

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

Powder Coating Materials, Epoxy

1 SCOPE:

1.1 Form:

This specification covers epoxy coating material in powder form.

1.2 Application:

This product is typically used on electrically conductive metal surfaces without a primer as an interior protective coating to provide corrosion protection, abrasion resistance, and functional fluid resistance, but usage is not limited to such applications. Outdoor use may result in ultraviolet degradation of coating properties.

1.3 Classification:

Powder coating materials covered by this specification are classified as follows:

- Class 1 No restrictions on cure temperature
- Class 2 300 °F (149 °C) maximum cure temperature

Unless a specific class is ordered, Class 1 shall be supplied.

1.4 Safety - Hazardous Materials:

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

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2. APPLICABLE DOCUMENTS:

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2473 Chemical Film Treatment for Aluminum Alloys, General Purpose Coating
AMS-QQ-A-250/4 Aluminum Alloy 2024, Plate and Sheet

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM A 366/A 366M Steel, Sheet, Carbon, Cold Rolled, Commercial Quality
ASTM B 117 Operating Salt Spray (Fog) Apparatus
ASTM B 209 Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM D 522 Mandrel Bend Test of Attached Organic Coatings
ASTM D 523 Specular Gloss
ASTM D 609 Preparation of Cold-Rolled Steel Panels for Testing Paint, Varnish, Conversion Coatings, and Related Coating Products
ASTM D 1654 Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D 1729 Visual Evaluation of Color Differences of Opaque Materials
ASTM D 1730 Preparation of Aluminum and Aluminum-Alloy Surfaces for Painting
ASTM D 2197 Adhesion of Organic Coatings by Scrape Adhesion
ASTM D 2794 Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
ASTM D 3359 Measuring Adhesion by Tape Test
ASTM D 3363 Film Hardness by Pencil Test
ASTM D 3451 Testing Polymeric Powders and Powder Coatings
ASTM D 3924 Standard Environment for Conditioning and Testing Paint, Varnish, Lacquers, and Related Materials
ASTM D 3951 Commercial Packaging
ASTM D 4060 Abrasion Resistance of Organic Coatings by the Taber Abraser

2.3 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

FED-STD-595 Colors
MIL-C-5541 Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-D-50030 Decontaminating Agent, DS2
MIL-PRF-23699 Lubricating Oil, Aircraft Turbine Engines, Synthetic Base, NATO Code Number O-156
MIL-PRF-83282 Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft, Metric, NATO Code Number H-537

2.3 (Continued):

TT-C-490 Cleaning Methods for Ferrous Surfaces and Pretreatments for Organic Coatings
TT-S-735 Standard Test Fluids, Hydrocarbon

2.4 U.S. Government Printing Office Publications:

Available from Superintendent of Documents, U.S. Government Printing Office, Washington DC 20402.

29 CFR 1910.1450(b) Code of Federal Regulations List of Carcinogens or Suspected Carcinogens

3. PROPERTIES:

3.1 Material:

The powder material shall consist of formulated epoxy polymer consisting of resin, curing agents, catalysts, fillers, pigments, and flow control agents. The powder material shall be capable of application by electrostatic means and shall cure by melting and fusing at elevated temperature. When applied to a substrate in accordance with the appropriate heating/fusing procedures and ambient application conditions specified by the supplier, the powder shall form a coating that meets or exceeds all requirements of this specification.

3.2 Properties:

Property requirements for epoxy powder coating materials shall be in accordance with Section 3 and Table 1. In case of conflict among requirements of specifications invoked by this document, the most stringent requirement shall be observed.

3.2.1 Air Quality Compliance: Coating materials shall meet the requirements of the cognizant air quality authority for the locality in which the coating powder is applied.

3.2.2 Hazardous Materials Compliance: The material shall have no adverse effect on the health of exposed personnel when used for its intended purpose. The lead content of the coating shall not exceed 0.06 percent by weight. The coating material shall not contain any cadmium, chromates, or declared or suspected carcinogenic materials in accordance with 29 CFR 1910.1450(b). If any of these substances are present as an impurity in a raw ingredient, their concentration shall be less than 0.1 percent by weight.

