INCH-POUND

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DETAIL SPECIFICATION

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

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 chemical agent resistant coating (CARC) system used on tactical military equipment. It is intended for use as a guide in selection of the appropriate materials and procedures, and as a supplement to information available in the below referenced cleaning, pretreating, and coating specifications. The document also includes information on touchup/repair, health and safety guidelines, environmental restrictions, national stock numbers (NSN) for CARC and CARC-related materials, and application equipment and techniques (see 6.5).

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents 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 documents cited in sections 3 and 4 of this specification, whether or not they are listed.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: U.S. Army Research Laboratory, ATTN: AMSRL-WM-MA, APG MD 21005-5069 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 8010

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 listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS AND STANDARDS

FEDERAL

TT-C-490 - Cleaning Methods and Pretreatment of Ferrous Surfaces for Organic Coatings
TT-P-28 - Paint, Aluminum, Heat resisting (1200° F)
FED-STD-141 - Paint, Varnish, Lacquer and Related Materials; Methods of Inspection, Sampling and Testing
FED-STD-595 - Colors Used in Government Procurement

DEPARTMENT OF DEFENSE

MIL-C-5541 - Chemical Conversion Coatings for Aluminum and Aluminum Alloys
MIL-C-8514 - Coating Compound, Metal Pretreatment, Resin-Acid
MIL-A-8625 Anodic coatings, for Aluminum and Aluminum Alloys
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-C-46168 - Coating, Aliphatic Polyurethane, Chemical Agent Resistant
MIL-P-53022 - Primer, Epoxy Coating, Corrosion Inhibiting, Lead and Chromate
MIL-P-53030 - Primer Coating, Epoxy, Water Reducible, Lead and Chromate Free
MIL-C-53039 - Coating, Aliphatic Polyurethane, Single Component, Chemical Agent Resistant
MIL-P-53084 - Primer, Cathodic Electrodeposition, Chemical Agent Resista
MIL-DTL-64159 - Coating, Water Dispersible Aliphatic Polyurethane, Chemical Agent Resistant
MIL-T-81772 - Thinner, Aircraft Coating
MIL-PRF-85582 - Primer Coatings: Epoxy, Waterborne

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Document Automation and Production Service, Building 4D, 700 Robbins Avenue, 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 are those cited in the solicitation.

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 the documents which are DoD adopted are those lissted in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

A380 - Standard Practice for Cleaning, Descaling, and Passavation of Stainless Steel Parts, equipment and Systems
B117 - Salt Spray (Fog) Testing.
B244 - Measurement of Thickness of Anodic coatings on Aluminum and of Other Nonconductive Coatings on Nonmagnetic basis Metals with Eddy-Current Instruments
B499 - Measurement of Coating Thickness by the Magnetic Method: Non-Magnetic Coatings on Magnetic Basis Metals
D1193 - Standard Specification for Reagent water
D3359 - Measuring Adhesion by Tape Test

(Application for copies should be addressed to the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.)

AMERICAN WOOD PRESERVERS ASSOCIATION (AWPA)

AWPA-C22 - Lumber and Plywood for Permanent Wood Foundations – Preservative Treatment by Pressure Processes
AWPA-P5 - Preservative, Waterborne, Standards for

(Application for copies should be addressed to the American Wood Preservers Association, P.O. Box 5690, Granbury, Texas 76049-0690.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE-AMS-QQ-P-416 - Plating, Cadmium (Electrodeposited)
SAE-AMS-M-3171 - Magnesium alloy, Processes for Pretreatment and Preventation of Corrosion on
SAE –AS-22805 - Spray Kit, Self-Pressurized

(Application for copies of SAE Aerospace Material specifications should be addressed to SAE, 400 Commonwealth Drive, Warrendale, PA 15096-001.)

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

Rule 102 - Photochemically Reactive Solvents
Rule 1107 - Manufactured Metal Parts and Products Coatings
Rule 1124 - Aerospace Assembly and Component Coating Operations

(Application for copies should be addressed to the South Coast Air Quallity Management District, 9150 E. Flair Drive, El Monte, CA 91731.)

STEEL STRUCTURES PAINTING COUNCIL (SSPC)

SSPC-SP-5 - White Metal Blast Cleaning
SSPC-SP-6 - Commercial Blast Cleaning
SSPC-SP-10 - Near-White Blast Cleaning

(Application for copies should be addressed to the Steel structures Painting Council, 4400 Fifth Avenue, Pittsburgh, PA 15213.)

2.4 Order of precedence. 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; cleaning, pretreating, priming, and topcoating. The cleaning and pretreating procedures are standard methods required in any finishing process. When a wash primer pretreatment is used, drying/reaction must be complete when used under CARC. Otherwise adhesion and the CARC system may be adversely affected. The anticorrosive primers are 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 List (QPL) items; that is, there is a list of approved suppliers which must be used for product procurement. In addition, each batch of polyurethane topcoat must be checked by the specification preparing activity (SPA) for validation of the spectral reflectance (camouflage properties) and DS2 resistance. The local safety office, preventative medicine activity, and local medical support facility must be consulted prior to initiating CARC application. For guidance, see appendix B. For miscellaneous requirements, see 3.8. Pertinent specifications are listed in table I.

TABLE I. The CARC System .

Process	Ferrous Metal	Non-Ferrous Metal
Cleaning	TT-C-490	TT-C-490
Pretreating	TT-C-490, I (Zn phosphate) DOD-P-15328 (wash primer) MIL-C-8514 (wash primer)	DOD-P-15328 (wash primer) MIL-C-8514 (wash primer) MIL-C-5541 (chromate conversion) MIL-A-8625 (anodize)
Priming	MIL-P-53022 MIL-P-53030 MIL-P-53084	MIL-PRF-23377 MIL-P-53022 MIL-P-53030 MIL-P-53084 MIL-PRF-85582
Topcoating	MIL-PRF-22750 (interior only) MIL-C-46168 MIL-C-53039 MIL-DTL-64159	MIL-PRF-22750 (interior only) MIL-C-46168 MIL-C-53039 MIL-DTL-64159

3.2 Cleaning. Improperly cleaned surfaces are unacceptable because they limit or interfere with paint adhesion, causing subsequent paint loss in service, which will leave the substrate unprotected from the environment. Unless otherwise specified, the surface should be thoroughly cleaned according to TT-C-490. Method of cleaning is determined by the base material properties, the nature of the soil and the degree of contamination and by use of any of the methods or combination of the methods below:

a. Chemical methods (such as solvent cleaning, alkaline cleaning, acid cleaning, pickling, descaling with hydride or paint stripping), or
b. Electrochemical cleaning methods (such as electropolishing, electrolyte alkaline, or electrolytic pickling), or
c. Mechanical means such as blasting, chipping, wire brushing, or grinding.

Cleaning materials/methods, which may be effective against one type of contaminant, may be ineffective against others; therefore, multiple cleaning methods may be required to provide a clean surface. Detergents or solvents must be used to remove soil prior to abrasive blasting or mechanical cleaning. Surface oxides, rust weld spatter and other inorganic contaminants shall be removed prior to pretreatment using appropriate mechanical/chemical cleaning methods. After cleaning, all surfaces shall be kept free from dirt, dust, finger marks, and other contaminants. Meticulous cleaning prior to pretreatment and painting operations cannot be overemphasized since this factor is of prime importance in obtaining a satisfactory coating meeting the requirements of this specification.

3.2.1 Ferrous metal surfaces. Unless otherwise specified, ferrous metal surfaces to be painted shall be cleaned in accordance with 3.2. Where blasting is appropriate, blast in accordance with Steel Structures Painting Council (SSPC) Specification SSPC-SP-6 to remove millscale, products of corrosion, dirt, casting, sand, slag, and other foreign substances. Also, when stated, blast-cleaning shall be in accordance with SSPC-SP-5 or SSPC-SP-10, as required (see Steel Structures Painting Council Manual, Volume 2 for more information). Blast-cleaned surfaces that are to be pretreated with wash primer shall be chemically treated within four hours and dried for at least one hour at 70 ^{o}F to ensure completeness of the chemical reaction prior

to application of a primer. This is done to improve the adhesion of the prime coat that should be applied as soon as practicable after pretreatment. If more than four hours pass before pretreatment, the blasted surface must 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. Blasting shall not be used on surfaces which could be damaged, such as machine parts and sheet metal thinner than 16 gage (0.0625 inch).

3.2.1.1 Exemptions from abrasive blasting. Blasting is optional on components painted for protection during limited storage, from which the paint will be worn off as soon as the equipment is placed in use. 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 dry and free from oil, grease, dirt, and rust 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 may be cleaned to base metal by such alternate means 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 inch) and thinner may 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 may not be approved for use on assemblies which may entrap acid/alkali or when for any reason chemical cleaning is considered inadvisable.

3.2.2 Zinc surfaces. Zinc surfaces, including zinc-coated substrates, need to 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.

3.2.6 Cleanliness. After cleaning, all surfaces shall be kept free from dirt, dust, fingerprints, and other contaminants until treated as specified in 3.3. Prior to pretreatment, the surface must pass the water break test described in 4.2.3.1.

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 two most common types are straight conversion (either chromate or phosphate) and organic (vinyl wash primer) modified conversion.

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:

3.3.1.1 Zinc phosphate conforming to TT-C-490, type I.

3.3.1.2 Wash primer (DOD-P-15328 and MIL-C-8514) conforming to TT-C-490, type III. These organic pretreatments are applied to clean metal surface to prepare it 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 should be coated with primer as soon as practicable, but no more than 24 hours later. Otherwise, it shall be stripped and the finishing process started again. Under standard atmospheric conditions of 60 to 90^{o} Fahrenheit (F), the material is sufficiently dry for recoating one hour after application.

However, it may be possible to apply the wash primer outside this range provided appropriate quality controls are used (see 4.2.3). The pretreatment should not be applied to wet surfaces. The dry film thickness should be from 0.3 to 0.5 mil. To prepare DOD-P-15328, the resin component should be well stirred with care taken that all settled pigment is completely dispersed. The acid component should be added slowly with stirring, continuing until a complete blending of the mixture is assured. 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 it up. The pretreatment is most effective when freshly mixed and must be used within 8 hours after the addition of the acid component. The quantity of pretreatment mixed for use shall be the amount required for immediate application. The acid component is not thinner. It is a necessary activator and must be used exactly as directed.

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:

3.3.2.1 Anodize aluminum and aluminum alloy castings in accordance with MIL-A-8625. Minimum thickness of 0.0007 inches is required for wrought aluminum and 0.0004 inches is required for castings.

3.3.2.2 Chemical conversion conforming to MIL-C-5541.

3.3.2.3 Wash primer conforming to TT-C-490, type III (see 3.3.1.2) can be used but MIL-C-8514 is the preferred wash primer for aluminum and aluminum alloy.

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 C22 for above-ground, or AWPA P-5 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 which will be 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 may be specified prior to application of a wash primer conforming to DOD-P-15328 or MIL-C-8514 (see 3.3.1.2).

