for 168 hours. Panels shall be immersed at a minimum depth of 50%. At the end of the test period, remove and examine for compliance with 3.6.6. For type III coatings, prime the pretreated panel (see 4.6.1.3) before applying powder coating.

4.6.16 Fluid resistance. For each panel of type I and II, spray the coating on a pretreated steel test panel (see 4.6.1.2) to a dry film thickness of 2 ± 0.2 mils (50 ± 5 microns) and cure according to manufacturers' instructions. For type III, prime the pretreated panel (see 4.6.1.3) before applying the powder coating. For each fluid tested, spray the coating on a test panel (see 4.6.1.2 and 4.6.1.3) to a dry film thickness of 2 ± 0.2 mils (50 ± 5 microns) and cure according to manufacturers' instructions. Immerse the panels in the different fluids according to the time period and temperature in table XI. Panels shall be immersed at a minimum depth of 50%. The coating shall be examined one hour after removal from the fluid for conformance to 3.6.7.

TABLE XI. Fluids.

Fluid	Fluid Temperature	Time of Immersion (minimum)
Hydrocarbon Fluid (corresponding to JP-8)	77 ± 2 °F (25 ± 1 °C)	168 Hours
Lubricating Oil (conforming to MIL-PRF-23699)	250 ± 5 °F (121 ± 3 °C)	24 Hours
Hydraulic Fluid (conforming to MIL-PRF-83282)	150 ± 5 °F (66 ± 3 °C)	24 Hours
Fuel JP-5, Diesel	77 ± 2 °F (25 ± 1 °C)	168 hours

4.6.17 Acid resistance (only for Green 383, 34094, Green 808, Dark Green 34082, Woodland Desert Sage, 34201, and IRR Foliage Green 504, 34160). Using the film prepared and cured according to manufacturers' instructions, place a 3 to 5 ml spot of a 10 percent by volume acetic acid solution on the surface of the coating. Cover the film with an appropriate size watch glass and allow to stand for one hour. Rinse with water thoroughly, allow drying, and examining the film for blistering and color change for compliance with 3.6.8.

4.6.18 STB resistance. Spray one 4 by 12 inch pretreated and primed steel test panel (see 4.6.1.2 and 4.6.1.3) to a dry film thickness of 2 ± 0.2 mils (50 ± 5 microns). Cure according to manufacturers' instructions. Scribe a 1 inch diameter wax ring using a china marker on the painted surface of the panel. Place approximately 1 ml of STB agent on the panel surface. Do not cover. Allow to stand 30 minutes then thoroughly wash with water. An STB slurry mix of 40 parts STB and 60 parts water by weight shall be used. Examine for compliance with 3.6.9.

4.6.19 Chemical agent resistance (type III and IV coatings only).

4.6.19.1 Panel preparation. For type III, spray eight steel test panels pretreated (see 4.6.1.2) and primed (see 4.6.1.3). Coupons shall be circular discs with a 2.42 inch (61.5 mm) diameter for chemical agent testing to a dry film thickness between 1 ± 0.1 mil (25 ± 2.5 microns). Air dry 2 hours and spray the coating to be tested to a dry film thickness between 2 ± 0.2 mils (50 ± 5 microns). Cure according to manufacturers' instructions.

4.6.19.2 Test conditions. Because the desorption rate of agents from paint is temperature dependent, all agent tests shall be conducted at 77 °F (25 °C). Extremely toxic materials are used in this testing. Agent HD, a vesicant agent, is also a known carcinogen. Agent GD is a toxic nerve agent, exposure to which is difficult to treat. Consequently, all work shall be performed in an approved fume hood, and appropriate measures to protect individuals at risk of exposure shall be taken.

4.6.19.3 Test apparatus. The test apparatus used for both HD and GD testing consist of a temperature controlled Plexiglas box (approximately 0.5 m x 0.5 m x 1 m) containing five separate test cells. Four of these cells are used to test sample Chemical Agent Resistant Coating (CARC) panels. The fifth is used to test a control panel. All five tests shall be run simultaneously. The test cells are machined from aluminum and consist of two parts that are clamped together to hold the test panels in place. Maintain a gastight seal. Agent desorbed from the test panels is entrained by dry nitrogen that passes through a temperature-humidity-flow controller, with final temperature controlled by a proportional temperature controller. The nitrogen passes through an external chamber fitted with a bleed valve before entering the test cells. Determine the agent recovered in micrograms for compliance with 3.6.10.

