



AEROSPACE MATERIAL SPECIFICATION

AMS-STD-32239™

Issued

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Coating System, Advanced Performance,
for Exterior Aerospace Applications

RATIONALE

AMS-STD-32239 represents a transfer of material requirements, test methods, and procurement information from MIL-PRF-32239C.

1. SCOPE

1.1 Form

This specification establishes requirements for coating systems having high durability for use as aircraft exterior surface finishes. These coating systems normally are comprised of a surface treatment, a primer, and a topcoat. Alternatively, a coating system may be comprised of a surface treatment and a unicoat. Testing includes use of a chemical stripper for removal and a cleaning compound for topcoat washing, but these components are not a part of the coating system.

1.2 Application

The coating systems covered by this specification are typically applied to external surfaces of military aircraft but are not limited to such application. If the coating systems qualified to this specification are to be used on other than external surfaces, further testing will be required for the specific application.

1.3 Classification

The coating systems covered by this specification shall be classified as follows:

Composition 1	Coating systems containing trivalent chromium compounds
Composition 2	Coating systems containing magnesium particles
Composition 3	Coating systems containing lithium-based compounds
Composition 4	Coating systems containing magnesium oxide compounds
Composition 5	Coating systems containing rare earth compounds

Type 1	Coating systems exhibiting Skydrol® LD-4 resistance
Type 2	Coating systems exhibiting no Skydrol® LD-4 resistance

Class 1	Standard flexibility coating systems
Class 2	High-flexibility coating systems
Class 3	Low-flexibility coating systems

Grade 1	Standard pigmented coating systems
Grade 2	Low-infrared (IR) pigmented coating systems

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Documents

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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 that 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.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS3721	Tape for Organic Coatings Adhesion Testing
AMS3819	Cloths, Cleaning, For Aircraft Primary and Secondary Structural Surfaces
AMS4035	Aluminum Alloy, Sheet and Plate, 4.4Cu - 1.5Mg - 0.60Mn (2024-O), Annealed; or when specified, "As Fabricated" (2024-F)
AMS4037	Aluminum Alloy, Sheet and Plate, 4.4Cu - 1.5Mg - 0.60Mn (2024; -T3 Flat Sheet, -T351 Plate), Solution Heat Treated
AMS4911	Titanium Alloy, Sheet, Strip, and Plate, 6Al - 4V, Annealed
AMS-STD-595	Colors Used in Government Procurement
AS7378	Test Method for Condition in Container of Liquid Organic Coating Components
AS9100	Quality Management Systems - Requirements for Aviation, Space, and Defense Organizations

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D522/D522M	Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings
ASTM D523	Standard Test Method for Specular Gloss
ASTM D1193	Standard Specification for Reagent Water
ASTM D1200	Standard Test Method for Viscosity by Ford Viscosity Cup
ASTM D1974	Standard Practice for Methods of Closing, Sealing, and Reinforcing Fiberboard Boxes
ASTM D2243	Standard Test Method for Freeze-Thaw Resistance of Water-Borne Coatings
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 D2805	Standard Test Method for Hiding Power of Paints by Reflectometry
ASTM D3330/D3330M	Standard Test Method for Peel Adhesion of Pressure-Sensitive Tape
ASTM D3335	Standard Test Method for Low Concentrations of Lead, Cadmium, and Cobalt in Paint by Atomic Absorption Spectroscopy
ASTM D3359	Standard Test Methods for Rating Adhesion by Tape Test
ASTM D3363	Standard Test Method for Film Hardness by Pencil Test
ASTM D3960	Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings
ASTM D6905	Standard Practice for Impact Flexibility of Organic Coatings
ASTM G62	Standard Test Methods for Holiday Detection of Coatings used to Protect Pipelines
ASTM G155	Standard Practice for Operating Xenon Arc Lamp Apparatus for Exposure of Materials

