



AEROSPACE MATERIAL SPECIFICATION

Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AMS 2521A

Superseding AMS 2521

Issued 11-1-67

Revised 4-15-78

REFLECTION-REDUCING COATINGS FOR INSTRUMENT GLASSES

1. SCOPE:

- 1.1 **Form:** This specification covers optical-quality coatings applied to instrument glasses.
- 1.2 **Application:** Primarily to reduce the intensity of reflection from the surfaces of instrument glasses and to increase light transmission through the glasses.
2. **APPLICABLE DOCUMENTS:** The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications (AMS) and Aerospace Recommended Practices (ARP) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.
- 2.1 **SAE Publications:** Available from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.
- 2.1.1 **Aerospace Material Specifications:**
AMS 2350 - Standards and Test Methods
- 2.1.2 **Aerospace Recommended Practices:**
ARP 924 - Specification and Inspection of Glass for Integrally Lighted Aerospace Instruments
- 2.2 **ASTM Publications:** Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.
- ASTM B117 - Salt Spray (Fog) Testing
ASTM D1003 - Haze and Luminous Transmittance of Transparent Plastics
ASTM E11 - Wire-Cloth Sieves for Testing Purposes
ASTM G21 - Determining Resistance of Synthetic Polymeric Materials to Fungi
- 2.3 **Government Publications:** Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120, except as specified in 2.3.4.
- 2.3.1 **Military Specifications:**
MIL-E-12397 - Eraser, Rubber-Pumice (for Testing Coated Optical Elements)
- 2.3.2 **Military Standards:**
MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing of
MIL-STD-1241 - Optical Terms and Definitions

SAE Technical Board rules provide that: "All technical reports, including standards approved by the Board, are advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. There is no agreement to conform to or be guided by any technical report. In formulating and approving technical reports, the Board and its committees will not investigate or consider patents which may apply to the subject matter. Prospective users of the report are responsible for protecting themselves against liability for infringement of patents."

2.3.3 Federal Specifications:

L-T-90 - Tape, Pressure-Sensitive, Adhesive, (Cellophane and Cellulose Acetate)

2.3.4 U. S. Army Drawings: Available from Quality Assurance Directorate, DRDAR-TST-S, U. S. Army Armament Research and Development Command, Dover, NJ 07801.

D7680606 - Coating, Eraser Abrasion Tester

3. TECHNICAL REQUIREMENTS:

3.1 Material: The composition of the coating material shall be optional with the coating vendor.

3.2 Properties of the Applied Coating: The coating, applied to substrate materials having indices of refraction within the range 1.47 - 1.55, shall conform to the following requirements. Tests shall be performed on the coated parts or on coated glass witness specimens of the same index of refraction and surface finish as the substrate for the coated parts, coated in the same evaporation run as the parts, and positioned in the chamber so as to represent the optical and durability characteristics of the parts.

3.2.1 Spectral Properties:

3.2.1.1 Specular Reflectance: The specular reflectance from each coated surface, measured with a calibrated spectrophotometer as defined in ASTM D1003, shall not exceed the following limits for energy incident on the surface at the angles specified below:

Wavelength Range Millimicrons	Reflectance, %, max	
	For Angle of Incidence Shown	
	0 to 15 deg, incl	30 deg ± 0.5
450 to 675, incl	0.6 absolute	---
450 to 650, incl	---	1.0 absolute
500 to 620, incl	0.35 average	0.50 average
425 to 700, incl	0.35 average	0.50 average

3.2.1.2 Light Absorption: Within the wavelength range 425 - 700 millimicrons, light loss shall not exceed the following limits per surface, determined with a calibrated spectrophotometer as defined in ASTM D1003:

Maximum average absorption	0.5%
Maximum absolute absorption	2.0%

3.2.2 Durability: The coating, subjected to the adhesion test of 4.5.1 followed by the abrasion resistance test of 4.5.2, shall show no evidence of peeling, flaking, cracking, crazing, or delamination and shall have no change in spectral characteristics resulting in nonconformance to the requirements of 3.2.1.