4.6.19.4 Test procedure. Place a 5 cm² circular template on the area of the test panel to be contaminated with agent. Use a grease pencil to mark a circle around the template; the grease mark serves to keep the agent from spreading out of the designated area. Place 50 micro liters of agent HD or GD on the test area. Place a glass cover slip (microscope slide) over the test area to minimize evaporation of the agent. After 30 minutes remove the cover slip, rinse the agent from the panel with isopropanol and allow to air dry for approximately 45 seconds. Place the panel in the test cell, which has been maintained at 77 °F (25 °C), with the coated area positioned such that the nitrogen stream shall pass across the contaminated area. Nitrogen is used instead of air to eliminate the possibility of reaction of the desorbed agent over the time of the test, which is 22 hours. Pass the nitrogen through an impinger containing the appropriate solvent, n-decane for HD and iso-octane (2, 2, 4-trimethylpentane) for GD. The flow of nitrogen shall be maintained at 0.252 grams/mm across each sample. Terminate the test at the end of 22 hours.

4.6.19.5 Analysis. Transfer the contents of each impinger to a 25 ml volumetric flask. Rinse the impinger twice with the same solvent and add the rinse to the flask. Bring the volume up to the mark with solvent and mix well. Transfer a 1 ml portion to a GC vial for analysis. Perform the analysis on a Finnigan-MAT GQC ion-trap mass spectrometer equipped with a 25 m MS-S capillary column, using helium as the carrier gas. Standardize the mass spectrometer by serial dilutions of an agent solution in the appropriate solvent, analyzed in the same conditions. The instrument conditions are as follows: introduce the samples from an AST 2000 auto sampler, volume of 1 micro liter, onto the GC column in splitless mode; injector temperature of 280 °C (536 °F). Temperature program the column from an initial temperature of 50 °C to 120 °C (122 °F to 248 °F) at a rate of 10°/mm; followed by an increase of 25 °C/min (77 °F/min) to a final temperature of 200°C (392 °F). Acquire mass spectra in electron impact mode over the mass range of 50-150 for HD and 50-200 for GD. Under these conditions, HD has a retention time of 8.15 minutes. Integrate the peak areas of the relevant portion of the reconstructed ion chromatograms for the ion at m/z 109. Under the cited conditions GD elutes as a pair of completely resolved diastereomeric enantiomers with retention times of 9.56 and 10.04 minutes. Integrate the peak areas of the relevant portion of the reconstructed ion chromatograms for the ion at m/z 99. Construct the standard response curve for HD and GD using the integrated area on

the y axis and concentration ($\mu\text{g/ml}$) on the x axis. Use the linear regression analysis function of an Excel spreadsheet, which shall calculate the slope, intercept, and correlation coefficient of the standard response curve. The slope and intercept of the standard response curve are used to calculate concentration of agent HD or GD in the impinger solutions. Calculate the total amount of agent (in micrograms) that outgassed from the CARC panel by multiplying the concentration of agent in the impinger solution (micrograms/milliliter read from the standard curve) by the volume of the impinger solution (25 ml).

4.6.19.6 Chemical agent resistance for type IV, ammunition container applications. Nuclear, Biological and Chemical Contamination Survivability (NBCCS) requirements when tested in accordance with Test Operating Procedure (TOP) 8-2-111 "Chemical, Biological, and Radiological (CBR) Contamination Survivability, Small Items of Equipment" shall be applied. Requirements for hardness and compatibility in accordance with TOP 8-2-111 are not required. Testing shall be conducted by an approved test laboratory authorized to handle and store surety chemical materials VX, HD, and GD. The test activity must submit their NBC Contamination Survivability test plan to the U.S. Army Developmental Test Command, 314 Longs Corner Road, Aberdeen Proving Ground, MD 21005-5055 for approval prior to conducting any test. An NBCCS assessment shall be performed at the U.S. Army Test Development Command with acceptable results of coating decontamination prior to usage.

