Society of Automotive Engineers, Inc.
TWO PENNSYLVANIA PLAZA, NEW YORK, N.Y. 10001

AEROSPACE MATERIAL SPECIFICATION

AMS 3614

Issued March 1, 1974
Revised

POLYCARBONATE SHEET AND PARTS
Optical Grade, Coated

1. SCOPE:

1.1 Form: This specification covers an optical-quality, transparent polycarbonate plastic to which a hard protective surface coating has been applied, supplied in the form of flat sheet or formed parts made from flat sheet.

1.2 Application: Primarily for parts, such as vehicle windows, requiring optical quality and serviceability under adverse environmental conditions.

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) 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., Two Pennsylvania Plaza, New York, New York 10001.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

ASTM D673 - Mar Resistance of Plastics
ASTM D1003 - Haze and Luminous Transmittance of Transparent Plastics
ASTM D1044 - Resistance of Transparent Plastics to Surface Abrasion
ASTM D1499 - Operating Light - and Water-Exposure Apparatus (Carbon-Arc Type) for Exposure of Plastics
ASTM D1501 - Exposure of Plastics to Fluorescent Sunlamp
ASTM D2134 - Softening of Organic Coatings by Plastic Compositions
ASTM D3029 - Impact Resistance of Rigid Plastic Sheeting or Parts by Means of a Tup (Falling Weight)
ASTM G23 - Operating Light- and Water-Exposure Apparatus (Carbon-Arc Type) for Exposure of Nonmetallic Materials
ASTM G26 - Operating Light- and Water-Exposure Apparatus (Xenon-Arc Type) for Exposure of Nonmetallic Materials

2.3 Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

2.3.1 Federal Specifications:

O-A-76 - Acetic Acid, Glacial, Technical
TT-I-735 - Isopropyl Alcohol
TT-M-261 - Methyl Ethyl Ketone, Technical
TT-N-95 - Naptha, Aliphatic

2.3.2 Military Specifications:

MIL-P-83310 - Plastic Sheet, Polycarbonate, Transparent

Printed in U.S.A.

2.3.3 Military Standards:

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-810 - Environmental Test Methods

3. TECHNICAL REQUIREMENTS:

3.1 Material:

3.1.1 Basic Polycarbonate: The polycarbonate sheet material to be coated shall conform to MIL-P-88310.

3.1.2 Hard Coating: The hard coating shall be formulated for, and processed onto, the polycarbonate base material in such a manner that the total product will meet the requirements specified herein.

3.1.3 Storage Life: The product shall meet the requirements of this specification when tested at any time up to 12 months from the date of manufacture when stored in the original shipping container. The protective covering applied to the coated optical surfaces shall be removable without special handling or cleaning.

3.2 Properties: The product shall conform to the following requirements; tests shall be performed on the product supplied and in accordance with the specified test methods:

3.2.1 Abrasion Resistance: Specimens shall show not more than a 5% increase in haze measurement (for example, 1.8% haze before and 6.8% haze after) after being abraded by one of the methods specified in Table I, using separate specimens for each test. Haze measurements shall be determined, before and after abrasion, in accordance with ASTM D1003, Procedure A.

TABLE I

ABRASION RESISTANCE

Method	Number of Cycles, min	Test Method	Test Conditions
Taber Abraser	300	ASTM D1044	CS-10F calibrase wheel with 500 g load
Goodyear Abrader	1000	4.5.1	0.75 psi (5.2 kPa) shoe pressure; water lubricant

3.2.2 Mar Resistance: Specimens shall show not more than 5% increase in haze measurement after being subjected to the mar resistance test in accordance with 4.5.2. Haze measurements shall be determined, before and after testing, in accordance with ASTM D1003, Procedure A.

3.2.3 Chemical Resistance: Specimens shall show no crazing when subjected to contact with TT-M-261 methyl ethyl ketone for 30 min. ± 1, determined in accordance with 4.5.3.

3.2.4 Coating Porosity: Not more than 1 specimen from each set of 5 specimens for each test fluid shall show evidence of crazing, determined in accordance with 4.5.4.