3.2.3 Environmental Resistance: The coating shall show no change in spectral characteristics resulting in nonconformance to the requirements of 3.2.1 after exposure to any of the following:

3.2.3.1 Elevated temperature in accordance with 4.5.3.

3.2.3.2 Sand and dust in accordance with 4.5.4.

3.2.3.3 Fungus in accordance with 4.5.5.

3.2.3.4 Thermal shock in accordance with 4.5.6.

3.2.3.5 Continuous exposure to salt spray in accordance with ASTM B117 for not less than 50 hours.

3.2.3.6 Humidity in accordance with 4.5.7. After exposure, the coating, lighted and inspected in accordance with ARP 924, shall show no evidence of a cloudy or hazy appearance.

3.3 Quality: The coating shall be uniform in quality and condition, clean, smooth, and free from foreign materials and from physical imperfections and optical imperfections detrimental to performance of parts, determined in accordance with ARP 924.

3.3.1 Surface Imperfections: Imperfections in the clear aperture area of the coating, as defined in MIL-STD-1241, shall not exceed the following limits, evaluated in accordance with ARP 924:

Article	Scratch	Spatter	Pinhole, Void, or Lint
Window	#80	#50	#50
Cover glass or cover wedge	#60	#20	#40
Lighting wedge	#40	#20	#40

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The coating vendor shall supply all samples and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.6. Purchaser reserves the right to perform such confirmatory testing as he deems necessary to ensure that the coating conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to requirements for specular reflectance (3.2.1.1), light absorption (3.2.1.2), durability (3.2.2), salt spray resistance (3.2.3 and 3.2.3.5), humidity resistance (3.2.3 and 3.2.3.6), and quality (3.3) are classified as acceptance tests and shall be performed on each lot of coated parts.

4.2.2 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests and shall be performed on the initial lot of coated parts supplied and after each change in approved material or processing unless otherwise specified by purchaser.

4.2.2.1 For direct U.S. Military procurement, substantiating test data and, when requested, preproduction test material shall be submitted to the cognizant agency as directed by the procuring activity, the contracting officer, or the request for procurement.

4.3 Sampling: Shall be not less than the following:

4.3.1 Acceptance Tests: One part or one witness specimen for each requirement except as specified in 4.3.1.1.

4.3.1.1 Sampling for inspection to quality requirements shall be in accordance with MIL-STD-105, Normal Inspection Level II, with an acceptance quality level (AQL) of 2.5. Samples shall be coated parts.

4.3.2 Preproduction Tests: Thirty parts or witness specimens, five for each requirement except that the durability and humidity resistance tests shall be performed on the same five specimens and all 30 specimens shall be inspected for conformance to quality requirements.