3.2.3 Shelf Life: The powder materials shall meet all requirements of this specification for five years from date of manufacture when powder is stored unopened in the original container at or below 80 °F (27 °C), 50% ± 5 RH. The supplier's certification of shelf life shall be acceptable to meet requirements of this specification.

3.2.4 Powder Quality: The powder, as received by the purchaser, shall be a free-flowing blended powder of uniform color, and free of lumps, agglomerates, foreign particles, or other defects which could affect the application or storage properties of the coating material.

3.3 Finished Coating Properties:

Finished coating (dry film) properties shall conform to Table 1. All evaluations shall be conducted on test panels prepared in accordance with 4.3.

TABLE 1 - Properties of Cured Coatings on Test Panels

| Property | Requirement | Test Method |
|--------------------------|-------------|-------------|
| Coating Appearance | 3.3.1 | 4.4.1 |
| Coating Color | 3.3.2 | 4.4.2 |
| Corrosion Resistance | 3.3.4 | 4.4.4 |
| Adhesion - Tape Test | 3.3.5 | 4.4.5 |
| Adhesion - Scrape Test | 3.3.5 | 4.4.5 |
| Solvent Resistance | 3.3.6 | 4.4.6 |
| Flexibility | 3.3.7 | 4.4.7 |
| Hardness | 3.3.8 | 4.4.8 |
| Fluid Resistance | 3.3.9 | 4.4.9 |
| Aromatic Fuel Resistance | 3.3.10 | 4.4.10 |
| Water Resistance | 3.3.11 | 4.4.11 |
| DS2 Resistance | 3.3.12 | 4.4.12 |
| Impact Resistance | 3.3.13 | 4.4.13 |
| Abrasion Resistance | 3.3.14 | 4.4.14 |

- 3.3.1 Coating Appearance: The cured coating shall be uniform and smooth when visually examined with no magnification in accordance with 4.4.1. The purchaser shall specify acceptable coating appearance (See 8.1).
- 3.3.2 Color: The desired coating color shall be designated by the purchaser using FED-STD-595B, for Government use, or other appropriate color standard. The applied coating shall match the standard color specified by the purchaser when examined as specified in 4.4.2.
- 3.3.3 Specular Gloss: The 60 degree specular gloss of the cured coating film shall be in accordance with 4.4.3 (See Table 2).
- 3.3.4 Corrosion Resistance: The coating shall achieve a mean creepage rating of 3 or higher (creepage = 1/4 to 3/8 inch, 6.4 to 9.5 mm) on steel and a mean creepage rating of 5 or higher (1/8 to 3/16 inch, 3.2 to 4.8 mm) on aluminum when tested in accordance with 4.4.4.

TABLE 2 - Specular Gloss of Test Panels

| Classification | Minimum | Maximum |
|----------------|---------|---------|
| Gloss | 90% | |
| Semi-gloss | 15% | 45% |
| Flat | | 5% |

- 3.3.5 Adhesion: The coatings shall exhibit an adhesion rating of 5A when tested in accordance with 4.4.5. The coating shall resist removal from the substrate by a 3 kg weight when subjected to a scrape test in accordance with 4.4.5.
- 3.3.6 Solvent Resistance: The cured coating film shall withstand a solvent soaked cloth rub test without removal of coating from the substrate when tested in accordance with 4.4.6.
- 3.3.7 Flexibility: Test panels shall exhibit no cracking, peeling, or loss of adhesion when bent over a mandrel in accordance with 4.4.7.
- 3.3.8 Hardness: The cured coating shall have a pencil hardness of not less than HB when tested in accordance with 4.4.8.
- 3.3.9 Fluid Resistance: The coating film shall not exhibit blistering, softening, delamination, discoloration, staining, or other visible film defects when tested in accordance with 4.4.9.
- 3.3.10 Aromatic Fuel Resistance: The coating shall exhibit no wrinkling or blistering and no more than slight discoloration or softening when tested in accordance with 4.4.10. Coating hardness and adhesion properties shall return to original values measured prior to immersion within two hours after removal from the test fluid.
- 3.3.11 Water Resistance: The applied coating shall not soften, delaminate from the substrate, or leach pigment to the water when tested in accordance with 4.4.11. The coating shall achieve a rating of 5A when tested for delamination.
- 3.3.12 Decontaminating Agent DS2 Resistance: The coating shall exhibit no blistering, wrinkling, discoloration, film softening, or delamination when tested in accordance with 4.4.12. The coating shall achieve a rating of 5A.
- 3.3.13 Impact Resistance: The cured coating film shall have a minimum direct and reverse impact resistance of 48 inch-pounds (5.4 Nm) without evidence of cracking or flaking in accordance with 4.4.13

3.3.14 Abrasion Resistance: The weight loss of coating from test panels shall not exceed 60 milligrams. The testing procedure shall be in accordance with 4.4.14.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The manufacturer of the product shall supply all materials for test and shall be responsible for the performance of all required tests. The purchaser reserves the right to sample and to perform any confirming tests deemed necessary to ensure that the product conforms to the specified requirements.

4.2 Classification of Tests:

4.2.1 First Article Inspection: Unless waived or modified by the purchaser, first article inspection tests are defined as the complete set of material property performance requirements included in 3.3 and summarized in Table 1. These tests shall be performed on samples taken from the initial powder production lot (4.2.2.1) prior to delivery of the material to the purchaser. The first article inspection tests shall also be performed when a change of raw material ingredients and/or processing requires reapproval as in 4.5.2 or when the purchaser requires conforming tests.

4.2.2 Acceptance Tests: Tests specified in Table 1 are acceptance tests and shall be performed on each production lot of material unless waived or modified by the purchaser. Sufficient quantities of material shall be taken at random from each lot to perform all required tests.

4.2.2.1 Production Lot: A lot shall be defined as all powder manufactured from an initial batch of raw materials processed in one continuous production run (See 5.1.3.1).

4.2.2.2 A statistical sampling plan may be used in lieu of acceptance tests if approved by the purchaser.

4.3 Preparation for Test:

All tests and test preparations shall be conducted in accordance with ASTM D 609, ASTM D 1730, ASTM D 3451 and with the test methods identified in 4.4, Table 1, and Table 3.

TABLE 3 - Test Panel Requirements

| Test | Requirement | Material and Dimensions | Number of Panels per Requirement |
|--------------------------|--------------------------------|-------------------------|----------------------------------|
| Coating Appearance | 3.3.1 | 4.3.2.1 | 3 |
| Coating Color | 3.3.2 | 4.3.2.1 | 3 |
| Specular Gloss | 3.3.3 | 4.3.2.1 | 3 |
| Corrosion Resistance | 3.3.4 | 4.3.2.2 | 6 |
| Adhesion - Tape Test | 3.3.5 | 4.3.2.1 | 3 |
| Adhesion - Scrape Test | 3.3.5 | 4.3.2.1 | 3 |
| Solvent Resistance | 3.3.6 | 4.3.2.3 | 3 |
| Flexibility | 3.3.7 | 4.3.2.1 | 3 |
| Hardness | 3.3.8 | 4.3.2.1 | 3 |
| Fluid Resistance | 3.3.9 | 4.3.2.1 | 3 |
| Aromatic Fuel Resistance | 3.3.10 | 4.3.2.1 | 3 |
| Water Resistance | 3.3.11 | 4.3.2.1 | 3 |
| DS-2 Resistance | 3.3.12 | 4.3.2.1 | 3 |
| Impact Resistance | 3.3.13 | 4.3.2.3 | 3 |
| Abrasion Resistance | 3.3.14 | 4.3.2.4 | 3 |
| Control | 3.3.9, 3.3.10 and 3.3.12 | 4.3.2.5 | 1 |

4.3.1 Test Conditions: Unless otherwise specified, the ambient testing conditions shall be in accordance with ASTM D 3924 at Standard Conditions: 77 °F ± 2 (25 °C ± 1) and 50% ± 5 RH.

4.3.2 Test Panel Preparation:

4.3.2.1 Panels for All Tests Except Corrosion Resistance, Abrasion Resistance, Flexibility, and Impact: Test panels shall be fabricated from ASTM B 209, ASTM B 209M, or AMS-QQ-A-250/4, 2024-T3 aluminum alloy. Panels shall be nominally sized 3 x 6 x 0.050 inches (75 x 150 x 1.3 mm) and shall be conversion coated in accordance with AMS 2473 or MIL-C-5541, Class 1A.

4.3.2.2 Panels for Corrosion Resistance Tests:

4.3.2.2.1 One set of three panels shall be fabricated from ASTM A 366/A 366M steel. Panels shall be nominally sized 3 x 6 x 0.050 inches (75 x 150 x 1.3 mm) and shall be phosphate coated in accordance with TT-C-490, Type 1 (zinc phosphate).

- 4.3.2.2.2 One set of three panels shall be fabricated from ASTM B 209, ASTM B 209M, or AMS-QQ-A-250/4, 2024-T3 aluminum alloy. The panels shall be nominally sized 3 x 6 x 0.050 inches (75 x 150 x 1.3 mm) and shall be conversion coated in accordance with AMS 2473 or MIL-C-5541, Class 1A.
- 4.3.2.3 Panels for Flexibility and Impact Tests: One set of three panels shall be fabricated from ASTM B 209, ASTM B 209M, or AMS-QQ-A-250/4, 2024-T0 aluminum alloy. The panels shall be nominally sized 3 x 6 x 0.020 inches (75 x 150 x 0.5 mm) and shall be conversion coated in accordance with AMS 2473 or MIL-C-5541, Class 1A.
- 4.3.2.4 Panels for Abrasion Tests: One set of three panels shall be fabricated from ASTM B 209, ASTM B 209M, or AMS-QQ-A-250/4, 2024-T3 aluminum alloy. The panels shall be nominally sized 3 x 6 x 0.050 inches (75 x 150 x 1.3 mm) and shall be conversion coated in accordance with AMS 2473 or MIL-C-5541, Class 1A.
- 4.3.2.5 Control Panels: One set of three control panels shall be fabricated from ASTM B 209, ASTM B 209M, or AMS-QQ-A-250/4, 2024-T3 aluminum alloy. The panels shall be nominally sized 3 x 6 x 0.050 inches (75 x 150 x 1.3 mm) and shall be conversion coated in accordance with AMS 2473 or MIL-C-5541, Class 1A.
- 4.3.3 Application of Coating: All panels specified in 4.3.2 shall be electrostatically coated with epoxy powder material to provide a cured film thickness of 0.002 to 0.003 inch (0.051 to 0.076 mm) and cured in accordance with manufacturer's specifications except that Class 2 material cure temperature shall not exceed 300 °F (149 °C). After the baking cycle and prior to testing, the test panels shall be conditioned at standard temperature and humidity for 24 hours.
- 4.4 Test Methods:
- 4.4.1 Coating Appearance: The cured coating shall be examined, with no magnification, for conformance with the specified coating appearance in accordance with 3.3.1. A slight orange peel appearance may be acceptable for Class 2 coatings (See 8.1). The purchaser shall determine acceptable coating appearance.
- 4.4.2 Color: The applied coating shall match the standard color specified by the purchaser when examined as specified in ASTM D 1729.
- 4.4.3 Specular Gloss: Specular gloss shall be tested in accordance with ASTM D 523 for compliance with Table 2.
- 4.4.4 Corrosion Resistance: Test panels prepared in accordance with 4.3.2.2 and 4.3.3 shall be edge sealed with a paraffin wax or tape suitable for the purpose. Test panels shall be scribed with two intersecting lines through the coating to bare metal in accordance with ASTM D 1654. Scribed panels shall be exposed for 2000 hours to 5% neutral salt fog in accordance with ASTM B 117. Upon removal, the scribed panels shall be washed gently in warm running water until free from visible salt deposits and immediately examined in accordance with ASTM D 1654, Procedure A. The scraping method shall be used. Test panels shall be evaluated for creepage at 500 hour increments. After 2000 hours of exposure, the panels shall be examined for compliance with 3.3.4.

