INCH-POUND

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DETAIL SPECIFICATION

CHEMICAL AGENT RESISTANT COATING (CARC) SYSTEM APPLICATION PROCEDURES AND QUALITY CONTROL INSPECTION

Comments, suggestions, or questions on this document should be addressed to: Director, U.S. Army Research Laboratory, Weapons and Materials Research Directorate, Materials and Manufacturing Technology Branch, Specifications 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/.

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

1. SCOPE

1.1 Scope. This document covers the general requirements for application and inspection of the CARC systems used on tactical military equipment. It is intended for use as a guide in selection of the appropriate materials and procedures for the surfaces to be painted, and as a supplement to information available in the below referenced cleaning, pretreating, and coating specifications. This document does not alleviate the need for proper selection for corrosion control.

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 SPECIFICATIONS

TT-P-28	- Paint, Aluminum, Heat Resisting.
TT-C-490	- Chemical Conversion Coatings And Pretreatments For Ferrous Surfaces (Base For Organic Coatings).

FEDERAL STANDARDS

FED-STD-595	- Colors Used in Government Procurement.
FED-STD-595/17925	- Miscellaneous, Gloss.
FED-STD-595/24533	- Green, Semigloss.
FED-STD-595/26307	- Gray, Semigloss.
FED-STD-595/Color Chip Numbers	- 30051, 33446, 34031, 34094, 37030, 37031, 37038. All colors are flat or lusterless.

COMMERCIAL ITEM DESCRIPTIONS

A-A-59745	- Zinc-Rich Coatings

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-DTL-5541	- Chemical Conversion Coatings on Aluminum and Aluminum Alloys.
MIL-C-8514	- Coating Compound, Metal Pretreatment, Resin-Acid.
MIL-A-8625	- Anodic Coatings for Aluminum and Aluminum Alloys.
MIL-DTL-12468	- Decontaminating Agent, STB.
MIL-P-14105	- Paint, Heat-Resisting (for Steel Surfaces).

DOD-P-15328	- Primer (Wash), Pretreatment (Formula No. 117 for Metals) (Metric).
MIL-PRF-22750	- Coating, Epoxy, High-Solids.
MIL-PRF-23377	- Primer Coatings: Epoxy, High-Solids.
MIL-PRF-32348	- Powder Coating, Camouflage Chemical Agent Resistant Systems.
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-53084	- Primer, Cathodic Electrodeposition, Chemical Agent Resistant.
MIL-DTL-64159	- Camouflage Coating, Water Dispersible Aliphatic Polyurethane, Chemical Agent Resistant.
MIL-T-81772	- Thinner, Aircraft Coating.
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.

Department of the Army Technical Bulletin

TB-43-0242	- WD CARC Spot Painting (3 December 2007)

(Copies of this document are available online at https://www.logsa.army.mil/etmpdf/files/080000/084390.pdf or from USAMC Logistics Support Activity, Redstone Arsenal, AL 35898-7465.)

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 A380	- Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems. (DoD adopted)
ASTM B117	- Standard Practice for Operating Salt Spray (Fog) Apparatus. (DoD adopted)
ASTM B244	- Standard Test Method for Measurement of Thickness of Anodic Coatings on Aluminum and of Other Nonconductive Coatings on Nonmagnetic Basis Metals with Eddy-Current Instruments. (DoD adopted)
ASTM B499	- Standard Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Non-Magnetic Coatings on Magnetic Basis Metals. (DoD adopted)

ASTM D610 - Standard Practice for Evaluating Degree of Rusting on Painted Steel Surfaces. (DoD adopted)
ASTM D1193 - Standard Specification for Reagent Water. (DoD adopted)
ASTM D1640 - Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature. (DoD adopted)
ASTM D1654 - Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments. (DoD adopted)
ASTM D3359 - Standard Test Methods for Measuring Adhesion by Tape Test.
ASTM D5895 - Standard Test Methods for Evaluating Drying or Curing During Film Formation of Organic Coatings Using Mechanical Recorders.

(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.)

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)
AWPA-T1 - Processing and Treatment Standard.
AWPA-P5 - Standard for Waterborne Preservatives.

(Copies of these documents are available from www.awpa.com/shop/index.asp or American Wood Protection Association, P.O. Box 361784, Birmingham, AL 35236.)

SAE INTERNATIONAL
AMS-QQ-P-416 - Plating, Cadmium (Electrodeposited). (DoD adopted)
AMS-M-3171 - Magnesium Alloy, Processes for Pretreatment and Prevention of Corrosion On. (DoD adopted)

(Copies of these documents are available from www.sae.org/servlets/index or SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001.)

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
Rule 102 - Definition of Terms.
Rule 1107 - Coating of Metal Parts and Products.

(Copies of these documents are available from www.aqmd.gov/aqmd/Interfaces/onsiteservices.html or South Coast Air Quality Management District, 21865 Copley Drive, Diamond Bar, CA 91765.)

SSPC: THE SOCIETY FOR PROTECTIVE COATINGS
SSPC-SP2 - Hand Tool Cleaning.
SSPC-SP3 - Power Tool Cleaning.
SSPC-SP5/NACE No. 1 - White Metal Blast Cleaning.
SSPC-SP10/NACE No. 2 - Near White Blast Cleaning.

(Copies of these documents are available from www.sspc.org or SSPC: The Society for Protective Coatings, 40 24th Street, 6th Floor, Pittsburgh, PA 15222-4656.)

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 Definition. Application of the CARC system consists of four distinct steps, each of which is critical to the performance of the overall system. The steps are cleaning, pretreating, priming, and topcoating. To ensure CARC system adhesion, all pretreatment chemical reactions shall be complete prior to applying primer and topcoat. The anticorrosive primers are primarily epoxies and the topcoats are polyurethanes for exterior surfaces and an epoxy for interior surfaces. All of the coatings in the CARC system are Qualified Products Database (QPD) items, except for the zinc-rich primers conforming to A-A-59745. There is a list of approved suppliers which shall be used for product procurement. In addition, each batch of polyurethane topcoat shall be checked by the specification's qualifying activity for validation of the spectral and specular reflectance (camouflage properties) and Super Tropical Bleach (STB) resistance. The STB composition shall be in accordance with MIL-DTL-12468. The local safety office, preventative medicine activity, and local medical support facility shall be consulted prior to applying the CARC system. For miscellaneous requirements, see section 3.8. Pertinent CARC system specifications are listed in table I. The choice of the coating system belongs to the government and this document is not intended to allow users to circumvent the system specified in the system requirements.

TABLE I. The CARC system.

Process	Ferrous Metal	Non-Ferrous Metal
Cleaning	TT-C-490	MIL-DTL-5541 / TT-C-490
Pretreating	TT-C-490, type I (zinc phosphate) DOD-P-15328 (wash primer) MIL-C-8514 (wash primer)	DOD-P-15328 (wash primer) MIL-C-8514 (wash primer) MIL-DTL-5541 (chemical conversion) 1/ MIL-A-8625 (anodize)
Priming	A-A-59745 MIL-DTL-53022 MIL-DTL-53030 MIL-DTL-53084 MIL-PRF-23377, type I and II, class N 2/ MIL-PRF-32348	MIL-PRF-23377, type I and II, class N MIL-DTL-53022 MIL-DTL-53030 MIL-DTL-53084 MIL-PRF-85582, type I and II, class N MIL-PRF-32348
Topcoating	MIL-PRF-22750 (interior only) MIL-DTL-53039 MIL-DTL-64159 MIL-PRF-32348	MIL-PRF-22750 (interior only) MIL-DTL-53039 MIL-DTL-64159 MIL-PRF-32348

1/ Use of type II conversion coating (non-hexavalent chromium) preferred, if approved for application.
2/ May be used for mixed metal applications. Specific approval shall be obtained for use on ferrous substrates.

3.2 Cleaning. Meticulous cleaning prior to pretreatment and painting operations is critical to meeting the requirements of this specification. Improperly cleaned surfaces interfere with paint adhesion, resulting in premature paint peeling during service. Unless otherwise specified, surfaces shall be cleaned according to TT-C-490. Surface oxides, rust, weld spatter, oil, grease and all other organic and inorganic contaminants shall be removed prior to pretreatment. The

cleaning method shall be determined by the base material properties, the nature of the soil(s), the degree of contamination and the part geometry. The following TT-C-490 methods shall be used singly or in combination to produce a clean surface:

a. Method I Mechanical or abrasive cleaning.
b. Method II Solvent cleaning by immersion, spray or vapor.
c. Method III Hot Alkaline cleaning by immersion, spray or electrolytic methods.
d. Method IV Emulsion with or without added water.
e. Method V Alkaline derusting.
f. Method VI Phosphoric acid (alcohol, detergent or solvent type with detergent)

After cleaning, all surfaces shall be kept free from dirt, dust, finger marks, and other contaminants until treated as specified. If the CARC system cannot be applied immediately after cleaning, then the parts shall be protected from flash rusting and from contamination. Prior to applying the CARC system, the parts shall be re-inspected and cleaned, as required, and pass the water break test (see 4.2.3.1).

3.2.1 Abrasive blasting of ferrous metal surfaces. Unless otherwise specified, ferrous metal surfaces to be painted shall be cleaned in accordance with 3.2. If abrasive blasting is needed to remove mill scale, products of corrosion, dirt, casting, sand, slag and other foreign substances, then follow the procedure in the Society for Protective Coatings specification SSPC-SP5/NACE No. 1 or SSPC-SP10/NACE No. 2, unless otherwise specified. Blast cleaned surfaces shall be coated within four hours with a suitable wash primer or other approved coating material. Applied wash primer shall be dried for at least one hour at a preferred temperature range of 60 to 90 ºF (16 to 32 ºC). If more than four hours pass before pretreatment, the blasted surface shall be inspected and found free of corrosion or foreign matter, and pass the water break test (see 4.2.3.1) prior to pretreatment and priming. When the use of hexavalent chromium is restricted by contractual requirements, TT-C-490, type I or zinc-rich primers conforming to A-A-59745 shall be used as the alternatives on blasted ferrous substrates. Approval by the contracting officer shall be received prior to use of zinc-rich primers on blasted ferrous substrates.

3.2.1.1 Exemptions from abrasive blasting. Abrasive blasting shall not be used on surfaces that could be damaged, such as machine parts and sheet metal thinner than 16 gauge (0.0625 inches or 1.5875 mm). Blasting is optional, on components painted for protection during limited storage, where the paint wears off as soon as the equipment is placed in use. Component examples are track assemblies, track roller assemblies (including mounting frames), interiors of weld-type box sections, bulldozer components (including rippers, scarifiers, ejectors, push plates, blades, bowls, and buckets), scrapers and crane shovels, interiors of cement mixer drums, and interiors of aggregate driers. However, these surfaces shall be cleaned using one of the methods described in 3.2 and shall be free from oil, grease, dirt, and rust. All surfaces shall be dry prior to painting.