3.2.5 Adhesion: The coating shall not separate from the polycarbonate substrate, determined by the "snap tape" test in accordance with 4.5.5.

3.2.6 Hardness: The coated specimen shall exhibit an initial hardness value of not less than 35, determined in accordance with ASTM D2134.

3.2.7 Impact Resistance: The coating shall not separate from the polycarbonate substrate, determined by the "snap tape" test of 4.5.5 after impact loading in accordance with 4.5.6.

3.2.8 Light Transmission and Haze: Specimens shall show light transmission greater than 82% with haze not exceeding 2%, determined in accordance with ASTM D1003, Procedure A, both percentages based on 0.25 in. (6.4 mm) thick specimens.

3.2.9 Optical Integrity:

3.2.9.1 Coating: Foreign material, such as lint or dust particles, or processing imperfections, such as bubbles or scratches, within the specified optical area shall not exceed 4 imperfections of 0.06 in. (1.5 mm) or less in diameter or fiber inclusions of 0.25 in. (6.4 mm) or less in length, or a combination of both, determined in accordance with 4.5.7. Inclusions or imperfections greater than specified above shall be cause for rejection. The optical area shall be defined as the central 75% area of an untrimmed sheet, the entire formed and coated part except the peripheral 1.0 in. (25 mm), or as specified on the applicable part drawing.

3.2.9.2 Overall: The overall optical integrity shall conform to the requirements of MIL-P-83310.

3.2.10 Humidity: The coating shall not separate from the polycarbonate substrate, determined by the "snap tape" test of 4.5.5 after humidity exposure in accordance with 4.5.8.

3.2.11 Artificial Ultraviolet Exposure: The coating shall not separate from the polycarbonate substrate, determined by the "snap tape" test of 4.5.5 after exposure to ultraviolet light in accordance with 4.5.9.

3.2.12 Artificial Weathering: The coating shall conform to the requirements for abrasion resistance (3.2.1), adhesion (3.2.5), impact resistance (3.2.7), light transmission and haze (3.2.8), optical integrity (3.2.9), and quality (3.3) after exposure to the environment of a carbon- or xenon-arc weatherometer for not less than 1000 hr in accordance with ASTM D1499, ASTM G23, or ASTM G26.

3.3 Quality: The product shall be uniform in quality and condition, clean, smooth, and free from foreign materials and from imperfections detrimental to fabrication, appearance, or performance of parts.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of the product 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 assure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests of the product as-received to determine conformance to adhesion (3.2.5), hardness (3.2.6), light transmission and haze (3.2.8), optical integrity (3.2.9), and quality (3.3) requirements are classified as acceptance or routine control tests.

4.2.2 Qualification Tests: Tests to determine conformance to all technical requirements of this specification are classified as qualification or periodic control tests and may be the basis for approval of the product (see 4.4.1).

4.3 Sampling:

4.3.1 Sampling Schedule: Unless otherwise specified, sampling shall be in accordance with Single Sampling for Normal Inspection, General Inspection Level II, with an Acceptable Quality Level (AQL) of 1.5 specified in MIL-STD-105 as shown in Table II. Tests specimens shall be taken at random throughout the lot.

TABLE II

SAMPLING SCHEDULES

Number of Inspection Units in the Lot	Number of Inspection Units from Which Samples are to be taken	Accept	Reject
1 - 90	8 (4.3.1.1)	0	1
91 - 280	32	1	2
281 - 500	50	2	3

4.3.1.1 If number of inspection units to be sampled equals or exceeds lot size, inspect 100%.

4.3.2 Lot: A lot is defined as all material produced in a single production run made from the same batch of raw materials under the same fixed conditions and submitted for inspection at one time.

4.3.3 Inspection Unit: Unless otherwise specified, an inspection unit is defined as each coated sheet or part.

4.4 Approval:

4.4.1 Sample material shall be approved by purchaser before material for production use is supplied, unless such approval be waived. Results of tests on production material shall be essentially equivalent to those on the approved sample.