2.3 U.S. Government Publications

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

MIL-DTL-81706	Chemical Conversion Materials for Coating Aluminum and Aluminum Alloys
MIL-PRF-23377	Primer Coatings: Epoxy, High-Solids
MIL-PRF-23699	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Numbers: O-152, O-154, O-156, and O-167
MIL-PRF-83282	Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Metric, NATO Code Number H-537
MIL-PRF-85285	Topcoat, Aircraft and Support Equipment
MIL-PRF-85570	Cleaning Compounds, Aircraft, Exterior
MIL-PRF-87937	Cleaning Compound, Aerospace Equipment

2.4 U.S. Air Force Technical Orders

Copies of these documents are available online at <https://www.robins.af.mil/About-Us/Technical-Orders/>.

TO 1-1-8	Application and Removal of Organic Coatings, Aerospace and Non-Aerospace Equipment
TO 1-1-691	Cleaning and Corrosion Prevention and Control, Aerospace and Non-Aerospace Equipment

2.5 PRI Publications

Available from Performance Review Institute, 161 Thorn Hill Road, Warrendale, PA 15086-7527, Tel: 724-772-1616, www.p-r-i.org.

PD2000	PRI-QPL Program Requirements
PRI QPL-AMS-STD-32239	Products Qualified Under AMS-STD-32239

2.6 ANSI Accredited Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

ANSI Z400.1/Z129.1 Hazardous Workplace Chemicals - Hazard Evaluation and Safety Data Sheet and Precautionary Labeling Preparation

2.7 ISO Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

ISO 4618 Paints and Varnishes - Vocabulary

ISO 9001 Quality management systems - Requirements

ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories

2.8 AIA Publications

Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, www.aia-aerospace.org.

NASM24693 Screw, Machine, Flat Countersunk Head, 100 Degrees, Cross Recessed, UNC-2A and UNF-2A

2.9 Definitions

Definitions of terms and expressions used for coatings as given in ISO 4618 apply, with the exception of the following:

BATCH: Quantity of one component of a product with the same composition and resulting from the same production run.

LIVERING: Related to gelling when a material takes on body caused by the evaporation of solvents or the oxidation of the material.

POT LIFE: The time period after the coating is mixed for which it can be applied and meet the performance requirements of this specification.

UNICOAT: A single coating that replaces the standard primer and topcoat combination within a coating system.

VOLATILE ORGANIC COMPOUND (VOC): VOC is composed of one or more volatile organic compounds containing at least elements of carbon and hydrogen or in which hydrogen is partially or completely replaced by halogens, oxygen, sulfur, phosphorus, or nitrogen, and with the exception of carbon monoxide, carbon dioxide, and carbonates, and which has a vapor pressure of 10 mmHg (1.3 kPa) or more at 68 °F (20 °C). This specification recognizes, by exception, the use of EPA defined exempt solvents.

3. TECHNICAL REQUIREMENTS

3.1 Materials

The coating system shall consist of a surface treatment, a primer, and a topcoat or a surface treatment and a uncoat. The aforementioned products are the minimum products necessary to achieve the performance requirements detailed herein. Materials used in the manufacture of components of a coating system supplied under this specification shall be products conforming to the requirements of this specification.

Qualified products for applicable cleaning compounds shall be selected from the qualified products list (QPL) of MIL-PRF-87937, Type IV or MIL-PRF-85570, Type II. Qualified products for applicable chemical strippers shall be selected from TO 1-1-8 or selected from the Tinker Air Force Base (AFB) Purchase Description list.

3.1.1 Prohibited Materials

No component of any system element shall contain cadmium or cadmium compounds or more than 0.05% lead or lead compounds. Confirmation of the exact concentration in the coating's solids shall be determined using any authoritative quantitative method, such as ASTM D3335. Composition 2 through Composition 5 system components shall not contain chromium or chromium compounds.