3.2.1.2 Vehicles. Ferrous metal surfaces of vehicles shall be cleaned for painting in accordance with 3.2.1, except as specified herein. Surfaces that cannot be cleaned by blasting shall be cleaned to base metal by alternate means such as three dimensional/abrasive cleaning, chipping, powered wire brushing, or grinding to the required degree specified for commercial sand blasting, if authorized by the contracting agency. Sheet metal and sheet metal parts of 8 gage (0.164 inches or 4.166 mm) and thinner shall be cleaned to bare metal by acid pickling in accordance with TT-C-490, with a maximum of five percent sulfuric acid included. However,

chemical cleaning shall not be approved for use on assemblies which entrap acid/alkali or when for any reason chemical cleaning is considered inadvisable. Wire brushes used to clean ferrous surfaces shall be either steel or stainless steel. Brass brushes shall not be used, as there is a possibility of depositing brass particles on the steel surface potentially accelerating corrosion. Hand tool cleaning shall be in accordance with SSPC-SP2 and power tool cleaning shall be in accordance with SSPC-SP3.

3.2.2 Zinc surfaces. Zinc surfaces, including zinc-coated substrates, shall be cleaned and activated prior to being pretreated for painting as specified in 3.3.

3.2.3 Aluminum and aluminum-alloy surfaces. Aluminum and aluminum alloys shall be cleaned in accordance with 3.2, followed immediately by treatment as specified in 3.3.

3.2.4 Magnesium alloy surfaces. Magnesium alloy surfaces shall be cleaned in accordance with SAE-AMS-M-3171, followed immediately by treatment as specified in 3.3.

3.2.5 Cadmium surfaces. Cadmium surfaces shall be cleaned in accordance with SAE-AMS-QQ-P-416, followed immediately by treatment as specified in 3.3.

3.3 Pretreating. Chemical surface treatments for metallic substrates provide improved adhesion for subsequent coatings and temporary protection from corrosion. For best results, the pretreatment shall be applied as soon as possible after proper cleaning (see 3.2). The three most common pretreatments are chromate, phosphate and organic-modified conversion coatings.

3.3.1 Ferrous metal, zinc or cadmium surfaces. These surfaces shall be treated as soon as possible after cleaning as specified in 3.2 with one of the following:

a. Zinc phosphate conforming to TT-C-490, type I.
b. Wash primer (DOD-P-15328 and MIL-C-8514) conforming to TT-C-490, type III.

3.3.1.1 Organic pretreatments. The organic pretreatments in 3.3.1 b are applied to clean metal surfaces to prepare for a more permanent protective anticorrosive primer. Although wash primers afford some protection for up to 24 hours, they are not intended for permanent protection and shall be coated with primer as soon as practical, however no more than 24 hours after application. After more than 24 hours following application, the wash primer shall be stripped and the finishing process started again. The pretreatment is sufficiently dry for priming one hour after application under preferred atmospheric conditions of 60 to 90 ºF (16 to 32 ºC). The pretreatment shall not be applied to visibly wet surfaces or where the surface temperature is less than 50°F (10°C). The dry film thickness shall be 0.3 to 0.5 mils (7.5 to 12.5 microns). To prepare DOD-P-15328, the resin component shall be stirred or agitated to ensure that all solids content are completely dispersed. The acid component shall be added slowly with stirring, continuing until a complete blending of the mixture is achieved. The pretreatment material is then ready for use. If the resin component is thickened or gelled, do not add the acid component until fluidity has been restored. This can be achieved by warming up the resin component. The pretreatment is most effective when freshly mixed and shall be used within 8 hours after the addition of the acid component. The quantity of the pretreatment mixed for use shall be the amount required for immediate application. The acid component is not a thinner. It is a necessary activator and shall be used exactly as directed by the manufacturer. When thinning is required for spray application, follow the manufacturers' recommendations.

3.3.2 Aluminum surfaces. Aluminum surfaces shall be treated as soon as possible after cleaning as specified in 3.2 with one of the following:

a. Anodized aluminum and aluminum alloy castings in accordance with MIL-A-8625. Minimum thickness of 0.0007 inches (.018 mm) is required for wrought aluminum and 0.0004 inches (.010 mm) is required for castings.
b. Chemical conversion conforming to MIL-DTL-5541.
c. Wash primer conforming to DOD-P-15328 or MIL-C-8514.

3.3.3 Magnesium alloy surfaces. Prior to painting, magnesium alloy surfaces shall be treated in accordance with SAE-AMS-M-3171, type I or III, or DOD-P-15328 with half of the specified phosphoric acid. Treated surfaces that become scratched in handling shall be touched up in accordance with SAE-AMS-M-3171, type I.

3.3.4 Wood surfaces. Unless otherwise specified (see 6.2), wood shall be pressure treated and marked in conformance with AWPA-T1 for above ground, or AWPA-P5 for ground contact installations. Wood shall be dried to the specified moisture content appropriate for the size, species, and ultimate service conditions, but in no case greater than 20 percent. Wood painted with CARC shall be sealed with a polyurethane-based wood sealer.

3.3.5 Stainless steel surfaces. These surfaces shall be treated as soon as possible after cleaning as specified in 3.2 or by one of the alternative methods described in ASTM A380 if the surface is still active. Abrasive blasting shall be specified prior to application of a wash primer conforming to DOD-P-15328 or MIL-C-8514 (see 3.3.1 b and 3.3.1.1).

3.3.6 Blasted steel armor. On blasted ferrous armor substrates that have Rockwell C hardness (HRC) greater than 40, wash primer containing phosphoric acid shall not be used. This is due to the risk of hydrogen embrittlement from the phosphoric acid in the component B of the wash primer. In lieu of wash primer, TT-C-490, type I or zinc-rich primer conforming to A-A-59745 shall be used as the pretreatment. Refer to 3.2.1, abrasive blasting of ferrous metal surfaces, for alternatives to hexavalent chromium containing pretreatments. For blasted ferrous substrates greater than HRC 42, prior approval from the contracting officer shall be received before zinc-rich primers are used as an alternative.

3.4 Priming. The primer shall be applied to a clean, dry surface within 24 hours of cleaning and pretreating. The preferred temperature range for the application of these primers shall be 60 to 90 ºF (16 to 32 ºC). If priming is done outside of this range, then all quality control checks shall be done (see 4.2.3) to verify film integrity. The paint and surface shall be approximately the same temperature and not less than 50°F (10°C). Application shall be by brush or spray, depositing a continuous, adherent, dry film which is smooth, uniform, and free from runs, sags, or other defects that might interfere with the application and adhesion of subsequent coatings (see 4.2.3.8). If paint heaters are used to assist in application, the substrate to be coated shall be at least an ambient temperature of 60 ºF (16 ºC). Dipcoating is not a recommended application method for CARC primers. The anticorrosive primers are primarily epoxies and two component products. The powder coating primers are epoxies, but are one component materials. The zinc-rich primers are either two component epoxies or one component moisture cured urethanes. They are applied to metal substrates to provide corrosion resistance and a surface to which the CARC topcoat firmly adheres. The two component products dry by a two stage process of solvent evaporation and chemical crosslinking, and they have a finite potlife, typically 6-8 hours.

Environmental conditions, particularly temperature and relative humidity can affect potlife, curing, and adhesion. In areas where air quality regulations restrict volatile emissions, do not add thinner to the coating material if that addition exceeds the regulatory limit. If thinner needs to be added, consult with the manufacturer of the primer for the appropriate thinner to stay within the regulatory limits. The specific information below for the seven primers is summarized in table II. If a contract requires the use of zinc-rich primer, then MIL-DTL-53022 or MIL-DTL-53030 shall be applied over the zinc-rich primer as a barrier coat between the zinc-rich primer and the topcoat. In addition to the liquid primers, there is also an epoxy anticorrosive powder coating primer (MIL-PRF-32348) that can be used in the CARC paint system. When a contract specifies the use of either MIL-DTL-53022 or MIL-DTL-53030, alternative primers MIL-DTL-53084 or MIL-PRF-32348 are authorized for use also with the approval of the contracting officer.

TABLE II. General application guidelines for epoxy primers. 1/ 2/

SPECIFICATION	MIXING	REDUCTION	APPLICATION
MIL-PRF-23377	Slowly add component B to component A. Preferred temperature range 60 to 90 °F (16 to 32 ºC) prior to mixing as specified by the manufacturer.	Stir and strain. Set 30 minutes before use.	Spray with one full coat. Wait 4-6 hours prior to topcoating. Use within 8 hours. Thickness 0.8-1.2 mils. 3/
MIL-PRF-32348	Follow the instructions from the manufacturer for preparation and application.	Reduction does not apply, since these products are powder coatings and do not use solvents.	Follow the instructions from the manufacturer.
MIL-DTL-53022	One part component B to four parts component A. Add B to A. Preferred temperature range 60 to 90 °F (16 to 32 ºC) prior to mixing.	If necessary and allowed, reduce up to 20%. Stir and strain. Set 30 minutes before use.	Spray with one full coat. Wait 30-60 minutes prior to topcoating. Use within 8 hours for type I and 4-6 hours for type II, III and IV. Thickness 1.5 ± 0.2 mils.
MIL-DTL-53030	Mix component A until uniform. One part component B with three parts component A for type I and 1 part component B to 4 parts component A for type II. Add B to A. Preferred temperature range 60 to 90 °F (16 to 32 ºC).	Using deionized water, reduce according to manufacturers' instructions. Use mechanical mixer and add water slowly. Mix and strain. Stir 30 minutes before use.	Spray with one full coat. Wait 30-60 minutes before topcoating. Use within 6 hours. Thickness 1.5 ± 0.2 mils. High humidity retards dry, low humidity accelerates dry. Make sure surface is free of water prior to topcoating.
MIL-DTL-53084	Follow the manufacturers' instructions.	Reduce with very pure deionized water.	Follow the instructions from the manufacturer.

TABLE II. General application guidelines for epoxy primers - Continued.

SPECIFICATION	MIXING	REDUCTION	APPLICATION
A-A-59745	Mix and agitate pigmented component thoroughly. Mix as specified by the manufacturer. Preferred temperature range 60 to 90 °F (16 to 32 °C) prior to mixing.	Reduce, if necessary, by manufacturers' specifications. Set 30 minutes before use for epoxy type.	Dry times and recoat times based upon manufacturers' specifications. Protect moisture cure from moisture for extended potlife. Epoxy type use within 4-6 hours. Thickness 2.5-3.5 dry mils.
MIL-PRF-85582	Thoroughly mix component A. Mix as specified by the manufacturer. Preferred temperature range 60 to 90 °F (16 to 32 °C) prior to mixing.	Use deionized water. Stir and strain. Set 30 minutes before use.	Spray with one full coat. Wait 30-60 minutes prior to topcoating or based upon manufacturers' recommendations. Use within 4 hours. Thickness 0.8-1.2 mils.3/ Apply at 60-100 °F (16-38 °C). High humidity retards dry, low humidity accelerates dry. Make sure surface is free of water prior to topcoating.

1/ Always add component B to component A, never in reverse.
2/ Times prior to topcoating are for 70 °F (21 °C). At 60 °F, doubling the time is necessary to get adequate curing for topcoating.
3/ For aluminum-steel assemblies. If aluminum only, 0.6 - 0.9 mils is acceptable.

TERMS: 1 mil = 25 microns.