3.4 Priming. The primer shall be applied to a clean, dry surface as soon as possible after cleaning and pretreating. The ambient temperature should be between 60 and 90 ^{o}F, but the primers may be applied outside this range without adverse effects, provided appropriate quality control checks are performed (see 4.2.3). The paint and surface shall be approximately the same temperature, and application shall be by brush or spray, depositing a continuous, adherent, dry film which is smooth, even, and free from runs, sags, or other defects which might interfere with the application and adhesion of subsequent coats (see 4.2.3.8). If paint heaters are used to assist in application, the substrate to be coated must be at least at an ambient temperature of 60 ^{o}F. Dipcoating is not recommended for CARC primers. The five anticorrosive primers are epoxies, and all are two component products. They are applied to metal substrates to provide corrosion resistance and a surface to which the CARC topcoat will firmly adhere. As two component products, they dry by a two stage process of solvent evaporation and chemical crosslinking, and they have a finite potlife, typically 8 hours. Environmental conditions, particularly temperature and relative humidity, will affect potlife, curing, and adhesion. For ordering information (NSN) see appendix A; for health, safety and environmental information, see appendix B; and for application equipment and techniques, see appendix C. In areas where air quality regulations restrict volatile emissions, do not add thinner to the coating material if that addition will exceed the regulatory limit. The specific information below for the five primers is summarized in table II.

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 per liter (g/L)(2.8 pounds per gallon [lb/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 class N. Class C contains strontium chromate based corrosion inhibitors and class N contains non-chromate based 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 authorized.

3.4.1.3 Preparation. Thoroughly stir each of the components separately prior to admixing. While slowly pouring component B into component A, continue to stir until the manufacturers specified volume mixing ratio is achieved. Reduction of component A (pigmented solution) with component B (clear solution) shall be per manufacturer's instructions. Component B shall always be added to component A, and this procedure shall not be reversed. The temperature of each component shall be 65 to 95 ^{o}F before mixing.

3.4.1.4 Reduction. Reduce the admixed primer if necessary with MIL-T-81772 type II, but do not exceed the VOC limit of 340 g/L (2.8 lb/gal). The reduced primer should be continuously stirred to allow thorough mixing and to counter pigment settling. It should then be strained through a 40 mesh paint filter or equivalent and allowed to 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 must be thoroughly cleaned as specified in 3.2 and pretreated as specified in 3.3. To insure 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 should be sprayed with one full wet coat and needs to dry up to 6 hours (dry to touch) before applying the topcoat. Time will depend on conditions. The admixed primer must be used within 8 hours after mixing to insure performance. The dry film thickness should be between 0.6 and 0.9 mils for aluminum and between 0.8 and 1.2 mils for aluminum-steel assemblies. The largest factor affecting cure is temperature. At 70 ^{o}F, the dry to touch time is up to 6 hours when checked according to FED-STD-141, method 4061. The effect of decreasing temperature within a facility's painting area will double the cure time for each 18 degree drop in temperature under 70 ^{o}F. The cure time can be accelerated by a heated atmosphere.

3.4.1.6 Components. The primer furnished under this specification shall be products which are authorized by the qualifying activity for listing on the Qualified Products List (QPL) (see 6.4).

3.4.2 MIL-P-53022 (primer, epoxy, corrosion inhibiting, lead and chromate free).

3.4.2.1 Description. This specification covers a flash drying, corrosion inhibiting epoxy primer for ferrous and nonferrous metals. It is formulated lead and chromate free, and type I will satisfy hydrocarbon emissions as defined in Rule 102 of the South Coast Air Quality Management District, while type II satisfies a 420 g/L (3.5 lb/gal) VOC level. It is a two package system consisting of a pigmented epoxy resin (part A) and a polyamine - epoxy adduct catalyst (part 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 and provides a lead and chromate free formulation.

3.4.2.3 Preparation. The components shall be thoroughly mixed prior to and after admixing. Mix four parts of part A to one part of part B by volume and stir until well blended. The temperature of each component shall be 65 to 95 ^{o}F before mixing.

3.4.2.4 Reduction. If necessary and allowed, the admixed primer can be reduced for spraying up to 20 percent by volume with MIL-T-81772, type I or II. The thinned primer should be thoroughly stirred, strained through a 40 mesh paint filter or equivalent and allowed to stand 30 minutes prior to use and should continue to be stirred throughout the primer application.

3.4.2.5 Application. All surfaces to be painted must be thoroughly cleaned as specified in 3.2 and pretreated as specified in 3.3. To insure 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 1.0 and 1.5 mil with one full wet coat. The primer need only be set to touch before applying the topcoat. This is usually between 15 and 45 minutes in accordance with FED-STD-141, method 4061, depending on conditions. The admixed type I primer must be used within 8 hours after catalyzing to insure performance, but type II material must be used within four hours. Potlife is shortened at higher temperatures. The largest factor affecting cure is temperature. At 70 ^{o}F, the dry to touch time is between 15 and 45 minutes. Dry to handle time is 90 minutes to 4 hours depending on the type. The effect of decreasing the temperature within a facility's painting area will double the cure time for each 18 degree drop in temperature under 70 ^{o}F.

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 Qualified Products List (QPL) (see 6.4 and 6.5).

3.4.3 MIL-P-53030 (primer coating, epoxy, water reducible, lead and chromate free).

3.4.3.1 Description. This primer is a water reducible, air-drying, corrosion inhibiting epoxy primer. It is a two component system with a pigmented polyamide (component A) and a clear epoxy (component B). The primer is formulated lead and chromate free and contains no more than 340 g/L (2.8 lbs/gal) of volatile organic compounds as applied, in accordance with Rule 1107 of the South Coast Air Quality Management District.

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 stir component A until uniform. Mix one volume of component B with three volumes of component A until a smooth homogeneous mixture is achieved. The temperature of each component shall be 65 to 95 ^{o}F before mixing.

3.4.3.4 Reduction. Reduce the admixed primer with deionized water to a spraying viscosity of 18 - 24 seconds in a number 2 Zahn cup. The thinned primer shall be stirred thoroughly, strained through a 40 mesh paint filter or equivalent and allowed to stand for 30 minutes prior to use.

3.4.3.5 Application. All surfaces to be painted must be thoroughly cleaned as specified in 3.2 and properly pretreated as specified in 3.3. To insure 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 waiting period, the primer shall be sprayed to a dry film thickness between 1.0 and 1.5 mils with one full wet coat. The primer need only be set to touch (FED-STD-141, method 4061) before applying the topcoat, but all water must have evaporated. This is usually between 30 minutes and one hour depending on conditions. The admixed primer must be used within 6 hours after catalyzing to insure performance. The largest factor affecting cure is temperature. At 70 ^{o}F, the dry to touch time is 30 to 60 minutes and the dry to handle time about 2 hours. The effect of decreasing the temperature within a facility's painting area will double the cure time for each 18 degree drop in temperature under 70 ^{o}F. Due to the fact that the primer is a water-reducible system, a high relative humidity will retard the dry time while a low relative humidity will accelerate the process. Potlife is shortened by temperature increase.

3.4.3.6 Comments. The primer furnished under this specification shall be a product that is authorized by the qualifying activity for listing on the Qualified Products List (QPL) (see 6.4). Since the sprayed primer contains water, care must be taken to insure the surface is dry to touch before application of polyurethane topcoats. Premature top coating may lead to an undesirable reaction between water evaporating from the primer and the catalyst component of the urethane being applied. The undesirable reaction will produce defects such as blisters, gas bubbles or pinholes in the topcoat film, compromising the CARC properties.

3.4.4 MIL-P-53084 (primer, cathodic electrodeposition, chemical agent resistant).

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

3.4.4.2 Use. This primer is intended for use on properly cleaned and pretreated ferrous and nonferrous metal surfaces. It is formulated lead and chromate free 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 should provide instructions for mixing and thinning. Prepare the primer bath by mixing resin feed and pigment paste components that have been rinsed and thinned (reduced) with pure deionized water that is free of bacteria (conductivity less than 10 microhms per centimeter). After mixing components allow bath to be stirred and agitated for a 24-hour period to facilitate thorough mixing and reduction.

3.4.4.4 Reduction. After preparation of the bath, allow it to stir for 24 hours prior to use. During the deposition process, the bath must be constantly agitated.

3.4.4.5 Application. All surfaces to be painted must be thoroughly cleaned as specified in 3.2 and pretreated as specified in 3.3. To insure 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 manufacturer's 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 Qualified Products List (QPL) (see 6.4).

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 have a maximum volatile organic compound (VOC) content of 340 grams per liter (g/L)(2.8 pounds per gallon [lb/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) 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 authorized.

3.4.5.3 Preparation. The epoxy primer shall be prepared by first thoroughly mixing each of the components separately. 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 temperature of each component shall be 65 to 95 ^{o}F before mixing.

3.4.5.4 Reduction. Reduce the admixed primer with water according to the manufacturer's recommended procedure using water conforming to type IV of ASTM D 1193. The thinned primer shall be stirred thoroughly, strained through a 40 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 must be thoroughly cleaned as specified in 3.2 and properly pretreated as specified in 3.3. To insure 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 with one full wet coat to a dry film thickness between 0.6 and 0.9 mils for aluminum and between 0.8 and 1.2 mils for aluminum-steel assemblies. The primer need only be set to touch (FED-STD-141, method 4061) before applying the topcoat. This is usually between 30 minutes and 1 hour depending on conditions. The admixed primer must be used within 4 hours after catalyzing to insure performance. The largest factor affecting cure is temperature. At 70 ^{o}F, 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 will double the cure time for each 18 degree drop in temperature under 70 ^{o}F. Due to the fact that this is a water-reducible system, a high relative humidity will retard the cure time while a low relative humidity will accelerate 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 Qualified Products List (QPL) (see 6.4). Since the sprayed primer contains water, care must be taken to insure the surface is dry to touch before application of urethane topcoats. Premature topcoating may lead to an undesirable reaction between the water evaporating from the primer and the catalyst component of the urethane being applied.

TABLE II. General application guidelines for epoxy primers.

SPECIFICATION	MIXING	REDUCTION	APPLICATION
MIL-PRF-23377	Add Comp B to Comp A Temp 65-95 °F, prior to mixing as specified by manufacturer.	Stir and strain Set 30 minutes before use	Spray with one full coat. Wait 5-6 hours prior to topcoating Use within 8 hours Thickness 0.8-1.2 mils 1/
MIL-P-53022	Four parts Comp A to one part Comp B Add B to A Temp 65-95 °F, 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 5-6 hours prior to topcoating. Use within 8 hours Thickness 1.0-1.5 mils
MIL-P-53030	Stir Comp A until uniform One part of Comp B with three parts of Comp A Add B to A Temp 65-95 °F	20 sec with #2 Zahn cup using deionized water Stir and strain Set 30 minutes before use	Spray with one full coat. Wait 5-6 hours prior to topcoating. Use within 6 hours Thickness 1.0-1.5 mils High humidity retards dry, low humidity accelerates dry. Make sure surface is free of water prior to topcoating
MIL-P-53084	Follow the manufacturer's instructions	Reduce with very Pure deionized water	Follow the instructions from the manufacturer.
MIL-PRF-85582	Stir separate components Mix as specified by manufacturer Temp 65-95 °F prior to mixing	Use deionized water Stir and strain Set 30 minutes before use	Spray with one full coat Wait 5-6 hours prior to topcoating Use within 4 hours Thickness 0.8-1.2 mils 1/ Apply at 60-100 °F High humidity retards dry, low humidity accelerates dry Make sure surface is free of water prior to topcoating

1/ For aluminum-steel assemblies. If aluminum only, 0.6 - 0.9 mil is acceptable.

Note: Times prior to topcoating are for 70 °F. At 60 °F, doubling the time may be necessary to get adequate curing for topcoating.

