

METRIC

MIL-PRF-24712B

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SUPERSEDING

MIL-PRF-24712A

25 May 1995

PERFORMANCE SPECIFICATION
COATINGS, POWDER, THERMOSETTING

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

1. SCOPE

1.1 Scope. This specification covers thermosetting powder coatings for shipboard metallic equipment, furniture, electrical enclosures, and other miscellaneous metal parts and outfitting hardware in non-immersion service in both interior and exterior environments.

1.2 Classification. Powder coatings covered by this specification are of the following types and classes, as specified (see 6.2).

1.2.1 Types.

- a. Type I - Epoxy resin, without zinc.
- b. Type II - Epoxy resin, zinc-rich.
- c. Type III - Triglycidyl Isocyanurate (TGIC) polyester resin.
- d. Type IV - Hybrid of these resin systems.

1.2.2 Classes.

- a. Class 1 - Exterior, non-immersion service, first coat of a two-coat system.
- b. Class 2 - Exterior, non-immersion service, topcoat of a two-coat system.
- c. Class 3 - Exterior, non-immersion service, single-coat product.
- d. Class 4 - Interior dry service, wet service, single-coat product.

Comments, suggestions, or questions on this document should be addressed to: Commander, Naval Sea Systems Command, ATTN: SEA 05S, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard DC 20376-5160 or emailed to CommandStandards@navy.mil, with the subject line "Document Comment". Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at <https://assist.dla.mil>.

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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 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 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

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

FEDERAL SPECIFICATIONS

TT-C-490 - Chemical Conversion Coatings and Pretreatments for Ferrous Surfaces (Base for Organic Coatings)

FEDERAL STANDARDS

FED-STD-595 - Colors Used in Government Procurement

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-DTL-24441 - Paint, Epoxy-Polyamide, General Specifications for

MIL-DTL-24607 - Enamel, Interior, Nonflaming (Dry), Chlorinated Alkyd Resin, Semigloss

MIL-PRF-24635 - Coating Systems, Weather-Resistant, Exterior Use

(Copies of these documents are available online at <http://quicksearch.dla.mil>.)

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

CODE OF FEDERAL REGULATIONS

29 CFR 1910, 1915, 1917, 1926, and 1928 - Hazard Communication Act, Final Rule

29 CFR 1990 - Identification, Classification, and Regulation of Potential Occupational Carcinogens

40 CFR 261, Appendix II - Toxicity Characteristic Leaching Procedure (TCLP)

40 CFR 355, Appendices A and B - The List of Extremely Hazardous Substances and their Threshold Planning Quantities

40 CFR 372.65 - Specific Toxic Chemical Listings

(Copies of these documents are available online at www.gpoaccess.gov/index.html.)

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ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA SW-846 - Test Methods for Evaluating Solid Waste, Physical/Chemical Methods

EPA 600/4-020 - Methods for Chemical Analysis of Water and Wastes

(Copies of these documents are available online at www.epa.gov.)

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)

NIOSH Analytical Method 7500 - Silica, Crystalline, by XRD

OSHA Analytical Method ID-191 - Polarization Light Microscopy of Asbestos

(Copies of these documents are available online at www.osha.gov.)

UNITED STATES DEPARTMENT OF HEALTH AND HUMAN SERVICES

National Institute of Environmental Health Sciences (NIEHS) National Toxicology Program (NTP)
Latest Annual Report of Carcinogens

(Copies of this document are available online at www.os.dhhs.gov.)

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 ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)

AAMA 2603 - Voluntary Specification, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels (with Coil Coating Appendix)

(Copies of this document are available online at <http://corporateportal.ppg.com>.)

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

ACGIH 0026 - Threshold Limit Values for Chemical Substances and Biological Exposure Indices

(Copies of this document are available online at www.acgih.org.)

ASTM INTERNATIONAL

ASTM A1008 - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable

ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus

ASTM D149 - Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

ASTM D522 - Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings

ASTM D523 - Standard Test Method for Specular Gloss

ASTM D714 - Standard Test Method for Evaluating Degree of Blistering of Paints

ASTM D1654 - Standard Test Method for Evaluation of Painted or Coated Specimens Subjected Corrosive Environments

ASTM D1729 - Standard Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials

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- ASTM D2244 - Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
- ASTM D2247 - Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity
- ASTM D2794 - Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
- ASTM D3359 - Standard Methods for Measuring Adhesion by Tape Test
- ASTM D3363 - Standard Test Method for Film Hardness by Pencil Test
- ASTM D5894 - Standard Practice for Cyclic Salt Fog/UV Exposure of Painted Metal, (Alternating Exposures in a Fog/Dry Cabinet and a UV/Condensation Cabinet)
- ASTM E1349 - Standard Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional (45:0 or 0:45) Geometry

(Copies of these documents are available online at www.astm.org.)

INTERNATIONAL AGENCY FOR RESEARCH ON CANCER (IARC)

International Agency for Research on Cancer (IARC) Monographs

(Copies of this document are available online at www.who.int/bookorders.)

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC-SP 10/NACE No. 2 - Near-White Blast Cleaning

(Copies of this document are available online at www.sspc.org.)