3.4.1 MIL-PRF-23377 (Primer Coatings: Epoxy, High-Solids).

3.4.1.1 Description. This specification covers the requirements for corrosion inhibiting, chemical and solvent resistant, solvent-borne, epoxy primer coatings that have a maximum volatile organic compound (VOC) content of 340 grams/liter (g/l) (2.8 pounds/gallon (lbs/gal)). The specification contains formulations that allow for standard pigments (type I) and low infrared reflective pigments (type II). It also differentiates between two classification systems, class C and N. Class C contains either barium or strontium chromate based corrosion inhibitors and class N contains non-chromate based corrosion inhibitors.

3.4.1.2 Use. This primer is intended for use on pretreated aluminum alloy surfaces as a corrosion inhibitive, chemical resistant primer. It is compatible with CARC topcoats. Type II shall not be used, except on aircraft, where specifically required (see 6.6).

3.4.1.3 Preparation. Thoroughly mix and stir component A prior to admixing. While slowly pouring component B into component A, continue to stir until the manufacturer's specified volume mixing ratio is achieved. Each component shall be properly metered to assure correct mixing ratios. Reduction of the admixed material shall be according to the manufacturers' instructions. Component B shall always be added to component A and this procedure shall never

be reversed. The preferred temperature range of each component shall be 60 to 90 °F (16 to 32 ºC) before mixing.

3.4.1.4 Reduction. Reduce the admixed primer if necessary with MIL-T-81772 type II or thinner recommended by the manufacturer, but do not exceed the VOC limit of 340 g/l (2.8 lbs/gal). The reduced primer shall be continuously stirred to allow thorough mixing and to counter pigment settling. Strain through a 60 mesh minimum paint filter or equivalent. Let stand at room temperature for 30 minutes to allow primer adequate time to induct or follow the manufacturers' instructions.

3.4.1.5 Application. All surfaces to be painted shall be thoroughly cleaned as specified in 3.2 and pretreated as specified in 3.3. To ensure a chemically clean surface, perform the test in 4.2.3.1. Failure to comply with 4.2.3.1 is sufficient cause to do additional cleaning. The primer shall be applied to the specified film thickness and needs to dry up to 6 hours (dry to touch) before applying the topcoat. Times vary depending upon environmental conditions and the manufacturers' recommendations. The admixed primer shall be used within 8 hours after mixing to ensure performance. The dry film thickness shall be between 0.6 and 0.9 mils (15 and 22.5 microns) for aluminum and between 0.8 and 1.2 mils (20 and 30 microns) for aluminum-steel assemblies. The largest factor affecting cure is temperature. At 70 °F (21 °C), the dry to touch time is 30 minutes and the surface is dry to handle within 6 hours when checked according to ASTM D1640.

3.4.1.6 Comments. The primer furnished under this specification shall be products that are authorized by the qualifying activity for listing in the QPD (see 6.4).

3.4.2 MIL-DTL-53022 (Primer, Epoxy Coating, Corrosion Inhibiting, Lead and Chromate Free).

3.4.2.1 Description. This specification covers an air drying, corrosion inhibiting epoxy primer for ferrous and nonferrous metals. It is formulated lead and chromate free. A type I coating shall satisfy hydrocarbon emissions, as defined in Rule 102 of the South Coast Air Quality Management District, while a type II coating has a maximum VOC content of 420 g/l (3.5 lbs/gal). Type III and IV coatings are hazardous air pollutants-free (HAP-free) and have a maximum VOC content of 340 g/l (2.8 lb/gal). A type V coating is furnished in self-contained portable kits. The kits contain the type IV corrosion inhibiting epoxy primer in a touch-up system. The specification is a two package system consisting of a pigmented epoxy resin (component A) and a polyamine-epoxy catalyst (component B).

3.4.2.2 Use. This primer is intended for use on properly cleaned and pretreated ferrous and nonferrous surfaces. It is an acceptable primer system to use with CARC topcoats.

3.4.2.3 Preparation. The component A shall be thoroughly mixed and stirred prior to admixing. Mix one part of component B to four parts of component A by volume and stir until well blended. Allow the admixed material to sit according to the manufacturer's recommended induction time. The preferred temperature range of each component shall be 60 to 90 °F (16 to 32 ºC) before mixing.

3.4.2.4 Reduction.

3.4.2.4.1 Type I and II primers. If necessary and allowed, the admixed primer shall be reduced for spraying up to 20 percent by volume with MIL-T-81772, type I or II, or thinner recommended by the manufacturer.

3.4.2.4.2 Type III and IV primers. The type III and IV primers shall use only HAP-free solvents that are recommended by the manufacturer to maintain the HAP-free material for application. The thinned primer shall be thoroughly stirred, strained through a 60 mesh minimum paint filter or equivalent and allowed to sit according to the manufacturer's recommended induction time prior to use and shall continue to be stirred throughout the primer application. Mechanically mixing with an air agitator shortens the induction time. Consult with manufacturer for reduced induction time. When thinning is required for primer obtained by National Stock Number (NSN) through the General Services Administration (GSA) Global Supply program, MIL-T-81772 is allowed as the thinner only if an approved HAP-free thinner is not available.

3.4.2.5 Application. All surfaces to be painted shall be thoroughly cleaned as specified in 3.2 and pretreated as specified in 3.3. To ensure a chemically clean surface, perform the test in 4.2.3.1. Failure to comply with 4.2.3.1 is sufficient cause to do additional cleaning. After completion of the 30 minute induction period, when required, the primer shall be sprayed to a dry film thickness of 1.5 ± 0.2 mils (37.5 ± 5 microns). The primer needs only to be dry to touch at these film thicknesses before applying the topcoat. This is usually between 30 and 60 minutes in accordance with ASTM D5895, depending on conditions. The admixed type I primer shall be used within 8 hours to ensure performance, but type II, III and IV material shall be used within 4-6 hours. Potlife is shortened at higher temperatures. The largest factor affecting cure is temperature. At 70 ^{o}F (21 **º**C**)**, the dry to touch time is between 30-60 minutes. Dry to handle time is 90 minutes to 4 hours depending on the coating type. The use of plural metering spray equipment eliminates the requirement to have an induction period of the mixed primer before application.

3.4.2.6 Comments. The primer furnished under the specification shall be products which are authorized by the qualifying activity for listing on the QPD (see 6.4).

3.4.3 MIL-DTL-53030 (Primer Coating, Epoxy, Water Based, Lead and Chromate Free).

3.4.3.1 Description. This primer is a water based, air-drying, corrosion inhibiting epoxy primer. It is a two component system with a pigmented polyamide (component A) and a clear to milky epoxy catalyst (component B). The primer is formulated HAP-free, lead and chromate free and contains no more than 340 g/l (2.8 lbs/gal) VOC as applied, in accordance with Rule 1107 of the South Coast Air Quality Management District. The primer is furnished in coating types I, II, and III. Type I is basic corrosion performance, water reducible technology. Type II is enhanced corrosion performance, water dispersible technology. The enhanced corrosion performance includes 1,000 hours salt spray and 40 cycles on the cyclic corrosion test. Type III is self contained portable kits. The kits contain the type II coating epoxy primer in a touch-up system.

3.4.3.2 Use. The primer is intended for use on pretreated ferrous and nonferrous substrates and is compatible with CARC topcoats.

3.4.3.3 Preparation. Thoroughly agitate and mix component A until uniform. If necessary, use a paint shaker to disperse any settled pigment in component A. Mix one volume of component B with three volumes of component A for a type I coating or one volume of component B with four volumes of component A for a type II coating until a smooth homogeneous mixture is achieved. The preferred temperature range of each component shall be 60 to 90 ^{o}F (16 to 32 ºC) before mixing. Component B shall be added to component A under constant agitation.

3.4.3.4 Reduction. Reduce the admixed primer with deionized water conforming to ASTM D1193 type IV, or according to manufacturers' recommendations. Water shall be added under

constant agitation. The thinned primer shall be strained through a 60 mesh minimum paint filter or equivalent and allowed to stand for 30 minutes prior to use or according to manufacturers' recommendations. Mechanical mixing shortens the induction time. Consult with the manufacturer for these times.

3.4.3.5 Application. All surfaces to be painted shall be thoroughly cleaned as specified in 3.2 and properly pretreated as specified in 3.3. To ensure a chemically clean surface, perform the test in 4.2.3.1. Failure to comply with 4.2.3.1 is sufficient cause to do additional cleaning. After completion of the 30 minute induction period, the primer shall be sprayed to a required dry film thickness 1.5 ± 0.2 mils (37.5 ± 5 microns). The primer needs only be dry to touch (ASTM D5895) before applying the topcoat. This is usually between 30 to 60 minutes depending on conditions. The admixed primer shall be used within 6 hours to ensure performance. The largest factor affecting cure is temperature. At 70 ^{o}F (21 ºC**)**, the dry to touch time is 30 to 60 minutes and the dry to handle time about 2 hours. Due to the fact that the primer is a water based system, a high relative humidity shall retard the dry time while a low relative humidity shall accelerate the process. Temperature increase shortens potlife.

3.4.3.6 Comments. The primer furnished under this specification shall be a product authorized by the qualifying activity for listing on the QPD (see 6.4). Since the sprayed primer contains water, care shall be taken to ensure that the primer surface is dry to touch before application of MIL-DTL-53039. Premature topcoating leads to compromised CARC properties.

3.4.4 MIL-DTL-53084 (Primer, Cathodic Electrodeposition, Chemical Agent Resistant).

3.4.4.1 Description. This primer is a waterborne, cathodic epoxy electrodeposition primer formulated lead and hexavalent chrome free. It meets solvent emission maximums of 144 g/l (1.2 lbs/gal) VOC.

3.4.4.2 Use. This primer is intended for use on properly cleaned and pretreated ferrous and nonferrous metal surfaces and is compatible with CARC topcoats. Since it is applied with an immersion-type procedure and cured by baking, this primer is designed for a large-scale production process.

3.4.4.3 Preparation. The manufacturer shall provide instructions for mixing and thinning. Prepare the primer bath by mixing resin feed and pigment paste components, or single-component blended feed with pure deionized water that is free of bacteria (conductivity less than 10 microhms/centimeter). After mixing components allow bath to be stirred and agitated for at least a one (1) hour period to facilitate thorough mixing and reduction.

3.4.4.4 Reduction. After preparation of the bath, allow it to stir for at least one hour prior to use. Continuous agitation, even while coating, is necessary after preparation to maintain homogeneity of the diluted electrodeposition primer bath.

3.4.4.5 Application. All surfaces to be painted shall be thoroughly cleaned as specified in 3.2 and pretreated as specified in 3.3. To ensure a chemically clean surface, perform the test in 4.2.3.1. Failure to comply with 4.2.3.1 is sufficient cause to do additional cleaning. Since the primer is applied via cathodic electrodeposition, the substrate to be coated is the negative electrode, while the side electrodes are positive. Coat and cure as recommended by the coating manufacturers' instructions.

3.4.4.6 Comments. The primer furnished under this specification shall be products which are authorized by the qualifying activity for listing on the QPD (see 6.4). If a black electrocoat primer is used, the minimum topcoat dry film thickness shall be 2.0 mils (50 microns) to ensure the infrared reflectance (IR) signature requirements of the topcoat are met.

3.4.5 MIL-PRF-85582 (Primer Coatings: Epoxy, Waterborne).

3.4.5.1 Description. This specification covers the requirements for corrosion inhibiting, chemical and solvent resistant, waterborne, epoxy primer coatings that meet a maximum VOC of 340 g/l (2.8 lbs/gal). The specification contains formulations that allow for standard pigments (type I) and low infrared reflective pigments (type II). It also differentiates between systems with barium chromate (class C1), strontium chromate (class C2) and non-chromate (class N) based corrosion inhibitors.