TERMS: one mil = 0.001 inch

3.5 Topcoating. The four CARC topcoats provide chemical agent resistance and color for the system. In addition, the polyurethanes (exterior surfaces) provide camouflage protection to visible and near infrared means of detection, while 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. The CARC topcoats inhibit absorption of chemical agents into the paint film and allow the decontamination process to be simplified. It is best to apply the topcoat to a freshly primed substrate within 24 hours. The drying time between priming and topcoating should be no more than 168 hours, but in no case less than the minimum time specified for the recoating test of 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. Adhesion testing (see 4.2.3.6) shall be used to monitor innercoat adhesion. As with CARC primers, application should be by brush or spray, the paint and substrate should be approximately the same temperature, and ambient temperature should be between 60 and 90 ^{o}F at application and for a period of time after application sufficient to assure adequate cure prior to exposure to adverse conditions (see 4.2.3.2). For ordering information (NSN) see appendix A; for health, safety and environmental information, see Appendix B; and for application equipment and techniques, see Appendix C. In areas where air quality regulations restrict volatile emissions, do not add thinner to the coating material if that addition will exceed the regulatory limit. The specific information below for the four topcoats is summarized in table III.

3.5.1 MIL-C-46168 (coating, aliphatic polyurethane, 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 a finish coat on military combat equipment. It is two component, lead and chromate (hexavalent) free, and is available in two types. Type II meets South Coast Air Quality Management District Rule 102. Type IV is a high solids formulation with a VOC content of 420 g/L (3.5 lb/gal).

3.5.1.2 Use. MIL-C-46168 is intended to provide a film which can be easily and effectively decontaminated after exposure to liquid chemical agents. It can be applied over any of the five epoxy primers described in 3.4, or to a CARC basecoat which is at least set to touch, as in pattern painting, or to a completely cured and thoroughly cleaned existing CARC finish, as in rework. It should not be applied over an existing alkyd or lacquer finish. As a camouflage topcoat, it should be applied to exterior surfaces and interior surfaces routinely visible from the outside; e.g., door ramps, hatches, etc.

3.5.1.3 Preparation. Component A shall be thoroughly mixed by stirring or agitation to a smooth, homogeneous state. Care must be exercised to redisperse any pigment which may have settled to the bottom of the container. Component A which contains grit or seeds after thorough mixing or which has thickened abnormally should not be used. Component B shall be a clear to pale yellow liquid which is free of crystals or sediment. A cloudy, milky, or crystalline gel indicates that the catalyst should not be used. If the container for component B is swollen, do not open it. Dispose of it as a hazardous waste. Both components should always be measured because accuracy is very important. MIL-C-46168 should be mixed four parts by volume of component A with one part by volume of component B. Always add component B to component A. Components from different manufacturers shall not be mixed. After combining the two components, the coating should be thoroughly mixed into a smooth, homogenous state.

3.5.1.4 Reduction. If necessary for spray application, MIL-C-46168, type II may be reduced up to one part by volume of the applicable solvent with four parts by volume of the mixed coating. The applicable solvent for type II is MIL-T-81772, type I. If type IV is to be reduced for application, the applicable solvent is MIL-T-81772, type I, unless otherwise specified by the coating manufacturer. Care must be exercised to follow the manufacturer's instructions to insure that the VOC of the coating as applied remains at or below the required level of 420 g/L (3.5 lb/gal). After reduction, MIL-C-46168 (except colors Aircraft Green and Interior Aircraft Black) shall be strained through a 40 mesh paint filter or equivalent to remove any impurities. While thinning should not be necessary for brush application, the admixed coating can be reduced as above, if required.

3.5.1.5 Application. Spray application can be accomplished with one full wet coat. For satisfactory camouflage properties, it is necessary to apply the coating to a minimum dry film thickness of 1.8 mils. Under certain temperature and humidity conditions, for more even results, it may be advisable to apply two coats of a minimum thickness of 0.9 mils each and allow solvent flash off between coats. Component B is water sensitive and caution must be taken to ensure water or high humidity does not come in contact with the coating. Mixed coating must be used within eight hours and cannot be stored. Pot life is shortened by temperature increase. Once opened, component B must be used that day or stored in a sealed dry air/airless container. Curing time increases with low temperature or lower humidity, and decreases with higher temperature or higher humidity. At temperatures of 70 ^{o}F and above, MIL-C-46168 will dry within the specification requirements when tested in accordance with FED-STD-141, method 4061 (set 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, MIL-C-46168 requires twice as long to cure. Do not use MIL-C-46168 on items attaining temperatures in excess of 400 ^{o}F, such as manifolds, exhaust pipes, and mufflers; use MIL-P-14105. Do not apply MIL-C-46168 to a surface which is contaminated with moisture.

3.5.1.6 Comments. MIL-C-46168 is a Qualified Products List (QPL) item, and procurement must be from an approved supplier. In addition, there is a batch validation requirement which specifies that a sample from every batch must be approved for visible and near infrared reflectance properties (see 6.4). Type II is the standard formula, and type IV is the alternate formulation for use where VOC regulations limit solvent emissions to 420 g/L (3.5 lbs/gal). To avert undesirable reactions, spray lines used for epoxy paints should not be used for polyurethanes without complete flushing or cleaning with solvents. MIL-C-46168 is normally applied under camouflage pattern painting (CPP) guidelines in three-color patterns containing Green 383, Brown 383, and Black. In desert applications, Tan 686A is available. For further information on patterns, contact the U.S. Army Research Laboratory, ATTN: AMSRL-WM-MA, Aberdeen Proving Ground, MD 21005-5069.

3.5.2 MIL-C-53039 (coating, aliphatic polyurethane, single component, chemical agent resistant).

3.5.2.1 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 a maximum VOC of 420 g/L (3.5 lbs/gal) as packaged.

3.5.2.2 Use. MIL-C-53039 is intended to provide a film which can be easily and effectively decontaminated after exposure to liquid chemical agents. It can be applied over any of the five epoxy primers described in 3.4, or to a CARC basecoat which is at least set to touch, as in pattern painting, or to a completely cured and thoroughly cleaned existing finish, as in rework. It should not be applied over an existing alkyd or lacquer finish. As a camouflage topcoat, it should be applied to exterior surfaces and interior surfaces routinely visible from the outside; e.g., door ramps, hatches, etc.

3.5.2.3 Preparation. Thoroughly mix by stirring or agitation to a smooth, homogeneous state. Care must be exercised to redisperse any pigment which may have settled 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.

3.5.2.4 Reduction. If necessary for spray application and where VOC regulations allow, MIL-C-53039 may be reduced up to one part by volume of the applicable solvent with four parts by volume of the coating. The applicable solvent is MIL-T-81772, type I or as specified by the coating manufacturer. After reduction, MIL-C-53039 (except colors Aircraft Green and Interior Aircraft Black) shall be strained through a 40 mesh paint filter or equivalent to remove any impurities. While thinning should not be necessary for brush application, the coating may be reduced as above, if required.

3.5.2.5 Application. Spray application can be accomplished with one full wet coat. For adequate camouflage properties, it is necessary to apply the coating to a minimum dry film thickness of 1.8 mils. Under certain temperature and humidity conditions, for more even results, it may be advisable to apply two coats of a minimum thickness of 0.9 mils each. The coating is water sensitive and caution must be taken to insure water or high humidity does not come in contact with the coating at any time. Once opened, MIL-C-53039 must be used within eight hours unless stored in a vat under a nitrogen or argon blanket, or in a sealed dry air/airless container. Curing time increases with lower temperatures or lower humidity, and decreases with higher temperature or higher humidity. At temperatures of 70 ^{o}F and above, MIL-C-53039 will dry within the specification requirements in accordance with FED-STD-141, method 4061 (set 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, MIL-C-53039 requires twice as long to cure. Do not apply to items attaining temperatures in excess of 400 ^{o}F, such as manifolds, exhaust pipes, or mufflers; use MIL-P-14105. Do not apply MIL-C-53039 to a surface which is contaminated with moisture.

3.5.2.6 Comments. MIL-C-53039 is a Qualified Products List (QPL) item, and procurement must be from an approved supplier. In addition, there is a batch validation requirement which specifies that a sample from every batch must 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). To avert undesirable reactions, spray lines used for epoxy paints should not be used for polyurethanes without complete flushing or cleaning with solvents. MIL-C-53039 is normally applied under camouflage pattern painting (CPP) guidelines in 3-color patterns containing Green 383, Brown 383, and Black. In desert applications, Tan 686A is available. For further information on patterns, contact the U.S. Army Research Laboratory, ATTN: AMSRL-WM-MA, Aberdeen Proving Ground, MD 21005-5069.

3.5.3 MIL-DTL-64159 (coating, water dispersible aliphatic polyurethane, chemical agent resistant).

3.5.3.1 Description. This specification covers water-dispersible, chemical agent resistant, aliphatic polyurethane coatings for use as a finish coat on all military tactical equipment, which includes ground, aviation and related support assets. The materials are free of hazardous air pollutants (HAP-free), lead and chromate (hexavalent chromium) free, and have a maximum volatile organic compound (VOC) content of 220g/L (1.8 lb/gal) as packaged. The material is available in two types. Type I contains silica-based flattening agents and type II contains polymeric flattening agents.

3.5.3.2 Use. MIL-DTL-64159 coatings are intended to provide surfaces that are easily and effectively decontaminated after exposure to liquid chemical agents. This coating may be used in areas where Air Pollution Regulations are in force. It can be applied over any of the five epoxy primers listed in table I and described under 3.4, or to a CARC basecoat which is a least set to touch, as in pattern painting, or to a completely cured and thoroughly cleaned existing finish, as in rework. It should 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 coating application.

3.5.3.3 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 and component B which 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 part A to part B. Make certain that water does not come in contact with component A prior to mixing. Component B is very water sensitive and caution must be taken to insure that water or high humidity do not come in contact with the component at any time prior to admix. Mix component A well, then add 1 part by volume of component B to 2 parts by volume of component A, and apply vigorous mechanical agitation to combined components with a high-shear mixer.

3.5.3.4 Reduction. The admixed coating can be reduced by adding up to one part by volume of deionized water (type IV, ASTM D1193) to three parts by volume of the admix or as specified by manufacturer's instruction for spray application. Reduction with water should occur while the material is being mechanically agitated to insure proper incorporation with other components.

3.5.3.5. Application. Spray application can be accomplished with one full wet coat. For adequate camouflage properties, it is necessary to apply the coating to a minimum dry film thickness of 0.0018 inches (1.8 mils). Under certain temperature and humidity conditions, for more even results, it may be advisable to apply two coats of a minimum thickness of 0.9 mils each. Curing time increases with lower temperatures or higher humidity, and decreases with higher temperature or lower humidity. At temperatures of 70 ^{o}F and above, MIL-DTL -64159 will dry within the specification requirements in accordance with FED-STD-141, method 4061 (set 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, set 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, MIL-DTL-64159 requires twice as long to cure. Do not apply to items attaining temperatures in excess of 400 ^{o}F, such as manifolds, exhaust pipes, or mufflers; use MIL-P-14105. Do not apply MIL-DTL-64159 to a surface which is contaminated with moisture.

3.5.3.6 Comments. MIL-DTL-64159 is a Qualified Products List (QPL) item, and procurement must be from an approved supplier. In addition, there is a batch validation requirement which specifies that a sample from every batch must be approved for visible and near infrared reflectance properties (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 lb/gal). To avert undesirable reactions, spray lines used for epoxy paints should not be used for polyurethanes without complete flushing or cleaning with solvents. MIL-DTL-64159 is normally applied under camouflage pattern painting (CPP) guidelines in 3-color patterns containing Green 383, Brown 383, and Black. In desert applications, Tan 686A is available. For further information on patterns, contact the U.S. Army Research Laboratory, ATTN: AMSRL-WM-MA, Aberdeen Proving Ground, MD 21005-5069.

