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SUPERSEDING
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DETAIL SPECIFICATION

CHEMICAL CONVERSION COATINGS ON ALUMINUM AND ALUMINUM ALLOYS

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

1. SCOPE

1.1 Scope. This specification covers chemical conversion coatings formed by the reaction of chemical conversion materials with the surfaces of aluminum and aluminum alloys.

1.2 Classification. The chemical conversion coatings are of the following types and classes.

1.2.1 Types. The chemical conversion coatings are of the following types (see 3.1):

Type I – Compositions containing hexavalent chromium.
Type II – Compositions containing no hexavalent chromium.

1.2.2 Classes. The materials, which form protective coatings by chemical reaction with aluminum and aluminum alloys, are of the following classes (see 6.1 and 6.4).

Class 1A - For maximum protection against corrosion, painted or unpainted.
Class 3 - For protection against corrosion where low electrical resistance is required.

Comments, suggestions, or questions on this document should be addressed to: Commander, Naval Air Warfare Center Aircraft Division, Code 491000B120-3, Highway 547, Lakehurst, NJ 08733-5100 or emailed to thomas.omara@navy.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at http://assist.daps.dla.mil.

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2. APPLICABLE DOCUMENTS

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

2.2 Government documents.

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

FEDERAL STANDARDS

FED-STD-141	-	Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-PRF-23377	-	Primer Coatings: Epoxy, High-Solids
MIL-DTL-81706	-	Chemical Conversion Materials for Coating Aluminum and Aluminum Alloys
MIL-PRF-85582	-	Primer Coatings: Epoxy, Waterborne

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

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

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) INTERNATIONAL

ASTM-B117	-	Salt Spray (Fog) Apparatus, Operating. (DoD adopted)
ASTM-D3359	-	Adhesion By Tape Test, Measuring. (DoD adopted)

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

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AMERICAN SOCIETY FOR QUALITY (ASQ)

ASQ-Z1.4	-	Procedures, Sampling and Tables for Inspection by Attributes

(Copies of this document are available from American Society for Quality, 600 North Plankinton Ave., Milwaukee, WI 53203 or http://www.asq.org.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE) INTERNATIONAL

SAE-AMS4027	-	Aluminum Alloy, Sheet and Plate, 1.0Mg-0.60Si-0.28Cu-0.20Cr, (6061; -T6 Sheet, -T651 Plate) Solution and Precipitation Heat Treated. (DoD adopted)
SAE-AMS4037	-	Aluminum Alloy, Sheet and Plate, 4.4Cu-1.5Mg-0.60Mn, (2024; -T3 Flat Sheet; -T351 Plate) Solution Heat Treated. (DoD adopted)

(Copies of these documents are available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or http://www.sae.org.)

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 Materials. If no material type is specified type I shall be used. Unless otherwise specified in the contract or order, substitutions of either type I for type II, or type II for type I coatings are not permitted. The materials used to produce a chemical conversion coating shall be approved for the selected type, class, form, and application method in accordance with the qualification requirements of MIL-DTL-81706 and shall have been accepted for listing on the applicable qualified products list (see 6.5). Replenishing chemicals, such as fluorides, added to a bath to maintain its efficiency, shall not degrade the performance of the coating being applied.

3.2 Cleaning. Prior to coating, the base metal shall be mechanically or chemically cleaned such that a water break-free surface is obtained after rinsing (see 6.6). Abrasives containing iron such as steel wool, iron oxide, rouge, or steel wire are prohibited for all cleaning operations. Treated parts that have become soiled shall be cleaned with materials that will remove the soil without damaging the base metal, the part, or the conversion coating. If the coating is damaged, the damaged area shall be recleaned and recoated or the part shall be rejected.

3.3 Application. Unless an application method is specified in the contract or order

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(see 6.4), the chemical conversion coating shall be applied nonelectrolytically by spray, brush, or immersion after all heat treatments and mechanical operations such as forming, perforating, machining, brazing, and welding have been completed (see 6.11 and 6.14). Assemblies containing nonaluminum parts that may be attacked, embrittled, or damaged in any way by the conversion coating process shall not be coated as assemblies unless the nonaluminum parts are masked.

3.4 Touch-up. If specified in the contract or order, mechanically damaged areas from which the coating has been removed shall be touched up or rejected. The damaged areas shall be touched up with MIL-DTL-81706 material approved on QPL-81706 for the applicable type, class, form, and method. The area to be touched up shall be not greater than 5 percent of the total item surface area (see 6.4 and 6.17).

