MIL-C-24449A(SH)
3 August 1981
SUPERSEDING
MIL-C-24449(SHIPS)
1 March 1971
(See 6.5)

MILITARY SPECIFICATION

CAST POLYMETHYL METHACRYLATE FOR SHEET STOCK, CUSTOM CASTINGS, AND FINISHED WINDOWS

This specification is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers polymerized methyl methacrylate sheet stock, custom castings, and windows of optical quality for service in pressure vessels for human occupancy.

2. APPLICABLE DOCUMENTS

2.1 Issues of documents. The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

STANDARD

MILITARY

MIL-STD-129 - Marking for Shipment and Storage.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 3112, Department of the Navy, Washington, DC 20362 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FSC 9330

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

D 256 - Impact Resistance of Plastics and Electrical Insulating Materials, Test for.
D 542 - Index of Refraction of Transparent Organic Plastics, Tests for.
D 570 - Water Absorption of Plastics, Test for.
D 621 - Deformation of Plastics Under Load, Test for.
D 638 - Tensile Properties of Plastics, Test for.
D 648 - Deflection Temperature of Plastics Under Flexural Load.
D 695 - Compressive Properties of Rigid Plastics, Test for.
D 696 - Coefficient of Linear Thermal Expansion of Plastics, Test for.
D 702 - Cast Methacrylate Plastic Sheets, Rods, Tubes, and Shapes, Specification for.
D 732 - Shear Strength of Plastics, Test for.
D 785 - Rockwell Hardness of Plastics and Electrical Insulating Materials, Test for.
D 790 - Flexural Properties of Plastics and Electrical Insulating Materials, Tests for.
D 792 - Specific Gravity and Density of Plastics by Displacement, Tests for.
D 1003 - Haze and Luminous Transmittance of Transparent Plastics, Test for.
E 308 - Spectrophotometry and Description of Color in CIE 1931 System, Recommended Practice for.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ANSI/ASME PVHO Safety Standard for Pressure Vessels for Human Occupancy, Appendix A-Design of Viewports.

(Application for copies should be addressed to the American Society of Mechanical Engineers, 345 E. 47th Street, New York, NY 10017.)

UNIFORM CLASSIFICATION COMMITTEE AGENT

Uniform Freight Classification Ratings, Rules and Regulations

(Application for copies should be addressed to the Uniform Classification Committee Agent, Tariff Publication Officer, Room 1106, 222 South Riverside Plaza, Chicago, IL 60606.)

NATIONAL MOTOR FREIGHT TRAFFIC ASSOCIATION, INC. AGENT

National Motor Freight Classification

(Application for copies shouuld be addressed to the National Motor Freight Traffic Association, Inc., ATA TRAFFIC Dept., 1616 "P" Street, N.W., Washington, DC 20036.)

(Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

3. REQUIREMENTS

3.1 First article. When specified (see 6.2.1), the contractor shall furnish sample unit(s) for first article inspection and approval (see 4.3 and 6.3).

3.2 Material. Material shall be premium quality, heat-resistant, optical grade, cast methyl methacrylate, hereinafter referred to as acrylic.

3.2.1 Condition. Material supplied shall be in a fully polymerized state and shall be a monolithic homogeneous solid, essentially free of monomer (see table I). Cast sheets shall be cast oversize, or include prolongations for machining of test coupons.

3.2.2 Recovered materials. Material and finished products covered by this specification may be fabricated using materials produced from recovered materials to the extent practicable without jeopardizing the properties specified in table I. The term "recovered materials" means materials which have been collected or recovered from solid waste and reprocessed to become a source of raw materials, as opposed to virgin raw materials. None of the above shall be interpreted to mean that the use of used or rebuilt products is allowed under this specification unless otherwise specifically specified.

3.3 Properties. Physical and mechanical properties shall be as specified in table I.

TABLE I. Physical and mechanical properties.