3.5.4 MIL-PRF-22750 (coating, epoxy, high-solids).

3.5.4.1 Description. This specification covers the requirements for a two-component, high-solids epoxy coating with a maximum volatile organic compound (VOC) content of 340 grams/liter (g/L) (2.8 pounds /gallon (lbs/gal)) and which is formulated to be free of cadmium, chromium and lead. The coating is supplied as a kit.

3.5.4.2 Use. MIL-PRF-22750 is intended to provide a film which can be easily and effectively decontaminated after exposure to liquid chemical agents. It can be applied over any of the five epoxy primers described in 3.4, or to CARC basecoat which is at least set to touch or which is completely cured and thoroughly cleaned, as in rework. It should 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 should be applied only to interior surfaces.

3.5.4.3 Preparation. Prior to combining the two components together, the individual components A and B shall each be thoroughly mixed by stirring or agitation to a smooth homogeneous state. Care must be exercised to redisperse any pigment which may have settled 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 should be thoroughly mixed into a smooth, homogeneous state.

3.5.4.4 Reduction. The admixed coating shall be compatible with any thinner meeting MIL-T-81772, type II. Caution must be taken when thinning so as not to exceed the maximum VOC content of 340 gm/L in areas where air pollution regulations are enforced. The thinned paint shall be thoroughly stirred, strained through a 40 mesh paint filter or equivalent to remove any impurities, and allowed to stand at room temperature for 30 minutes before using. The viscosity shall be no greater than 50 seconds through a No. 4 Ford cup.

3.5.4.5 Application. After completion of the 30 minute waiting period, spray a mist coat of the MIL-PRF-22750 over the primer and allow to dry for 30 minutes. It should be thin, discontinuous and translucent (not full hiding). Application of the mist coat helps to prevent bleeding of the primer. Follow this step with a full, wet coat to a total dry film thickness of 1.3 to 1.7 mils. For aircraft, apply two coats to a total dry film thickness of 2.0 to 2.4 mils. Thick films of epoxy coating are less likely than other coatings to run or sag, so care must be taken not to exceed recommended film thickness limits. Mixed coating must be used within 8 hours and pot life is shortened by higher temperatures. Curing time increases with lower temperature and decreases with higher temperature. At temperatures of 70 ^{o}F and above, MIL-PRF-22750 will dry within specification requirements in accordance with FED-STD-141, method 4061 (set to touch in four hours, dry hard in eight hours, and complete cure in seven days). At 52 ^{o}F, the drying times are approximately doubled.

3.5.4.6 Comments. MIL-PRF-22750 is a Qualified Products List (QPL) item, and procurement must be from an approved supplier. The responsible technical activity is the Naval Air Systems Command (Attention: Commander, Naval Air Systems command (Code 4.3.4.1), 48066 Shaw Road, Bldg. 2188, Patuxent River, MD 20670), see 6.4. To avert undesirable reactions, spray lines used for both epoxy and polyurethane paints must be completely flushed or thoroughly cleaned before switching. MIL-PRF-22750 is the CARC for interior surfaces, and is normally applied in gloss white (Color #17875), semigloss green (Color #24533), or semigloss gray (Color #26307), but can be obtained in other FED-STD-595 colors.

TABLE III. Application characteristics for CARC topcoats.

SPECIFICATION	MIXING	REDUCTION	APPLICATION
MIL-C-46168	Stir Comp A until uniform Four parts Comp A with one part Comp B Add Comp B to Comp A	If necessary and allowed, reduce up to 20% Stir and strain	Spray with one full coat Temp/humidity may dictate 2 coats Comp B is water sensitive so don't let water/humidity come in contact with coating Use Comp B the day can is opened or reseal completely Use admix within 8 hrs; apply at 1.8–2.5 mils Curing time increases with lower temperature, while curing time decreases with higher temperature At 70 ^{o}F, complete cure in one week, but at 60 ^{o}F, cure time is about doubled.
MIL-C-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 up to 20% Stir and strain	Spray one full coat Temp/humidity may indicate two coats Coating is water sensitive so don't let water or high humidity come in contact with the coating Once opened, use within 8 hours. Apply at minimum thickness of 1.8 – 2.5 mils Cure time increases with low temp and low humidity, and decreases with higher temp and higher humidity At 70 ^{o}F, complete cure in one week, but at 60 ^{o}F the cure time is about doubled.
MIL-DTL-64159	After individual components are 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 in 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	Spray one full coat Temp/humidity may indicate two coats Use admix within 4 hours. Apply at minimum thickness of 1.8 – 2.5 mils Cure time increases with low temp and high humidity, and decreases with higher temp and lower humidity At 70 ^{o}F, complete cure in one week, but at 60 ^{o}F the cure time is about doubled.
MIL-PRF-22750	Components must be thoroughly mixed. Mix as specified by the manufacturer	If necessary and allowed, up to the allowed VOC limit. Stir and strain. Let stand 30 minutes	Apply mist coat over primer, wait 30 minutes (to prevent primer bleeding), spray with a full coat to 1.3 - 1.7 mils Use within 8 hours At 70 ^{o}F, complete cure is in one week, but at 60 ^{o}F cure time is about doubled.

TERMS: one mil = 0.001 inch

3.6 Application. 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 must be stripped down to the epoxy primer if present, or to the substrate if an epoxy primer is not present. For rework, polyurethane and epoxy topcoats can only be applied over previously painted epoxy or polyurethane topcoats.

3.6.1 Surface preparation. Scratches or other light damage to polyurethane or epoxy topcoats will require scuff sanding at the immediate blemish area, except as described in 4.2.3.4. Damage or corrosion extending to the substrate will require sanding and repriming. All traces of corrosion must be abraded from the substrate. The surface immediately surrounding exposed substrate should then be sanded, using a feathering-in technique; that is, sand 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. Sanding of any type shall be followed by wiping down the exposed area to be painted using an environmentally acceptable procedure that will remove all loose sanding debris, mill scale, grease, oil (including fingerprints), and diesel/gasoline residue. This procedure must be performed in a well ventilated area while wearing gloves to prevent skin contact with thinner solvents. Consult preventive medicine personnel to determine appropriate gloves and protective clothing, and to determine if respiratory protection is needed. Do not use other petroleum or alcohol-based thinners 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 primer or MIL-C-5541 and allowed to react 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 Finishing procedures.

3.6.2.1 Epoxy 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; i.e., tapering off quantity applied to a thin edge. Do not apply epoxy primer beyond the blend-in edge.

3.6.2.2 CARC topcoat. Ensure that the surface to which the topcoat is applied is clean and dry. The surface temperature should be between 60 ^{o}F and 90 ^{o}F at application and for a period of time after application (see 4.2.3.2) 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-P-53030, all water must evaporate prior to top-coating. If the primer has dried for more than 168 hours, it should be lightly scuff sanded and solvent wiped to promote adhesion. Application of CARC topcoats to surfaces previously painted with CARC (e.g., in repair of light topcoat damage) may proceed while the original coat is still tacky. Polyurethane which has fully cured should be thoroughly cleaned prior to refinishing. Epoxy which has fully cured should 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 which will be subjected to temperatures in excess of 400 ^{o}F, 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). Spray application by conventional techniques can be difficult, but a small, self-pressurized spray kit (see appendix A, table IX) is available for use in CARC touchup procedures.

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

3.6.3 Safety. For general health and safety guidance, see appendix B.

3.7 CARC process notes.

a. Mix thoroughly - 55 gallon drums must be put on a drum tumbler for at least 6 hours before use. A paint shaker for smaller sized containers saves time and eliminates stirring by paddle.
b. Keep moisture away from component B in MIL-C-46168 and MIL-DTL-64159 and from MIL-C-53039, either by the use of a very dry (-32 degrees dew point air dryer) air, desiccant air dryer on air line, or nitrogen 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.
d. Clean equipment thoroughly and in accordance with manufacturer's 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 may dry out pumping system gaskets, a good grade of light oil (e.g., automatic transmission fluid) can 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 must 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 will react even though thinner or solvent is present and block up mixed material hoses.
m. Do not spray in unventilated areas without proper EPA and OSHA approved spray equipment (see appendix B).
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.
p. To prevent solidification, do not leave mixed materials in hoses, cups, or pumps for longer than 2 hours when not in use.
q. Do not allow painters to dictate the spray method used. Management should select the most cost effective method and train painters to use the appropriate method.
r. Use of commercially available chemical accelerators is strictly prohibited.

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 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 patterns. Tan 686A is the base coat for dessert application and black CARC coated component parts will be as indicated on end item drawing or as specified in 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 would not 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 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/products. When 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 that is applied to non-ferrous metals, such as aluminum may be tested by the quality assurance test that controls the respective pretreatment, for example, MIL-C-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 it is necessary to perform one of these procedures after an item is coated, the finish must be completely removed to the substrate at least four inches in all directions from the work area and in all areas which will reach 400 ^{o}F 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 PSI, 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 may slowly undergo chemical changes without hazard and may result in components not being usable. Although ideal storage range is 70 - 75 ^{o}F (21 - 24 ^{o}C), normal storage temperature (min/max) of 32 - 122 ^{o}F (0 - 50 ^{o}C) is allowed. CARC components which are stored at temperatures below the minimum cited above are not degraded, but they must 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 General Services Administration (GSA) or though the supply system after the labeled shelf life expiration date, do not accept it. If a unit accepts CARC that is expired it must 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-C-53039 or component B of either MIL-C-46168 or MIL-DTL-64159, the contents will react to produce carbon dioxide, which will result in pressure building up inside the container. Do not reseal if contamination is suspected. If the paint reaches minimum temperatures of 32 ^{o}F or below, it will thicken; however, upon rewarming it is usable. The temperature range specified (60 - 90 ^{o}F/16 - 32 ^{o}C) must 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. When specified, standard test panels may 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. To determine suitability of the coating mixes with prevailing application parameters i.e., atmospheric conditions, painting techniques, equipment, thinning and mixing ratios, etc., and to determine the adequacy of production procedure, practice surfaces (with the specified pretreatment) should be prepared daily prior to actual painting. Separate surfaces should be prepared (coated) for each coating operation; i.e., 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 (low carbon steel panels shall be substituted for metal parts which are not steel) for each coating shall be prepared. These surfaces shall be coated with the 4-inch dimension positioned vertically and the 12 inches 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.

4.2.3 Tests. Materials, prior to their use, shall be inspected, sampled and tested in accordance with the applicable specification and standard 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 QPL 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 of the spectral reflectance characteristics of the paint lot when required by the applicable specification.

TABLE IV. Examination.

Item No.	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.	All surfaces not kept clean after cleaning as specified.	3.2.6
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
122.	Topcoats not applied as specified.	3.5
123.	Previously painted surfaces not treated as specified.	3.6
124.	Base topcoat not Green 383 as specified (except for aircraft).	3.8.1
125.	Surfaces not requiring paint should 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

4.2.3.1 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 must 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, etc., 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, re-examine the surface for corrosion, foreign matter or oily residues and repeat the water break test prior to pretreatment. After testing, all moisture must be removed to ensure a clean, dry surface for painting. Cleaning materials which may be effective against one type of contaminant may be ineffective against others. Multiple cleaning procedures may 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 catalyzed 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, additional time must be allowed before the test is performed. 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 in length. Evidence of actual paint removal; that is, the topcoat is removed down to the primer, is evidence of an unacceptably catalyzed topcoat or an uncured film. These items can 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 must be reworked in accordance with 3.6 to repair any areas of topcoat removal. This test must 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 should 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 B 499, an eddy current tester in accordance with ASTM B 244, or other acceptable standard methods. Recommended thickness requirements for CARC primers and topcoats are listed in table V; however, the upper limits may be exceeded as long as the remaining quality assurance provisions specified in section 4 are met. Previously applied coatings to the test area must be identified prior to topcoating, such as repair or rework areas. These previous coatings must be measured and recorded in sequence to accommodate each progressive coating thickness determination. Unless otherwise specified, rejection will not be made based on the recommendations of table V, but on subsequent performance failure of another quality assurance provision of section 4.