4.6.20 Accelerated weathering. For type III, spray the coating on four pretreated and primed steel test panels and four aluminum test panels (see 4.6.1.2 and 4.6.1.3) to a dry film thickness of 2 ± 0.2 mils (50 ± 5 microns) and cure according to manufacturers' instructions. For each substrate, three panels are to be tested and one retained as a control. Determine the color and infrared reflectance as in 4.6.2 and measure the 60 and 85 degree gloss. Expose three panels for 800 hours to accelerated weathering in accordance with ASTM G154 using a UV 340A light source. Measure the 60 and 85 degree gloss and determine the color and infrared reflectance of the exposed film. Examine the panel for chalking by rubbing with a piece of velvet or cheese cloth. Check for compliance with 3.6.11.

4.6.21 Weather resistance. For type III, prepare five 3×6 inch test panels (see 4.6.1.2 and 4.6.1.3). Cure according to manufacturers' recommendations. The chemical agent resistant coating shall be placed outdoors, for the equivalent of 560 MJ/m^2 of total UV irradiance, in an accelerated outdoor exposure according to ASTM G90. At 70 MJ/m^2 intervals examine the panels for compliance with 3.6.12. Determine chalking in accordance with ASTM D4214. Wash the panels with a warm soap solution using a soft sponge or cloth, rinse, dry and examine for color change at each interval. The exposure racks shall be angled at latitude of $33^\circ 23'$ North and $112^\circ 35'$ West.

4.6.22 Corrosion testing. For the type I and II primer coatings, prepare ten (10) pretreated steel and five (5) aluminum 3×6 inch panels as specified in 4.6.14. For the corrosion testing, five (5) each of the steel prepared panels shall be exposed to the salt spray resistance and cyclic corrosion resistance. Coat the edges and uncoated metal surfaces with suitable coating. For type IV ammunition coatings, prepare five (5) pretreated steel panels as specified in 4.6.14.

4.6.22.1 Salt spray resistance. For the primer panels, take five (5) of the steel panels and the five (5) aluminum panels from 4.6.22 and make a "X" scribe through the primer. For type I primer, expose the steel panels for 1,500 hours and the aluminum panels for 3,000 hours in accordance

with ASTM B117. For type II primer, expose the steel panels for 1,000 hours and the aluminum panels for 3,000 hours in accordance with ASTM B117. Upon removal, wash the panels gently in warm water until free from any visible salt deposits and examine immediately for compliance with 3.6.13.1. Nonconformance to 3.6.13.1 shall constitute failure of this test. The ammunition powder coatings shall be "X" scribed and exposed for 400 hours. Nonconformance to 3.6.13.1 shall constitute failure of this test.

4.6.22.2 Cyclic corrosion resistance. Take the remaining five (5) steel panels from 4.6.22 and make an "X" scribe through the primer. Expose the panels to accelerated cyclic corrosion for 60 cycles according to GMW 14872. Upon removal, rinse the panels until visible salt deposits are removed. Examine immediately for compliance with 3.6.13.2. Strip the primer with suitable paint remover and inspect for rust, pitting or corrosion not evident with paint present. Nonconformance to 3.6.13.2 shall constitute failure of this test.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system command. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. Type I coatings are primer coatings applied and cured using the powder coat process. These primer coatings are intended for use on properly cleaned and pretreated steel and aluminum, meeting unique military requirements. These requirements include adhesion to a wide variety of metals, flexibility, corrosion resistance, and resistance to leaking fluids. Type II coatings are primer coatings designed for interior use as a one coat system having the corrosion resistance of the type I and having the color and gloss of the interior finishes. The color and gloss of the type II powder coat primer may be characteristic of the interior topcoat color as designated by FED-STD-595. Examples of the commonly used interior colors for tactical equipment are color numbers 17925 and 24533. Type III coatings are finish coatings applied and cured using the powder coat process. They are intended to provide surfaces that are easily and effectively decontaminated after exposure to liquid chemical agents. It may be used in areas where VOCs and VOHAPs are regulated. It is applied over epoxy primers (conforming to the latest revision of MIL-PRF-23377, MIL-DTL-53022, MIL-DTL-53030, MIL-DTL-53084, the type I coating in this specification or MIL-PRF-85582), depending on the application and substrate. For adequate camouflage properties, it is necessary to apply the coatings to a minimum dry film thickness of 2 ± 0.2 mils (50 ± 5 microns).