3.4.5.2 Use. The primer is intended for use on pretreated nonferrous substrates and is compatible with CARC topcoats. Type II shall not be used except on aircraft where specifically required (see 6.6).

3.4.5.3 Preparation. The epoxy primer shall be prepared by first thoroughly mixing or agitating component A. Component A is the pigmented base component of epoxy resin solution, and component B is the curing agent. The two components are then mixed in the volume ratio specified by the manufacturer. The preferred temperature range of each component shall be 60 to 90 ^{o}F (16 to 32 ºC) before mixing.

3.4.5.4 Reduction. Reduce the admixed primer with deionized water conforming to ASTM D1193 type IV, or according to the manufacturer's recommended procedure. The thinned primer shall be stirred thoroughly, strained through a 60 minimum mesh paint filter or equivalent and allowed to stand for 30 minutes prior to use. Continuously stir the reduced primer throughout the coating application.

3.4.5.5 Application. All surfaces to be painted shall be thoroughly cleaned as specified in 3.2 and properly pretreated as specified in 3.3. To ensure a chemically clean surface, perform the test in 4.2.3.1. Failure to comply with 4.2.3.1 is sufficient cause to do additional cleaning. After completion of the 30 minute induction period, the primer shall be sprayed to a dry film thickness between 0.6 and 0.9 mils (15 and 22.5 microns) for aluminum and between 0.8 and 1.2 mils (20 and 30 microns) for aluminum-steel assemblies. The primer needs only be dry to touch conforming to ASTM D5895 before applying the topcoat. This is usually between 30 minutes and 1 hour depending on conditions. The admixed primer shall be used within 4 hours to ensure performance. The largest factor affecting cure is temperature. At 70 °F (21 ºC), the dry to touch time is within one hour and the primer is dry to handle within 6 hours. The effect of decreasing the temperature within a facility's painting area doubles the cure time for each 18 degree drop in temperature under 70 °F (21 ºC). Due to the fact that this is a water-reducible system, a high relative humidity retards the cure time while a low relative humidity accelerates the process.

3.4.5.6 Comments. The primer furnished under this specification shall be products which are authorized by the qualifying activity for listing on the QPD (see 6.4). Since the sprayed primer contains water, care shall be taken to ensure the surface is dry to touch before application of urethane topcoats. Premature topcoating leads to an undesirable reaction between the water evaporating from the primer and the catalyst component of the urethane being applied.

3.4.6 A-A-59745 (Zinc-Rich Coatings).

3.4.6.1 Description. These primers are VOC compliant zinc-rich primers designed for direct application to blasted ferrous surfaces in place of other pretreatments. These primers are either two component epoxies or single component moisture cured polyurethanes. These coatings shall contain a minimum of 90% by weight of zinc dust pigment in their dried films and conform to Commercial Item Description (CID) A-A-59745, Zinc-Rich Coatings. The primers shall be over coated with CARC. Zinc-rich primers shall be primed only with MIL-DTL-53022 or MIL-DTL-53030 prior to the application of the CARC topcoat. These primers shall meet a VOC content no greater than 420 g/l (3.5 lbs/gal).

3.4.6.2 Use. These primers are designed for enhanced corrosion resistance providing cathodic protection and self healing properties. These products shall be used with CARC. Epoxy primer MIL-DTL-53022 or MIL-DTL-53030 shall be applied at a minimum of 1.0 dry mils (25 microns) as a barrier coat between the zinc-rich primer and the CARC topcoat.

3.4.6.3 Preparation. The pigment portion of the coating shall be thoroughly mixed prior to use or admixing. Follow instructions specified by the manufacturer. Constant agitation shall be used during application to prevent settling of the zinc pigment. The moisture cured type is a single component and does not require any admixing. The epoxy two component types shall be mixed following the manufacturers' specifications.

3.4.6.4 Reduction. If necessary and allowed due to environmental regulations, the primer shall be reduced according to the manufacturer's recommended procedure. The moisture cured zinc-rich primer does not require any induction time, but the epoxy type requires a 30 minute induction time.

3.4.6.5 Application. All surfaces to be painted shall be thoroughly cleaned as specified in 3.2. The zinc-rich coating shall be applied directly to blasted ferrous metal for maximum performance. The primer shall be sprayed to a dry film thickness no less than 2.5 dry mils (62.5 microns) or as recommended by the manufacturer. If not specified, the recommended dry film thickness range is between 2.5-3.5 mils (62.5-87.5 microns). Dry times and recoat times are as specified by the manufacturer. The pot life of the moisture cured urethane type is unlimited, if kept free from moisture contamination. The pot life of the epoxy types is 4-6 hours at 70 ºF (21 ºC).

3.4.6.6 Comments. For approved zinc-rich primers to be used on Army tactical equipment, contact 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.

3.4.7 MIL-PRF-32348 (Powder Coating, Camouflage, Chemical Agent Resistant Systems.

3.4.7.1 Description. This specification covers powder coatings for use on metallic substrates as an anticorrosive primer with CARC and a camouflage and non-camouflage CARC for use as a finish coat on military combat equipment. Type I is a corrosion inhibiting epoxy primer for ferrous and nonferrous metals. For interior application, the type II powder primer can be used to replace the two coat system of epoxy primer and MIL-PRF-22750 topcoat. The powder primer must have prior approval from ARL in the specific topcoat color. The type III powder covers both camouflage and non-camouflage CARC for use as finish coats on military combat equipment. The type IV powder covers ammunition container CARC. These can be used on all tactical military equipment, which includes ground, aviation, and related support assets. Because powder coatings do not

require solvents, these coatings shall be VOC-free and volatile organic hazardous air pollutant-free (VOHAP-free).

3.4.7.2 Use. This primer is intended for use on properly cleaned (see 3.2) and pretreated (see 3.3) ferrous and nonferrous metal surfaces. It is formulated lead and chromate free and is compatible with all CARC topcoats. Since this product is electrostatically applied and requires baking for cure, this primer is designed primarily for small and component parts. Parts shall be evaluated for their ability to withstand the baking temperatures required in accordance with the manufacturers' recommendations prior to coating. The type III powder is applied over either approved liquid or powder primers. The type IV powder is applied directly to properly cleaned and pretreated metal.

3.4.7.3 Preparation. The manufacturer shall provide instructions for the preparation for application.

3.4.7.4 Reduction. Since this is a powder coating and does not use solvent, reduction does not apply.

3.4.7.5 Application. All surfaces shall be properly cleaned and pretreated before application to steel or aluminum substrates. The powder coatings are applied and cured using the powder coat process specified by the manufacturer. This is generally an electrostatic application of the powder material, where the part is electrically connected to an earth ground and the powder is positively charged during application. Be sure to read and follow all safety instructions provided by the manufacturer with the powder equipment to avoid injuries associated with electrical current flow.

3.4.7.6 Comments. The primers and topcoats furnished under this specification shall be products which are authorized by the qualifying activity for listing on the QPD.

3.5 Topcoating. The four CARC topcoats provide chemical agent resistance and color for the system. In addition, the polyurethanes (exterior surfaces) provide camouflage and survivability properties. The epoxy (interior surfaces) provides a smooth, easily-cleaned surface which is resistant to wear. These coatings also offer improved performance and prolonged service life. It is best to apply the topcoat to a freshly primed substrate within 24 hours. In no case, shall the topcoat be applied over the primer more than 168 hours after priming and less than the minimum time specified for the recoating test by the material specifications. Dipcoating is not recommended for the CARC topcoats (see 3.4). If topcoating proceeds after 168 hours, either scuff sanding followed by a solvent wipe or a primer mist coat is required (see 4.2.3.2). Adhesion testing (see 4.2.3.6) shall be used to monitor intercoat adhesion. As with CARC primers, application shall be by brush or spray, the paint and substrate shall be approximately the same temperature, and ambient temperature shall be between 60 and 90 ^{o}F (16 and 32 ^{o}C) at application and for a period of time after application sufficient to assure adequate cure prior to exposure to adverse conditions. In areas where air quality regulations restrict volatile emissions, do not add thinner to the coating material if that addition exceeds the regulatory limit. Environmentally acceptable solvents or solvent blends shall be used for reduction. The specific information below for the different topcoats is summarized in table III.

TABLE III. Application characteristics for CARC topcoats.

SPECIFICATION	MIXING	REDUCTION	APPLICATION
MIL-DTL-53039	Stir or agitate until uniform. Paint containing grit, seeds, skins, abnormal thickening or excessive pigment settling shall not be used.	If necessary and allowed, reduce with a VOHAP-free thinner supplied by the manufacturer, not to exceed VOC limits where applicable. Stir and strain.	Coating is water sensitive, so don't let water come into contact with the coating. High humidity accelerates dry and cure times, and promotes blistering. Once opened, use within 8 hours unless protected by a nitrogen or argon blanket. Apply a minimum dry film thickness of 1.8 mils. Cure time increases with low temperature and low humidity, and decreases with higher temperature and higher humidity. At 70 ^{o}F (21 ^{o}C), the coating completely cures in one week.
MIL-DTL-64159	After component A is thoroughly stirred or agitated to redisperse settled pigments then add 1 part by volume of component B to 2 parts by volume of component A and mix well with a mechanical mixer	If necessary reduce to sprayable viscosity 3 parts by volume admix with up to 1 part by volume of water or in accordance with manufacturer's directive using a mechanical mixer. Stir and strain.	Use the admix coating within 6 hours. Apply a minimum dry film thickness of 1.8 mils. Cure and dry time increases with low temp and high humidity, and decreases with higher temp and lower humidity. At 70 ^{o}F (21 ^{o}C), the coating completely cures in one week.
MIL-PRF-22750	Component A shall be thoroughly mixed. Mix as specified by the manufacturer.	If necessary and allowed, reduce up to the allowed VOC limit. Stir and strain. Let stand 30 minutes.	Apply in one or two coats, as specified by the manufacturer, to a total dry film thickness between 1.7 - 2.3 mils. Use within 8 hours. At 70 ^{o}F (21 ^{o}C), the coating completely cures in one week.
MIL-PRF-32348 1/	Follow the instructions from the manufacturer for preparation and application.	Reduction does not apply, since these products are powder coatings and do not use solvents.	Follow the instructions from the manufacturer.

1/ MIL-PRF-32348 is both a primer and CARC topcoat specification. Refer to section 3.4.7.

TERMS: 1 mil = 25 microns.

3.5.1 MIL-DTL-53039 (Coating, Aliphatic Polyurethane, Single Component, Chemical Agent Resistant).

3.5.1.1 Description. This specification covers both camouflage and non-camouflage, chemical agent resistant, aliphatic polyurethane coatings for use as finish coats on military combat equipment. It is a single component, moisture cured finish which is lead and chromate (hexavalent) free, and has VOC ranging from 0-420 g/l (0.0-3.5 lbs/gal) depending upon the type

of coating as packaged. This specification also encompasses formulations that are flattened with either siliceous or polymeric flattening agents. Each type has VOHAP-free formulations. Unless silica flattening agents are otherwise allowed, types containing polymeric flattening agents are preferred.