4.4.2 Vendor shall use ingredients, manufacturing procedures, processes, and methods of inspection on production material which are essentially the same as those used on the approved sample material. If any change is necessary in ingredients, in type of equipment for processing, or in manufacturing procedures which could affect quality or properties of the material, vendor shall submit samples for reapproval unless purchaser grants written approval after review of a detailed statement of materials and processing used on the approved sample and those proposed. No production material made by the revised procedure shall be shipped prior to receipt of approval of such procedure.

4.5 Test Methods:

4.5.1 Abrasion Resistance Test, Goodyear Abrader:

4.5.1.1 Test Apparatus: Shall be an abrader in accordance with Fig. 1, identified as a "Goodyear Abrader."

4.5.1.2 Test Specimens: Shall be the as-received thickness cut to 4.0 x 8.0 in. (102 x 203 mm).

4.5.1.3 Abrading Materials: Shall be as follows:

4.5.1.3.1 Pad material shall be chloroprene-base rubber, 10 Durometer A hardness, 0.125 in. ± 0.016 (3.18 mm ± 0.41) thick.

4.5.1.3.2 Abrasive film shall be aluminum oxide lapping film, 12 micron grit.

4.5.1.3.3 Lubricant shall be water.

4.5.1.4 Procedure: Shall be as follows:

4.5.1.4.1 Prepare a number of abrading shoes equal to the number of specimens to be tested. Add weight to each abrading shoe to provide a total weight of 6.00 lb ± 0.01 on the shoe area of 8.0 sq in. ± 0.1 (2724 g ± 4.54 on the shoe area of 5161 mm^2 ± 64) per shoe, or a shoe pressure of 0.75 psi (5.2 kPa). Mount the specimens and the abrading shoes.

4.5.1.4.2 Thoroughly wet the surface of the specimens with distilled water and maintain continuous surface wetting from the dripping orifice.

4.5.1.4.3 Set the cycle counter to zero and the machine speed to 20 cpm before starting the testing machine.

4.5.1.4.4 Start the testing and stop testing at the completion of 1000 cycles.

4.5.1.4.5 Wash the specimens free of abrasion dust and chips with distilled water and air dry, taking care not to scratch or alter the abraded area.

4.5.1.4.6 Report the percentage increase in haze for each specimen and the average of all specimens.

4.5.2 Mar Resistance Test: Specimens suitable for haze determination in accordance with ASTM D1003, Procedure A, shall be subjected to the mar resistance test of ASTM D673, using 1000 g ± 10 of No. 80 silicon carbide grit.

4.5.3 Chemical Resistance Test: Chemical resistance shall be determined in accordance with the crazing test defined in MIL-P-83310 except that the test fluid, MEK (TT-M-261), shall be applied to a 0.5 x 0.5 in. (13 x 13 mm) piece of filter paper placed on each of the five specimens used. After 30 min. ± 1 exposure of the specimens in an unstressed condition, the filter paper patches shall be removed, the affected surfaces flooded with demineralized water, and air dried and the specimens placed in the test fixture with the treated area centered on the tangent line of the 2000 psi (13.8 MPa) outer fiber stress. The chemical resistance stress-craze test shall then proceed under load for 30 min. ± 1 in a dry state.

4.5.4 Coating Porosity Test: Coating porosity shall be determined in accordance with the crazing test defined in MIL-P-83310 except that specially prepared test fluids shall be applied to a 0.5 x 0.5 in. (13 x 13 mm) piece of filter paper placed on each specimen. Five specimens shall be used for each of two test fluids prepared as follows; percentages are by volume:

Test Fluid A - 95% glacial acetic acid, conforming to O-A-76 and 5% water

Test Fluid B - 90% aliphatic naphtha, conforming to TT-N-95
10% methyl ethyl ketone, conforming to TT-M-261

The test shall be continued for not less than 30 min. with the specimens loaded to an outer fiber stress of 2000 psi (13.8 MPa) and the filter paper patches constantly wet with the applicable test fluid.

