

INCH-POUND

MIL-B-29604(AS)  
15 December 1994

## MILITARY SPECIFICATION

## BODY ARMOR, HARD, SMALL ARMS PROTECTIVE, PRU-61/P22P-15

This specification is approved for use by the Naval Air 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 the general requirements and inspections for hard body armor worn by helicopter aircrewmembers for protection against small arms projectiles.

1.2 Classification. The hard body armor will be one of the following sizes (see 6.2c):

Small  
Medium  
Large  
X-Large

## 2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 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 issue of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation (see 6.2d).

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Systems Standardization, Code 4.1.11B120-3, Naval Air Warfare Center Aircraft Division, Highway 547, Lakehurst, NJ 08733-5100, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A

FSC 8470

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## SPECIFICATIONS

## FEDERAL

- A-A-1898 - Cushioning Material, Packaging, (Cellulosic, Water Absorbent)
- CCC-P-91 - Padding; Rubberized, Curled Hair
- PPP-B-601 - Boxes, Wood, Cleated-Plywood
- PPP-B-636 - Boxes, Shipping, Fiberboard
- PPP-F-320 - Fiberboard: Corrugated and Solid, Sheet Stock (Container Grade), and Cut Shapes

## MILITARY

- MIL-W-4088 - Webbing, Textile, Woven Nylon
- MIL-T-5038 - Tape, Textile and Webbing, Textile, Reinforcing, Nylon
- MIL-C-12369 - Cloth, Ballistic, Nylon (Validated)
- MIL-F-21840 - Fastener Tapes, Hook and Pile, Synthetic
- MIL-C-43734 - Cloth, Duck, Textured Nylon

## STANDARDS

## MILITARY

- MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes
- MIL-STD-129 - Marking for Shipment and Storage
- MIL-STD-453 - Inspection, Radiographic
- MS27983 - Fastener, Snap, Style 4 (Validated)
- MS51940 - Loop, Slide (For Equipage)

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from DODSSP, Standardization Document Order Desk, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.1.2 Government drawings. The following Government drawings form a part of this document to the extent specified herein. Unless otherwise specified, the issues shall be those in the solicitation.

## NAVAL AIR SYSTEMS COMMAND DRAWINGS

- 3241AS401 - Hard Ballistic Armor Assembly, PRU-61/P22P-15
- 3241AS402 - Hard Ballistic Armor Insert, PRU-61/P22P-15
- 3241AS403 - Encasement Assembly, PRU-61/P22P-15
- 3241AS404 - Pull Handle, Disconnect Strap and Retaining Strap Assemblies, PRU-61/P22P-15

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## NAVAL AIR SYSTEMS COMMAND DRAWINGS (Cont'd)

- 3241AS405 - Hard Ballistic Armor Sub-Assembly, PRU-61/P22P-15
- 3241AS406 - Label, Identification, PRU-61/P22P-15
- 3241AS490 - Encasement Pattern, Small, PRU-61/P22P-15
- 3241AS491 - Encasement Pattern, Medium, PRU-61/P22P-15
- 3241AS492 - Encasement Pattern, Large, PRU-61/P22P-15
- 3241AS493 - Encasement Pattern, Extra Large, PRU-61/P22P-15

(Unless otherwise specified, copies of drawings required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity, or as directed by the contracting officer.)

**2.2 Non-government publications.** The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of documents which are DoD adopted are those listed in 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 6.2d).

## AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- D 635 - Plastics, Self-supporting, in a Horizontal Position, Rate of Burning and/or Extent of Time of Burning of
- D 792 - Plastics by Displacement, Specific Gravity, (Relative Density) and Density of
- D 2000 - Rubber Products, in Automotive Applications
- D 2584 - Resins, Cured Reinforced, Ignition Loss of
- D 3951 - Packaging, Commercial

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

**2.3 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 shall take precedence. Nothing in this document, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

**3. REQUIREMENTS**

**3.1 Qualification.** The hard body armors furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable qualified

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products list at the time of award of contract (see 4.3 and 6.4). Qualification of any one size assembly, under this specification, will automatically qualify a supplier for all sizes specified herein (see 1.2).

3.2 First article. When specified (see 6.2e), a sample shall be subjected to the first article inspection (see 6.5) in accordance with 4.4.

3.3 Materials and components. The materials and components shall conform to applicable specifications, standards, and drawings and shall be as specified herein. Equivalent materials and parts require approval by the Naval Air Warfare Center Aircraft Division Warminster (Code 603), Warminster, Pennsylvania 18974-5000. Requests for use of equivalent items shall be submitted to the Contracting Officer. Recycled materials (see 6.7).

3.3.1 Fiberglass laminate. The fiberglass laminate shall consist of a minimum of 20 percent by weight of unsaturated polyester type unfilled resin and may contain modifying monomers or polymers and the remainder shall be undyed fiberglass fabric.

3.3.1.1 Flame resistance. The fiberglass laminate shall be self-extinguishing or non-burning.

3.3.2 Spall cover. The spall cover shall be fabricated from nylon ballistic cloth conforming to MIL-C-12369, Class I as specified in 3.4 and drawing 3241AS402.

3.3.3 Rubber edging. The rubber edging shall be fabricated from rubber in accordance with 3AA615A14F17Z of ASTM D 2000 as specified in 3.4 and drawing 3241AS402.

3.3.4 Encasements. The front and back encasements shall be fabricated from ballistic aramid cloth conforming to MIL-C-43734, Color 106 Olive Green (see 3.4.1.1).

3.3.5 Webbings.

3.3.5.1 Front encasement assembly webbing. The webbing for the front encasement assembly shall be fabricated from nylon conforming to MIL-W-4088, Type VIII, Class I, 1 23/32 inch wide as specified in drawing 3241AS403.

3.3.5.2 Back encasement assembly webbing. The webbing for the back encasement assembly shall be fabricated from nylon conforming to MIL-W-4088, Type IV, Class II, 3 inch wide as specified in drawing 3241AS403.

3.3.5.3 Pull handle assembly webbing. The webbing for the pull handle assembly shall be fabricated from nylon conforming to MIL-W-4088, Type XV, Class II, 2 inch wide as specified in drawing 3241AS404.

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3.3.6 Tapes.

3.3.6.1 Back encasement assembly tape. The tape for the back encasement assembly shall be fabricated from nylon conforming to MIL-T-5038, Type III, Class II, 1 inch wide as specified in drawing 3241AS403.

3.3.6.2 Pull handle assembly and back armor retaining strap assembly. The tape for the pull handle assembly and back armor retaining strap assembly shall be fabricated from nylon conforming to MIL-T-5038, Type IV, Class II, 1 inch wide as specified in drawing 3241AS404.

3.3.6.3 Quick disconnect strap assembly tape. The tape for the quick disconnect strap assembly shall be fabricated from nylon conforming to MIL-T-5038, Type III, Class II, 3/4 inch wide as specified in drawing 3241AS404.

3.3.7 Hook and pile tape.

3.3.7.1 Hook tape. The hook tape shall be nylon in accordance with MIL-F-21840, Type II, Class I, 1 and 2 inch wide as specified in drawing 3241AS403.

3.3.7.2 Pile tape. The pile tape shall be nylon in accordance with MIL-F-21840, Type II, Class I, 1 and 2 inch wide as specified in drawing 3241AS403.

3.3.8 Snap fasteners. The eyelets, studs, sockets and buttons shall be in accordance with MS27983-4, -3, -2, -1, respectively, as specified in drawing 3241AS404.

3.3.9 Loop slide. The loop slide shall be in accordance with MS51940 as specified in drawing 3241AS404.

3.3.10 Quick release strap clip and side release buckle. The quick release strap clip and side release buckle shall be part numbers 627-0075 and 101-0100, respectively, of ITW Waterbury, 952 South Main Street, Waterbury, CT 06721, Cage No. 82399 as specified in drawing 3241AS404.

3.4 Design and construction. The hard body armor shall consist of a fiberglass laminate component bonded to the back of a ceramic component forming a composite armor insert. The exposed surface of the ceramic component shall be covered with a spall cover. A rubber edging shall extend around the periphery of the composite armor insert. The insert shall be placed inside the protective encasement. The design and construction of the hard armor assembly shall conform to the drawings listed in Section 2.1.2 and as specified herein.

3.4.1 Patterns. Standard patterns will be furnished by the Government to the contractor for use in cutting working patterns

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(see 6.6). The working patterns shall be identical to the Government patterns. Neither the Government patterns nor the working patterns shall be altered in any way. Seams shall be in accordance with seam allowances specified in 3.4.

3.4.1.1 Component parts. The component parts shall be cut from the material specified, in accordance with the pattern parts in Table 1.

3.4.2 Assembly of components by bonding. All components to be assembled shall be thoroughly cleaned of all foreign matter. Surfaces to be bonded shall be properly prepared in a manner which will insure a proper bond capable of meeting the applicable performance requirements. The required adhesive shall be applied uniformly over the entire contact areas of the components to be joined. There shall be no evidence of unadhered areas and no smearing of the adhesives on the exposed surfaces of the components. When bonding the rubber edging, the adhesive may extend beyond the edges of the rubber edging up to a maximum of 3/16 inch.

3.4.2.1 Age and condition of adhesive. Old, partially congealed, or partially polymerized adhesive shall not be used. Adhesive containers to be refilled shall be free of such adhesive prior to refilling. Regardless of age or condition of the batch of adhesive in use during a work shift, a full batch shall be substituted at the start of the next shift.

3.4.3 Cut edges. The cut edges of the nylon webbing and tapes, except for the hook and pile fastener tapes, shall be seared, prior to the fabrication, to prevent fraying. No sharp edges shall be formed. The cut edges of the nylon duck cloth, except those that are completely covered by nylon binding tape, hook and pile fastener tapes, or are completely encased by the seam construction, shall be overedged stitched (serged).

3.4.4 Seams and stitching. All the seams and stitching used in the fabrication of the hard armor shall conform to the requirements of applicable drawings.

3.5 Identification markings. Identification markings for the hard body armor and its components shall be as specified in applicable drawings.

3.5.1 Serial numbers. The hard body armor and components shall be identified by individual serial numbers assigned by the manufacturer. Serialization shall be by a block of consecutive numbers to cover the entire acquisition document quantity.

3.6 Performance.

3.6.1 Visual and dimensional examination. When visually examined as specified, the body armor component or assembly shall conform to the requirements of this specification. Tables VI,

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VII and applicable drawings shall be used to classify and enumerate the defects and any dimension that is not within the specified tolerance shall be classified as a defect.

3.6.2 Physical properties (fiberglass laminate component).

3.6.2.1 Resin content. The minimum resin content, when tested as specified in 4.8.2.1, shall be 20 percent by weight of unsaturated polyester type unfilled resin and may contain modifying monomers or polymers.

3.6.2.2 Flame resistance. The fiberglass laminate component, when tested as specified in 4.8.2.2, shall be self-extinguishing or non-burning.

3.6.3 Areal density. The areal density of the body armor inserts, without spall cover and rubber edging, when tested as specified in 4.8.3, shall be  $9.0 \pm 0.2$  pounds per square foot.

3.6.4 Ballistic resistance. The body armor insert without spall cover and rubber edging, when tested as specified in 4.8.4, shall have a V50 protection ballistic limit of not less than 2850 feet per second with a caliber .30 AP M2 projectile.

3.6.5 Temperature extremes test. There shall be no delamination between the fiberglass laminate component and the ceramic component or between the fiberglass plies when tested as specified in 4.8.5.

3.6.6 End item radiographic examination. The completed armor inserts, when tested as specified in 4.8.6, shall be examined for defects specified in Table VI.

3.6.7 Adhesion of rubber edging. There shall be no visual separation of the rubber edging from the armor insert when tested as specified in 4.8.7.

3.6.8 Adhesion of the spall cover. There shall be no visual peeling of the tab formed on the spall cover when tested as specified in 4.8.8.

3.7 Workmanship. After completion, the hard armor shall be thoroughly cleaned and all loose thread, lint, and foreign matter shall be removed. The hard body armor shall not contain any non-specified holes, abraded areas, tears, cuts, mends, needle chews, spots, or stains. Drill holes for the encasement shall be not greater than 1/16 inch in diameter and shall be covered by the components. The hard body armor shall conform to the quality and grade established by this specification.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is



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responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, 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 this document where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of sections 3 and 5. The inspection set forth in this document shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the document shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements; however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

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

- a. Qualification inspection (see 4.3).
- b. First article inspection (see 4.4).
- c. Quality conformance inspection (see 4.5).
- d. Quality conformance verification inspection (see 4.6).

4.3 Qualification inspection: Qualification inspection of the hard body armors shall be as specified in Table II.

4.3.1 Qualification samples. Qualification samples shall consist of three hard body armors (size optional to the manufacturer). Samples shall be forwarded to the test facility set forth in the letter of authorization to submit samples (see 6.3). The samples shall be plainly identified by securely attached durable tags marked with the following information:

Samples submitted by (Name) on (Date) for qualification inspection in accordance with the requirements of MIL-B-29604(AS) and qualification test number ( ) under authorization (reference authorizing letter).

4.3.2 Retention of qualification. The retention of qualification shall consist of periodic verification to determine compliance of the qualified hard body armors with the requirements of this specification. The time and method of periodic verification shall be specified by the activity



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responsible for the Qualified Products List and shall be included in the Notice of Qualification letter.

4.4. First article inspection. The first article inspection of the hard body armors shall be as specified in Table III.

4.4.1 First article samples. Unless otherwise specified, as soon as practicable after award of the contract or order, the contractor shall submit three hard body armors of each of the size(s) specified in the acquisition document (see 6.2c). The samples shall be representative of the construction, workmanship, components and materials to be used during production. When a contractor is in continuous production of these hard body armors from contract to contract, submission of further first article inspection samples, on the new contract, may be waived at the discretion of the procuring activity (see 6.2e). Approval of the first article inspection samples or the waiving of the first article inspection does not preclude the requirements for performing the quality conformance inspection. The first article inspection samples shall be furnished to the Government as directed by the contracting officer (see 6.2f).

4.4.2 First article test report. Upon completion of the first article inspection program (4.4), the government activity responsible for conducting the program (see 6.2f) shall report the results of the tests, with appropriate recommendations, to the contracting officer.

4.4.3 First article sample disposition. Upon successful completion of the first article inspection program, sample disposition will be as follows:

- a. One sample (each size) will be returned to the manufacturer for use in monitoring production, and
- b. Two samples (each size) will be destroyed during the first article inspection program and shall not be considered as part of the quantity to be delivered under the contract.

4.5 Quality conformance inspection. Quality conformance inspection shall consist of the examinations and tests specified in Table IV. The sampling and inspection levels and acceptance criteria shall conform to MIL-STD-105.

4.5.1 Sampling.

4.5.1.1 Inspection lots.

4.5.1.1.1 Maximum lot size. The maximum lot size for tests and examinations shall not exceed one thousand (1,000).

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4.5.1.1.2 Minimum initial production lot. The minimum lot size for the initial production lot shall be as specified by the acquiring activity (see 6.2g).

4.5.1.1.3 Body armor assembly. An inspection lot shall be expressed in units of one front or back body armor end item made under essentially the same conditions and from the same materials. The sample unit shall be one body armor assembly.

4.5.1.1.4 Fiberglass laminate component. The lot size shall be expressed in units of front or back fiberglass laminate component. The sample unit shall be one fiberglass laminate component. When the fiberglass laminate is molded and bonded to the ceramic component in a simultaneous operation, the specimens required for testing shall be cut from composite armor inserts that have been ballistically tested.

4.5.1.1.5 Composite armor insert. The lot size shall be expressed in units of composite armor inserts, front or back without spall cover. The sample unit shall be one composite armor insert, front or back.

4.5.1.1.6 Packaging. An inspection lot size shall be expressed in units of one fully prepared shipping container, containing body armor assemblies, fully prepared for delivery from essentially the same materials and components. The sample unit shall be one shipping container, containing body armor assemblies, fully prepared for delivery with the exception that it need not be sealed.

4.5.1.2 Sampling for examinations and tests of the body armor assemblies or components. The sample size, acceptance criteria, examinations, and tests required for the body armor assemblies or components shall be as specified in Table II.

4.5.2 Certification of compliance. When specified (see 6.2h), components and materials listed below may be accepted on the basis of the contractor's certification of compliance with the requirements of this specification. The certification shall be accompanied with test, inspection or other verifiable data. The Government reserves the right to verify the validity of the certification.

- a. That the ceramic material conforms to applicable drawing requirements.
- b. Adhesive for bonding ceramic component to fiberglass laminate component conforms to applicable drawing requirements.
- c. Adhesive for bonding spall cover to ceramic component conforms to applicable drawing requirements.

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- d. Adhesive for bonding rubber edging to composite laminate conforms to applicable drawing requirements.

#### 4.6 Quality conformance verification.

4.6.1 Quality conformance verification inspection. The quality conformance verification inspection shall be as specified in Table V.

4.6.2 Quality conformance verification samples. Upon completion of the tests and examinations specified in Table IV, a random sample shall be selected from each lot in accordance with MIL-STD-105, Inspection Level S-3. The tests and examinations required for the hard body armor shall be as specified in Table V. The sample size and acceptance criteria shall be in accordance with MIL-STD-105 for single sampling plans for normal inspections. Each assembly, selected as a sample unit, shall be identified by its assigned serial number (see 3.5.1) and shall be forwarded to the inspection facility specified in the acquisition document (see 6.2). Additionally, the serial numbers of the units within the lot, represented by the sample units, shall be furnished to the inspection facility.

4.6.3 Quality conformance verification approval. Upon completion of the quality conformance verification inspection, the Government activity responsible for conducting the inspection program (see 6.2) shall report the results of tests, with recommendations, to the contracting officer of the procuring activity specified in the acquisition document. Final acceptance of the lot from which the samples were selected shall be based upon completion of the inspection program by the Government Quality Assurance Representative/Specialist.

#### 4.7 Test equipment.

4.7.1 Gage. The thickness of the armor insert shall be measured using a Federal Products Corporation, P.O. Box 9400, 114 Eddy St., Providence, RI 02940, deep throat type gage with standard tips conforming to Model KP125 or KP129 or equal.

#### 4.8 Inspection methods.

##### 4.8.1 Visual and dimensional examination.

4.8.1.1 Liquid penetrant and visual examination of ceramic component. The ceramic component shall be examined visually and with liquid penetrant on both sides and edges, after furnace firing and prior to application of the adhesive for bonding of the ceramic component to the fiberglass laminate component. Unless otherwise specified the examination shall be performed at the contractor's plant (see 6.2i). The liquid penetrant examination shall be performed in accordance with Appendix A. Defects shall be classified in accordance with the applicable defects listed in Table VI.

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4.8.1.2 Visual examination of composite armor insert.

Visual examination shall be conducted in accordance with Appendix B, on the face side and edge of the ceramic portion of the composite armor insert, and on the exposed surface and edge of the fiberglass laminate component just prior to application of the adhesive for bonding of the spall cover. Defects shall be classified in accordance with the applicable defects listed in Table VI.

4.8.1.3 Armor plate and encasement fit. The end item shall be examined for fit of the armor plate into the encasement. The armor plate shall ease into the encasement without effort and close the opening securely with the hook and pile fastener tapes. Defects shall be classified in accordance with the applicable defects listed in Table VII.

4.8.1.4 End item visual examination. The hard body armors shall be examined visually for conformance to this specification. Defects shall be classified in accordance with the applicable defects listed in Table VII.

4.8.1.5 Dimensional examination of composite armor inserts prior to application of spall cover. The composite armor insert shall be examined prior to application of spall cover for conformance to the dimensional requirements specified on applicable drawings. Defects shall be classified in accordance with the applicable defects listed in Table VII.