Property	Unit of value	Value required
Optical uniformity	Must pass readability tests	
Hardness, Rockwell M	Minimum	90
Specific gravity	---	1.19 ±0.01
Refractive index	---	1.49 ±0.01
Luminous transmittance,	Minimum, percent	
Inches		
0.0 - 0.249		92
0.250 - 0.499		90
0.500 - 0.999		89
1.000 - 1.999		87
2.000 - 2.999		85
3.000 - 4.250		83
Heat distortion temperature		
3.6°F/min at 264 lb/in^2	Minimum, °F	185
Thermal expansion at 20°F.	Maximum, in/in/°F	33 x 10^{-6}
Water absorption:		
24 hours at 73°F	Maximum, percent	0.25
To saturation	Maximum, percent	2
Tensile strength	Minimum, lb/in^2	9,000

TABLE I. Physical and mechanical properties. - Continued

Property	Unit of value	Value required
Tensile elongation	Minimum, percent	2
Mod of elasticity, tension	Minimum, lb/in^2	400,000
Compressive strength	Minimum, lb/in^2	15,000
Mod of elasticity, compression	Minimum, lb/in^2	400,000
Flexural strength	Minimum, lb/in^2	14,000
Shear strength	Minimum, lb/in^2	8,000
Impact strength	Minimum, ft lb/in notch	0.25
Compressive deformation under load, 4000 lb/in^2, 122°F, 24 hours	Maximum, percent	1.0
Residual monomer, methyl methacrylate and ethyl acrylate	Maximum, percent	1.6
Ultraviolet (290-330 nm) transmittance (for 0.5 inch thickness)	Maximum, percent	5

3.3.1 Dimensions. Finished windows shall conform to the dimensions specified on the engineering drawing specified by the contracting activity (see 4.6.2 and 6.2.1). For custom castings or sheet stock, thickness shall be equal to or exceed the thickness of the window. Unless otherwise specified (see 6.2.1), dimensions shall be measured at 73°F ± 2°F.

3.3.2 Optical uniformity and distortion. Sheets, custom castings, and finished windows shall have smooth and parallel optical surfaces. Fine print shall be legible through the material when placed 20 inches away as specified in 4.7.6.

3.3.3 Visual defects (see 4.6.1).

3.3.3.1 Sheet stock. Sheet stock shall be colorless and free of visible cracks, checks and crazing. Inclusions (any imbedded particle or bubble) shall not exceed 0.125 inch. Total number of inclusions larger than 0.016, but smaller than 0.125 inch shall be less than the limit determined by dividing the volume of the sheet stock in cubic inches by 641. For purposes of inspection, a 2-inch wide border around the edge of the sheet shall not be included in the evaluation of casting quality.

3.3.3.2 Custom castings. Custom castings shall be colorless and free of visible internal cracks, checks and crazing. Inclusions shall not exceed 0.030 inch. Total number of inclusions larger than 0.016 but smaller than 0.030 inch shall be less than the limit determined by dividing the volume of the custom casting in cubic inches by 641. For the purposes of inspection, the surplus material on the casting to be removed during machining of the window shall not be included in the evaluation of casting quality.

3.3.3.3 Finished windows. Finished windows shall be colorless and free of visible cracks, checks, and crazing. Inclusions and surface scratches are acceptable only if the dimensions, location, density of population, size of population and spacing between adjacent flaws do not exceed the limits specified by ANSI/ASME PVHO Safety Standard.

3.3.4 Luminous transmittance. Sheets, custom castings, and windows shall have the optical clarity specified in table I (see 4.7.10).

3.3.5 Construction. The completed window shall be constructed of one piece of custom cast material.

3.3.5.1 If machined from a custom casting, pouring and polymerizing of the custom casting shall be done in one pour.

3.3.5.2 The window shall be annealed at least once during the fabrication process. The final mandatory annealing shall take place after the forming, machining, and machine polishing operations have been completed by the fabricator. The window shall be annealed for 24 hours at $175^{\circ}F$ at a cooldown rate not to exceed $5^{\circ}F$/hour.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

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

(a) First article inspection (see 4.3).
(b) Quality conformance inspection (see 4.4).

4.3 First article inspection. First article inspection shall consist of the examination and tests specified in table II. First article inspection shall be performed on material coupons taken from a lot of material slated for fabrication of the windows and on the first window produced under this acquisition. If the acquisition is limited to acquisition of material only, the first article inspection shall address itself only to material.

TABLE II. Examinations and tests.

Examinations and tests	First article	Quality conformance	Requirement paragraph	Examination and test paragraph
Dimensions	X	X	3.3	4.6.2
Optical uniformity and distortion	X	X	3.3	4.7.6
Visual defects	X	X	3.3	4.6.1
Hardness, Rockwell M	X	---	3.3	4.7.7
Specific gravity	X	---	3.3	4.7.9
Refractive index	X	---	3.3	4.7.1
Luminous transmittance	X	---	3.3	4.7.10
Heat distortion temperature: 3.6 °F/min at 264 lb/in^2	X	---	3.3	4.7.11
Coefficient of thermal expansion	X	---	3.3	4.7.2
Water absorption:				
24 hours at 73 °F	X	---	3.3	4.7.12
To saturation	X	---	3.3	4.7.12
Tensile strength	X	X	3.3	4.7.13
Tensile elongation	X	X	3.3	4.7.13
Mod of elasticity, tension	X	X	3.3	4.7.13
Compressive strength	X	X	3.3	4.7.14
Mod of elasticity, compression	X	X	3.3	4.7.14
Flexural strength	X	---	3.3	4.7.15
Shear strength	X	---	3.3	4.7.16
Impact strength	X	---	3.3	4.7.3
Compressive deformation under load	X	X	3.3	4.7.5
Ultraviolet transmittance	X	X	3.3	4.7.4
Residual monomer	X	X	3.3	4.7.8

4.3.1 First article inspection report. The contractor shall prepare a first article inspection report in accordance with the data ordering document included in the contract (see 6.2.2).

4.4 Quality conformance inspection. Quality conformance inspection shall consist of the examination and tests of table II and shall be performed on individual lots of products (sheet stock castings, custom castings, and finished windows) submitted for acceptance.

4.4.1 Quality conformance inspection report. The contractor shall prepare quality conformance inspection reports with each shipment in accordance with the data ordering document included in the contract (see 6.2.2). The contractor shall furnish four copies of a report of the results of the tests for physical properties, mechanical properties, chemical properties, inclusion ratio, and other data for the material in the shipment to the extent required by this specification. Reports shall include the purchase order number, manufacturer of materials, manufacturer's trade name, and manufacturer's lot number of the polymerized castings.

4.5 Sampling.

4.5.1 Lot. A lot of sheet stock or custom castings shall consist of material produced at one time from the same batch of raw materials. A lot of windows shall consist of all windows fabricated from a single lot of material.

4.5.2 Sheet stock casting. From each lot of sheet stock produced, all the test coupons required by tests of table II shall be taken from a single sheet chosen at random from the lot.

4.5.3 Custom casting. All the test coupons shall be taken from a single custom casting selected at random from each lot and subjected to the examination and tests specified in table II.

4.5.4 In a case where a lot of windows is to be fabricated from several sheets or from custom castings belonging to different lots of castings, all the lots of material shall be inspected for conformance to the requirements of table II.

4.5.5 Individual sheets or custom castings belonging to different lots of material which have not been previously inspected for quality conformance to 4.4, shall be individually inspected for quality conformance.

4.5.6 Regardless of the size of window lots, each finished window shall be examined individually for conformance to requirements of 3.3.1, 3.3.2, and 3.3.3.

4.5.7 Rejection. If any of the requirements of 3.3 are not met, the entire lot of material or windows shall be rejected.

4.5.8 Retest. Rejected lots of windows may be resubmitted if the defect was not in the material and the subsequent rework brings the windows up to the requirements of 3.3.

4.6 Examination.

4.6.1 Visual defects. Defects such as cracks, checks, and crazing shall be determined visually with the unaided eye, except what is necessary to correct for 20 - 20 vision.

4.6.2 Dimensions. Dimensions shall be determined by micrometer.

4.7 Test methods. Test methods shall be in accordance with the methods specified in 4.7.1 through 4.7.16. Unless otherwise specified herein, test specimens shall be prepared and conditioned as described in the cited ASTM standard.

4.7.1 Refractive index. Refractive index shall be determined in accordance with ASTM D 542, method A. Two specimens shall be tested.

4.7.2 Thermal expansion. Thermal expansion shall be measured in accordance with ASTM D 696. Two specimens shall be tested.

4.7.3 Impact strength. Impact strength shall be determined in accordance with ASTM D 256, method A. Two specimens shall be tested.

4.7.4 Ultraviolet transmittance. A specimen 0.5 inch thick shall be cut from the casting and after polishing on both sides, shall be subjected to an ultraviolet transmittance test in accordance with ASTM E 308.

4.7.5 Compressive deformation. Compressive deformation under load shall be determined by the constant load application method in accordance with ASTM D 621. Stress level in the test specimen shall be 4,000 pounds per square inch (lb/in^2), calculated on the basis of original specimen cross-section. Ambient test temperature shall be maintained at $72^{\circ}F \pm 1^{\circ}F$. Two specimens shall be tested.

4.7.6 Optical uniformity and distortion. Optical uniformity and distortion shall be determined using ASTM D 702.

4.7.7 Hardness, Rockwell M. Surface hardness of the sheets or blocks used as test specimens shall be determined in accordance with ASTM D 785, method A. A minimum of two random determinations shall be made on the surfaces of each specimen.

4.7.8 Residual monomer. Specimens shall be tested in accordance with ANSI/ASME PVHO-a, Appendix A, B.4.F.

4.7.9 Specific gravity. Specific gravity shall be determined on two specimens of regular shapes and not less than 1/8 cubic inch volume in accordance with ASTM D 792.

4.7.10 Luminous transmittance. Specimens shall be tested in accordance with ASTM D 1003, procedure A.

4.7.11 Heat distortion temperature. Specimens shall be tested in accordance with ASTM D 648 at 264 lb/in^2.

4.7.12 Water absorption. Specimens shall be tested in accordance with ASTM D 570. A minimum of two specimens shall be taken. Average water absorption for 24 hours at $73^{\circ}F$ and saturation at $73^{\circ}F$ shall be reported.

4.7.13 Tensile strength, tensile elongation, and modulus of elasticity in tension. Specimens shall be tested in accordance with ASTM D 638. A minimum of two specimens shall be taken for each test.

4.7.14 Compressive strength and modules of elasticity in compression. Specimens shall be tested in accordance with ASTM D 695. A minimum of two specimens shall be tested.

4.7.15 Flexural strength. Specimens shall be tested in accordance with ASTM D 790. A minimum of two specimens shall be tested.

4.7.16 Shear strength. Specimens shall be tested in accordance with ASTM D 732. A minimum of two specimens shall be tested.

4.8 Packaging inspection. Packaging, packing, and marking shall be inspected for compliance with section 5 of this document.

5. PACKAGING

(The packaging requirements specified herein apply only for direct Government acquisitions.)

5.1 Level C packaging. Each sheet, casting or window shall be protected as follows:

(a) Each item shall be enclosed in a non-abrasive wrap or bag of polystyrene or polyethylene. Wraps or bags shall be secured with pressure-sensitive tape. Staples or heat sealing shall not be used.
(b) Sharp or beveled edges shall be cushioned by completely wrapping or encasing the item with a cushion-absorbing material such as single-faced corrugated board, cushion bag or plastic mold.
(c) After being protected, each item shall be packaged in a double-wall corrugated fiberboard box of minimum 275 lb/in^2, meeting Uniform Freight Classification Rules (Rule 41).