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

3. REQUIREMENTS

3.1 Qualification. Powder coatings furnished under this specification shall be products that are authorized by the qualifying activity for listing on the applicable qualified products list before contract award (see 4.2 and 6.3). Unless otherwise specified in the applicable test method of this specification, all of the requirements below apply to all types and classes of coatings.

3.1.1 Description of coatings. At the time of qualification submittal, the vendor shall identify the powder coating being qualified by (a) type and class for which qualification is sought, and (b) unique product nomenclature. At a minimum, this unique product nomenclature shall consist of the coating name, alphanumeric identifier, and color designation. The color designation shall include the FED-STD-595 color number if applicable (see 6.2 and 6.3). Nomenclature shall be as specific as necessary to uniquely identify the product.

3.2 Materials. The material shall be a uniform, finely ground, free-flowing powder. The powder shall consist of a resin and curing agent system, catalysts, fillers, colorants, and flow-control agents in order to form a powder formulation capable of being applied by electrostatic spraying, flocking, or fluidized bed processes, as specified in the coating vendor's data sheet. The thermosetting powder resin types may be epoxy, TGIC polyester, polyurethane, or hybrids of these resins. The composition of the coating furnished to this specification shall be the responsibility of the vendor, except as limited by this specification. When applied to a metallic substrate prepared as described in the vendor's data sheet, and subjected to a heating cycle as described in the vendor's data sheet, the material shall coalesce, fuse, and subsequently cure to form a coating that meets or exceeds all the requirements of this specification.

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3.2.1 Condition in container. The powder shall be uniform, free of grit, abrasives, dirt, or other impurities. The delivered powder shall show no visible evidence of clumping or caking.

3.3 Metals content, hazardous pigments, and additives. When tested as specified in 4.4, the content of each soluble metal and total content of each metal in the coating shall be no greater than the values listed in [table I](#). In addition, asbestos and asbestos-form pigments shall not exceed 0.1 percent by weight in the cured coating film, and crystalline silica shall not exceed 0.1 percent by weight. If the total metal content for an individual metal is less than the allowed soluble metal content for that metal, the total metal value may be submitted for the soluble metal value and the actual test for soluble metal need not be performed.

3.4 Toxins, carcinogens, and reproductive stressors. The materials used in the powder coating systems, unless specific material maximum levels are cited herein (see 3.3), shall have no known carcinogenic or potentially carcinogenic materials identified by OSHA (29 CFR 1910.105) as regulated carcinogens, or IARC latest monographs, or the latest NTP report, or ACGIH 0026 and shall have no extremely hazardous substances (EHS) or toxic chemicals identified in 40 CFR 355 and 372.65, respectively. The powder manufacturer is responsible for maintaining carcinogenic free materials. The manufacturer shall not, unless specific material maximum levels are cited herein, allow the addition of any prohibited materials to the formulation; and when any of these prohibited materials are/may be present, as a result of being present as a trace or impurity in another ingredient(s), the concentration shall not equal or exceed 0.1 percent by weight. When evaluated in accordance with 4.5 [the Health Hazard Assessment (HHA)], the powder and the coating it produces shall have no adverse effect on the health of personnel when used for its intended purpose (see 4.5 and 6.9). Questions pertinent to this toxicity requirement shall be referred by the contracting activity to the qualifying activity. The qualifying activity will act as advisor to the contracting activity. The qualifying activity will arrange for review of questions by the appropriate departmental medical service (see 4.5).

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TABLE I. Metals content of coatings.^{1/}

Metal and its Compound in Each Coating Dry Film	Soluble Metal, Maximum (mg/L)	Total Content, Maximum (% weight)
Antimony	15.0	0.015
Arsenic	5.0	0.005
Barium (excluding barite)	100.0	0.100
Beryllium	0.75	0.0002
Cadmium	1.0	0.0005
Chromium VI compounds	1.0	0.001
Chromium and chromium III compounds	560.0	0.56
Cobalt	50.0	0.005
Copper	25.0	0.01
Fluoride salts	180.0	0.18
Lead	5.0	0.005
Mercury	0.2	0.0002
Molybdenum	350.0	0.35
Nickel	20.0	0.02
Selenium	1.0	0.002
Silver	5.0	0.001
Tantalum	100.0	0.100
Thallium	7.0	0.007
Tungsten	100.0	0.100
Vanadium	24.0	0.01
Zinc ^{1/}	250.0	0.25
NOTE: ^{1/} These limits on zinc do not apply to Type II coatings, which may contain sacrificial zinc for corrosion control.		

3.5 Film properties. The powder coating shall be capable of being applied by established commercial powder-coating methods over metallic substrates that have been solvent cleaned and either abrasive blasted, iron or zinc phosphate coated, chemical conversion coated, or coated with an electro-deposited epoxy primer (i.e., e-coat). All types and classes of coatings shall be capable of being applied to a dry film thickness of 4 to 10 mils (101 to 254 μm) in a single coat, and meet the requirements of this specification in that thickness range. When applied to panels as specified in 4.6, and examined in accordance with 4.7.1, the coating shall be visibly smooth, even, and free of runs, sags, streaks, flow lines, blisters, orange-peel, or other surface imperfections.