3.5 Appearance. The chemical conversion coating shall be continuous in appearance and visibly discernible in daylight. It shall be free from areas of powdery or loose coating, voids, scratches, flaws, and other defects or damages which reduce the serviceability of parts or are detrimental to the protective value and paint bonding characteristics. The size and number of contact marks shall be minimal, consistent with good practice. If specified in the contract or order, contact marks shall be touched up with MIL-DTL-81706 material approved on QPL-81706 for the applicable type, class, form, and method to prevent localized corrosion (see 6.4 and 6.8).

3.6 Performance characteristics.

3.6.1 Corrosion resistance. At the end of 168 hours of exposure to the 5 percent salt spray test specified in 4.4.1, test specimens (see 4.2.2) treated with the applicable class of coating shall meet the following corrosion resistance requirements (see 6.14):

a. No more than 5 isolated spots or pits (see 6.9), none larger than 0.031 inch in diameter, per test specimen. Areas within 0.25 inch from the edges, identification markings, and holding points during processing or salt spray exposure shall be excluded. Loss of color shall not be cause for rejection.

b. No more than 15 isolated spots or pits, none larger than 0.031 inch in diameter, on the combined surface area of all five test specimens, subjected to the salt spray test.

3.6.2 Paint adhesion (wet tape). When the production paint system (6.13) or the paint system specified in 4.2.2.1.1 is applied to the applicable test specimens (see 4.2.2), no intercoat separation shall occur between the paint system and the conversion coating, or between the conversion coating and the base metal, when tested in accordance with 4.4.2 (an adhesion rating of 4A or better according to ASTM-D3359 Procedure A) (see 6.12). If the conversion coated parts do not require painting for end use, the paint adhesion test may be omitted if specifically authorized by the acquisition activity (see 6.4).

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3.7 Electrical contact resistance of class 3 coatings. Electrical contact resistance testing shall be as specified in the contract or order (see 6.4). The test method, frequency of testing, and required resistance values shall be specified by the acquisition activity to meet the needs of a particular application (see 6.1.2.1).

3.8 Chemical analysis of the conversion solution. Chemical analysis of the conversion solution shall consist of concentration, pH, and temperature evaluations to determine that the bath is within the ranges specified by the chemical manufacturer (see 6.11).

3.9 Workmanship. The chemical conversion coatings covered by this specification shall be produced by treatments and processes that produce coated components as specified in this specification.

4. VERIFICATION

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

a. Process control inspection (see 4.2).
b. Conformance inspection (see 4.3).

4.2 Process control inspection.

4.2.1 Process control tests and solution analysis. Test specimens shall be tested in accordance with table I and 4.2.1.1. In addition to the tests in table I, solution analysis shall be performed on all the processing solutions in the chemical conversion line (see 3.8) to verify that the chemical concentrations are within ranges established for optimum performance (see 6.11 and 6.14). Process control tests are conducted to determine compliance of the chemical conversion coatings with the requirements of this specification and are acceptable as evidence of the properties being obtained with the equipment and procedures employed.

TABLE I. Process control tests.

Tests	Class	Number of test specimens	Test specimen preparation paragraph	Requirement paragraph	Test paragraph
Corrosion resistance	1A 3	5 5	4.2.2 4.2.2	3.6.1 3.6.1	4.4.1 4.4.1
Wet tape adhesion	1A 3	2 2	4.2.2-4.2.2.1 4.2.2-4.2.2.1	3.6.2 3.6.2	4.4.2 4.4.2
Electrical contact resistance	3	5	4.2.2	3.7	4.4.1

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4.2.1.1 Frequency of process control testing and solution analysis. Solution analysis shall at a minimum be performed once every week (see 6.15). The process control tests specified in table I shall at a minimum be conducted on a monthly basis. In addition, the interval between each monthly test shall not exceed 35 days. If production in accordance with this specification is not performed for 35 days or more, process control tests and solution analysis shall be conducted at the restart of production.

4.2.2 Process control test specimens. Test specimens used for process control testing shall be 3 inches wide, 10 inches long, with a nominal thickness of not less than 0.020-inch. The test specimens shall be processed with the hardware during an actual production run, including all pre- and post-treatment processes such as cleaning and rinsing, except as specified below. Unless otherwise specified in the contract or order (see 6.4), either of the following alloy options for the process control test specimens shall be used:

Option 1 - A set of test specimens shall be used for each alloy and temper treated during the monthly process control period.

Option 2 - The test specimens shall be 2024-T3 aluminum alloy in accordance with SAE-AMS4037 for class 1A coatings and 6061-T6 aluminum alloy test specimens in accordance with SAE-AMS4027 for class 3 coatings. Aluminum alloy 2024-T3 test specimens may be used in lieu of 6061-T6 test specimens for testing class 3 coatings (see 6.10). When castings are being processed and the cleaning procedures used are detrimental to the wrought test specimens, the test specimens shall be cleaned in a proper manner (see 3.2) and the conversion coated with the castings. If the production parts are not 2024-T3 aluminum alloy and the etch or deoxidizer may be detrimental to the test specimens, the manufacturer’s recommended cleaning practices shall be used.

4.2.2.1 Preparation of paint adhesion specimens. Unless otherwise specified on the contract or order (see 6.4), the paint system to be used on the test specimens for adhesion testing (see 4.4.2 and 6.13) shall be the same system used for the production work (applied and cured in the same manner as the production work) or the paint system specified in 4.2.2.1.1.

4.2.2.1.1 Epoxy primer coatings. Test specimens shall be furnished with one coat of a volatile organic compound (VOC) compliant epoxy-polymide primer conforming to MIL-PRF-23377 or MIL-PRF-85582. In either case, the primer shall be applied to a dry film thickness of 0.0006 to 0.0009 inch (0.6 to 0.9 mil) and dried in accordance with the applicable primer specification before testing in accordance with 4.4.2.

4.2.3 Failure. Failure to conform to any of the process control requirements specified in table I shall result in immediate cessation of production. The reason for failure shall be determined and corrected before production resumes. All traceable and retrievable work from the last acceptable process control test to the time when the failure was determined shall be rejected, unless the work under review can be demonstrated to meet the requirements of this

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specification. Unless otherwise specified, parts that have been painted or incorporated into an assembly shall not be considered retrievable.

4.3 Conformance inspection.

4.3.1 Sampling. Samples for visual examinations shall be selected from each lot (see 4.3.2) of treated articles, items, parts, or components. Unless otherwise specified in the contract or order (see 6.4 and 6.18), the sampling plan and acceptance criteria shall be as specified in ASQ-Z1.4, inspection level II.

4.3.2 Visual lot examination. Samples selected in accordance with 4.3.1 shall be visually inspected for compliance with 3.5 and 3.9. Each lot shall be inspected to ensure that the lot consists of all conversion coated items of the same type, class, form, and method, treated under the same process conditions, and submitted for acceptance at one time. Unless otherwise specified on the contract or order, the lot size shall not exceed the number of parts, articles, items, or components resulting from one day's production (see 6.4).

4.3.3 Failure. Failure to conform to 4.3.2 shall result in rejection of the represented lot.

4.4. Test methods.

4.4.1 Corrosion resistance test. Five test specimens prepared in accordance with 4.2.2 shall be used for corrosion resistance testing. After the coating application, the test specimens shall be dried at 60 to 100 ºF (16 to 38 ºC) for 24 hours (see 6.14). The test specimens shall then be subjected to a 5 percent salt spray test in accordance with ASTM-B117 for 168 hours, except that the significant surface shall be inclined 6 ± 2 degrees from the vertical. After exposure, test pieces shall be cleaned in running water not warmer than 100 ºF (38 ºC), blown with clean, dry unheated air, and visually examined for conformance to 3.6.1. The dry unheated air for type I shall be not warmer than 100 ºF (38 ºC) and for type II shall follow the manufacturer's recommended temperature ranges.

4.4.2 Wet tape adhesion test. Two test specimens prepared in accordance with 4.2.2 and 4.2.2.1 shall be tested for wet tape adhesion. The test shall be conducted in accordance with FED-STD-141, method 6301, to determine conformance to 3.6.2.

5. PACKAGING

5.1 Not applicable.

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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 conversion coatings covered by this specification are intended for use, throughout the Department of Defense, on aluminum and aluminum alloy substrates that are not anodized. They are used to repair anodized coatings on aluminum. They are designated as a post treatment to ion-vapor deposition (IVD) aluminum used on many military platforms as a cadmium alternative or galvanic corrosion inhibitor. Type I and II conversion coatings provide corrosion protection on unpainted items, as well as improve adhesion of paint finish systems on aluminum and aluminum alloys. The conversion coatings covered by this specification exceed commercially available products due to the nature of their use on aircraft.

6.1.1 Class 1A. Class 1A chemical conversion coatings are intended to provide corrosion prevention on unpainted items as well as improve adhesion of paint finish systems on aluminum and aluminum alloys. Coatings of this type may be used, for example, on tanks, tubing, and component structures where paint finishes are not required for interior surfaces but are required for the exterior surfaces.