5.2 Level C packing. Sheets, castings or windows shall be packed flat (not edgewise) in containers acceptable by the common carrier which will insure safe delivery at destination. Container and method of shipment shall comply with Uniform Freight or National Motor Freight Classification Rules or other carrier rules or regulations applicable to the mode of transportation.

5.3 Marking. In addition to any special marking required (see 6.2.1), interior packages and exterior shipping containers shall be marked in accordance with MIL-STD-129.

5.3.1 Special marking.

(a) Package and shipping container marking shall include specification number, manufacturer's code, lot number, and date of manufacture.
(b) Shipping containers shall include arrows and precautionary marking as specified in MIL-STD-129 for fragile items.

6. NOTES

6.1 Intended use. This specification covers sheet stock and custom castings from which viewport lens windows are fabricated (see 6.4). The windows are primarily used in pressure vessels for human occupancy where superior physical and mechanical properties are required in addition to optical properties and where failure of a window would result in serious injury or death.

6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents should specify the following:

(a) Title, number, and date of this specification.
(b) When a first article sample is required (see 3.1).
(c) Dimensions required (see 3.3.1).
(d) Special marking, if required (see 5.3).

6.2.2 Data requirements. When this specification is used in a contract which incorporates a DD Form 1423 and invokes the provisions of 7-104.9(n) of the Defense Acquisition Regulation (DAR), the data requirements identified below will be developed as specified by an approved Data item Description (DD Form 1664) and delivered in accordance with the approved Contract Data Requirements List (DD Form 1423) incorporated into the contract. When the provisions of DAR-7-104.9(n) are not invoked, the data specified below will be delivered by the contractor in accordance with the contract requirements. Deliverable data required by this specification is cited in the following paragraphs:

Paragraph	Data requirement	Applicable DID	Option
4.3.1	Report, first article inspection	DI-T-4902	-----
4.4.1	Reports, test	DI-T-2072	-----

(Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

6.2.2.1 The data requirements of 6.2.2 and any task in section 3, 4, or 5 of the specification required to be performed to meet a data requirement may be waived by the contracting/acquisition activity upon certification by the offeror that identical data were submitted by the offeror and accepted by the Government under a previous contract for identical item acquired to this specification. This does not apply to specific data which may be required for each contract, regardless of whether an identical item has been supplied previously (for example, test reports).

6.3 First article inspection. Invitations for bids should provide that the Government reserves the right to waive the requirement for samples for first article inspection as to those bidders offering a product which has been previously acquired or tested by the Government, and that bidders offering such products, who wish to rely on such production or test, must furnish evidence with the bid that prior Government approval is presently appropriate for the pending contract.

6.4 Definitions.

6.4.1 Sheet stock. Sheets of acrylic plastic cast on a production line basis and carried as a standard production item in a manufacturer's catalog.

6.4.2 Custom casting. Casting of any shape that is not carried as a standard production item in a manufacturer's catalog.

6.4.3 Window. Transplant, impermeable and pressure-resistant insert in the viewport (penetration in the pressure vessel hull).

6.5 Changes from previous issue. Asterisks (*) are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

Preparing activity:
Navy - SH
(Project 9330-N915)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

OMB Approval
No. 22-R255

INSTRUCTIONS: The purpose of this form is to solicit beneficial comments which will help achieve procurement of suitable products at reasonable cost and minimum delay, or will otherwise enhance use of the document. DoD contractors, government activities, or manufacturers/vendors who are prospective suppliers of the product are invited to submit comments to the government. Fold on lines on reverse side, staple in corner, and send to preparing activity. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements. Attach any pertinent data which may be of use in improving this document. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity.

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MIL-C-24449A(SH)

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CONTRACT NUMBER

MATERIAL PROCURED UNDER A

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1. HAS ANY PART OF THE DOCUMENT CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?

A. GIVE PARAGRAPH NUMBER AND WORDING.

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