3.6 Cure parameters. The powder cure cycle (time at temperature) shall be as specified by the powder vendor, but in no case shall the temperature exceed 232 °C (450 °F). The potential for the powder cure cycle to adversely affect metallic substrates is described in 6.1.1.

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3.7 Color (type I, III, and IV (non-zinc) coatings only). The color of the cured powder coating shall be specified as a FED-STD-595 color number, unless the contracting activity specifies some other color standard or sample (see 6.2 and 6.7).

- a. When measured in accordance with 4.7.2, colors defined by Tristimulus values shall match the following:

Colors by defined tristimulus values	Tristimulus Values		
	<u>L</u>	<u>a</u>	<u>b</u>
Navy Haze Gray No. 27 (FED-STD-595 #26270)	+56.00	-1.83	-1.37

b. When measured in accordance with 4.7.2, all other colors shall match the FED-STD-595 number specified (see [table VI](#)), or other color as specified (see 6.2).

3.7.1 Color difference. The color difference of the cured powder coating from the specified color shall be obtained as specified in 4.7.2.1. The measured color difference terms [ΔE , Δa , Δb , ΔL] from the appropriate Haze Gray No. 27 (see 3.7a) or specified FED-STD-595 color card (see 3.7b) in Commission Internationale de l'Eclairage (CIE) (International Commission on Illumination) LAB units shall be not greater than the CIELAB units listed below as either positive or negative (+ or -) values:

Color Difference Values				
Colors defined by tristimulus values	<u>ΔE</u>	<u>Δa</u>	<u>Δb</u>	<u>ΔL</u>
Navy Hazy Gray No. 27 (26270)	0.5	0.3	0.3	0.3
FED-STD-595 color number	<u>ΔE</u>	<u>Δa</u>	<u>Δb</u>	<u>ΔL</u>
26008, 26173, 26373, 36173, 36270, 36373	0.5	0.3	0.3	0.3
All other FED-STD-595 colors	1.0	0.5	0.5	0.5

3.8 Gloss (type I, III, and IV (non-zinc) coatings only). When tested in accordance with 4.7.3, the 60-degree specular gloss of all colors, except Navy Haze Gray No. 27 (FED-STD-595 color 26270), shall be between 45 and 85. The 60-degree specular gloss of Navy Haze Gray No. 27 (FED-STD-595 color 26270) shall be between 45 and 60.

3.9 Flexibility. When tested in accordance with 4.7.4, the cured film of applied powder coating shall show no cracking or loss of adhesion in the bend area of all panels.

3.10 Adhesion. When tested in accordance with 4.7.5, the cured film of applied powder coating shall have a minimum classification of 5B on all panels.

3.11 Impact resistance. When tested in accordance with 4.7.6, the cured powder coating film on each panel shall have a minimum direct impact resistance of 16 newton-meters (140 inch-pounds).

3.12 Hardness. When tested in accordance with 4.7.7, the coating shall have a minimum gouge and scratch hardness of 2H.

3.13 Salt spray corrosion resistance (classes 1 and 4 only). When tested and evaluated in accordance with 4.7.8, one set of three blasted and one set of three phosphate treated powder coated test panels shall meet the following requirements:

- Minimum mean creep rating from the scribe of 6 [maximum 3 millimeters ($\frac{1}{8}$ inch)].
- Minimum corrosion rating of 10 (no corrosion) in areas away from the scribe.
- There shall be no visible blistering on the coating surface on any test panel.

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3.14 Touch-up paint compatibility. When tested in accordance with 4.7.9, the touch-up materials shall have an adhesion of at least 4B to the underlying powder coating substrate.

3.15 Humidity (classes 2 and 3 only). When tested in accordance with 4.7.10, the cured film of applied powder coating on each panel shall show no visible blistering or wrinkling, and shall have no loss of adhesion from the requirements of 3.10.

3.16 Weathering and corrosion (classes 2 and 3 only). When tested and evaluated in accordance with 4.7.11, one set of three blasted and one set of three phosphate treated powder coated test panels shall meet the following requirements:

- a. Minimum mean creep rating from the scribe of 6 [maximum 3 millimeters ($\frac{1}{8}$ inch)].
- b. Minimum corrosion rating of 10 (no corrosion) in areas away from the scribe.
- c. There shall be no visible blistering on the coating surface.
- d. Maximum of 30 percent change in gloss from the originally measured value.

3.17 Alternative humidity and weathering (classes 2 and 3 only). Vendor's powder coatings that have successfully passed the humidity and weathering requirements of AAMA 2603, and a 1000-hour salt fog test in accordance with 3.13 and 4.7.8, shall be considered to have met the requirements of 3.15 and 3.16 (see 4.7.12).

3.18 Batch specific volatile organic content (VOC) certification. The manufacturer shall prepare label instructions in accordance with 29 CFR 1910. Each container shall be affixed with a hazardous chemical warning label in accordance with 29 CFR 1910.1200. To comply with the Environmental Protection Agency (EPA) National Emission Standards for Hazardous Air Pollution (NESHAP) requirements for shipbuilding and ship repair, the following two statements shall appear on each paint can label:

- a. A certification that the powder coating in the container meets the NESHAP requirements for shipbuilding and ship repair.
- b. A statement of the ratio of volatile content to solids expressed as grams of volatile organic hazardous air pollutants (VOHAP) per liter of solids.