- 4.4.5 Adhesion: The coatings shall be tested for adhesion in accordance with ASTM D 3359. The scrape test shall be in accordance with ASTM D 2197, using a 3 Kg weight. The coatings shall be evaluated for compliance with 3.3.5.
- 4.4.6 Solvent Resistance: A cotton cloth shall be soaked in methyl ethyl ketone (MEK) solvent and rubbed back and forth twenty-five times (fifty passes) over the coating with firm finger pressure. The rubbed coating film shall be examined for compliance with 3.3.6.
- 4.4.7 Flexibility: Test panels shall be bent 180 degrees over a 0.50 inch (13 mm) diameter mandrel with the coating side facing out in accordance with ASTM D 522, Method B. The coating shall be examined for cracking, peeling, or loss of adhesion. Cracks occurring at either edge extending less than 0.25 inch (6.4 mm) shall be disregarded.
- 4.4.8 Hardness: The cured coating shall be tested in accordance with ASTM D 3363 using a pencil hardness of HB.
- 4.4.9 Fluid Resistance: Test panel sets shall be separately immersed for 24 hours in MIL-PRF-23699 lubricating oil at a temperature of $250\text{ }^{\circ}\text{F} \pm 5$ ($121\text{ }^{\circ}\text{C} \pm 3$) and MIL-PRF-83282 hydraulic fluid at a temperature of $150\text{ }^{\circ}\text{F} \pm 5$ ($66\text{ }^{\circ}\text{C} \pm 3$). The coating film shall be examined four hours after removal from the fluid. Softening shall be determined in accordance with ASTM D 3363. Delamination shall be determined in accordance with ASTM D 3359. The coating shall achieve a rating of 5A. Discoloration shall be determined by comparison with a control panel in accordance with ASTM D 1729.
- 4.4.10 Aromatic Fuel Resistance: One panel shall be immersed in TT-S-735, Type III hydrocarbon fluid at $75\text{ }^{\circ}\text{F} \pm 5$ ($24\text{ }^{\circ}\text{C} \pm 3$) for seven days (168 hours). Upon removal, the panel coating shall be examined for wrinkling, blistering, discoloration, and softening under visual inspection. Coating hardness and adhesion properties shall be measured prior to immersion and again two hours after removal from the fluid to determine compliance with 3.3.10. Softening shall be determined in accordance with ASTM D 3363. Delamination shall be determined in accordance with ASTM D 3359. The coating shall achieve a rating of 5A. Discoloration shall be determined by comparison with a control panel in accordance with ASTM D 1729.
- 4.4.11 Water Resistance: Test panels shall be prepared as specified in 4.3.2.1 and 4.3.3. Both front and back faces of the panels and edges shall be coated. The panels shall be immersed for four days (96 hours) in distilled water at $120\text{ }^{\circ}\text{F} \pm 3$ ($49\text{ }^{\circ}\text{C} \pm 1.5$). The applied coating shall be evaluated for softening, delamination from the substrate, and leaching of pigment to the water. Softening shall be determined in accordance with ASTM D 3363. Delamination shall be determined in accordance with ASTM D 3359. Leaching of pigment shall be determined by visual inspection for water discoloration and comparison with a control panel in accordance with ASTM D 1729.