TABLE V. Dry film thickness (mils).

MIL-C-8514	0.3 – 0.5
DOD-P-15328	0.3 – 0.5
MIL-PRF-23377	0.8 – 1.2 [1]
MIL-P-53022	1.0 – 1.5
MIL-P-53030	1.0 – 1.5
MIL-P-53084	1.0 – 1.2
MIL-PRF-85582	0.8 – 1.2 [1]
MIL-C-46168	1.8 – 2.5
MIL-C-53039	1.8 – 2.5
MIL-DTL-64159	1.8 – 2.5
MIL-PRF-22750	1.3 – 1.7

1 Except for aircraft, then 0.6 – 0.9

Primer thickness requirements are subject to the manufacturer's recommendations.

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-C-46168, MIL-C-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 QPL for MIL-C-46168, MIL-C-53039 or MIL-DTL-64159 can supply CARC camouflage. For every batch, the spectral reflectance, gloss, and DS2 resistance are verified with batch validation by the U.S. Army Research Laboratory, ATTN: AMSRL-WM-MA, Aberdeen Proving Ground, MD 21005-5069. 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 the Army Research Laboratory (ARL) shall be made available to inspectors for each batch of paint applied. Slight visual color differences are expected between manufacturers or batches and 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, or a dry film color which is obviously not as specified (i.e., caused by improper mixing or application).

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 D 3359, method B, cross cut tape adhesion, using the 6-line pattern and 2 mm spacing. After the test has been performed, removal of 3 or more squares constitutes test failure, but minor flaking from scribe intersections is permitted, as is removal of overspray. In any case, the scribed area must 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 FED-STD-141, method 6301. Removal beyond one-sixteenth inch on either side of the scribed lines constitutes test failure.

4.2.3.7 Corrosion resistance. Panels may 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 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 ^{o}F or equivalent) the parts or representative panels shall be subjected to a 336-hour 5 percent salt spray test in accordance with ASTM B117. If panels are used, seal the edges with wax or other suitable material. Corrosion in excess of a trace of rusting (ASTM D610, No. 9) or more than five scattered blisters, none larger than 1 mm in diameter visible to the unaided eye on the panel or actual parts shall be cause for rejection. 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 6.6 for a test protocol under consideration).

4.2.3.7.1 Non-ferrous substrates. Test variations may be followed for testing the primer coat used on non-ferrous substrates. Those specified for use in the respective pretreatment specification may 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. 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 chemical agent resistant coating (CARC) system of primers and topcoats is designed for use on the exterior and interior of tactical military equipment where resistance to absorption of liquid chemical agents is required. It may also be used where severe exposure situations require a coating with excellent durability and corrosion resistance. The coatings and their characteristics are listed in table VI.

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 lb/gal	SCAQMD 1124 2.9 lb/gal	SCAQMD 1107 2.8 lb/gal
MIL-PRF-23377		X	Class N	X	X	X
MIL-P-53022	X	X	X	X	1/	1/
MIL-P-53030	X	X	X	X	X	X
MIL-P-53084	X	X	X	X	X	X
MIL-PRF-85582		X	X Class N	X	X	X
MIL-PRF-22750	N/A	N/A	X	X	X	X
MIL-C-46168	N/A	N/A	X	X Type IV		
MIL-C-53039	N/A	N/A	X	X		
MIL-DTL-64159	N/A	N/A	X	X	X	X

1/ This requirement is not addressed nor required by the specification, but products are available which meet appropriate performance requirements of the document and the noted regulatory standard. Contact appropriate preparing activity for more information.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this specification.
b. Issue of DoDISS cited in solicitation and specific issue of individual documents referenced (see 2.2.1 and 2.2.2)
c. Type of finish as defined in 3.1
d. When blast cleaning required (see 3.2.1)
e. When wood surfaces will not be pressure –treated (see 3.3.4)
f. Color of topcoat if other than those in the 3-color pattern (see 3.5)
g. Camouflage painting and marking of Army materiel conforming to AR 750-1
h. Referenced National Stock Number (NSN's). See appendix A for applicable NSN number associated with the CARC and CARC related items, including topcoats, primers, pretreatments, wood sealers, thinners, and miscellaneous items.
i. Health and safety issues including facilities, worker safety procedures and equipment, toxic and hazardous waste management, and occupational health requirements (see appendix B)
j. Equipment including general guidelines and a brief list of things to do and not to do can be found in appendix C.

6.3 Color chips. Color chips for CARC finishes are available from two sources. Chips for the camouflage colors in MIL-C-46168, MIL-C-53039 and MIL-DTL-64159 are obtained from the U.S. Army Research Laboratory, ATTN: AMSRL-WM-MA, Aberdeen Proving Ground, MD 21005-5069, 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 have a batch validation requirement which should eliminate the need for inspection by color chips (see 4.2.3.5). For appearance information only, color chips can be obtained by using the five digit color number of FED-STD-595. See appendix A for the equivalent color numbers. The non-camouflage colors found in MIL-C-46168, MIL-C-53039, MIL-DTL-64159 and MIL-C-22750 shall match the appropriate color chips from FED-STD-595. These chips can be purchased from the General Services Administration, Specification Section, 7th and "D" Streets, S.W., Washington, DC 20407.

6.4 Preparing activity responsibility. The preparing activity responsible for MIL-PRF-22750, MIL-PRF-23377, and MIL-PRF-85582 is the Naval Air Systems Command (Code 4.3.4.1), 48066 Shaw Road, Bldg. 2188, Patuxent River, MD 20670. The preparing activity for MIL-C-46168, MIL-P-53022, MIL-P-53030, MIL-C-53039, MIL-P-53084 and MIL-DTL-64159 is the U.S. Army U.S. Army Research Laboratory, ATTN: AMSRL-WM-MA, Aberdeen Proving Ground, MD 21005-5069.

6.5 Experimental products 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 are not currently available in the specification. With end user approval, these new products may be used prior to appearing on the applicable Qualified Products List (QPL). Subsequent revision of the specification allows the EPP products to be converted to normal QPL listings.

6.6 Corrosion resistance. New product formulations for CARC topcoats are capable of far better performance and durability. In the future, preproduction corrosion resistance testing will be in accordance with a Joint Test Protocol (JTP) procedure such as described herein. Corrosion resistance shall be demonstrated on steel specimens (parts or representative 4 x 12-inch 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 ^{o}F or equivalent) the parts or representative panels shall be subjected to a 1000-hour 5 percent salt spray test in accordance with ASTM B117 and 40-cycle exposure to GM 9540P. When panels are used, seal the edges with suitable material. For both required procedures, corrosion in excess of 5 mm creepback from a scribe (ASTM D1654, 5) on the panel or actual parts shall be cause for rejection. Corrosion in unscribed areas in excess of a trace of rusting (ASTM D1654, 8F) or more than five scattered blisters, none larger than 1 mm in diameter visible to the unaided eye on the panel or actual parts shall be cause for rejection. Staining of the coating from scribe corrosion products, 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

6.7 Subject term (key word) listing.

Application procedures
Chemical agent resistant coating (CARC)
Corrosion resistance
Dry film thickness
National Stock Numbers (NSNs)
Quality control inspection

6.8 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

Custodian:
Army – MR
Navy – SH

Civil Agency - GSA

Review activity:
Army – AR, AT, AV, EA, MD1, MI
Navy – CG, MC

Preparing Activity
Army-MR

(Project 8010-0101)

APPENDIX A

NATIONAL STOCK NUMBERS

A.1 SCOPE

A.1.1 Scope. This appendix lists national stock numbers (NSN) for CARC and CARC-related items, And the use of these NSNs is a mandatory part of this specification. The information contained herein is intended for compliance with the specification. CARC related items include topcoats, primers, pretreatments, wood sealers, thinners, and miscellaneous items.

TABLE I. Chemical Agent Resistant Coating (CARC) colors for MIL-C-46168, type II.

Color	One Quart Kit (NSN)	One Gallon Kit (NSN)	Five Gallon Kit (NSN)
* Green 383, 34094	8010-01-160-6741	8010-01-162-5578	8010-01-160-6742
* Brown 383, 30051	8010-01-160-6744	8010-01-160-6745	8010-01-160-6746
Dark Green, 34082	8010-01-141-2412	8010-01-130-3343	8010-01-131-0611
Field Drab, 33105	8010-01-141-2414	8010-01-130-3345	8010-01-148-3662
Earth Yellow, 33245	8010-01-141-2415	8010-01-130-3346	8010-01-131-0612
Sand, 33303	8010-01-141-2416	8010-01-130-3347	8010-01-131-6259
* Black, 37030	8010-01-141-2419	8010-01-131-6254	8010-01-131-6261
**Tan 686A, 33446	8010-01-260-0910	8010-01-260-0909	8010-01-260-0908
Aircraft Green, 34031	8010-01-141-2420	8010-01-131-6255	8010-01-131-6262
Olive Drab, 34088	8010-01-146-2650	8010-01-055-2319	8010-01-144-9875
Aircraft Gray, 36300	8010-01-144-9882	8010-01-127-8908	8010-01-144-9876
Aircraft White, 37875	8010-01-144-9883	8010-01-144-9872	8010-01-144-9877
Aircraft Red, 31136	8010-01-144-9884	8010-01-144-9873	8010-01-144-9878
Aircraft Black, 37038	8010-01-144-9885	8010-01-146-2646	8010-01-144-9879
Int. Aircraft Black (With Glass Beads), 37031	8010-01-144-9886	8010-01-146-2647	8010-01-146-4376
Insignia Blue, 35044	8010-01-144-9887	8010-01-146-2648	8010-01-144-9880
Int. Aircraft Gray, 36231	8010-01-170-7583	8010-01-146-2649	8010-01-170-0132
Aircraft Yellow, 33538	8010-01-247-8885	8010-01-235-8059	8010-01-235-5079
Dark Sandstone, 33510	8010-01-260-7480	8010-01-260-7479	8010-01-260-7478

* Basic three-color CARC camouflage coatings
** CARC for desert applications

APPENDIX A

TABLE II. Chemical Agent Resistant Coating (CARC) Colors for MIL-C-46168, Type IV.

Color	One Quart Kit (NSN)	One Gallon Kit (NSN)	Five Gallon Kit (NSN)
* Green 383, 34094	8010-01-260-7481	8010-01-260-0911	8010-01-260-0912
* Brown 383, 30051	8010-01-260-7482	8010-01-260-0916	8010-01-260-0917
* Black, 37030	8010-01-260-0913	8010-01-260-0914	8010-01-260-0915
**Tan 686A, 33446	8010-01-306-9681	8010-01-306-9680	8010-01-306-9682
Field Drab, 33105	8010-01-260-0918	8010-01-260-0919	8010-01-260-0920
Sand, 33303	8010-01-260-0921	8010-01-260-0922	8010-01-260-7483
Aircraft Green, 34031	8010-01-316-2221	8010-01-316-2219	8010-01-316-2220
Aircraft Black, 37038	8010-01-340-5175	8010-01-340-7060	8010-01-340-5176

* Basic three-color CARC camouflage coatings
** CARC for desert applications

TABLE III. Chemical Agent Resistant Coating (CARC) Colors for MIL-C-53039.