3.19 Dielectric strength. When tested, the cured film of applied powder coating shall have an average dielectric strength greater than 30 volts per micrometer (762 volts per mil) (see 4.7.13).

4. VERIFICATION

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

- a. Qualification inspection (see 4.2).
- b. Conformance inspection (see 4.3).

4.2 Qualification inspection. Qualification inspection shall be conducted at a laboratory acceptable to Naval Sea Systems Command (NAVSEA). Qualification inspection shall consist of all of the tests specified in [table II](#). Qualification tests on Class 1 and 2 products shall be performed on panels prepared with a single coat of the powder coating being qualified, even though they are intended to be used as part of a two-coat system. Failure to meet any requirement is reason for failure to qualify.

4.2.1 Extension of qualification. Any powder coating qualified to Class 1 will also qualify for Class 4, within the same type. Any powder coating qualified to Class 3 will also qualify for Classes 2 and 4, within the same type.

4.2.2 Loss of qualification. After qualified product list (QPL) approval, any subsequent change in product composition will result in cancellation of QPL listing and the necessity for the vendor to apply for re-qualification.

4.3 Conformance inspection. Conformance inspection shall consist of the tests indicated in [table II](#).

4.3.1 Lot. For the purpose of conformance inspection and test sampling, a lot is defined as all the powdered material of the same type and class, from a single, uniform batch, produced and offered for delivery at one time (see 6.10.1).

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TABLE II. Tests.

Property	Requirements	Tests	Panel Preparation (see 4.6.2)	Conformance Inspection (see 4.3)
Hazardous ingredients	3.3	4.4	N/A	
Toxicity	3.4	4.5	N/A	
Film properties	3.5	4.7.1	^{1/}	X
Color match ^{3/}	3.7	4.7.2	^{1/}	X
Color difference ^{3/}	3.7.1	4.7.2.1	^{1/}	X
Gloss ^{3/}	3.8	4.7.3	^{1/}	X
Flexibility	3.9	4.7.4	^{2/}	X
Adhesion	3.10	4.7.5	^{2/}	
Impact	3.11	4.7.6	^{2/}	
Hardness	3.12	4.7.7	^{1/}	
Salt spray corrosion	3.13	4.7.8	^{2/}	
Paint compatibility	3.14	4.7.9	^{1/}	
Humidity	3.15	4.7.10	^{2/}	
Weathering corrosion	3.16	4.7.11	^{2/}	
Alternate humidity and weathering	3.17	4.7.12	N/A	
Dielectric strength	3.19	4.7.13	4.6	
NOTES:				
^{1/} Panels prepared using iron phosphate pretreatment only.				
^{2/} Two panel sets prepared, using iron phosphate pretreatment for one, and abrasive blasting for the other.				
^{3/} Color match, color difference, and gloss not required for Type II zinc-rich coatings.				

4.3.2 Sampling for conformance tests. As a minimum, the vendor shall randomly select one sample from each lot as defined in 4.3.1. The sample shall be subjected to the tests as indicated in [table II](#).

4.4 Metals content, hazardous pigments, and additives. Soluble and total metal content, except tantalum and tungsten, shall be determined on pulverized, cured powder coating film of the coating system in accordance with 40 CFR Part 261, Appendix II, and the appropriate test listed in [table III](#). The test sample shall consist of particles sieved through a U.S. sieve No. 50. Asbestos shall be analyzed in accordance with OSHA Validated Analytical Method ID-191, with the coating sample treated as a bulk settled dust and the test result reported as percent by weight of the dry enamel film. Crystalline silica (respirable) shall be analyzed in accordance with NIOSH Analytical Method 7500 with the coating sample treated as a bulk settled dust. Soluble metal content shall be reported as milligrams per liter (mg/L). Total metal content shall be reported as %WT of the cured film. The test results for each metal shall be in conformance with the appropriate requirements of 3.3. Tantalum and tungsten soluble metal content and total metal content shall be analyzed as specified in 4.4.1. Formulation data may be used by vendors in lieu of testing required under this paragraph to demonstrate compliance with hazardous metal content requirements of this specification. The manufacturer's formulation data must have a consistent and quantitatively known relationship to the testing required. Calculation of individual hazardous metal contents can be based on either manufacturer testing of batches or supplier data for raw materials used in the product. The coating manufacturer must provide for each individual hazardous metal a formulation value that will not be exceeded if a sample from any quality control approved production batch of the coating is tested in accordance with this paragraph (see [table III](#) and [IV](#)).

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TABLE III. Test methods for evaluating solid waste – physical/chemical methods, SW-846.

Metal/Material	Digestion Test Method
All metals, except Chromium (VI)	3050
Chromium (IV)	3060
Antimony	7040 or 7041
Arsenic	7060 or 7061
Barium	7080 or 7081
Cadmium	7131
Total Chromium	7190
Chromium (IV)	7195, 7196, or 7197
Lead	7421
Mercury	7470 or 7471
Nickel	7520 or 7521
Selenium	7740 or 7741
Silver	7760 or 7761

TABLE IV. Methods for chemical analysis of water and waste, EPA-600/4-020.