6.1.1 Type IV ammunition coating. For steel ammunition container powder coating applications,

drawing number 12998172 requirements take priority over inconsistencies between the technical drawing and specification. For a list of approved decontamination test laboratories, contact U.S. Army Dugway Proving Ground, ATTN: TEDT-DPW-CT, MS#6, Building 4564, Dugway, Utah 84022-5006.

6.2 Acquisition requirements. Acquisition documents should specify the following:

- a. Title, number, and date of this specification.
- b. Type and class of coating (see 1.2.1 and 1.2.2).
- c. Part or identifying number (PIN) (see 1.3).
- d. Color characteristics (see 3.2.1).
- e. Finish coat (see 3.2.2).
- f. If a toxicity clearance is required (see 3.8).
- g. If qualification samples are required and where to send them (see 4.2 and 6.4).
- h. If extension of qualification samples are required and where to send them (see 4.3 and 6.4).
- i. If conformance samples are required and where to send them (see 4.4).
- j. Packaging requirements (see 5.1).
- k. Whether MSDS are required with each shipment (see 6.4.2).

6.3 Basis of purchase. The coating covered by this specification should be purchased by mass, the unit being one pound.

6.4 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in the QPD, whether or not such products have actually been so listed by that date. The attention of contractors is called to this requirement and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. Samples for QPD testing (see 4.2) and for the extension testing program (see 4.3) should be submitted to ARL, ATTN: RDRL-WMM-C, Organic Coatings Team, Building 4600, Deer Creek Loop, Aberdeen Proving Ground, MD 21005-5066.

6.4.1 Conformity to qualified sample. All lots of coatings supplied under this specification must be manufactured using the same formulation, raw materials and supplier(s) of raw materials, methods of manufacture, equipment, and geographic location as the qualification sample, unless changes have been approved by the qualifying activity.

6.4.2 MSDS. Contracting officers will identify those activities requiring copies of a completed MSDS prepared in accordance with FED-STD-313. The pertinent Government mailing addresses for submission of data are listed in FED-STD-313.

6.4.3 Sample identification for qualification inspection. Samples for QPD testing and for the extension testing program are to be identified in a cover letter with the following information:

- Manufacturer's name and product number.
- Submitted by (name and date).
- Specify the number of samples.
- Specify the reason for submitting the samples.

Specification MIL-PRF-32348; Type_____, Class_____, Color_____,
“Powder Coating, Camouflage Chemical Agent Resistant Systems”.

Provide a copy of the MSDS.

Provide a copy of the notarized statement of composition.

Provide a copy of the technical data sheet.

Provide a copy of the test report.

6.4.4 Toxicity clearance. Department of the Army Regulation (AR) 40-5, Preventive Medicine, AR 70-1, Acquisition Policy, and Department of the Army Pamphlet 70-3, Acquisition Procedures require a toxicity clearance. Army toxicity’ questions and/or a toxicity clearance request should be addressed to: Commander, U.S. Army Center For Health Promotion And Preventive Medicine (MCHB-TS-T), 5158 Blackhawk Road, Aberdeen Proving Ground, MD 21010-5403.

6.4.5 Retention of qualification. To retain qualification of products approved for listing in the QPD, the manufacturer will be requested to verify by certification to the qualifying activity that its product(s) comply with the requirements of this specification. Unless otherwise specified by the qualifying activity, the time of periodic verification by certification will be in two-year intervals from the date of original qualification and will be initiated by the qualifying activity.

6.5 Conformance rejection and retest. Failure in any conformance inspection will result in the rejection of the batch from which it was obtained. Rejected material cannot be resubmitted for acceptance without written approval from the qualification activity (see 4.4). The application for resubmission will contain all details concerning previous rejections and measures taken to correct these deficiencies.

6.6 Detail specification. MIL-DTL-53072, Chemical Agent Resistant Coating (CARC) System Application Procedures and Quality Control Inspection, is available for application procedures and quality control inspection of this coating.

6.7 Subject term (key word) listing.

CARC
Colors
Finish coat
HAPs
Metallic substrates
Pigment
Primer
Tactical equipment
VOCs
VOHAPs

CONCLUDING MATERIAL

Custodians:

Army - MR
Navy - SH
Air Force - 11

Preparing activity:

Army - MR

Project 8010-2010-009

Review activities:

Army - MD1, MI
Navy - AS, CG
Air Force - 84, 99

Civil agency:

GSA/FAS

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at <https://assist.daps.dla.mil/>.