Color	One Quart Can (NSN)	One Gallon Can (NSN)	Five Gallon Can (NSN)
* Green 383, 34094	8010-01-229-7546	8010-01-229-9561	8010-01-229-7547
* Brown 383, 30051	8010-01-229-7543	8010-01-229-7544	8010-01-229-7545
* Black, 37030	8010-01-229-7540	8010-01-229-7541	8010-01-229-7542
**Tan 686A, 33446	8010-01-276-3638	8010-01-276-3639	8010-01-276-3640
Sand, 33303	8010-01-234-2934	8010-01-234-2935	8010-01-234-2936
Aircraft Green, 34031	8010-01-246-0717	8010-01-246-0718	8010-01-246-0719
Aircraft White, 37875	8010-01-334-3785	8010-01-328-3233	8010-01-334-3786

* Basic three-color CARC camouflage coatings
** CARC for desert applications

TABLE IV. Chemical Agent Resistant Coating (CARC) Colors for MIL-DTL-64159, Type 1.

Color	Three Pint Kit (NSN)	Three Quart Kit (NSN)	Three Gallon Kit (NSN)	15 Gallon Kit (NSN)
* Green 383, 34094	8010-01-492-6637	8010-01-492-6638	8010-01-492-6639	8010-01-492-6640
* Brown 383, 30051	8010-01-492-6641	8010-01-492-6642	8010-01-492-6643	8010-01-492-6644
**Tan 686A, 33446	8010-01-492-6645	8010-01-492-6646	8010-01-492-6648	8010-01-492-6649
* Black, 37030	8010-01-492-6650	8010-01-492-6651	8010-01-492-6652	8010-01-492-6654
Aircraft Green, 34031	8010-01-492-6655	8010-01-492-6656	8010-01-492-6657	8010-01-492-6658
Gray, 36300	8010-01-492-6659	8010-01-492-6660	8010-01-492-6661	8010-01-492-6663

* Basic three-color CARC camouflage coatings
** CARC for desert applications

APPENDIX A

TABLE V. Chemical Agent Resistant Coating (CARC) Colors for MIL-DTL-64159, Type 2.

Color	Three Pint Kit (NSN)	Three Quart Kit (NSN)	Three Gallon Kit (NSN)	15 Gallon Kit (NSN)
* Green 383, 34094	8010-01-493-3168	8010-01-493-3169	8010-01-493-3170	8010-01-493-3171
* Brown 383, 30051	8010-01-493-3172	8010-01-493-3173	8010-01-493-3174	8010-01-493-3175
**Tan 686A, 33446	8010-01-493-3176	8010-01-493-3177	8010-01-493-3179	8010-01-493-3180
* Black, 37030	8010-01-493-3182	8010-01-493-3183	8010-01-493-3190	8010-01-493-3191
Aircraft Green, 34031	8010-01-493-3192	8010-01-493-3193	8010-01-493-3194	8010-01-493-3195
Gray, 36300	8010-01-493-3196	8010-01-493-3197	8010-01-493-3198	8010-01-493-3199

* Basic three-color CARC camouflage coatings
** CARC for desert applications

TABLE VI. Chemical Agent Resistant Coating (CARC) Colors for MIL-PRF-22750.

Color	Two Quart Kit (NSN)	Two Gallon Kit (NSN)
White, 17925	8010-01-309-9562	8010-01-313-8701
Green, 24533	8010-01-313-8710	8010-01-313-8711
Black, 37038	8010-01-314-6071	8010-01-314-6072
White, 37875	8010-01-148-7042	
Gray, 16081	8010-01-053-2658	8010-01-082-2437

TABLE VII. Heat Resistant Paint Colors for MIL-P-14105.

Color	One Quart Can (NSN)	One Gallon Can (NSN)
Green 383, 34094	8010-01-235-2693	8010-01-235-4164
Brown 383, 30051	8010-01-235-2694	8010-01-235-2695
Black, 37030	8010-01-235-4165	8010-01-235-4166

APPENDIX A

TABLE VIII. Chemical Agent Resistant Coating (CARC) Primers.

Specification	One Quart Kit (NSN)	One Gallon Kit (NSN)	Five Gallon Kit (NSN)
MIL-PRF-23377, TYPE I*	8010-01-312-1170	8010-01-312-1169	8010-01-312-1168
MIL-P-53022, TYPE I	8010-01-193-0516	8010-01-193-0517	8010-01-187-9820
MIL-P-53022, TYPE II	8010-01-309-0329	8010-01-309-0328	8010-01-309-0327
MIL-P-53030	8010-01-193-0519	8010-01-193-0520	8010-01-193-0521
MIL-PRF-85582, TYPE I	8010-01-218-0856	8010-01-218-7354	

* Actual volume of MIL-PRF-23377 is double the column headings.

TABLE IX. Miscellaneous Items.

Specification	Quart (NSN)	Gallon (NSN)	5 Gallon (NSN)	55 Gallon (NSN)
MIL-T-81772, TYPE I		8010-00-181-8080	8010-00-181-8079	8010-00-280-1751
MIL-T-81772, TYPE II		8010-01-200-2637	8010-01-212-1704	8010-01-168-0684
DOD-P-15328	8030-00-850-7076	8030-00-281-2726	8030-00-165-8577	
MIL-C-8514		8030-01-015-6104	8030-00-082-2425	
Spray Kit, Self-Pressurized SAE-AS-22805		4940-00-803-6444		

APPENDIX B

HEALTH, SAFETY AND ENVIRONMENTAL CONSIDERATIONS

B.1 SCOPE

B.1.1 Scope. This appendix is not a mandatory part of the specification. The information contained herein is intended for guidance only in health and safety, including facilities, worker safety procedures and equipment, toxic and hazardous waste management, and occupational health requirements.

B.2 APPLICABLE DOCUMENTS

B.2.1 Government documents.

B.2.1.1 Other Government documents. The following other Government documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

AR 200-1	Environmental Protection and Enhancement
TG No. 144	Guidelines for Controlling Health Hazards in Painting Operations.
TB MED 502	Occupational and Environmental Health Respiratory Protection Program.
DHHS (NIOSH) Publication No. 2002-144	Certified Equipment List.
Title 29 CFR 1910.134	Respiratory Protection

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Document Automation and Production Service, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

B.3 General guidance. The following general guidance is based on information from the Army Surgeon General. The local safety office, Preventive Medicine Activity, and local medical support facility must be consulted prior to initiating CARC painting. Refer to Army TG 144 for respiratory protection guidance when using CARC. If airborne chemical exposures exceed Army standards, a full respiratory protection program is required until it can be demonstrated to preventive medicine personnel that airborne chemical exposures have been controlled to acceptable levels without the use of respiratory protection. There are three basic health hazards in CARC coatings:

B.3.1 Solvents. The solvents present in paint may be toxic in high concentrations.

B.3.2 Hexamethylene diisocyanate and hexamethylene diisocyanate prepolymers. These are contained in MIL-C-53039, in component B of MIL-C-46168, and in MIL-DTL-64159. Precautions must be taken to limit skin contact and vapor and aerosol inhalation.

B.3.3 Lead and chromate pigments. Two primer specifications, MIL-PRF-23377 and MIL-PRF-85582, and four pretreatments, DOD-P-15328, MIL-C-8514, MIL-C-5541, and MIL-A-8625 allow or require the use of chromate pigments. Both of these pigments can be toxic. Precautions must be taken to limit skin contact and inhalation. The Army is working to eliminate lead and chromate from all coating specifications.

B.3.3.1 Refinishing lead and other chromated pigmented formulations. The refinishing of older vehicles or legacy systems that used formulations containing lead chromate and other chromate pigments in CARC topcoats or primers require special precautions and the operating personnel will need to consult the preventive medicine personnel on the use of appropriate personal protective equipment and other precautions before removing CARC from older vehicles.

B.3.4 If current OSHA facility guidelines are being met, no additional protection is needed for CARC application. If current guidelines are not being met, some additional costs to meet these guidelines are to be expected, but do not occur solely from the requirements to apply CARC paint. Based upon findings for realistic assessment of vapor and aerosol hazards associated with CARC spray finishing operations, no significant change in respiratory protection is warranted by conversion to CARC. Medical surveillance required should be determined by the installation medical authority based on the specific hazard to which personnel are exposed. Questions regarding medical surveillance should be directed to the U.S Army Center for Health Promotion and Prevention Medicine at CDR, USACHPPM, Occupational Medicine Program, ATTN: MCHB-TS-MOM, Aberdeen Proving Ground, MD 21010-5403.

B.3.5 Epoxy primers and coatings. Precautions must be taken to limit skin contact and vapor and aerosol inhalation.

B.4 Respiratory protection for all paint systems.

B.4.1 Spray painting indoors.

a. An approved or accepted pressure demand or continuous flow, type C, full-facepiece hood or helmet supplied-air respirator is the standard respirator to be worn when spray painting indoors. However, alternatives are permitted when authorized by preventive medicine personnel.
b. In all cases, the alternative respirator system must be approved for protection from contaminants at the levels documented.

B.4.2 Spray painting outdoors.

a. An approved or accepted pressure demand or continuous flow, type C, full-facepiece hood or helmet supplied-air respirator must be worn when

(1) spray painting outdoors and solvent concentrations exceed the limits of an applicable organic vapor cartridge[1] respirator system, or
(2) working in a confined space (see Note 1).

b. Alternatives are permitted when authorized by preventive medicine personnel.
c. In all cases, the alternative respirator system must be approved for protection from contaminants at the levels documented.

B.4.3 Brush roller painting indoors and outdoors.

a. Respiratory protection is not required when painting in open spaces and authorized by preventive medicine personnel.
b. An approved half-mask respirator with organic vapor cartridge[1] with paint prefilter (or HEPA, P95, P99 or P100 filter if required) will be required if solvent or pigment atmospheric concentrations exceed standards.
c. An approved or accepted pressure demand or continuous flow, type C, full-facepiece hood or helmet supplied-air respirator is required if diisocyanate or chromate atmospheric concentrations exceed Army standards.

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1 A cartridge may be a canister if gas masks are used.

APPENDIX B

NOTE 1: This information is not to be considered as an all-encompassing document on confined space work. The term open space is any area not meeting the definition of confined space.

(1) Confined space, as defined in the glossary of TG 144, Guideline for controlling Health Hazards in Painting Operations, is subject to the accumulation of toxic or combustible gases or the development of an oxygen deficient or enriched atmosphere. Therefore, respiratory protection is required when working in a confined space. The type of respiratory protective equipment depends on the type of confined space encountered. For the definitions of oxygen deficient atmosphere, oxygen enriched atmosphere, combustible atmosphere, toxic atmosphere, immediately dangerous to life or health (IDLH) atmosphere, and not immediately dangerous to life or health (NIDLH) atmosphere, see TG No. 144.
(2) Confined space includes, but is not limited to, storage tanks, process vessels, bins, boilers, ventilation or exhaust ducts, sewers, underground utility vaults, tunnels, pipelines, and open top spaces more than 4 feet in depth such as pits, tubs, vaults, and vessels.
(3) Confined space may also include areas in and under vehicles or equipment where airflow is restricted.
(4) When painting indoors and not in paint booths, a confined space is defined as an area which as a volume of less then 10,000 cubic feet or a ceiling height less than 16 feet.
(5) Confined space outdoors is an area where the painter is enclosed and dilution ventilation cannot occur. This includes painting in shelters with a ceiling height less than 16 feet or areas where three sides are enclosed and airflow is limited.
(6) Confined space includes touch-up areas containing partitions, balconies or other structural barriers to the extent that they obstruct cross ventilation.