Metal/Material	Test Method
Beryllium	210.1 or 210.2
Cobalt	219.1 or 219.2
Copper	220.1 or 220.2
Fluoride	340.1, 340.2, or 340.3
Molybdenum	246.1 or 246.2
Thallium	279.1 or 279.2
Vanadium	286.1 or 286.2
Zinc	289.1 or 289.2

4.4.1 Tantalum and tungsten content. The tantalum and tungsten content of the coating shall be determined using any appropriate spectroscopy test method. Conduct the tests in accordance with the instrument manufacturer's directions for the use of the instrument. The powder vendor is responsible for establishing data supporting the test method choice and analytical accuracy. The test results for tantalum or tungsten shall be in conformance with the requirements of 3.3.

4.5 Toxicity. An HHA shall be conducted to ensure conformance to 3.4, as required by the qualifying activity. The Navy and Marine Corps Public Health Center (NMCPHC) will evaluate the materials used in the powder coating systems using the administrative HHA data provided by the manufacturer/distributor to the NMCPHC.

4.6 Test panels. The test panel material, dimensions, surface preparation and pretreatment, and test coating application shall be as described below.

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4.6.1 Material and dimensions. The test panel material shall be Commercial Steel (CS), Type B, in accordance with ASTM A1008. Panels shall be not less than 100 millimeters by 150 millimeters by 3 millimeters (4 inches by 6 inches by 0.125 inch), except that panels for flexibility testing (see 4.7.4) and impact testing (see 4.7.6) shall be in accordance with the referenced ASTM test specification.

4.6.2 Surface preparation and pretreatment. When two sets of test panels are specified in [table II](#) and 4.7, one set shall be prepared by abrasive blasting and the other set shall be cleaned and pretreated with iron phosphate prior to powder coating application.

4.6.2.1 Abrasive blasting. Abrasive blasting shall be to near-white metal cleanliness in accordance with SSPC-SP 10/NACE No. 2 with an anchor tooth profile of 0.025 to 0.075 millimeter (1.0 to 3.0 mils).

4.6.2.2 Iron phosphate pretreatment. Iron phosphate pretreatment shall be in accordance with TT-C-490, Type II, applied per the manufacturers' instructions.

4.6.3 Application methods. The powder coating shall be applied to the prepared panels using the electrostatic spray application method. The panels shall be pre-heated if required by the vendor's product data sheet in order to achieve the specified coating thickness (see 4.6.4). The cured coating DFT shall be 50 to 100 μm (2 to 4 mils) for the flexibility and impact tests. For all other tests, the cured coating thickness shall be 100 to 250 μm (4 to 10 mils), nominally. The measured cured coating thickness on the panels shall be as specified on the vendor's product data sheet.

4.6.4 Cure schedule. The powder coating shall be cured following the recommended temperature and time schedule on the vendor's product data sheet. When the vendor's schedule covers a range of times and temperatures, a time and temperature in the middle of the range shall be used. The pre-heat and cure schedule used for the panels shall be as specified in 3.6.

4.7 Test methods. The following describe the required performance tests.

4.7.1 Film properties. Panels prepared as specified in 4.6 shall be visually examined for conformance to the appearance requirements of 3.5. The panels shall be examined at a distance of 30.5 centimeters (12 inches) and inspect at an angle of 90 degrees to the surface.

4.7.2 Color. Panels shall be prepared and coated as described in 4.6 and tested as described below.

4.7.2.1 Instrumental color difference determination. Test specimens shall be prepared in accordance with 4.6. The color difference shall be calculated in accordance with ASTM D2244 using a spectrophotometer having a D_{65} light source, a 45-degree illumination angle, and a 0-degree viewing angle in accordance with ASTM E1349.

4.7.2.1.1 Instrument demonstration. The instrument shall be demonstrated to read the color of National Institute for Science and Technology [NIST (formerly National Bureau of Standards; NBS)] traceable standards with the color differences of 3.7. After calibration of the instrument, the L, a, and b color values of at least two FED-STD-595 color cards of the color being procured, which shall have been received from the Government not greater than 1 year prior to the date of this use, shall be measured. The value of E shall be calculated for each color card. The mean values of E, L, a, and b shall be determined for each color card. These mean values shall be used to calculate the color difference values. The color values of the test coating shall be measured. The color difference terms shall be calculated. If using an instrument that automatically calculates the color differences, the color card mean values as the baseline for the color difference calculations shall be entered. The results of the color difference calculation shall be in accordance with the requirements of 3.7. (Note: If the contracting activity has specified a color standard or sample other than a FED-STD-595 color number (see 3.7 and 6.2), this standard or sample shall be substituted instead of the FED-STD-595 color card described above.)

4.7.2.2 Referee color matching. If the cured powder coating measured in accordance with 4.7.2.1 does not match the FED-STD-595 color card (or other color reference specified by the contracting activity) when visually examined, the discrepancy shall be resolved by an independent laboratory certified to the NIST National Volunteer Laboratory Accreditation Program for coating testing. When tested in accordance with ASTM D1729, the test coating, prepared as specified in 4.6, shall visually match the FED-STD-595 color card (or other specified reference) that most closely corresponds to the mean values calculated in 4.7.2.1.

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4.7.3 Gloss. The 60-degree specular gloss shall be tested in accordance with ASTM D523, and shall meet the requirements of 3.8.

4.7.4 Flexibility. Two sets of three panels prepared and coated as specified in 4.6 shall be bent 180 degrees over a 6.4-millimeter (0.25-inch) mandrel in accordance with ASTM D522, Method B. Each panel shall be visually examined immediately and shall meet the requirements specified in 3.9.

4.7.5 Adhesion. Two sets of three panels prepared and coated as specified in 4.6 shall be tested for adhesion in accordance with ASTM D3359, Method B, except that the cut spacing shall be 5 millimeters (0.2 inch) apart. Each panel shall meet the requirements specified in 3.10.

4.7.6 Impact resistance. One set of four test panels shall be prepared and coated as specified in 4.6 and tested in accordance with ASTM D2794. Direct impact (intrusion) tests shall be conducted and the results for each panel shall conform to 3.11.

4.7.7 Hardness. One panel shall be prepared and coated as specified in 4.6 and tested in accordance with ASTM D3363. The average of 5 determinations shall conform to the requirements of 3.12. (An additional panel may be used if needed in order to provide adequate coated surface area to perform the test.)

4.7.8 Salt spray (fog) resistance. Two sets of three panels shall be prepared and coated as specified in 4.6, scribed in accordance with ASTM D1654, and salt spray (fog) tested in accordance with ASTM B117. The test duration shall be in accordance with the schedule below. Upon completion of salt fog testing, the panels shall be evaluated in accordance with ASTM D1654 using Procedure A for the scribed areas and Procedure B for the un-scribed areas. The coating shall meet the requirements of 3.13.

ASTM B117 Salt Fog Exposure Testing Duration	
3000 hours:	All Type II coatings
1000 hours:	All Class 1 coatings except Type II above
	All Class 2 and 3 coatings (see 3.17)
500 hours:	All Class 4 coatings except Type II above

4.7.9 Touch-up paint compatibility. Panels shall be prepared and powder coated as specified in 4.6. The panels shall be over-coated as applicable with one of the three liquid touch-up paints as described below, and the adhesion of the touch-up paint will be tested in accordance with ASTM D3359, Method B, and shall meet the requirements of 3.14. The powder coating shall be lightly scuff sanded before topcoating using 100-grit abrasive paper or cloth. Type I and II powder coated panels shall be over-coated by brushing with one coat of epoxy paint conforming to MIL-DTL-24441, Formula 150, Type III or IV, at 3 to 4 mils DFT. Two Type III and IV powder coated panels shall be prepared as above and shall be over-coated by brushing one panel with one coat of silicone alkyd conforming to MIL-PRF-24635, Type II, Class 2, at 1 to 2 mils DFT. The second panel shall be over-coated by brushing with one coat of chlorinated alkyd conforming to MIL-DTL-24607, at 1 to 2 mils DFT. For purposes of this test, use color number 27880, soft white, as a representative color. After 72 hours of cure nominally at 21 °C (70 °F) and 50 to 70 percent relative humidity, the adhesion of the touch-up paint will be tested in accordance with ASTM D3359, Method B, and shall meet the requirements of 3.14.

4.7.10 Humidity resistance. Two sets of two panels shall be prepared and coated as specified in 4.6. The panels shall be exposed in a humidity cabinet in accordance with ASTM D2247 and operated at 38±1 °C (100±2 °F) and 100 percent relative humidity. The panels shall be exposed for 1000 hours. After exposure, the panels shall be evaluated for blistering in accordance with ASTM D714, visually examined for wrinkling, and tested for adhesion in accordance with 4.7.5. The powder coating shall meet the requirements of 3.15.

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4.7.11 Weathering and corrosion (classes 2 and 3 only). Two sets of three panels, prepared as specified in 4.6, shall be tested in accordance with ASTM D5894. Each panel shall have an intentional scribe, nominally 7.5 centimeters (3 inches) in length, vertically along the panel, extending to the steel substrate. After 2016 hours (12 weeks), each panel shall be evaluated in accordance with ASTM D1654 for scribe-creep and corrosion, visually examined for blisters, and tested for gloss in accordance with 4.7.3. The powder coating shall meet requirements of 3.16.

4.7.12 Alternative weathering. To meet the requirements of 3.17, the vendor shall test demonstrating conformance to AAMA 2603.

4.7.13 Dielectric strength. Five panels shall be prepared and coated as specified in 4.6. The dielectric strength of the powder coating materials shall be in accordance with ASTM D149 using a Type 3 electrode. The dielectric strength shall be determined for all panels in oil. Oil shall be used as a dielectric to prevent flashover and shall have no effect on the properties of the coating. The average dielectric strength of the five panels shall meet the requirements of 3.19.

5. PACKAGING

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

6. NOTES

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

6.1 Intended use. Although the qualification tests are performed over steel surfaces, these coatings are intended for use over bare steel substrates and may be used over other alloys or materials as appropriate. Powder coatings in accordance with this specification may be able to be applied by electrostatic spraying, flocking, or fluidized bed methods, depending on the specific product vendor recommendations. Not all classes under this specification are intended for use for each type. [Table V](#) shows the intended qualifications allowed for each type and class, with further intended uses described below:

- a. Type I and II epoxy powder coatings should not be used as topcoats in exterior service due to their poor weathering properties, but when used as a primer in a two-coat system, they can be top-coated with a Type III or IV coating.
- b. In a two-coat system, a Type I or II epoxy primer optimizes corrosion control performance, while a Type III or IV polyester or hybrid coating optimizes resistance to color and gloss change due to topside weathering.
- c. All types of coatings are intended to provide satisfactory performance for most shipboard interior dry service applications. However, there is limited color availability for Type II, zinc-rich epoxy powders.

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TABLE V. Intended use by type and class.

Class	Type I Epoxy, No Zinc	Type II Epoxy, Zinc-Rich	Type III TGIC Polyester	Type IV Hybrid/Other
Class 1 Exterior Primer of a 2-Coat System	Yes	Yes	No	Yes ^{1/}
Class 2 Exterior Topcoat of a 2-Coat System	No	No	Yes	Yes ^{1/}
Class 3 Exterior Single Coat	No	No	Yes	Yes ^{1/}
Class 4 Interior Dry Service, Single Coat	Yes	Yes	Yes	Yes ^{1/}
NOTE: ^{1/} A Type IV powder coating may be suitable for use in any of the four classes, depending on the specific powder properties and qualifications.				

6.1.1 Effects on mechanical properties. Specifiers of powder coatings should be aware that powder coatings cure cycle temperatures and times may affect the mechanical properties of heat treatable aluminum alloys, for example: 6061-T6. The specific powder and its cure cycle should be selected and controlled accordingly.

6.2 Acquisition requirements. Acquisition documents should specify the following:

- a. Title, number, and date of this specification.
- b. Type and class of powder coating required (see 1.2).
- c. FED-STD-595 color number or other color standard or sample designated by the contracting activity (see 3.7 and 6.7).
- d. Packaging requirements (see 5.1).

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in Qualified Products List QPL No. 24712 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from Commander, Naval Sea Systems Command, ATTN: SEA 05S, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard DC 20376-5160 or emailed to CommandStandards@navy.mil. An online listing of products qualified to this specification may be found in the Qualified Products Database (QPD) at <https://assist.dla.mil>.

6.4 Material safety data sheets. Contracting officers will identify those activities requiring copies of completed Material Safety Data Sheets prepared in accordance with FED-STD-313. The pertinent Government mailing addresses for submission of data are listed in FED-STD-313.

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6.5 Shelf-life. This specification covers items where the assignment of a Federal shelf-life code is a consideration. Specific shelf-life requirements should be specified in the contract or purchase order, and should include, as a minimum, shelf-life code, shelf-life package markings in accordance with MIL-STD-129 or FED-STD-123, preparation of a materiel quality storage standard for Type II (extendible) shelf-life items, and a minimum of 85 percent shelf-life remaining at time of receipt by the Government. These and other requirements, if necessary, are in DoD 4140.27-M, *Shelf-life Management Manual*. The shelf-life codes are in the Federal Logistics Information System Total Item Record. Additive information for shelf-life management may be obtained from DoD 4140.27-M, or the designated shelf-life Points of Contact (POC). The POC should be contacted in the following order: (1) the Inventory Control Points that manage the item 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: <https://www.shelflife.hq.dla.mil/>.

6.6 Lot acceptance and rejection criteria. If one or more defects are found in any sample (see 4.3.2), the entire lot represented by the sample should be rejected (see 6.10.2). If a lot is rejected, the contractor has the option of screening 100 percent of the lot for the defective characteristic(s) or providing a new lot tested in accordance with the sampling plan contained herein. The contractor should maintain for a period of 3 years after contract completion all records of inspection, tests, or any resulting rejections.

6.7 Colors. Commonly specified colors for naval ship applications (see 6.2) are listed in [table VI](#).

TABLE VI. FED-STD-595 color numbers and descriptions. ^{1/ 2/}

Class			Word Description
(1) Gloss	(2) Semi-gloss	(3) Low gloss	
10080	---	---	Brown (piping and valve marking)
---	20109	30109	Brown (20109 for replacement of DOD-E-18210, Formula 23)
---	20117	30117	Brown
10324	---	---	Tan (piping and valve marking)
10371	---	---	Spar (U.S. Coast Guard)/buff (piping and valve marking)
11105	---	---	Red (piping and valve marking)
11120	---	---	Red (OSHA safety color)
11136	21136	31136	Red (insignia red)
12197	---	---	International orange
12199	---	---	Red (U.S. Coast Guard)
12246	---	---	Orange (OSHA safety color)
---	22519	---	Rose-wood
---	22563	---	Beach-sand
13655	23655	33655	Yellow
---	23697	---	Sun glow
---	23814	---	Chartreuse (piping and valve marking)
14062	---	---	Dark green (piping and valve marking)
14097	24097	34097	Dark green (34092 for replacement of DOD-E-18214, Formula 19)
14120	---	---	Green (OSHA safety color)