6.1.2 Class 3. Class 3 chemical conversion coatings are intended for use as a corrosion preventive film for electrical and electronic applications where lower resistant contacts, relative to class 1A coatings, and anodic coatings in accordance with MIL-A-8625, are required (see 6.1.2.1). Coating thickness is varied by immersion time, and as a result, the same conversion material can be listed on QPL-81706 for both classes. Because class 3 coatings are thinner they are more susceptible to corrosion than class 1A coatings. If it is required to paint areas surrounding electrical contacts, class 3 coatings improve adhesion of paint systems on aluminum and aluminum alloys.

6.1.2.1 Electrical resistance testing. When under a nominal electrode pressure of 200 psi, class 3 coatings are qualified under MIL-DTL-81706 to have a resistance not greater than 5,000 microhms per square inch as supplied and 10,000 microhms per square inch after 168 hours of salt spray exposure. In addition to the coating or coating thickness (see 6.1.2), other variables heavily influence resistance values when using the test method specified in MIL-DTL-81706 or other similar methods. The following two variables (see 6.1.2.1.1 and 6.1.2.1.2) may have a greater effect on electrical resistance values than the conversion coating thickness.

6.1.2.1.1 Surface roughness of the specimen panel. Test specimens having rough surfaces will yield lower resistance values when subjected to a contact electrode pressure due to coating fracture. This reasoning can also be applied to the contact electrode.

6.1.2.1.2 Flatness of the contact electrode. If an electrode with a given surface area is not flat, the actual contact area will be lower than the theoretical value. A smaller contact area

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results in a higher resistance value. The same reasoning can be applied to the test specimen.

6.2 Responsibility for inspection. Unless otherwise specified in the contract or order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

6.3 Responsibility for compliance. All items must meet the requirements of section 3. The inspection set forth in this specification must become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirement in the specification will not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

6.4 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of the specification.
b. Type and class required (see 1.2.1 and 1.2.2).
c. Method of application, if restricted (see 3.3).
d. If touch-up is permitted for mechanically damaged areas (see 3.4).
e. Colorless coatings, if required (see 3.5).
f. If touch-up is permitted for contact marks (see 3.5)
g. Omit the paint adhesion test, if permitted (see 3.6.2).
h. If electrical resistance testing if required for class 3 coatings (see 3.7 and 6.1.2).
i. When electrical resistance testing is required, specify the required resistance values, frequency of testing, and test method (see 3.7 and 6.1.2).
j. Alloy and temper of the process control test specimens, if different than that specified in 4.2.2.
k. Paint finish system for treated parts, if applicable (see 4.2.2.1).
l. Quantity required.
m. Sampling plan, if different than that specified (see 4.3.1 and 6.18).
n. Lot size, if different than that specified (see 4.3.2).

6.5 Interchangeability. The various products approved in accordance with MIL-DTL-81706 and listed on QPL-81706 provide equivalent coatings within each type and class. These coatings are equivalent insofar as performance of the chemical conversion coating is concerned, to the provisions of this specification, but are not interchangeable from a chemical standpoint; that is, different materials cannot be mixed. The materials from one

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supplier cannot be mixed or used to strengthen an existing solution from another material supplier. As the chemical coating materials are proprietary products, the ingredients, processes, the method of application (e.g., spray, brush, or immersion), and the equipment required for application of the coating may vary. Contractors and military activities must take this into account in acquisition, in the design of parts, and in the establishment of facilities. Detail drawing of parts requiring treatment in accordance with this specification should specify class 1A or 3, where applicable the required type, I or II, and any paint finishing systems required to meet the performance desired. If the coating class is not specified, class 1A is recommended.

6.6 Cleaners. Use of a non-etch cleaner is preferred, particularly on wrought alloys. If an etch is used, caution must be taken to prevent pitting or intergranular attack. This is particularly important when using an alkaline etch because the aluminum tends to be more soluble than its alloying elements and existing intermetallics, such as copper, which may be further exposed. As a result, alkaline etching should be avoided (particularly when cleaning assembled structures). If an alkaline etch is used, it should always be followed by an acid neutralization step.

6.7 Abrasion resistance. The abrasion resistance of chemical coatings is relatively low. Coatings are reasonably durable when subjected only to moderate handling, but are readily removed by severe wear or erosion. However, cold forming operations, when performed with care, can generally be performed on treated metals without appreciable damage to the coatings.

6.8 Visual appearance. The simplest way to evaluate a conversion coating is to observe color, continuity in appearance, smoothness and adhesion to the base metal (see 3.5). Visual examination is performed to ensure that proper cleaning and coating procedures were used such that a coating with sufficient protection exists over the entire part. Materials qualified under MIL-DTL-81706 produce coatings that range in color from clear/colorless to iridescent yellow, brown, gray, or blue. It may be possible to develop acceptable color levels for a particular coating system by use of color chips. The following circumstances may exist that relate to color uniformity:

a. When several alloys are processed with the same conversion chemical, color may vary from alloy to alloy.

b. Due to the high level of impurities and oxidation on the surfaces of aluminum welds and castings, color may not be as uniform as that obtained by treating wrought alloys.

c. Dark spots may result from dripping or rundown of the conversion chemicals when the parts are lifted out of the treatment tank. A small amount of spotting does not result in coating degradation but must be minimized by quickly rinsing the parts after treatment, and use of proper racking techniques.

Visual examination does not reveal if the protective value of the coating has been impaired by contamination or by overheating during drying. If a clear coating is required, inspection difficulties may arise because visual inspection does not reveal the presence of a coating. For

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type I materials, existence of a coating can be verified by using a simple spot test specified in ASTM-B449. For type II materials, existence of a coating should be verified per the manufacturer's recommendation

6.9 Determination of a corrosion spot or pit. As a general rule, a corrosion spot or pit usually displays a characteristic tail or line, however, any visible corrosion or pitting except scratches or substrate surface defects is to be counted..

6.10 Test specimens (2024-T3). Due to high copper content, 2024-T3 aluminum alloy test specimens are more susceptible to salt spray failure than 6061-T6 aluminum alloy test specimens (see 4.2.2).

6.11 Chemical analysis of the conversion solution. Note that many conversion materials do not react sufficiently with aluminum surfaces at low temperatures. Conversion coating of parts in an unheated facility, such as a hangar, during colder periods of the year is not recommended.

6.12 Paint adhesion. Coated parts should be allowed to dry in accordance with the chemical manufacturer's recommendation before they are subsequently painted or adhesion failures may occur. When coated parts are stored for extensive periods before painting, they should be cleaned in accordance with 3.2 to reactivate the surface by removing dust particles. Excessively thick coatings may result in paint adhesion problems, such as blistering, due to higher amounts of soluble material under the paint.

6.13 Paint compatibility. Compatibility problems between conversion coatings and certain Chemical Agent Resistant Coatings (CARC) have been reported.

6.14 Temperature effects on corrosion protection. Unpainted conversion coatings will commence losing corrosion resistance properties if exposed to temperatures of 140 ºF (60 ºC) or higher, during drying, subsequent fabrication, or service. As temperatures and exposure times increase, the corrosion protection of unpainted conversion coated parts decreases. The reduction is believed to result from the coating dehydrating and the resulting insolubility of the chromates within the coating.

6.15 Solution analysis documentation. Documentation of the history of each processing bath, showing additions of replenishing chemicals to the bath and the results of all solution analyses performed must be maintained. Testing of the solution should be consistent with best industry practices and manufacturer's recommendations. Upon request of the acquisition activity, such records, as well as reports of the test results, should be made available. These records must be maintained for not less than one year after completion of the contract or order.

6.16 Shelf life. This specification covers items where shelf life is a consideration. Specific shelf-life requirements should be specified in the contract or purchase order. The shelf-life codes are contained in the Federal Logistics Information System Total Item Record. Additive information for shelf-life management may be obtained from *DoD 4140.27-M, Shelf-life*

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Management Manual, or the designated shelf-life Points of Contact (POC). The POC should be contacted in the following order: (1) the Inventory Control Points (ICPs), and (2) the DoD Service and Agency administrators for the DoD Shelf-Life Program. Appropriate POCs for the DoD Shelf-Life Program can be contacted through the DoD Shelf-Life Management website: http://www.shelflife.hq.dla.mil/.

6.17 Touch-up. If the area exceeds 5 percent, specific approval must be obtained from the acquisition activity before the area can be touched up.

6.18 Acceptance criteria. The contract or order will specify the acceptable quality levels for the sampling plan specified in 4.3.1 (see 6.4).

6.19 Subject term (key word) listing.

Chromates
Fluorides
Hexavalent chromium
Phosphates

6.20 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.

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

Preparing activity:
Navy - AS
(Project MFFP-0706)

Review activities:
Army - AR, AV, CR, CR4, MI, YD
Navy - OS, SH
Air Force - 71, 99

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