3.1.2 Toxicity

The coating system components shall have no adverse effect on the health of personnel when used for its intended purpose in accordance with the manufacturer's instructions and with appropriate handling procedures and precautions per the safety data sheet (see 4.8.2).

3.2 Quality

The coating system components taken from original containers as received by the purchaser shall be free from extraneous matter and show no skinning, gelling, hard settlement, or other objectionable properties that will prevent satisfactory application to produce a defect-free film when evaluated in accordance with AS7378.

3.2.1 All Materials or Components

Materials or components shall be capable of being reincorporated into a smooth, homogenous, and pourable mixture. It shall be free of grit, skin, seeds, lumps, foreign contaminants, and thickening or livering.

3.2.2 Surface Treatment Powders

System components supplied in powder form shall be uniform in composition and quality and be free from impurities and other defects that impair usability and adversely affect performance when the powder is mixed with water or other materials as specified by the manufacturer under normal agitation in preparation for use.

3.2.3 Mixing

All components shall be readily miscible when mixed according to the manufacturer's instructions.

3.3 VOC Content

The maximum volatile organic compound (VOC) content at application of system coatings, classified as primers, shall be no greater than 2.8 lb/gal (340 g/L). The maximum VOC content at application of system coatings, classified as topcoats, shall be no greater than 3.5 lb/gal (420 g/L). The VOC content of the admixed coating material (when thinned to typical spraying consistency) shall be reported in lb/gal (g/L) on the qualification test report when tested in accordance with ASTM D3960 (calculate using Paragraph 10.2 and Appendices X2 and X3). The values shall be included in the report.

3.4 Properties

The coating system, when components are prepared in accordance with the manufacturer's instructions, shall conform to the requirements shown in Table 1, determined in accordance with the specified test methods.

Table 1 - Properties

Paragraph	Property	Requirement	Test Method Paragraph
3.4.1	Storage Stability	Shall meet all requirements as packaged by the manufacturer for each form of coating system component.	4.7.5.1
	Coating System Component or Premixed Liquid Surface Treatment	Shall meet all requirements of this specification after 12-month storage in original as-received container. A subset of testing shall be performed using coating system components that have been subjected to the requirements of this paragraph. The subset of requirements and corresponding tests shall be 3.4.5, 3.4.6, 3.4.9, 3.4.12, 3.4.14 (aluminum only), 3.4.16, and 3.4.18 (MIL-PRF-83282 only).	
	Surface Treatment Concentrated Liquids and Powders	Shall meet all requirements of this specification after 6-month storage in original as-received container. A subset of testing shall be performed using coating system components that have been subjected to the requirements of this paragraph. The subset of requirements and corresponding tests shall be 3.4.5, 3.4.6, 3.4.9, 3.4.12, 3.4.14 (aluminum only), 3.4.16, and 3.4.18 (MIL-PRF-83282 only).	
	Touch-Up and Repair Kits or Repackaged Liquid Surface Treatment	Shall meet all the requirements of this specification after 6-month minimum indoor storage from date of repackaging, where the daily temperature of the ambient air is maintained between 35 to 95 °F (1.7 to 35 °C). A subset of testing shall be performed using coating system components that have been subjected to the requirements of this paragraph. The subset of requirements and corresponding tests shall be 3.4.5, 3.4.6, 3.4.9, 3.4.12, 3.4.14 (aluminum only), 3.4.16, and 3.4.18 (MIL-PRF-83282 only).	
3.4.2	Accelerated Storage Stability (Excludes Surface Treatment)	Shall meet all the requirements of this specification in original as-received container. The accelerated storage conditions shall be 7 days at 140 °F ± 5 °F (60 °C ± 3 °C). A subset of testing shall be performed using coating system components that have been subjected to the requirements of this paragraph. The subset of requirements and corresponding tests shall be 3.4.5, 3.4.6, 3.4.9, 3.4.12, 3.4.14 (aluminum only), 3.4.16, and 3.4.18 (MIL-PRF-83282 only).	4.7.5.2
3.4.3	Freeze/Thaw Stability (Water-Based Components Only)	Shall meet all the requirements specified herein as packaged by the manufacturer after being subjected to five cycles of freezing and thawing. A subset of testing shall be performed using coating system components that have been subjected to the requirements of this paragraph. The subset of requirements and corresponding tests shall be 3.4.5, 3.4.6, 3.4.9, 3.4.12, 3.4.14 (aluminum only), 3.4.16, and 3.4.18 (MIL-PRF-83282 only).	4.7.5.3
3.4.4	Odor	Shall retain no residual odor 48 hours after application and air dried.	4.7.5.4