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TABLE VI. FED-STD-595 color numbers and descriptions – Continued. ^{1/ 2/}

Class			Word Description
(1) Gloss	(2) Semi-gloss	(3) Low gloss	
14449	---	---	Light green (piping and valve marking)
---	24516	---	Clipper blue
---	24585	---	Pastel green
15042	25042	35042	Blue (sea blue)
15044	---	---	Dark blue (piping and valve marking)
15048	25048	35048	Blue (insignia blue)
15092	---	---	Blue (OSHA safety color)
15102	25102	---	Blue (light blue)
15182	---	---	Blue (U.S. Coast Guard)
15200	---	---	Light blue (piping and valve marking)
---	25526	---	Pastel blue
---	26008	---	Gray (26008 for replacement of DOD-E-699, Formula 20)
16081	---	---	Dark gray (piping and valve marking)
16099	---	---	Deck gray (U.S. Coast Guard)
---	26118	36118	Gray #11 (36118 for replacement of DOD-P-15183, Formula 109)
---	26173	36173	Gray #17 (ocean gray, Color #26173)
16187	---	---	Gray (piping and valve marking)
---	26231	36231	Gray #23 (36231 for replacement of MIL-DTL-700, Formula 20L)
---	26270	36270	Haze gray # 27 (26270 for Navy semi-gloss requirements)
16307	26307	36307	Gray #30 (bulkhead gray)
---	26373	36373	Gray #37 (light gray, Color #26373)
16376	---	---	Light gray (piping and valve marking)
---	26400	---	Yellow gray
16492	26492	36492	Gray #49 (gull or pearl gray)
---	26493	---	Pearl gray

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TABLE VI. FED-STD-595 color numbers and descriptions – Continued. ^{1/} ^{2/}

Class			Word Description
(1) Gloss	(2) Semi-gloss	(3) Low gloss	
---	26496	---	Green gray
17038	27038	37038	Black (27038 for replacement of DOD-E-698, Formula 24; 37038 for replacement of DOD-P-15146, Formula 104) (piping and valve marking)
17043	---	---	Gold (piping and valve marking)
17100	---	---	Dark purple (piping and valve marking)
17142	---	---	Light purple (piping and valve marking)
17155	---	---	Purple (OSHA safety color)
17875	27875	37875	White (insignia white – 17875 matches color of MIL-DTL-1115, Formula 30)
---	27880	---	Soft white
17886	27886	37886	White (bone white) (piping and valve marking)
17925	---	---	Gloss bright white
NOTES:			
^{1/} See FED-STD-595 for color cards.			
^{2/} Table VI provides FED-STD-595 color numbers and descriptions for commonly specified colors. To order colors not listed, the contracting officer should provide FED-STD-595 color number or other information necessary to identify the product desired.			

6.8 Suggested packaging and marking. Suggested packaging and marking are contained in [tables VII](#) and [VIII](#), respectively.

TABLE VII. Suggested packing and packaging.

Packaging	Recommended Requirements for Direct Government Acquisitions
Unit of procurement	The powder coatings covered by this specification should be purchased by weight. The unit of procurement should be in multiples of weight units as customarily supplied by the qualified vendor.
Commercial packaging	All containers should comply with the requirements of the Uniform Freight Classifications (UFCs), the National Motor Freight Classification (NMFC), and the applicable requirements of the Code of Federal Regulations 49 CFR, Department of Transportation (DOT).
Material Safety Data Sheets (MSDS) and ASTM F718	A copy of the MSDS and ASTM F718 should be attached to the shipping document for each destination (see 6.6).
VOC certification sheets	VOC certification sheets for each batch of coating should be provided when requested by the procuring activity

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TABLE VIII. Suggested marking.

Marking Type	Recommended Marking
Bar codes	Marking should include bar codes.
VOC	Powder coatings should not contain any VOC. To verify this, refer to the VOC certification sheet.
OSHA Hazard Communication Act and FED-STD-313.	Markings should include all information necessary to comply with the OSHA Hazard Communication Act and FED-STD-313.
Mixing and use instructions	Directions should refer user to product data sheets, MSDS, and ASTM F718 for information.

6.9 Toxicity evaluation. The NMCPHC requires sufficient information to permit an HHA of the product. Upon completion of the HHA, a copy will be provided by the NMCPHC to the Government for evaluation.

6.10 Definitions.

6.10.1 Lot. A lot should consist of all material manufactured at one time (batch) or all material produced by mixing multiple batches into one uniform unit of material.

6.10.2 Lot rejection criteria. Failure of a sample to pass any test should be cause for rejection of the lot.

6.11 Subject term (key word) listing.

Alkyd

Chromium compound free

Cobalt compounds

Lead free

Pigment

VOC (Volatile Organic Content)

6.12 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 – AV

Navy – SH

Air Force – 99

Preparing activity:

Navy – SH

(Project 8010-2009-049)

Review activities:

Army – MR

Navy – AS, CG

Air Force – 84

CIV – 6FEE

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