4.5.5 Adhesion Test: The "snap tape" adhesion test shall be performed on specimens cut from a coated panel not less than 12.0 x 12.0 in. (305 x 305 mm) in size, in the as-received condition and after being subjected to impact, humidity, and artificial ultraviolet exposure as specified. Test procedure shall be as follows:

4.5.5.1 Clean the surface to be tested with a clean flannel cloth or soft paper towel saturated with isopropyl alcohol (TT-I-735) and air dry with a filtered airstream. Allow the specimen to stand for not less than 30 min. in a clean environment after drying before continuing the test.

4.5.5.2 Scribe a four-line grid (nine squares) through the coating over an area approximately 0.5 x 0.5 in. (13 x 13 mm).

4.5.5.3 Apply a strip of tape, paper-backed 1-in. (25-mm) wide, 3M No. 250 or equivalent, not over 6 months from date of manufacture, centered over and completely covering the grid pattern and press firmly without wrinkles or bubbles in the test area.

4.5.5.4 Immediately pull or "snap" the tape quickly at a 90 deg (1.57 rad) angle from the surface and along the tape centerline until the tape has been completed removed.

4.5.5.5 Determine the extent of coating removal by lightly rubbing the test area with No. 000 steel wool, until the bared substrate has become hazy and less transparent.

4.5.5.6 Removal of the coating to any extent is unacceptable and the basis for rejection.

4.5.5.7 Report any evidence of nonadhesion.

4.5.6 Impact Resistance: Impact resistance of the coating, in distinction to the impact resistance of the substrate polycarbonate, shall be determined by no loss of adhesion, tested as specified in 4.5.5, after impact loading as follows:

4.5.6.1 Impact load specimens of as-received thickness by 12.0 x 12.0 in. (305 x 305 mm) in accordance with ASTM D3029, Procedure A, with the coated side down (tup striking on the opposite side). Increase the weight on the tup on each specimen to produce failure in the polycarbonate substrate (may require approximately 20 specimens).

4.5.6.2 Report the results in accordance with ASTM D3029, with the failure criteria being any evidence of coating separation determined as specified in 4.5.5.

4.5.7 Optical Integrity: Each coated sheet or part shall be examined at low viewing angles of 15 - 45 deg (0.262 - 0.780 rad) with back-lighting in order to identify and evaluate coating imperfections for conformance to 3.2.9.1.

4.5.8 Humidity Test: Specimens suitable for adhesion testing shall be subjected to the humidity cycling of MIL-STD-810, Method 507, Procedure I for 3 cycles. Immediately at the conclusion of the humidity test, perform the adhesion test in accordance with 4.5.5.

4.5.9 Artificial Ultraviolet Exposure Test: Specimens, approximately 4.0 x 4.0 in. (102 x 102 mm), shall be subjected to not less than 1000 hr of ultraviolet light exposure in equipment specified in ASTM D1501, or equivalent, modified to retain only the ultraviolet light exposure features. Immediately at the conclusion of the ultraviolet exposure, perform the adhesion test in accordance with 4.5.5.

4.6 Reports:

4.6.1 The vendor of the product shall furnish with each shipment three copies of a report showing the results of tests made on the product to determine conformance to the acceptance test requirements of this specification and a statement that the product conforms to all other technical requirements. This report shall include the purchase order number, material specification number, vendor's material designation, lot number, date of manufacture, form, size or part number, and quantity.

4.6.2 The vendor of finished or semi-finished parts shall furnish with each shipment three copies of a report showing the purchase order number, material specification number, contractor or other direct supplier of material, supplier's material designation, part number, and quantity. When material for making part is produced or purchased by the parts vendor, that vendor shall inspect each lot of material to determine conformance to the requirements of this specification, and shall include in the report a statement that the material conforms, or shall include copies of laboratory reports showing the results of tests to determine conformance.

4.7 Resampling and Retesting: If any specimen used in the above tests fails to meet the specified requirements, disposition of the product may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the product represented and no additional testing shall be permitted. Results of all tests shall be reported.