3.5.1.2 Use. MIL-DTL-53039 is intended for all tactical and support equipment. It can be applied over any of the anticorrosive primers described in 3.4, or to a CARC basecoat which is at least dry to touch, as in pattern painting, or aged and thoroughly cleaned, as in rework. It shall not be applied over an existing alkyd or lacquer finish. As a camouflage topcoat, it shall be applied to exterior surfaces and interior surfaces routinely visible from the outside, such as door ramps and hatches.

3.5.1.3 Preparation. Thoroughly mix by stirring or agitation to a smooth, homogeneous state. Care shall be exercised to redisperse any pigment which settles to the bottom of the container. Any package which shows evidence of grit, seeds, skins, abnormal thickening or excessive pigment settling shall not be used.

3.5.1.4 Reduction. If necessary for spray application and allowed by VOC regulations, reduce MIL-DTL-53039 with MIL-T-81772, type I solvent or thinner recommended by the manufacturer up to a maximum ratio of four parts by volume of the coating to one part by volume of the solvent. To maintain a HAP-free material upon application, follow the manufacturers' recommendations for thinning. When thinning is required for HAP-free types obtained by National Stock Number through the GSA Global Supply program, MIL-T-81772 is allowed as the thinner only if approved HAP-free thinner is not available. MIL-DTL-53039 (except colors Aircraft Green, 34031 and Interior Aircraft Black, 37031) shall be strained through a paint filter to remove any impurities. Thinning is not necessary for brush application, however, for spray application, the coating can be reduced as described above, if required. MIL-T-81772, type II solvent shall never be used with this CARC topcoat, as it affects the curing of this coating.

3.5.1.5 Application. For adequate camouflage properties, it is necessary to apply the coating to a minimum dry film thickness of 1.8 mils (45 microns). Under certain temperature and humidity conditions, for more even results, apply two coats of a minimum thickness of 0.9 mils (22.5 microns) each. The coating is moisture sensitive and caution shall be taken to ensure water does not come in contact with the coating at any time, especially with a compressed air source. High humidity conditions shorten the dry and cure times, and may cause blistering. Under high humidity conditions, the dry film thickness shall be kept at about 2.0 mils (50 microns) to minimize blistering. Once opened, MIL-DTL-53039 shall be used within eight hours unless stored in a pressure pot or container under a nitrogen or argon blanket, or in a sealed dry air/airless container. At temperatures of 70 ^{o}F (21 ^{o}C) and above, MIL-DTL-53039 dries within the specification requirements in accordance with ASTM D5895 (dry to touch in approximately 15 minutes, dry hard in three hours, dry through in four hours, with a complete cure within seven days). At 52 ^{o}F (11 ^{o}C), MIL-DTL-53039 requires twice as long to cure. Do not apply to items attaining temperatures in excess of 400 ^{o}F (204 ^{o}C), such as manifolds, exhaust pipes, or mufflers. Use MIL-P-14105 or TT-P-28, as applicable. Do not apply MIL-DTL-53039 to a surface which is contaminated with moisture.

3.5.1.6 Comments. MIL-DTL-53039 is a QPD item, and procurement shall be from an approved supplier. In addition, there is a batch validation requirement which specifies that a sample from every batch shall be approved for visible and near infrared reflectance properties (see 6.4). This

coating, when applied as packaged or reduced with exempt solvent, is suitable where VOC regulations limit solvent emissions to 420 g/l (3.5 lbs/gal) or lower. To avert undesirable reactions, spray lines used for epoxy paints shall not be used for polyurethanes without complete flushing or cleaning with solvents. MIL-DTL-53039 is often applied under camouflage pattern painting (CPP) guidelines in 3-color patterns containing Green 383, 34094, Brown 383, 30051, and Black, 37030. In desert applications, Tan 686A, 33446 is available. For further information on patterns, contact ARL, ATTN: RDRL-WMM-C, Organic Coatings Team, Building 4600, Deer Creek Loop, Aberdeen Proving Ground, MD 21005-5066.

3.5.2 MIL-DTL-64159 (Camouflage Coating, Water Dispersible Aliphatic Polyurethane, Chemical Agent Resistant).

3.5.2.1 Description. This specification covers water-dispersible, chemical agent resistant, aliphatic polyurethane coatings for use as a finish coat on all tactical military equipment, which includes ground, aviation and related support assets. The materials are VOHAP-free, free of inorganic HAPs other than cobalt and non-hexavalent chromium, and have a maximum VOC content of 220 g/l (1.8 lbs/gal) as packaged. The material is available in three coating types. Type I contains silica-based flattening pigments. Type II contains polymeric flattening pigments. Type III is furnished in self contained portable kits. The kits contain the type II CARC in a touch-up system. Unless silica flattening agents are otherwise allowed, types containing polymeric flattening agents are preferred.

3.5.2.2 Use. MIL-DTL-64159 coatings are intended for all tactical and support equipment. It can be applied over any of the primers listed in table I and described under 3.4, or to a CARC basecoat which is at least dry to touch, as in pattern painting, or to a completely cured and thoroughly cleaned existing finish, as in rework. It shall not be applied over an existing alkyd or lacquer finish. Substrates and regulatory requirements determine which epoxy primer is to be selected as the undercoat for this CARC application.

3.5.2.3 Preparation. The material is furnished in two components. Component A consists of a hydroxyl functional polyurethane dispersion that is formulated with prime and extender pigments, additives and solvents. Component B consists of an aliphatic isocyanate prepolymer type that is dispersible in water. The composition mixing ratio for the components is a two to one mixing ratio of component A to component B. Component B is very water sensitive and caution shall be taken to ensure that water or high humidity does not come in contact with the component at any time prior to admix. Mix and agitate component A to fully disperse all pigments, then add 1 part by volume of component B to 2 parts by volume of component A under constant agitation. Apply vigorous mechanical agitation to the combined components with a high shear mixer. The combined material shall be mixed for about 3 minutes with the high shear mixer. The admixed material noticeably thickens as it is being mixed. The mixer shall be a high speed air drill with a vortex cage mixer attachment. Do not hand mix or use a paint shaker to mix the two components together.

3.5.2.4 Reduction. Reduce the coating by adding up to one part by volume of deionized water (ASTM D1193, type IV) to three parts by volume of the admix or as specified by the manufacturers' instructions for spray application. Reduction with water shall occur while the material is being mechanically agitated to ensure proper incorporation with the other components. The same equipments used to combine the two components shall be used during the addition of water phase. Do not over thin the admixed material.

3.5.2.5 Application. For adequate camouflage properties, it is necessary to apply the coating to a minimum dry film thickness of 1.8 mils (45 microns). Under certain temperature and humidity conditions, for more even results, it is advisable to apply two coats of a minimum thickness of 0.9 mils (22.5 microns) each. Drying time increases with lower temperatures or higher humidity, and decreases with higher temperature or lower humidity. At temperatures of 70 ^{o}F (21 ^{o}C) and above, MIL-DTL -64159 dries within the specification requirements in accordance with ASTM D5895 (dry to touch in approximately 50 minutes, dry hard in 4 hours, dry through in five hours, with a complete cure within 7 days for type I, and dry to touch in approximately 60 minutes, dry hard in 6 hours, dry through in eight hours, with a complete cure within 7 days for type II). At 52 ^{o}F (11ºC), MIL-DTL-64159 requires twice as long to cure. Do not apply MIL-DTL-64159 to a surface which is contaminated with moisture. Do not apply to items attaining temperatures in excess of 400 ^{o}F (204 ^{o}C), such as manifolds, exhaust pipes, or mufflers. Use MIL-P-14105 or TT-P-28, as applicable.

3.5.2.6 Comments. MIL-DTL-64159 is a QPD item, and procurement shall be from an approved supplier. In addition, there is a batch validation requirement which specifies that a sample from every batch shall be approved for specular and gloss reflection (see 6.4). This coating, when applied as packaged or reduced with water, is suitable where VOC regulations limit solvent emissions to 220 g/l (1.8 lbs/gal). To avert undesirable reactions, spray lines used for epoxy paints shall not be used for polyurethanes without complete flushing or cleaning with solvents. The spray lines shall also be flushed with water prior to application to remove any undesirable solvents in the lines. MIL-DTL-64159 is often applied under camouflage pattern painting (CPP) guidelines in 3-color patterns containing Green 383, 34094, Brown 383, 30051, and Black, 37030. In desert applications, Tan 686A, 33446 is available. For further information on patterns, contact ARL, ATTN: RDRL-WMM-C, Organic Coatings Team, Building 4600, Deer Creek Loop, Aberdeen Proving Ground, MD 21005-5066.

3.5.3 MIL-PRF-22750 (Coating, Epoxy, High-Solids).

3.5.3.1 Description. This specification covers the requirements for a two-component, high-solids epoxy coating with a maximum VOC content of 340 g/l (2.8 lbs/gal) and which is formulated to be free of cadmium, chromium and lead. A coating kit is available for use.

3.5.3.2 Use. MIL-PRF-22750 is intended to provide an interior topcoat for all tactical and support equipment. It can be applied over any of the primers described in 3.4, or to CARC basecoat which is at least dry to touch or which is completely cured and thoroughly cleaned, as in rework. If rework takes place, the previous paint finish shall be scuff sanded and cleaned prior to this coating being applied. It shall not be applied over an existing alkyd or lacquer finish. Since epoxy-polyamide paint films are sensitive to ultraviolet radiation and tend to chalk upon exposure to sunlight, MIL-PRF-22750 shall be applied only to interior surfaces.

3.5.3.3 Preparation. Prior to combining the two components together, component A shall be thoroughly mixed by stirring or agitation to a smooth homogeneous state. Care shall be exercised to redisperse any pigment which settles to the bottom of the container. Material which contains evidence of pigment flotation, coarse particles, or objectionable settling, which cannot be readily dispersed, shall not be used. Components from different manufacturers shall not be mixed, nor shall components from different color kits be mixed. After combining the two components, the coating compound shall be thoroughly mixed into a smooth, homogeneous state. After combining the two components, the mixed material shall be allowed to sit for a 30 minute

induction time. The use of plural metering spray equipment eliminates the requirement to have a 30 minute induction period of the mixed primer before application.

3.5.3.4 Reduction. If the admixed coating needs to be thinned for application, solvent conforming to MIL-T-81772, type I or type II, or manufacturer's recommendation shall be used. Caution shall be taken when thinning so as not to exceed the maximum VOC content of 340 g/l (2.8 lbs/gal) in areas where air pollution regulations are enforced. The thinned paint shall be thoroughly stirred, strained through a 60 minimum mesh paint filter to remove any impurities, and allowed to stand at room temperature for 30 minutes before using.

3.5.3.5 Application. The application of the mixed coating shall be applied in one full coat to the required dry film thickness 1.7 to 2.3 mils (42.5 to 57.5 microns) or two coats, each being about 1 mil (25 microns) dry to help prevent blistering and gloss variations. Another option to help prevent bleeding, blistering or gloss variations is after completion of the 30 minute induction period, spray a mist coat of the MIL-PRF-22750 over the primer and allow to dry for 30 minutes. It shall be thin, discontinuous and translucent (not full hiding). Follow this step with a full wet coat to a total dry film thickness of 1.3 to 1.7 mils (32.5 to 42.5 microns). For aircraft, apply two coats to a total dry film thickness of 2.0 to 2.4 mils (50 to 60 microns). Mixed coating shall be used within 8 hours. Pot life is shortened by higher temperatures. Curing time increases with lower temperature and decreases with higher temperature. At temperatures of 70 ^{o}F (21 ^{o}C) and above, MIL-PRF-22750 dries within specification requirements in accordance with ASTM D5895 (dry to touch in four hours, dry hard in eight hours, and complete cure in seven days).

3.5.3.6 Comments. MIL-PRF-22750 is a QPD item, and procurement shall be from an approved supplier. To avert undesirable reactions, spray lines used for both epoxy and polyurethane paints shall be completely flushed or thoroughly cleaned before switching. MIL-PRF-22750 is the CARC for interior surfaces. This coating is supplied in many colors referenced in FED-STD-595, such as color numbers 17925, 24533 and 26307. For further information contact ARL, ATTN: RDRL-WMM-C, Organic Coatings Team, Building 4600, Deer Creek Loop, Aberdeen Proving Ground, MD 21005-5066.

3.6 Touch up and repair. When touching up damaged areas or applying CARC topcoat to an existing CARC topcoat, the procedure to be followed depends upon the type and condition of the existing finish. Items previously coated with alkyds, lacquers or vinyls shall be stripped down to the epoxy primer if present, or to the substrate if not. For rework, polyurethane and epoxy topcoats shall only be applied over previously painted epoxy or polyurethane topcoats that are free of defects, deterioration and/or corrosion. If coating over existing epoxies or polyurethanes aged more than 168 hours, the surface shall be cleaned and scuff sanded.

3.6.1 Surface preparation. Scratches or other light damage to polyurethane or epoxy topcoats shall require scuff sanding at the immediate blemish area. Damage or corrosion extending to the substrate shall require sanding or abrasive blasting and repriming. All traces of corrosion shall be removed from the substrate. The surface immediately surrounding exposed substrate shall then be sanded, using a feathering-in technique which requires sanding away paint film (primer and topcoat) so that the thickness of the film is smoothly tapered from bare metal/substrate to the top of the paint film. An area around the tapered section shall be scuff sanded to allow for overcoating with a suitable CARC topcoat. Sanding of any type shall be followed by wiping down the exposed area to be painted using an environmentally acceptable procedure that removes all loose sanding debris, mill scale, grease, oil (including fingerprints), and diesel/gasoline

residue. This procedure shall be performed in a well ventilated area while wearing gloves to prevent skin contact with cleaning solvents. Consult safety personnel to determine appropriate gloves and protective clothing, and to determine if respiratory protection is needed. Do not use other petroleum or alcohol-based cleaners or cleaning agents of any kind. All steel areas sanded down to bare metal shall be pretreated with wash primer DOD-P-15328 or MIL-C-8514. All aluminum areas sanded to bare metal shall be pretreated with wash pretreatment or MIL-DTL-5541 and allowed to set for 15 minutes. The minimum area allowed for touch-up shall be agreed upon for each contract between the Government and the applicator.

3.6.2 Repair procedures.

3.6.2.1 Primer. Choose the appropriate primer and prepare in accordance with 3.4. Apply evenly in one coat over the pretreated substrate and apply over portions of the exposed original primer coat using blend-in technique which is tapering off quantity applied to a thin edge.

3.6.2.2 CARC topcoat. Ensure that the surface to which the topcoat is applied is clean and dry. The surface temperature shall be between 60 ^{o}F (16 ^{o}C) and 90 ^{o}F (32 ^{o}C) at application and for a period of time after application sufficient to assure adequate cure prior to exposure to adverse conditions. Apply evenly to blend with the original surface around the area to be touched up using the blend-in technique (see 3.6.2.1). Allow epoxy primer to dry a minimum of 1 hour or until dry to touch before topcoating. For MIL-DTL-53030, all water shall evaporate prior to top-coating. If the primer has dried for more than 168 hours, it shall be lightly scuff sanded and solvent wiped to promote adhesion. Application of CARC topcoats to surfaces previously painted with CARC (in repair of light topcoat damage) can proceed while the original coat is still tacky. Polyurethane, which has fully cured, shall be thoroughly cleaned and scuff sanded prior to refinishing. Epoxy, which has fully cured, shall be cleaned, scuff sanded, and solvent wiped prior to refinishing. The surface shall be thoroughly clean of absorbed/deposited carbon, salt, fuel, oil, hydraulic/transmission fluid fingerprints and wax. Scuff sand to remove any visible paint defects such as chalk, then solvent wipe prior to application of new topcoat. Do not apply CARC topcoats to surfaces subjected to temperatures in excess of 400 ^{o}F (204 ^{o}C), such as exhaust systems or turbochargers.

3.6.2.3 Application methods. Rework (application of CARC topcoats to sound existing topcoat) shall use the conventional techniques of spraying or brushing. For touchup, suggested procedures include brushing (see appropriate application section of primer and topcoat descriptions) or sponging/wiping (suggested for small areas requiring wash primer). Use good quality equipment with proper technique for spray application by conventional techniques. Small self-pressurized spray kits are also available for use in CARC touch-up procedures. Do not use spray cans that are not officially CARC, as specified in paragraph 2.2.2 of TB-43-0242, WD CARC Spot Painting, dated 3 December, 2007. There are a number of spray cans that are labeled for CARC touch-up. They are a visual color match to CARC, but they do not have CARC properties or approval. They shall not be used for CARC touch-up. The only touch-up kits that shall be used are those approved by ARL. They contain the appropriate CARC and they are supplied in various packaged forms such as spray cans, cartridges and touch-up kits. These are supplied in both the MIL-DTL-53039 and MIL-DTL-64159 and are listed in the QPD.

3.6.2.4 Film thickness. The total thickness of previous coatings shall be checked prior to reworking. Limitations on maximum film thickness to be topcoated shall be determined by an adhesion test on the existing coating in accordance with 4.2.3.6. It is recommended not to exceed a

total of 20 mils (500 microns). For aircraft, the coating thickness (existing plus rework) shall not exceed 8 mils (200 microns). The maximum film thickness shall be 9 mils (225 microns) on a porous, cast item. If thicker prior coatings are experienced, adhesion failure and coating fissuring could result. Cracking (fissuring) of the topcoat due to too thick a film is subtle and difficult to find (magnification is often necessary) but is cause for rejection due to porosity and permeability.

3.7 CARC process notes.

a. Mix thoroughly. The 55 gallon drums supplied in closed head drums, which is normally the case for the MIL-DTL-53039, shall be put on a drum tumbler or drum roller for at least 6 hours before use. Other CARC supplied in open head drums shall be mixed using agitators. A paint shaker for smaller sized containers saves time and eliminates stirring with a paddle or mixer, which promotes moisture contamination and thus shortens the pot life.
b. Keep moisture away from component B in MIL-DTL-64159 and from MIL-DTL-53039, either by the use of very dry (-32 ºF (-36ºC) dew point air dryer) air, desiccant air dryer on air line, or nitrogen argon blanket.
c. Use a separate piece of equipment for epoxy primer and for the urethane topcoat, or thoroughly flush all lines used for both coatings when switching. Do a final flush with the solvent that is compatible with the CARC topcoat.
d. Clean equipment thoroughly and in accordance with manufacturers' instructions for use, and before prolonged storage.
e. Rotate inventory of material first in, first out. CARC has a one year shelf life.
f. Be sure to remove all thinner from coiled hoses before storage. Leave thinner in pumping system. Since thinner dries out pumping system gaskets, a good grade of light oil such as automatic transmission fluid shall be used to prevent this occurrence.
g. When automated equipment such as robotics are used, be sure to use meter mixing equipment, strict viscosity control, material quality control, and total system supervision shall be maintained.
h. Store material in a clean, dry, temperature controlled, OSHA approved storage facility (see 3.8.9).
i. Insist on operator training in operation, maintenance and storage of equipment.
j. Do not use material directly from the container unless thoroughly agitated and mixed.
k. Do not apply the coating to a surface which is contaminated with moisture.
l. Do not allow thinner to stand in the material hoses. The epoxy and the polyurethane material residue reacts, even though thinner or solvent is present, and blocks up mixed material hoses.
m. Do not spray in unventilated areas without proper EPA and OSHA approved spray equipment. For appropriate equipment contact your environmental safety and health coordinator.
n. Do not spray epoxy primer or CARC on a dirty surface. Remove all surface rust, oil, dirt, and loose paint before applying epoxy primer or CARC.
o. Do not leave component A or B of polyurethane topcoat in air-operated pumps for more than two hours without recirculation.
p. To prevent solidification, do not leave mixed materials in hoses, cups, or pumps for longer than 2 hours when not in use, unless a recirculation system is used.
q. Use of commercially available chemical accelerators is strictly prohibited.
r. Where Aircraft Black, color # 37038, is specified for use, Black, color # 37030 is authorized to be used in its place.

s. The effects of decreasing temperature within a facility's painting area doubles the cure time for each 18 degree drop in temperature under 70 ^{o}F (21 ºC**)**.
t. A heated atmosphere accelerates cure time.
u. Induction time is after all components are added, including thinner, if needed.

3.8 Miscellaneous requirements.

3.8.1 Camouflage (exterior). Unless otherwise specified, all material except aircraft shall have a base topcoat of the color Green 383, 34094 for the three color woodland pattern. The system used shall be compatible with and provide good adhesion for subsequent coatings used to provide the camouflage pattern. Tan 686A, 33446 is the base coat for desert application and black CARC component parts shall be indicated on end item drawings or as specified in the contract. CARC shall be topcoated only with CARC.

3.8.2 Surfaces not requiring paint. Fabrics, plastics, rubber working parts of machinery, lubrication fittings and other surfaces not normally painted shall not be painted unless required by the specification for the end item. Such surfaces shall be masked or protected during treatment and painting to prevent damage to them. If the paint doesn't interfere with their function, protection is not required and overspray is allowed.

3.8.3 Engines and other heated areas. Engines shall be cleaned and treated as specified herein and painted in accordance with the applicable engine specification. When cleaning and painting of exhaust manifolds, exhaust pipes, mufflers, and other parts subject to high temperatures in excess of 400 ^{o}F (204 ^{o}C) is specified in the applicable engine specification, the paint shall conform to MIL-P-14105 or TT-P-28, as applicable.

3.8.4 Sealing. Unless otherwise specified in the end item specification, sealing of the interiors of gear cases or similar compartments and reservoirs shall be in accordance with the applicable sealant specification. The sealer shall be applied prior to assembly and shall withstand immersion in lubricating oil, hydraulic fluids, and cutting compounds for the operating temperatures and atmospheric conditions specified for the end item, without wrinkling, blistering, peeling, or loss of adhesion.

3.8.5 Electrical components. Electrical components of equipment not otherwise governed by applicable specifications shall be treated and painted in accordance with the contractor's standard practice.

3.8.6 Aluminum alloys and products. When an aluminum product is processed, the corrosion resistance test described for primer applied to steel specimens outlined in paragraph 4.2.3.7 is not applicable. The primer applied to non-ferrous metals, such as aluminum, shall be tested by the quality assurance test that controls the respective pretreatment, for example, MIL-DTL-5541, for aluminum substrates.

3.8.7 Use of steel wool. Steel wool shall not be used in lieu of emery or garnet abrasives to clean aluminum or magnesium alloy surfaces.

3.8.8 Welding, soldering and brazing. Unless otherwise specified, welding, soldering and brazing shall not be permitted on an assembly after it has been painted with CARC finishes. If necessary to perform one of these procedures after an item is coated, the finish shall be completely removed to the substrate at least four inches in all directions from the work area and

in all areas that reach 400 ^{o}F (204 ^{o}C) and above, including the backside if it is CARC painted. Three recommended methods for removal are the use of plastic media blasting at approximately 40 lb/in^2 (2.812 kg/cm^2), the use of a suitable paint remover or the use of a hand-held portable sander/grinder equipped with a wire brush. After the procedure is finished, the stripped surfaces shall be cleaned, pretreated and repainted (see 3.6).

3.8.9 Handling and storage. Keep CARC components away from heat, sparks, and open flame. Store in tightly closed containers and protect from moisture and foreign materials. At maximum storage temperatures noted below, material slowly undergoes chemical changes without hazard and results in components not being usable. Although ideal storage temperature range is 70-75 ^{o}F (21-24 ^{o}C), normal storage temperature (min/max) of 32-122 ^{o}F (0-50 ^{o}C) shall be allowed. CARC components which are stored at temperatures below the minimum cited above are not degraded, but they shall be returned to usable temperature 60-90 ^{o}F (16-32 ^{o}C) before using. Guaranteed shelf life is 12 months from date of manufacture at 77 ^{o}F (25 ^{o}C).

3.8.9.1 Shelf life. If CARC is received from the GSA or through the supply system after the labeled shelf life expiration date, do not accept it. If a unit accepts CARC that is expired it shall submit a report of discrepancy (ROD) to the appropriate agency immediately. Contact the installation environmental office for guidance on proper disposal of expired materials.

3.8.9.2 Heat, light moisture. If container of material is exposed to heat, it can pressurize and burst. If moisture enters a container of MIL-DTL-53039 or component B of MIL-DTL-64159, the contents react to produce carbon dioxide, which results in pressure building up inside the container. Do not reseal if contamination is suspected. If the paint reaches minimum temperatures of 32 ^{o}F (0 ^{o}C) or below, it thickens however, upon rewarming it is usable. The temperature range specified 60-90 ^{o}F (16-32 ^{o}C) shall be attained throughout the paint before mixing and applying.

4. VERIFICATION

4.1 Inspection conditions. Unless otherwise specified, all inspections shall be performed in accordance with test conditions specified in applicable test method document or applicable paragraph(s) in the specification.

4.2 Examination. The end item treatment and painting shall be examined for the defects specified in table IV.

4.2.1 Test specimens. Unless otherwise specified, standard test panels shall be used instead of parts, provided they are of the same metal as the manufactured parts and have been coated in the same manner at approximately the same time.

4.2.2 Pre-production test surfaces. Determine daily, prior to actual painting, the suitability of the coating mixes with prevailing application parameters such as atmospheric conditions, painting techniques and equipment, thinning and mixing ratios. Determine daily, prior to actual painting, the adequacy of production procedures and practice surfaces (with the specified pretreatment). Separate surfaces shall be prepared (coated) for each coating operation that is pretreatment plus primer and pretreatment plus primer plus topcoat. Test surfaces either on actual steel parts or representative steel panels approximately 4 x 12 inches (10.16 x 30.48 cm) for each coating shall be prepared. Low carbon steel panels shall be substituted for metal parts which are not steel. These surfaces shall be coated with the 4 inch (10.16 cm) dimension positioned vertically and the

12 inch (30.48 cm) horizontally. They shall be observed for blushing, sagging, blisters, improper wet film thickness or other in-process defects detectable during or shortly after application and appropriate adjustments/corrections made. The final successfully coated test surface used to validate each batch/block of production coating application shall be evaluated and recorded.

TABLE IV. Examination.

Item Number	Defect	Reference Paragraph
101	Cleaning not as specified.	3.2
102	Ferrous metal surfaces to be painted not prepared as specified.	3.2.1
103	Surfaces that are not components exempted from abrasive blasting not prepared for painting as specified.	3.2.1.1
104	Ferrous metal surfaces of vehicles not cleaned for painting as specified.	3.2.1.2
105	Zinc surfaces not cleaned as specified.	3.2.2
106	Aluminum surfaces not cleaned as specified.	3.2.3
107	Aluminum-alloy surfaces not cleaned as specified.	3.2.3
108	Magnesium alloy surfaces not cleaned as specified.	3.2.4
109	Cadmium surfaces not cleaned as specified.	3.2.5
110	Pretreatment not applied after cleaning as specified.	3.3
111	Ferrous metal surfaces not treated as specified.	3.3.1
112	Zinc surfaces not treated as specified.	3.3.1
113	Cadmium surfaces not treated as specified.	3.3.1
114	Aluminum surfaces not treated as specified.	3.3.2
115	Magnesium alloy surfaces not treated as specified.	3.3.3
116	Wood surfaces not treated as specified.	3.3.4
117	Primer coatings not prepared as specified.	3.4
118	Primer coatings not reduced as specified.	3.4
119	Primer coatings not applied as specified.	3.4
120	Topcoats not prepared as specified.	3.4
121	Topcoats not reduced as specified.	3.5
123	Previously painted surfaces not treated as specified.	3.6
124	Base topcoat not Green 383, 34094 as specified (except for aircraft).	3.8.1
125	Surfaces not requiring paint shall not be painted unless required by the specification for the end item.	3.8.2
126	Engines not cleaned and treated as specified.	3.8.3
127	Sealing not as specified.	3.8.4
128	Electrical components of equipment not otherwise governed by applicable specifications not treated and painted as specified.	3.8.5
129	Steel wool usage not as specified.	3.8.7
130	Welding not as specified.	3.8.8
131	Soldering not as specified.	3.8.8
132	Brazing not as specified.	3.8.8
133	Handling of CARC components not as specified.	3.8.9
134	Storage of CARC components not as specified.	3.8.9

4.2.3 Validation. Materials, prior to their use, shall be inspected, sampled and validated to determine compliance with the requirements of the particular specification. However, tests in the material specifications are for the qualification process, and are not necessarily indicative of production performance. All primers and topcoats in the CARC system are QPD items. Certification from the primer or topcoat manufacturer shall include a copy of all quality conformance tests as well as a copy of the Army's validation for the topcoat of the spectral and specular reflectance characteristics of the paint lot when required by the applicable specification.

Conformance inspection requirements for epoxy primers MIL-DTL-53022 and MIL-DTL-53030 and any newly published or revised specification requires the submission from each production lot a batch validation letter detailing the batch number, manufacturer's code, specification and type number, QPL number and batch volume to U.S Army Research Laboratory, ATTN: RDRL-WMM-C, Organic Coatings Team, Building 4600, Deer Creek Loop, Aberdeen Proving Ground, MD 21005-5066.

4.2.3.1 Condition of surface. All properly cleaned and pretreated surfaces shall be examined just prior to painting to assure that the surface is dry and free from soil or contamination of any kind. Immediately prior to painting, the surface shall be subjected to a water break test. A mist of distilled water shall be atomized on the surface, employing any convenient small atomizing device. If the water droplets tend to coalesce into large lenses lasting for 25 seconds, (without a sudden flashout), the surface shall be considered as having satisfactorily passed the water break test. If the water gathers into droplets within 25 seconds (if the surface shows a "water break" within that time), the surface shall be considered as having failed the test. If the water forms a continuous film by flashing out suddenly over a large area, this shall be considered evidence of the presence of an impurity on the surface such as free alkali, residual detergent, and the surface shall be considered as having failed the test. Failure to support an unbroken water film shall be sufficient cause to do additional cleaning. If more than four hours have passed since performing the water break test and no pretreatment has been applied, re-examine the surface for corrosion, foreign matter or oily residues and repeat the water break test prior to pretreatment. After testing, all moisture shall be removed to ensure a clean, dry surface for painting. Use cleaning materials effective against the particular type of contaminant causing problems. Multiple cleaning procedures shall be required to provide the required water break free surface.

4.2.3.2 Solvent wipe. The solvent wipe test shall be performed to establish that the CARC finish coats are properly prepared and adequately cured to withstand adverse storage. Topcoat solvent wipe test shall be performed after a minimum of 168 hours air drying. If the temperature of the test item drops below 60 ^{o}F (16 ^{o}C), additional time shall be allowed before performing the test. Thoroughly wet a rag with acetone or methyl ethyl ketone (MEK) and briskly rub the painted surface for ten seconds to remove any dry spray or overspray. Wet another clean dry rag with acetone or MEK and briskly rub the same area with 20 strokes approximately six inches (15.24 cm) in length. Evidence of paint removal down to the previous coated surface is evidence of an unacceptably prepared topcoat or an uncured film. These items shall be rejected and reworked in accordance with 3.6 or allowed further cure time and the wipe test repeated. In the latter case, the tested area shall be reworked in accordance with 3.6 to repair any areas of topcoat removal. This test shall be performed in a well ventilated area while wearing gloves to prevent skin contact with the solvents. Contact the installation environmental office for guidance on proper disposal of rags used for the solvent wipe test.

4.2.3.3 Dry film thickness. The upper limits on film thickness are not mandatory for surface areas on which such limits are impractical to maintain; for example, contoured areas. However, film thickness shall be controlled in these areas, to prevent excessive deposition of paint. Film thickness tests shall be performed on uniform coated surfaces. Thickness testing shall be performed using a conventional nondestructive measuring device such as a magnetic tester in accordance with ASTM B499, an eddy current tester in accordance with ASTM B244, or other acceptable standard methods. Recommended thickness requirements for CARC primers and topcoats are listed in table V. If the upper limits are exceeded the remaining quality assurance provisions specified in section 4 shall be met. Previously applied coatings to the test area shall

be identified prior to topcoating, such as repair or rework areas. These previous coatings shall be measured and recorded in sequence to accommodate each progressive coating thickness determination. Unless otherwise specified, rejection shall not be made based upon the maximum dry film thickness recommendations of table V, but on subsequent performance failure of another quality assurance provision of section 4. The minimum film thickness shall be maintained. Primer thickness requirements are subject to the manufacturers' recommendations. Excessive primer thickness affects dry and recoat times and ultimately cure times. Adhesion problems occur with excessive primer thickness.

TABLE V. Dry film thickness (mils).

A-A-59745	2.5 – 3.5
MIL-C-8514	0.3 – 0.5
DOD-P-15328	0.3 – 0.5
MIL-PRF-23377	0.8 – 1.2 1/
MIL-DTL-53022	1.3 – 1.7
MIL-DTL-53030	1.3 – 1.7
MIL-PRF-32348	1.8 – 2.2
MIL-DTL-53084	1.0 – 1.2
MIL-PRF-85582	0.8 – 1.2 1/
MIL-DTL-53039	1.8 – 2.5 2/
MIL-DTL-64159	1.8 – 2.5 2/
MIL-PRF-22750	1.7 – 2.3

1/ Except for aircraft, then 0.6-0.9 mils.
2/ Except when using black electrocoat primer, then 2.0-2.5 mils.

TERMS: 1 mil = 25 microns.

4.2.3.4 Marring. Marring and surface lightening due to handling is characteristic of camouflage coatings and does not impede camouflage or the infrared properties of MIL-DTL-53039 or MIL-DTL-64159. This is typical of low gloss and low sheen coatings, and is especially prevalent in dark colors. It is not grounds for re-work unless the film has been damaged down to the substrate.

4.2.3.5 Camouflage requirements and batch validation. Only suppliers approved and listed on the applicable QPD for MIL-DTL-53039 or MIL-DTL-64159 and MIL-PRF-32348 under type III and type IV coatings supply CARC. For every batch manufactured, the spectral reflectance, gloss and STB resistance are verified with batch validation by ARL, ATTN: RDRL-WMM-C, Organic Coatings Team, Building 4600, Deer Creek Loop, Aberdeen Proving Ground, MD 21005-5066. The paint manufacturer usually initiates the process prior to shipment and results are normally available in four working days. A copy of the certification from ARL shall be made available to inspectors for each batch of paint applied. Slight visual color differences occur between manufacturers or batches yet are not grounds for equipment rejection as long as a batch certification is on hand from ARL and there are no film defects such as blushing or hazing. Improper mixing or application can cause a dry film color that is obviously not as specified. These batch certifications are supplied to the manufacturer on each batch of CARC topcoat that is manufactured.

4.2.3.6 Adhesion. Periodic checks shall be made of the overall adhesion of the CARC system, both primer to substrate and intercoat. Where possible, testing shall be performed daily on a production item in an area of uniform film thickness (see 4.2.3.3), after a minimum of 168 hours

drying time. The precise location for the adhesion test shall be in an obscure location and be acceptable to the cognizant Government quality assurance representative. The dry adhesion test shall be the default procedure. If results are questionable, the wet adhesion test shall be required.

4.2.3.6.1 Dry adhesion. Perform the adhesion test in accordance with ASTM D3359, method B, cross cut tape adhesion, using the 6-line pattern and 2 mm (0.079 inch) spacing. After the test has been performed, removal of 3 or more squares constitutes test failure. Minor flaking from scribe intersections is permitted, as is removal of overspray. Where the film build is greater than 5 mils (125 microns), adhesion testing shall be performed in accordance with ASTM D3359, method A. In any case, the scribed area shall be repaired in accordance with the procedure established in 3.6.1 and 3.6.2. Rejected items shall be reworked in accordance with 3.6.

4.2.3.6.2 Wet adhesion. The wet adhesion test shall be performed in accordance with ASTM D3359. Removal beyond .0625 inches (1.588 mm) on either side of the scribed lines constitutes test failure.

4.2.3.6.3 Force dry of CARC topcoat. The drying of CARC topcoats is normally performed at room temperature or force dried in a paint booth at temperatures up to 120 ^{o}F (49 ºC). Higher temperatures are used when small and component parts are put onto a conveyor line to expedite the process. When CARC topcoats are dried and cured at temperatures of 180 ^{o}F (82 ºC) or greater, then caution shall be taken to assure that the CARC can be recoated with itself. In cases as this, the CARC topcoat shall first be validated to assure that the higher temperatures do not affect the ability of the coating to be recoated. A representative part or sample panels shall be coated with the CARC system that is used in production and processed through the production line under the same conditions that are used to coat production parts. After the parts or panels have been exposed to the elevated temperatures, they shall be left to sit for 24 hours. They shall then be topcoated with the same CARC topcoat and air dried for 168 hours. Dry tape adhesion tests, as described in 4.2.3.6 and 4.2.3.6.1, shall be performed to check the intercoat adhesion. If the adhesion tests pass, then production shall start with the CARC that was evaluated. This testing shall be done whenever a production line starts up using elevated temperatures of 180 ^{o}F (82 ºC) or greater to dry, or whenever a change of CARC topcoat is made under the conditions of elevated temperatures for drying.

4.2.3.7 Corrosion resistance. Panels shall be used for preproduction, but for testing end items (hardware) on contracts, actual parts are to be used as well as the accelerated corrosion resistance test specified in TT-C-490. Corrosion resistance is demonstrated on steel specimens (representative 4 x 12 inch (10.16 x 30.48 cm) panels) after application of the primer. The minimum test frequency shall be in accordance with the technical data package or every 30 days. After complete curing (168 hours at 70 ºF (21 ºC) or equivalent) the parts or representative panels shall be subjected to a 5 percent salt spray test in accordance with ASTM B117 at 336 hours, or at 1,000 hours, or as specified based upon the specification primer and type used. If panels are used, coat the edges and uncoated metal surfaces with a suitable coating. Corrosion in excess of a trace of rusting (ASTM D610, No. 9) or more than five scattered blisters, none larger than 1 mm (0.039 in) in diameter visible to the unaided eye on the panel or actual parts shall be cause for rejection. When scribed panels are used, the scribed areas shall have ratings in accordance with ASTM D1654, method A of not less than 6 for steel or 8 for aluminum panels. Failure at edges and other sharp corners shall not be cause for rejection. Failure to meet the corrosion resistance requirement shall be cause for rejection of parts coated since the previous test period. CARC

product formulations are now capable of more vigorous corrosion resistance testing procedures (see 6.5) for a test protocol under consideration.

4.2.3.7.1 Non-ferrous substrates. Test variations shall be followed for testing the primer coat used on non-ferrous substrates. Those specified for use in the respective pretreatment specification shall be more appropriate for use (see 3.8.6).

4.2.3.8 Workmanship. When visually inspected, the coating shall be a smooth, continuous, adherent film which is free of such surface imperfections as runs, sags, blisters, orange peel, blushing, streaks, craters, blotches, brush marks, fish eyes, seediness or pinholes.

5. PACKAGING

5.1 Packaging. This section is not applicable to this specification.

6. NOTES

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

6.1 Intended use. The CARC system of primers and topcoats is designed for use on the exterior and interior of tactical military equipment. It may also be used where severe exposure situations require a coating with excellent durability and corrosion resistance.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this specification.
b. Type of finish as defined in 3.1.
c. When blast cleaning required (see 3.2.1).
d. When wood surfaces will not be pressure treated (see 3.3.4).
e. Color of topcoat if other than those in the 3-color pattern (see 3.5).
f. Camouflage painting and marking of Army materiel conforming to AR 750-1.
g. Referenced NSN.
h. Health and safety issues including facilities, worker safety procedures and equipment, toxic and hazardous waste management, and occupational health requirements.

6.3 Color chips. Color chips for CARC finishes are available from two sources. Chips for the camouflage colors in MIL-DTL-53039 and MIL-DTL-64159 are obtained from ARL, ATTN: RDRL-WMM-C, Organic Coatings Team, Building 4600, Deer Creek Loop, Aberdeen Proving Ground, MD 21005-5066, and are intended to be used by paint manufacturers in calibrating their instruments. These calibrated chips from ARL are not intended to be used for visual color inspections, but to assist paint formulators in color development work. Camouflage colors specified in the CARC topcoat specifications have a batch validation requirement and eliminate the need for inspection. If color inspection becomes a concern, request a copy of the batch validation letter. For appearance information only, color chips can be obtained by using the five digit color number of FED-STD-595. The non-camouflage colors found in MIL-DTL-53039, MIL-DTL-64159 and MIL-PRF-22750 should match the appropriate color chips from FED-STD-595. These chips can be purchased from the GSA Property Management, GSA/CO/3FPD, 470 L'Enfant Plaza East, SW, Suite 8100, Washington, DC 20407.

6.4 Qualifying activity responsibility. The qualifying activity responsible for MIL-PRF-23377 and MIL-PRF-85582 is the Commander, Naval Air Systems Command, Systems Standardization Division, Code 4L8000B120-3, Highway 547, Lakehurst, NJ 08733-5100. The qualifying activity responsible for MIL-DTL-53022, MIL-DTL-53030, MIL-DTL-53084, A-A-59745, MIL-PRF-32348, MIL-PRF-22750, MIL-DTL-53039 and MIL-DTL-64159 is ARL, Weapons and Materials Research Directorate, ATTN: RDRL-WMM-C, Aberdeen Proving Ground, MD 21005-5066.

6.5 Experimental program. ARL conducts an Experimental Products Program (EPP) to evaluate performance-based alternatives to specification products. These materials generally offer benefits such as environmental acceptability or improved performance that is not currently available in the specification. These products may be used prior to appearing on the applicable QPD with approval from the appropriate program office. These products will be issued an EPP approval letter prior to being included into an appropriate QPD. Subsequent revision of the specification allows the EPP products to be converted to normal QPD listings. Confirmation of EPP approval can be obtained from ARL, ATTN: RDRL-WMM-C, Organic Coatings Team, Building 4600, Deer Creek Loop, Aberdeen Proving Ground, MD 21005-5066.

6.6 Coating characteristics. The coatings and their characteristics are listed in the following table.

TABLE VI. Coating characteristics.

Specification	Primer Category		Toxic Metals	VOC Category		
	Pre-treated ferrous	Pre-treated non-ferrous	Lead and chromate free	Federal 3.5 lbs/gal (420 g/l)	SCAQMD Rule 1124 2.9 lbs/gal (348 g/l)	SCAQMD Rule 1107 2.8 lbs/gal (340 g/l)
MIL-PRF-23377		X	class N 1/	X	X	X
MIL-DTL-53022	X	X	X	X	X	X
MIL-DTL-53030	X	X	X	X	X	X
MIL-DTL-53084	X	X	X	X	X	X
MIL-PRF-85582		X	class N 1/	X	X	X
A-A-59745	X		X	X	X	X
MIL-PRF-32348	X	X	X	X	X	X
MIL-PRF-22750	N/A	N/A	X	X	X	X
MIL-DTL-53039	N/A	N/A	X	X	X	X
MIL-DTL-64159	N/A	N/A	X	X	X	X

1/ In accordance with Memorandum, AMSAM-EN-EV, 29 January 2009, Subject: Implementation of Non-Hexavalent Chromium Coating System on Army Aircraft, class N (type I or II) is approved for use as a primer on Army Aviation Systems.

6.7 Touch-up kits. Only authorized and approved touch-up kits are allowed for the repair, touch-up or stenciling of existing CARC coatings. These are supplied in various forms and are approved with QPD numbers by ARL. For further information, contact ARL, ATTN: RDRL-WMM-C, Organic Coatings Team, Building 4600, Deer Creek Loop, Aberdeen Proving Ground, MD 21005-5066. Spray cans that are designed specifically for a color match and not previously approved by ARL cannot be used.

6.8 New heavy metal-free pretreatments. Novel corrosion inhibitors, pretreatments, primers and topcoats are being developed and evaluated as alternatives to zinc phosphate, chromate conversion coatings and wash primers for inclusion in the CARC system. For further information on products being tested and approved, contact ARL, ATTN: RDRL-WMM-C, Organic Coatings Team, Building 4600, Deer Creek Loop, Aberdeen Proving Ground, MD 21005-5066 or the contracting agency.

6.9 Subject term (key word) listing.

Aircraft
Equipment
Guide
Powder
Pretreatments
Primer
Surfaces
Thinner
Topcoat

6.10 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

CONCLUDING MATERIAL

Custodians:
Army - MR
Navy - SH
Air Force - 11

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

Civil agency:
GSA/FAS

Preparing activity:
Army - MR

(Project 8010-2010-006)

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/.