4.4 Approval:

- 4.4.1 Sample coated parts shall be approved by purchaser before coated parts for production use are supplied, unless such approval be waived. Results of tests on production coated parts shall be essentially equivalent to those on the approved samples.
- 4.4.2 Vendor shall use ingredients, manufacturing procedures, processes, and methods of inspection on production coated parts which are essentially the same as those used on approved sample parts. If any change is necessary in ingredients, in type of equipment for processing, or in manufacturing procedures, vendor shall submit for reapproval a statement of the proposed changes in material and processing and, when requested, sample coated parts. Production parts coated by the revised procedure shall not be shipped prior to receipt of reapproval.
- 4.5 Test Methods:
- 4.5.1 Adhesion: Test specimens shall be clean and free from contaminants, including finger prints, that would affect the adhesion of the testing tape. A strip of L-T-90 pressure-sensitive tape, 1 in. (25 mm) in nominal width or approximately 2/3 of the least dimension of the test specimen if less than 1 in. (25 mm), shall be pressed firmly in contact across the entire coated surface. After 30 - 60 sec, the tape shall be removed quickly with a snap action which exerts the greatest possible stripping effect on the surface.
- 4.5.2 Abrasion Resistance:
- 4.5.2.1 Test Procedure: The coating shall be tested by holding a standard abrasion testing device in the hand and rubbing the coated surface with a standard eraser conforming to MIL-E-12397 mounted in the holding device. A force of approximately 2.0 - 2.5 lb (900 - 1100 g) shall be applied. Strokes of approximately 1 in. (25 mm) shall be made if the size of the element or specimen will permit it; smaller strokes for smaller specimens. All strokes shall be made on one path for 20 complete strokes.
- 4.5.2.2 Test Equipment: Assembly details of the Abrasion Tester may be obtained on written request from U. S. Army Armament Research and Development Command as indicated in 2.3.4. The only rubber eraser plug which is acceptable for this test is also available from the same source. All requests should make reference to Drawing D7680606.
- 4.5.3 Elevated Temperature: Specimens shall be heated to $315^{\circ}\text{C} \pm 8$ ($600^{\circ}\text{F} \pm 15$), held at temperature for not less than 15 min, and cooled to room temperature. Heating and cooling rates shall be not greater than 8°C (15°F) deg per minute.
- 4.5.4 Sand and Dust Resistance:
- 4.5.4.1 Test Chamber: The chamber shall consist of a dust-tight cabinet with the floor designed to permit the dust to fall into hoppers for recirculation. The facility shall be time-cycle-controlled to accomplish the exposure and shutdown required. A blower and dusting shall be provided to circulate the dust throughout the test chamber with the velocity and concentration outlined.
- 4.5.4.2 Test Procedure: The test samples shall be placed in the test chamber and the sand and dust density raised to, and maintained at, 0.1 - 0.5 g per cu ft ($3.53 - 17.65 \text{ g/m}^3$) and velocity between 100 and 500 ft per min. (508 and 2540 mm/s) within the test space. The internal temperature of the test chamber shall be maintained at $25^{\circ}\text{C} \pm 5$ ($77^{\circ}\text{F} \pm 9$) for not less than 6 hr, then raised to and maintained at $70^{\circ}\text{C} \pm 3$ ($158^{\circ}\text{F} \pm 5$) for not less than 6 hr additional. The relative humidity shall not exceed 30% at any time during the test. At the end of the exposure period, the sample shall be removed from the test chamber and allowed to cool to room temperature. Accumulated dust shall be removed by brushing, wiping, shaking, or blowing with clean, dry air.

4.5.4.3 Sand and Dust: Sand and dust used in the test shall be of angular structure and shall have characteristics as follows (See 8.2):

4.5.4.3.1 Particle Size: Shall be as follows, determined using U.S. Standard Sieve Series or equivalent as defined in ASTM E11:

- 100% shall pass through a 100 mesh screen or 150- μ m sieve.
- 98% \pm 2 shall pass through a 140 mesh screen or 106- μ m sieve.
- 98% \pm 2 shall pass through a 200 mesh screen or 75- μ m sieve.
- 75% \pm 2 shall pass through a 325 mesh screen or 45- μ m sieve.

4.5.4.3.2 Chemical Composition: Shall be as follows, determined by wet chemical methods or as agreed upon by purchaser and vendor:

Substance	% by Weight	
	min	max
SiO ₂	97	99
Fe ₂ O ₃	--	2
Al ₂ O ₃	--	1
TiO ₂	--	2
MgO	--	1
Ignition	--	2

4.5.5 Fungus Resistance: Testing shall be conducted in accordance with ASTM G21, using one species of fungus from each of the following groups (See 8.3):

Group	Organism	American Type Culture Collection No.	Quartermaster Number
I	Chaetomium globosum	6205	459
	Myrothecium verrucaria	9095	460
II	Memnaniella echinata	9597	1225
	Aspergillus niger	6275	458
III	Aspergillus flavus	10836	1223
	Aspergillus terreus	10690	82j
IV	Penicillium citrinum	9849	1226
	Penicillium ochrochloron	9112	477

4.5.6 Thermal Shock: Test specimens shall be heated to, and maintained at, 70° C \pm 3 (158° F \pm 5) for not less than 1 hr and immediately thereafter placed in direct contact with an ice cube at least 1 sq in. (650 mm²) in area for not less than 2 minutes.

4.5.7 Humidity Resistance: Test specimens shall be exposed continuously for not less than 24 hr in an atmosphere of 98% \pm 2 relative humidity at 50° C \pm 2 (122° F \pm 4).

4.6 Reports: