

INCH-POUND

MIL-PRF-46108C

3 June 1999

SUPERSEDING

MIL-A-46108B

8 August 1983

PERFORMANCE SPECIFICATION

ARMOR: TRANSPARENT

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the performance requirements for transparent armor used in armored military vehicles and aircraft. Transparent armor is the technical term for protective transparencies commonly called ballistic resistant windows.

1.2 Material selection. There is no restriction on the type of construction needed to fabricate the transparent armor specified herein for protective transparencies used in ballistic resistant windows. Construction may be monolithic or any combination of plies such as glass, plastic, and adhesive interlayers. All combinations of materials should be chemically and structurally compatible and produce integral bonds that will meet the requirements of this specification (see 6.3).

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements documents cited in sections 3 and 4 of this specification, whether or not they are listed.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Director, U.S. Army Research Laboratory, Weapons and Materials Research Directorate, ATTN: AMSRL-WM-M, Aberdeen Proving Ground, MD 21005-5069 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation (see 6.2).

STANDARDS

DEPARTMENT OF DEFENSE

MIL-STD-662	V ₅₀ Ballistic Test For Armor
MIL-STD-810	Environmental Test Methods And Engineering Guidelines

HANDBOOKS

DEPARTMENT OF DEFENSE

MIL-HDBK-722	Glass
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(Unless otherwise indicated, copies of the above specifications, standards, and handbooks are available from the Defense Automated Printing Service (DAPS), Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094).

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DoDISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C1036	Flat Glass (DoD adopted)
ASTM D1003	Haze and Luminous Transmittance of Transparent Plastics (DoD adopted)
ASTM D1044	Resistance of Transparent Plastics to Surface Abrasion (DoD adopted)
ASTM D4093	Photoelastic Measurements of Birefringence and Residual Strains in Transparent or Translucent Plastic Materials
ASTM F428	Intensity of Scratches on Aerospace Glass Enclosures
ASTM F520	Environmental Resistance of Aerospace Transparencies
ASTM F521	Bond Integrity of Transparent Laminates
ASTM F548	Intensity of Scratches on Aerospace Transparent Plastics
ASTM F735	Abrasion Resistance of Transparent Plastics and Coatings Using the Oscillating Sand Method

(Application for copies should be addressed to the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.)

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2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Pre-production. When specified by the procuring activity (see 6.2), a pre-production sample shall be required. The pre-production sample shall conform to all requirements in this specification.

3.1.1 First article. When specified in the contract or purchase order, a sample shall be subjected to first article inspection (see 4.2.2 and 6.2).

3.2 Design. Design criteria shall be dependent on the end use of the material. The size, shape, weight, thickness, and material composition shall be dependent upon the item being fabricated, and the threat described for that item or system.

3.2.1 Construction. The contractor shall select the methodology of construction, provided these methods are capable of yielding uniform and reproducible properties in the completed structure.

3.2.2 Materials. Unless otherwise specified (see 6.2), the contractor shall select the materials, but the materials shall be capable of meeting all of the operational and environmental requirements when tested in accordance with the methods specified in this document.

3.2.3 Glass. Glass used in transparent armor construction shall be as specified by the procuring activity (see 6.2). Consult MIL-HDBK-722 for guidance, and glass requirements shall be as specified in ASTM C1036.

3.2.4 Spall resistant ply. If a spall resistant inner ply is required it shall be as specified in 6.2.

3.2.5 Size and shape. The size and shape of the transparent armor shall be as specified by the procuring activity (see 6.2). Transparent armor may be flat or curved and special sizes and shapes may also be designed to meet specific needs.

3.2.6 Edgework. For handling purposes flares shall be ground, glass edges shall have a light seam. All edges shall be sealed for protection against environmental degradation.

3.3 Areal density. The armor shall be of the minimum areal density consistent with the ballistic protection requirements as specified by the procuring activity (see 6.2).

3.4 Ballistic limit. The ballistic limit of transparent armor used in military weapon systems shall be as specified in the contract or detailed specification for the particular weapon system. These ballistic limits shall be driven by end users' concerns about a specific arena of operation and shall be as specified in 6.2.

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3.5 Optical.

3.5.1 Luminous transmittance and haze. Requirements for luminous transmittance and haze shall be as specified by the procuring activity (see 6.2).

3.5.2 Optical deviation. Requirements for optical deviation shall be as specified by the procuring activity and the optical deviation shall be defined and measured (see 6.2).

3.5.3 Optical distortion. Requirements for optical distortion shall be as specified by the procuring activity and the optical distortion shall be defined and measured (see 6.2).

3.5.4 Birefringence. Requirements for birefringence shall be as specified by the procuring activity and the photoelastic measurements of birefringence and residual strains shall be determined for the transparent plastic materials used in the armor construction (see 6.2).

3.6 Environmental resistance. The transparent armor shall not crack, cloud, delaminate, or show any other evidence of deterioration when tested for environmental resistance. Additional requirements for the environmental resistance of the transparent armor shall be as specified in the engineering drawing, detailed specification or contract in accordance with MIL-STD-810 for the following environmental conditions:

- a. Low pressure (altitude)
- b. High temperature
- c. Low temperature
- d. Temperature shock
- e. Solar radiation (sunshine)
- f. Rain
- g. Humidity
- h. Fungus
- i. Salt fog
- j. Sand and dust
- k. Explosive atmosphere
- l. Leakage (immersion)
- m. Acceleration
- n. Vibration
- o. Acoustic noise
- p. Shock
- q. Gunfire
- r. Temperature, humidity, vibration, altitude

3.7 Allowable defects. For inspection purposes, the transparent armor is divided into three zones or grading areas. Area A is the edge to be concealed at assembly and is specified by the procuring activity (see 6.2). B is the area within 2 inches (50 mm) of the concealed edges, and C is the remaining central area. Maximum allowable defects shall conform to table I.

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TABLE I. Maximum allowable defects.

<u>Types of defects</u>	<u>Allowable defects</u> ^{1/}	
	<u>Area C</u>	<u>Area B</u>
Gaseous inclusions	1/16 in. (1.6 mm)	3/32 in. (2.4 mm)
Open gaseous inclusions	3/64 in. (1.2 mm)	1/16 in. (1.6 mm)
Stones and knots	1/32 in. (0.8 mm)	3/64 in. (1.2 mm)
Ream and string	Shall not be evident at an angle greater than 30° between line of sight and glass surface, with indirect daylight.	
Scratches and rubs	Use ASTM F548 for plastics and ASTM F428 for glass.	
Digs	1/16 in. (1.6 mm)	3/32 in. (2.4 mm)
Crush	Shall not be detectable at distances greater than 10 ft (3.0 m), with indirect daylight.	
Lint and hair	Shall not be detectable at distances greater than 3 ft (0.9 m) looking perpendicular to the glass, with indirect daylight.	
Insects or other organic matter	Shall not be detectable at distances greater than 3 ft (0.9 m) looking perpendicular to the glass, with indirect daylight.	
Inside dirt	3/32 in. (2.4 mm)	3/32 in. (2.4 mm)
Surface defects	Shall not be detectable at distances greater than 10 ft (3.0 m).	
Interlayer striae	Shall not be detectable at distance greater than 10 ft (3.0 m) looking perpendicular to the glass, with indirect daylight.	

^{1/} All discrete defects shall be separated by at least 12 in. (30 cm). The defects listed are the maximum permissible. Defects not specifically mentioned shall be compared to the defect they most closely resemble. Defect(s) include any related distortion to the area surrounding the defect.

3.8 Serviceability. Unless otherwise specified (see 6.2), minor imperfections that do not affect serviceability shall be permitted.

3.9 Marking of test samples. Transparent armor samples submitted for ballistic testing shall be clearly marked "IMPACT SIDE" on the side to be impacted by the test projectile. Caution shall be exercised in handling to prevent scratching of the plastic surface.

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4. VERIFICATION

4.1 Verification alternatives. Alternative test methods, techniques, or equipment, including the application of statistical process control, tool control, or cost effective sampling procedures may be proposed by the contractor. Acceptable alternative verification approaches shall be identified in the contract.

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

- a. Pre-production sample (see 4.2.1)
- b. First article inspection (see 4.2.2)
- c. Conformance inspection (see 4.2.3)

4.2.1 Pre-production sample. Unless otherwise specified (see 6.2), the pre-production sample shall be manufactured by the same methods proposed for the manufacture of subsequent production lots. The pre-production sample shall be subjected to all examinations and tests specified herein. If the pre-production sample is rejected, it will be returned to the contractor. Before submitting another pre-production sample, the contractor shall furnish the Government information concerning previous rejection, and the action taken to correct the defects. Subsequent quantities shall not be considered for acceptance until the approval of the pre-production sample has been obtained.

4.2.2 First article inspection. When required (see 3.1.1), the first article sample shall be examined for compliance with the requirements and verifications listed in sections 3 and 4. All samples shall be produced with materials and processes proposed for use on production transparent armor. Inspection shall be carried out by the contractor under Government surveillance, when specified (see 6.2).

4.2.3 Conformance inspection. Conformance inspection for acceptance of production transparent armor shall be conducted on a recurring basis and include the examinations and tests in sections 3 and 4.

4.2.4 Lot formation. An inspection lot shall consist of all the transparent armor produced for one order of a single part number, from an identifiable production period, from one manufacturer, submitted at one time for acceptance.

4.2.5 Initial production lot. The number of random samples selected for inspection, from each initial production lot of components, shall be defined by the procuring activity (see 6.2).

4.2.6 Production lots after initial lot. The number of random samples selected for inspection, from each production lot of components after the initial lot, shall be defined by the procuring activity (see 6.2).

4.2.7 Acceptance and rejection. The selected armor samples shall meet the requirements in table I for the represented lot to be acceptable. Failure of any test samples to meet the requirements in table I shall constitute rejection of the entire lot which they represent. Unless otherwise specified (see 6.2), the ballistic tests shall be conducted and the test results accepted prior to shipment of the lot of armor represented by the test samples.

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4.3 Examination.

4.3.1 Visual. The transparent armor shall be visually examined for compliance with the requirements for serviceability (see 3.8).

4.3.2 Marking of test samples. Verify the presence of the required markings.

4.4 Test methods (except ballistics). Transparent armor shall be tested in accordance with the test methods in table II.

TABLE II. Test Methods.

<u>Test</u>	<u>Number</u>
Abrasion resistance	ASTM D1044, ASTM F735
Birefringence	ASTM D4093
Bond integrity	ASTM F521
Environmental resistance	ASTM F520, MIL-STD-810
Luminous transmittance and haze	ASTM D1003

4.5 Ballistic acceptance test and procedure. The ballistic acceptance test of actual panels and the ballistic test procedure shall be conducted on a recurring basis in accordance with the ballistic test procedures outlined in MIL-STD-662. The contractor shall supply (for each three months of transparent armor fabrication) two test samples when the ballistic testing criteria is pass/fail, and up to ten samples (actual number of samples to be agreed upon by procuring activity and supplier) shall be required for V₅₀ ballistic testing. Ballistic acceptance testing shall be conducted at a Government approved facility to show conformance to the ballistic requirements in 3.4. The test samples shall be adequately identified as to contractor, contract number, manufacturer, date of manufacture, lot number, and architecture (or composition). The testing facility shall report raw data (a complete within limits description of what is being tested, including the method of confinement), velocities, ballistic limit, penetration observation, areal density, and thickness for each test sample.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When actual packaging of materiel is to be performed by DoD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activity within the Military Department or Defense Agency, or within the Military Department's System Command. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

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6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The transparent armor covered by this specification has military unique ballistic requirements and is intended to be used in military aircraft, ships, tactical vehicles, or other applications requiring protection against a variety of ballistic threat projectiles. Transparent armor constructions provide protection ranging from small caliber handguns to military rifles, and fragmentation from exploding ordnance.

6.2 Acquisition requirements. Acquisition documents should specify the following:

- a. Title, number, and date of the specification.
- b. Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.2.1 and 2.3).
- c. Pre-production sample, if required (see 3.1).
- d. First article, if required (see 3.1.1).
- e. Whether the material is to be specified (see 3.2.2).
- f. Glass requirements (see 3.2.3).
- g. Spall resistant ply, if required (see 3.2.4).
- h. Size and shape of the transparent armor (see 3.2.5).
- i. Acceptable value for areal density (see 3.3).
- j. Ballistic limits are to be specified by the end user (see 3.4).
- k. Luminous transmittance and haze requirements (see 3.5.1).
- l. Optical deviation requirements (see 3.5.2).
- m. Optical distortion requirements (see 3.5.3).
- n. Birefringence requirements and whether the photoelastic measurements of birefringence and residual strains are to be specified (see 3.5.4).
- o. Area to be concealed at assembly (see 3.7).
- p. Whether specific requirements pertaining to minor imperfections are to be specified (see 3.8).
- q. Whether the method of manufacture for the pre-production sample is to be specified (see 4.2.1).
- r. Whether inspection is carried out by the contractor under Government surveillance (see 4.2.2).
- s. Number of samples to be inspected from the initial production lot (see 4.2.5).
- t. Number of samples to be inspected from the production lots after the initial production lot (see 4.2.6).
- u. Acceptance requirements prior to shipment of the lot of armor, if different (see 4.2.7).
- v. Packaging requirements (see 5.1).

6.3 History.

6.3.1 Classification. The following historical information documented in the detailed version of this specification, MIL-A-46108B, classified transparent armor constructions as follows:

- Type I - Glass/plastic laminated construction - consists of one or more plies of glass as an exterior surface bonded to a plastic backing material.

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Type II - Glass-clad plastic “sandwich” construction - consists of two or more glass outer layers bonded to a plastic inner core.

Type III - All plastic laminated construction.

Type IV - All glass laminated construction.

6.4 Related standards. Advanced glass/plastic vision blocks have been fabricated for military fighting vehicles (see MIL-DTL-11352). Transparent armor has been installed in limousines used by political leaders and high ranking military officers. Also, the following documents may be useful:

ASTM D788	Poly(Methyl Methacrylate) (PMMA) Molding and Extrusion Compounds (DoD adopted)
ASTM D3935	Polycarbonate (PC) Unfilled and Reinforced Material (DoD adopted)
ASTM D4802	Poly(Methyl Methacrylate) Acrylic Plastic Sheet (DoD adopted)
ASTM F1233	Security Glazing Materials and Systems
UL 752	Safety Bullet-Resisting Equipment (DoD adopted)

6.5 First-time suppliers. First-time suppliers who have not previously supplied transparent armor to MIL-A-46108 or MIL-PRF-46108 and wish to have their material tested, may do so at their own expense. It is recommended that inquiries for testing be directed to Commander, U.S. Army Test and Evaluation Command, ATTN: AMSTE-TM-O, Aberdeen Proving Ground, MD 21005. Technical questions regarding testing may be directed to U.S. Army Aberdeen Test Center, ATTN: STEAC-LI, Aberdeen Proving Ground, MD 21005.

6.6 Subject term (key word) listing.

Ballistic limit
Birefringence
Glass
Limousines
Windows

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CONCLUDING MATERIAL

Custodians:

Army - MR

Navy - AS

Air Force - 11

Preparing activity:

Army - MR

(Project 9340-0018)

Review activities:

Army - AR, AT, GL

Navy - CG, SH

Air Force - 03, 84, 99

DLA - GS

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7, and send to preparing activity.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. 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.

I RECOMMEND A CHANGE:

1. DOCUMENT NUMBER
MIL-PRF-46108C

2. DOCUMENT DATE (YYYYMMDD)
19990603

3. DOCUMENT TITLE ARMOR: TRANSPARENT

4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)

b. ORGANIZATION

c. ADDRESS (Include Zip Code)

d. TELEPHONE (Include Area Code)
(1) Commercial
(2) AUTOVON
(if applicable)

7. DATE SUBMITTED
(YYYYMMDD)

8. PREPARING ACTIVITY

a. NAME
U.S. ARMY RESEARCH LABORATORY

b. TELEPHONE Include Area Code)
(1) Commercial 410-306-0725
(2) AUTOVON 458-0725

c. ADDRESS (Include Zip Code)
WEAPONS & MATERIALS RESEARCH DIRECTORATE
ATTN: AMSRL-WM-M
ABERDEEN PROVING GROUND, MD 21005-5069

IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT:
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