Paragraph	Property	Requirement	Test Method Paragraph
3.4.5	Viscosity	Shall meet the requirement for each component.	4.7.5.5
	Surface Treatment	Shall be suitable for application to aircraft surfaces by spray or brush.	
	Primer or Topcoat	Shall be suitable for application by conventional, high volume, low pressure (HVLP), airless, and electrostatic spray (suitably equipped in the event of water-based materials). Coating manufacturers shall define the recommended application viscosity range.	
3.4.6	Pot Life	Shall meet the performance and application requirements of this specification when primers and topcoats are applied 4 hours after initial mixing. A subset of testing shall be performed using coating system components that have been subjected to the requirements of this paragraph. The subset of requirements and corresponding tests shall be 3.4.5, 3.4.9, 3.4.12, 3.4.14 (aluminum only), 3.4.16, and 3.4.18 (MIL-PRF-83282 only). Test panels for this requirement shall be created by applying the primer 4 hours after mixing the primer, then applying the topcoat 4 hours after mixing the topcoat.	4.7.5.6
3.4.7	Drying Time	Shall meet the requirement for each component. As an alternative, the total time to apply surface treatment, primer, and topcoat to a dry-to-tape condition shall be 17 hours or less.	4.7.5.7
	Surface Treatment	Shall be dry-to-prime within 4 hours of application.	
	Primer	Shall be dry-to-topcoat within 5 hours of application.	
	Topcoat	Shall be dry-to-tape with no adhesion loss or permanent marring in 8 hours or less.	
3.4.8	Wet Edge	Shall not exhibit streaks, tiger stripes, or other visual irregularities on the test panels.	4.7.5.8
3.4.9	Surface Appearance	Shall exhibit a uniform, smooth surface and free from runs, sags, bubbles, streaks, hazing, seeding, dusting, floating, mottling, or other defects during visual evaluation after air drying a minimum of 24 hours.	N/A
3.4.10	Color	Shall match the applicable color standard in AMS-STD-595 with a color difference (ΔE) less than or equal to 1.0.	4.7.5.9
3.4.11	Infrared (IR) Reflectance (AMS-STD-595, Color Chip Number 36118), Grade 2 Coating Systems Only)	Shall be a maximum of 8% relative to National Institute of Standards and Technology (NIST) traceable Spectralon® white calibration standard and includes total IR reflectance (specular and diffuse) of the coating system.	4.7.5.10

Paragraph	Property	Requirement	Test Method Paragraph
3.4.12	Gloss	Shall meet the following specular gloss requirements:	4.7.5.11
	Camouflage Colors	85-degree angle of incidence 9 max 60-degree angle of incidence 5 max	
	Gunship Colors	85-degree angle of incidence 3 max 60-degree angle of incidence 3 max	
	Semigloss Colors	60-degree angle of incidence 15 min, 45 max	
	Gloss Colors	60-degree angle of incidence 90 min	
3.4.13	Opacity (Hiding Power)	Shall have a contrast ratio of no less than 0.95 for all colors except yellow, gloss color chip number 13538; orange, gloss color chip number 12197; and red, gloss color chip number 11136 of AMS-STD-595, which shall have a contrast ratio no less than 0.90.	4.7.5.12
3.4.14	Adhesion - Wet Tape	Shall have no less than a 4A rating, and no component of the coating system shall peel or delaminate from the substrate or any other component of the system.	4.7.5.13
3.4.15	Adhesion - Crosshatch	Shall have no less than a 4B rating, and no component of the coating system shall peel or delaminate from the substrate or any other component of the system.	4.7.5.14
3.4.16	Flexibility - Ambient Temperature Impact	Shall meet the requirement for class of coating system:	4.7.5.15
	Class 1 Coating Systems	Shall exhibit a minimum impact elongation of 10% for gloss and camouflage coating systems. This requirement remains the same after weathering per 4.7.5.18. Flexibility testing after weathering shall not be part of the subset of tests listed in 3.4.1, 3.4.2, 3.4.3, and 3.4.6.	
	Class 2 Coating Systems	Shall exhibit a minimum impact elongation of 40% for gloss and camouflage coating systems. This requirement remains the same after weathering per 4.7.5.18. Flexibility testing after weathering shall not be part of the subset of tests listed in 3.4.1, 3.4.2, 3.4.3, and 3.4.6.	
	Class 3 Coating Systems	Shall exhibit a minimum impact elongation of 10% for gloss, semigloss, and camouflage coating systems. This requirement is not required after weathering. No other flexibility testing shall be performed.	
3.4.17	Flexibility - Low Temperature (Class 1 and Class 2 Coating Systems Only)	Shall exhibit no cracking when evaluated with a 2-inch mandrel.	4.7.5.16

Paragraph	Property	Requirement	Test Method Paragraph
3.4.18	Fluid Resistance	Shall show no blistering, coating delamination, or adhesion loss; shall have no less than a 4B adhesion rating; shall not exhibit more than a 2-pencil hardness decrease from the original hardness; and shall not be softer than B. Class 2 coating systems are exempt from the pencil hardness component of this requirement. For all coating systems, color change (ΔE) shall be less than or equal to 3.0.	4.7.5.17
3.4.19	Weathering Resistance	Shall have a color change (ΔE) less than or equal to 1.0. Shall meet the requirements of 3.4.16 and 3.4.17. Shall meet the following 60-degree specular gloss requirements:	4.7.5.18
		Camouflage Colors	5 max
		Gunship Colors	3 max
		Semigloss Colors	15 min, 45 max
		Gloss Colors	90 min
3.4.20	Humidity Resistance	Shall not blister, exhibit any loss of adhesion less than a 4B rating, or exhibit other film defects. The coating system shall not exhibit a pencil hardness change of two units from the original pencil hardness value, and the value shall be no softer than B. Class 2 coating systems are exempt from the pencil hardness component of this requirement.	4.7.5.19
3.4.21	Outdoor Exposure	Shall perform equal to or better than the control coating system after a minimum exposure of 12 months.	4.7.5.20
3.4.22	Heat Resistance	Shall have no cracking, flaking, or adhesion loss and shall have a color change (ΔE) less than or equal to 1.0.	4.7.5.21
3.4.23	Solvent Resistance (Cure)	Shall withstand 25 methyl ethyl ketone (MEK) double-rubs (50 passes over the surface). Rubbing through the coating system and exposing primer or substrate indicates a failure.	4.7.5.22
3.4.24	Cleaning Efficiency	Shall meet the requirement when cleaned with cleaning compound and the selected sponge for testing.	4.7.5.23
	3M Scotch-Brite™ #63 cellulose sponge	Shall maintain a minimum cleaning efficiency of no less than 50%.	
	Melamine sponge authorized in TO 1-1-691	Shall maintain a minimum cleaning efficiency of no less than 75%.	
3.4.25	Strippability	Shall meet the requirement of each component within 24 hours. A chemical stripper may be specified to strip the topcoat, and a different chemical stripper may be specified to strip the primer.	4.7.5.24
	Topcoat	Shall be stripped no less than 90%.	
	Primer	Shall be stripped no less than 70%.	