NOTE 2: Approved respirators which provide more protection than the recommended device may be substituted in accordance with TB MED 502. For a list of approved full facepiece chemical cartridge respirators with high efficiency prefilters see DHHS (NIOSH) Publication No. 2002-144, Certified Equipment List.

B.4.4 Spray/brush roller painting in all confined spaces.

a. An approved or accepted pressure demand or continuous flow, type C, full-facepiece hood or helmet supplied-air respirator with auxiliary self-contained air supply is required in operations when an:

(1) individual cannot immediately exit a confined space safely if the primary air supply is interrupted, or
(2) immediately life threatening toxic environment is present (i.e., IDLH).

b. Alternative respiratory protection for brush and roller operations are only permitted when authorized by preventive medicine personnel.

B.5 Personal protection for mixing and spraying paint.

B.5.1 The requirements for non-CARC paint systems consist of cloth gloves, cloth or impervious paper disposal coveralls, eye protection, and a head covering. Protective equipment shall be stored in a clean and sanitary area outside of the paint spraying area. The cloth coveralls should be removed and hygienic showers taken prior to changing into street clothing. This is particularly important if any of the coatings contain lead or chromate pigments. The use of gloves is limited to protecting hands from overspray and paint adherence while spraying the paint. Gloves impermeable to solvents should be used where there is potential liquid contact, such as thinning and equipment clean-up procedures. Consult preventive medicine personnel for selection of appropriate gloves.

B.5.2 The same requirements hold for CARC finishes.

B5.3 Barrier creams are useful in preventing the adherence of paints to the skin and in combating the dryness associated with the defatting action of most solvents; however, the usefulness of barrier creams to prevent absorption of solvents through the skin is not documented. Consult preventive medicine personnel for selection of appropriate gloves for all tasks involving handling of solvents or solvent containing materials. Preventive medicine personnel can also help to identify appropriate skin cleansers. Solvents must never be used to remove paint/coating from the skin.

B.5.4 Potential health hazards after painting.

a. Hexamethylene diisocyanate does not present a health hazard after CARC has been applied unless heated to the point of thermal decomposition.
b. Solvents, to include cellosolve acetate if present, may be released during drying. The vapor concentrations measured at paint operations indicate levels well below current standards. The solvent vapors are typically irritating to the eyes and have low odor thresholds. If excessive solvent vapor concentrations are suspect in the drying area, the local preventative medicine/industrial hygiene personnel should be contacted.
c. Before welding or torch cutting on any painted metal, the finish must be completely removed to the substrate at least four inches in all directions from the work area and in all areas which will reach 400 ^{o}F and above, including the backside if it is painted.
d. Normal precautions should be taken when cleaning, sanding or grinding on painted surfaces. Particular safeguards are required if the topcoat or primer contains lead or hexavalent chromium and also if the coating covers cadmium plated components.
e. Protective clothing and equipment required for spraying will also be worn during cleanup.
f. Appropriate housekeeping procedures will be established to include, as a minimum, daily sweeping of paint booths, floors, and walls. Paint residue will be swept up and placed in properly controlled containers for disposal. All associated equipment will be wiped down daily. Use barrels with lids to contain dirty and clean rags. Dirty rag barrels must be kept closed. The barrels must be properly labeled and and used accordingly. Obtain proper labeling instructions from the facility Environmental Coordinator.

B.6 Environmental considerations.

B.6.1 This document will only review federal requirements, as state and local requirements are too varied. Before initiating CARC spray application operations, the local environmental office must be contacted and the provisions of AR 200-1 met.

B.6.2 Volatile organic compound (VOC) emissions for paint and coating applications arise from solvent evaporation from open containers or from initial spray, overspray, and the final coating film as it dries/cures. This is regulated by the Clean Air Act requirements. For assistance in determining emissions, contact the Army Center for Health Promotion and Prevention Medicine at CDR, USACHPPM, Air Quality Surveillance, ATTN: MCHB-TS-EAQ, Aberdeen Proving Ground, MD 21010-5403.

B.6.3 The EPA has designated a number of materials as hazardous. Among the designated materials are a number of paint constituents such as certain solvents (xylene and 1,1,1 trichloroethane, to name a few) and pigments (such as lead and chromate). These solvents or pigments can be present in uncured paint including overspray as well as in sludge in the sump of water wash type spray booths. Actual handling and disposal procedures must be determined in conjunction with AR 200-1 and the local environmental office.

APPENDIX C

APPLICATION EQUIPMENT AND TECHNIQUES

C.1 SCOPE

C.1.1 Scope. This appendix is not a mandatory part of the specification. The information contained herein is intended for guidance only. It contains general guidelines and a brief list of things to do and not to do.

C.2 Facilities. The paint booth is the major facility consideration in painting, as it is needed whenever anything more than touch up painting is planned. There are several types ranging in size from several cubic feet to large structures which are free standing booths. The size and location of a particular paint booth will depend upon the specific situation. Due to Occupational Safety and Health Administration (OSHA) and Environmental Protection Agency (EPA) requirements, any large scale (more than touch up) painting of CARC must be done in a paint booth.

C.2.1 Spray booths can be classified into two basic designs based on direction of airflow.

a. Sidedraft booths have horizontal airflow. These booths take advantage of momentum of spray mist and can be used when painting small to medium articles. Large articles may be painted in vehicular booths which also have horizontal airflow.
b. Downdraft booths have vertical airflow. These booths permit greater protection while allowing more freedom of movement for the painter.

C.2.2 Spray booths range in size from small bench models to chambers capable of holding a large airplane. Size of a spray booth is determined by the requirement for adequate space to permit painters easy access to top and sides of the object. If the object is transported by conveyor, the booth must be sufficiently long to allow coating within the time the object remains inside the booth.

C.2.3 Booth exhaust air filters must be replaced by plant environmental control personnel or responsible operating personnel. The spray booth can be equipped with filter doors or fresh air inlets to reduce dust. Air should enter the booth at low velocity (200 fpm or less) and in the same direction as it is being exhausted to avoid unnecessary turbulence.

C.2.4 The booth air cleaning section not only removes paint mist from exhaust air but acts as a means of air distribution within the booth. Maintenance requirements can be reduced if the booth is lined with a strippable coating, air filters are disposable, and glass shields over booth lights are cleaned and coated with a light layer of white petroleum grease. There are several types:

a. Baffle type. An arrangement of metal baffles is simplest and provides a constant flow of air. Mist removal and clean-up difficulties limit its use to low protection applications.
b. Dry filter. These booths combine low cost with highly efficient paint mist removal, but have the disadvantage of variable airflow. Airflow continuously decreases to a point where filters require replacement. Used filters shall be free of solvent before disposal or a fire hazard will be created.
c. Water wash. These incorporate various combinations of water curtains and sprays to scrub paint mist from exhaust air. They have advantages of constant airflow, inherent fire protection, and high mist removal. This is the most efficient system, but requires a greater cost.

C.2.5 Robotics. Facilities where large volumes of identical equipment will be painted might consider the use of robotics. Robotics can produce exact and precise results, repeatedly. Also, robotics remove people from the potentially hazardous paint booth environment.

C.2.6 Drying ovens. In cooler climates, drying ovens may be required to speed CARC curing process. Care must be taken to prevent overbaking, since this can interfere with adhesion of any subsequent coats of paint.

C.2.7 Preheat booth/cool down booth. In locations where temperatures can drop below 60 ^{o}F (16 ^{o}C), preheat booths should be available to raise the temperature on the equipment surface to the ideal temperature range (60 - 90 ^{o}F/16 - 32 ^{o}C) or to prevent condensation on vehicles during transition before applying CARC. Likewise, in areas where temperatures rise above 90 ^{o}F (32 ^{o}C) cool down booth should be available to reduce the surface temperature to the ideal range.

C.3 Equipment.

C.3.1 Spray guns.

a. Application. Spray gun equipment can be used for any type of finish and on any surface. It does not replace the brush for certain operations, yet there are definite types of work it can do more easily and better than the brush. The spray gun is obviously a tremendous time-saver and its use is recommended when a large volume of work is encountered. The spray gun is particularly adaptable to touch-up and maintenance work when the ability to blend old and new surfaces is important. Spray application of any finish type requires respiratory equipment. The proper operation of spray guns and auxiliary equipment is not difficult to learn, but the necessity exists for training operators. Only through such training can full flexibility and operation of spray guns be realized.
b. Selection. A paint spray gun is a mechanical means of bringing compressed air and paint together, atomizing or breaking up the paint stream into a spray, and ejecting it for the purpose of applying a coating. The three major types of system are conventional air spray, airless/or airless electrostatic spray, and air assisted airless spray. Other specialized systems are available for application of high solids coatings or where transfer efficiency is a concern; e.g., turbo spray with high air volume turbine and low air pressure (HVLP). As with the selection of a booth, the best choice will depend upon the specific situation.

(1) Conventional air spray. A spray gun uses compressed air to atomize the paint and direct it toward the surface. The air and paint enter the gun separately and leave in a controlled spray pattern. An external mix gun mixes the air and fluid outside the air cap, and an internal mix gun mixes them within the air cap. A bleeder-type gun has a continuous leakage of air from some part of the gun. This prevents building up air pressure within the hose and permits its use with small compressing systems that are not equipped with an automatic pressure-controlling device. The trigger in a bleeder-type gun controls only the flow of fluid. A nonbleeder-type is one in which the trigger controls the passage of both air and fluid. Some type of pressure-controlling device must be used with it. A suction-feed gun is designed to feed the fluid into the air stream through a vacuum created by the air stream flowing past the fluid source (aspiration). A pressure-feed gun feeds fluid into the air stream by means of pressurizing the fluid container.
(2) Airless spray/electrostatic spray. Paint flows from the supply source to an airless gun. The paint is forced through a small orifice under very high pressure, atomizing the liquid as it is discharged from the gun. If electrostatic assisted, the paint particles are charged at the same time by a high voltage potential applied at the gun. The particles are then attracted to the grounded surface.
(3) Air assisted airless spray. Air assisted airless spray operates at pressures under 950 pounds per square inch (psi), compared to airless spray/electrostatic spray which operates at 1,500 to 2,500 psi. Low pressure (10 to 30 psi) compressed air is added to the spray by an air cap. Thus, materials can be atomized with full spray patterns at low pressure, increasing efficiency and ease of handling.
(4) Comparison of types. The following table compares several of the characteristics of the preceding systems:

APPENDIX C

TABLE I. Application method comparison.

Item	Atomization	Application Speed	Atomization Efficiency	Transfer Efficiency
Air spray	"Class A" finish	Slow, but easily handled	Large amounts of overspray	30%
Airless/ Electrostatic spray	Deposits paint quickly	Fast, but needs an experienced painter	Less overspray	55%
Air assisted airless spray	Very efficient	Medium, in speed and in control	Little overspray	65%

c. Selection of air caps, needles and nozzles. The performance of an air gun with any kind of material depends primarily on the selection of the proper air cap, fluid needle, fluid tip (or nozzle) and air pressure. Manufacturers identify combinations of these parts intended to be used together, and their recommendations should be followed with respect to the proper combination for a particular material. Occasionally, changing the type of feed will necessitate a different combination of air cap, fluid tip, and fluid needle.

d. Spray gun techniques.

(1) Holding the gun. The gun must be held perpendicular to the work, and 6 to 10 inches from the surface.

(2) Making the proper stroke. The stroke is made with a free-arm motion, keeping the face of the air cap parallel with the surface being painted at all points of the stroke. The ends of the stroke are feathered out by triggering the gun; that is, by beginning the stroke pulling the trigger, and releasing the trigger just before ending stroke. This technique is not applicable to airless spray application. Arcing the gun during the stroke results in an uneven application and excessive overspray at the end of the stroke.

(3) Spraying corners. Spray within one or two inches of a corner. Then, holding the gun at a 45 degree angle to the painted surface, spray both sides of the corner at once. Spraying in another manner wastes material and causes overspray on the adjacent side.

(4) Speed of gun travel. Most guns are capable of applying the paint at a rated speed that is beyond the operator's skill in application. Adjust the gun to operate at a maximum speed consistent with material, rate of flow, surface, and individual skill.

(5) Dusting. Bleeder-type guns act as dusters simply by allowing the continuously escaping air to clean the painting surface. Nonbleeder-type guns emit air alone through the first half of the trigger travel, and can therefore be used as dusters. The point at which the trigger starts to release paint can readily be felt. For large-scale or continuous dusting, special dusting guns handling only air are available.

(6) Masking. When spraying, cover or mask all parts such as windows, gage, lubrication fittings, instruments, and other parts which are not to be painted.

e. Care of equipment. A spray gun is an instrument that has been designed and machined to close tolerances. Handle it with care so that the balance between the functional parts is not destroyed. Spray guns and related equipment require cleaning immediately after use. Paint that has hardened in a gun or hose is extremely difficult to remove, and usually causes a malfunction of the equipment. Be sure that the solvent used to clean the equipment is one in which the finishing material is soluble. Be sure to read the instructions that come with the pressure can regarding preservation of the nozzle.

C.3.2 Brushes and rollers.

a. Application. While spray application of CARC is the preferred procedure in most circumstances, there are occasions when other methods may be employed. Brush or roller application may be appropriate when the volume of work does not justify setting up the spray apparatus, spray equipment is not available or is inaccessible, masking procedure is extensive, or overspray would cause problems.
b. Selection and use. Choose the brush which is appropriate for the job. Factors to consider are the material, the surface, and the area to be painted. Use of rollers in CARC application will be impractical in many cases. Brushing should be done rapidly, because CARC will become tacky within a short time. Thinning after combining the two components may be required.
c. Cleaning and storage. In order to keep paint brushes soft and pliable, they should be cleaned immediately after use. Once the material has been allowed to stand overnight, no amount of cleaning will restore the original pliability or remove the hardened material from the heel of the brush. Solvent or thinners used with the material just applied by the brush are the best possible cleaners. After cleaning, never stand brushes, wet or dry, on their bristles. They will become permanently bent or distorted, and the brush will be ruined. Brushes that are not frequently used should be thoroughly cleaned with the appropriate solvent, dried, and stored in a wrapper to retain their shape. For care of rollers, follow the manufacturer's instructions.

C.4 Cleanup and disposal.

C.4.1 Failure to clean equipment properly after CARC application will result in damage to equipment. Once epoxies and polyurethanes dry in spray lines or spray guns, the equipment may be unrepairable. Solvents have little effect on dried CARC.

C.4.2 Polyurethane and epoxy coatings cannot use the same spray lines. The catalysts (component B) of the epoxies and the catalyst for polyurethane rapidly react when mixed and form a soft plastic. When plural component paint equipment is used, separate lines for the catalysts are strongly recommended to prevent equipment damage.

C.4.3 Spray equipment is cleaned by running solvent through lines. This procedure is the same as that used for other paints, but care must be taken to ensure that all paint is cleaned from equipment. Cleaning of polyurethane and epoxy application equipment cannot be overemphasized. Application equipment must be thoroughly cleaned immediately after use in accordance with manufacturer's instructions for use, and before any prolonged storage. Failure to clean equipment properly will result in loss of that equipment.

C.4.4 Disposal of unusable CARC components or mixtures, waste material (including material spilled or leaked, and empty containers), and all material used in cleanup must be done in accordance with Federal, State and local environmental control regulations for hazardous waste. Consult the installation environmental office for guidance

C.5 Equipment guidelines.

C.5.1 General consideration in selection.

a. As a general statement, air spray guns and pressure pots are the least expensive, but the most inefficient equipment available. Air spray guns and pressure pots cannot change colors quickly, and they are difficult to clean. They are immobile and heavy, unless cart

mounted. They have a limitation on how far work is from the object to be sprayed, and they can be dangerous if over pressurized without a safety relief valve, have a faulty gasket, or the C clamps are not tightened sufficiently.

b. Air spray and pressure pots must be cleaned thoroughly to prevent cured material from flaking off the sides of the pressure pot and being deposited on the work surface, unless liners are used inside the pot. Air spray and pressure pots are messy and wasteful, since original containers must be opened and poured into them, and reducing solvent must be added. The unused portion must be managed as hazardous waste. Contact the local environmental office for proper disposal guidance.

c. The use of air spray guns is also inexpensive, but they can be difficult to clean. Air vent holes on the top of the cup must be kept open to insure positive paint flow. The cup must not be turned upside down or the material will leak from the vent hole. The reactive material must be cleaned thoroughly from the neck of the cup while being mixed, or, mixed in another container and placed in the cup.

d. If a cup method is used, a remote cup is recommended. This method is much more maneuverable, and material is kept out of the seals in the cup.

e. Air spray and diaphragm pumping unit can be used. This method is inexpensive. The Pumping unit fits on a 5 gallon pail, no pressure is on the material, and no air is applied to the material. It can pump 1 gallon or 5 gallons, and it is easily cleaned. Color change is quicker than with pressure pots. Its drawback is it can only be used with a maximum of 25 feet of air and material hose.

C.5.2 Specific operation suggestions.

a. Mix all CARC components thoroughly prior to catalyzing and/or reduction for spray. Once reduced for spray application, CARC topcoats may require mild agitation to prevent settling.
b. Keep moisture away from component B in MIL-C-46168 and MIL-DTL-64159 as well as MIL-C-53039 either using dry air (-32 degrees dew point dryer), a desiccant air dryer in the airline, or nitrogen blanket.
c. Use separate equipment for epoxy primer and for polyurethane topcoat.
d. Clean equipment thoroughly and in accordance with manufacturer's instructions for use and before prolonged storage.
e. Rotate inventory of material, first in, first out, according to the date of manufacture.
f. Do not spray CARC on a dirty surface. Remove all surface rust, moisture, oil, dust, and loose paint before applying CARC.
g. When using automated equipment, such as robotics, use meter mixing equipment to obtain strict viscosity control, material quality control and total system supervision control.
h. Store material in clean, dry, temperature controlled OSHA-approved storage facility.
i. Ensure that operators of equipment are trained in operation, maintenance, and storage.
j. Store airless or air-assisted airless tips in solvent after using to keep them clean and free from material blockage.
k. Use tip protectors on airless spray guns.
l. Maintain a continuous electrical ground on all equipment to prevent static buildup which could produce a spark and ignite material. Approved grounding connections must be used.
m. Maintain clean, dry air to the air motor on air-operated equipment.
n. When spray guns are not being used, for instance during lunch or break time, place tip only of spray gun into a solvent bath.
o. Locate material filters on outbound side of pressure pots and pumps.
p. All air-operated equipment must have air regulators and pressure relief valves.
q. Use ball valves between system components so that components can be serviced without material leaking on floor.

r. Use filters that allow for drainage into waste containers so that filters can be cleaned and serviced properly.
s. Clean material filters on scheduled basis.
t. Filter as close to spray gun as possible.
u. Provide swivel unions between system components such as spray guns, hoses, filters and pumps for ease of disconnect.
v. Keep spray pattern 90 degrees to surface to be sprayed.
w. Move spray gun at a constant speed, maintaining a constant distance and angle to the work place to achieve an even coating.
x. Fill all manufacturer's service and spare parts list breakdowns for future reference and for ordering spare parts.
y. Place catalyst pumps in down positions to prevent crystallization.
z. Remove thinner from material hoses. Epoxy and urethane material residue will react and block mixed material hoses even though thinner or solvent is present.
aa. Do not unplug airless/electrostatic or air assisted airless tips with sharp objects. They are brittle and will destroy spray pattern.
bb. Remove components A and B of urethane topcoat promptly from air-operated pumps.
cc. Remove mixed material from hoses, cups and pumps within 2 hours when not in use to prevent solidification.
dd. Do not use quick disconnects on material lines. They will become inoperable because of material hardener.
ee. Do not restrict air flow to air operated equipment.
ff. Use high pressure plumbing on high pressure systems.
gg. Use manufacturer's recommended paint and air hose on paint systems.
hh. Drums must be put on a drum tumbler for at least six hours before use.
ii. Use only fluid pressure and air pressure necessary to atomize material. Excessive pressures cause excessive overspray and waste.
jj. When spray painting, avoid moving spray gun back and forth in an arc. This method causes excessive paint buildup in center of arc and thin edges on outer reaches.
kk. Wear proper and approved breathing apparatus when spray painting.
ll. Do not spray in unventilated areas without EPA and OSHA approved safety equipment.
mm. Remove all thinner from coiled hoses before storage. Leave thinner in pumping system.
nn. Do not direct spray device at anything other than object to be sprayed.
oo. Do not remove spray guns, hose, filters and/or systems components while under pressure. Be sure that all components are at atmospheric pressure when disconnecting them from system.
pp. Make sure that shop air and breathing air systems are separate and cannot be accidentally connected together.
qq. Use of paint pots with constant agitation systems can reduce settling of the mixed coating.
rr. When designing a painting facility, minimize the distance which the fluid must travel and the number of turns (90^{o} elbows) and valves placed in the delivery line.
ss. Plural component paint equipment is not the answer to eliminating the manual mixing of two component paints.
tt. Do not use CARC on items attaining temperatures in excess of 400 ^{o}F, such as manifolds, exhaust pipes, and mufflers. Use MIL-P-14105 or TT-P-28 as applicable.
uu. Dispose of all wastes in accordance with local, state and Federal regulations. Contact the local environmental office to obtain disposal guidance.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter must be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-DTL-53072C	2. DOCUMENT DATE (YYYMMDD) 20030606

2. DOCUMENT TITLE
CHEMICAL AGENT RESISTANT COATING (CARC) SYSTEM APPLICATION PROCEDURES AND QUALITY CONTROL INSPECTION

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	d. TELEPHONE(Include Area Code) (1) Commercial (2) DSN (If applicable)	7. DATE SUBMITTED (YYYYMMDD)

8. PREPARING ACTIVITY

a. NAME US Army Research Laboratory Weapons & Materials Research Directorate	b. TELEPHONE (Including Area Code) (1) Commercial (410) 306-0725 (2) DSN 458-0725
C. ADDRESS (Include Zip Code) ARL/WMRD ATTN: AMSRL-WM-MA Aberdeen Proving Ground, MD 21005-5069	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Standardization Program Office (DLSC-LM) 8725 John J. Kingman Road, Suite 2533, Fort Belvoir, VA 22060-6221 Telephone (703) 767-6888 DSN 427-6888

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