4.8.1.6 Examination of ceramic component for thickness. The ceramic component shall be examined for thickness prior to bonding to the fiberglass laminate. The ceramic component shall be uniform in thickness as specified in applicable drawings when examined in the following manner. The thickness shall be measured to 0.001 inch at five locations on the ceramic component. With the ceramic component considered as divided into four quadrants (one for each corner area), one reading shall be taken within each quadrant. Each reading shall be taken a minimum of 1-1/2 inches away from the edge. In addition, one reading shall be taken at the center of the ceramic component. All readings shall be spaced a minimum of 3 inches apart. The five readings shall be averaged and reported to the nearest 0.001 inch as the overall average. The differences between the greatest value and the overall average and the smallest value and the overall average shall not be more than 5 percent of the overall average thickness. All determinations shall be reported with the overall average. A deep throat type depth gage conforming to Federal Products Corp. Model KP 125 or KP 129, or equal, with standard measuring tips shall be used for taking the measurements.

4.8.1.7 Packaging. Each of the fully prepared shipping containers, containing hard body armors, selected as a sample unit from the lot, shall be visually examined to determine that

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the packaging, packing, and marking conform to the requirements specified in section 5 and Table VIII.

4.8.2 Physical properties (fiberglass laminate component).

4.8.2.1 Resin content. The fiberglass laminate component shall be tested in accordance with ASTM D2584. Three (3) determinations shall be made on one sample unit. An average of the three determinations shall be made to the nearest one (1) percent. The fiberglass laminate component shall pass the requirements specified in 3.6.2.1.

4.8.2.2 Flame resistance. The fiberglass laminate component shall be tested in accordance with ASTM D635. The fiberglass laminate component shall pass the requirements specified in 3.6.2.2.

4.8.3 Areal density. The areal density and ballistic tests shall be conducted on the same samples. The areal density in pound per square foot of the composite armor insert, without spall cover and without rubber edging, shall be calculated from measurements on the composite armor insert. The composite armor insert shall be weighed to the nearest 0.01 pound. The thickness shall be measured to 0.001 inch at four corner locations on the composite armor insert. Six measurements shall be made at each corner with the first measurement taken approximately 1 inch from the edge of the corner and the remaining five taken on a straight line toward the center of the armor with the measurements spaced at approximately 1-inch increments. Three measurements shall be taken at the low points of the fabric weave and three at the high points. A deep throat type gage conforming to Federal Products Corp. Model KP125 or KP129, or equal, with standard tips, shall be used for taking measurements. The average of the 24 readings shall be used in the calculation of the areal density. The edges of the glass fiber laminate shall be painted with a slow drying lacquer to seal the edges. The lacquer shall be allowed to dry (at least 1/2 hour) before proceeding with the determination of density. The average density of the composite armor insert shall be determined by Method A-3 of ASTM D792, except the immersed weight shall be determined to 0.01 pound and the liquid used shall be clean tap water, containing a wetting agent if necessary, which shall be changed just prior to examination of each lot. The areal density of the composite armor insert without spall cover and rubber edging shall be calculated to the nearest 0.01/lb./sq. ft. as follows: Areal density (lb./sq. ft.) =  $5.202 \times \text{Density (g/cc)} \times \text{Thickness (in.)}$ . The areal density of the composite armor insert shall pass the requirements specified in 3.6.4.

4.8.4 Ballistic resistance test. The composite armor insert shall be tested in accordance with Appendix D unless otherwise specified. The areal density shall be reported for each test insert. The insert having lowest areal density shall be tested first. Each succeeding insert tested shall be the next



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lowest areal density. The composite armor insert shall pass the requirements specified in 3.6.4.

4.8.5 Temperature extremes test. The composite armor insert, less the rubber edging and spall cover, shall be heated in an oven operating at 160° +/- 50F for 6 hours, +/- 1/4 hour. The test specimen shall be then allowed to cool to room temperature followed by cold exposure at -65° +/- 50F for 6 hours, +/- 1/4 hour. The specimen shall be allowed to warm to room temperature (70° to 90°F) and shall then be examined at edges for evidence of delamination of the fiberglass laminate component from the ceramic component or any delamination of the fiberglass plies. The composite armor insert shall pass the requirements specified in 3.6.5. Specimens that have passed the test may be returned to the production lot.

4.8.6 End item radiographic examination. The completed armor inserts shall be radiographically examined. Industrial radiography shall be performed in accordance with Appendix C. Radiography shall include the entire ceramic component area and shall contain the same permanent marking as the ceramic component. Radiographic films shall be made available to the Government upon request. The radiographic equipment and procedures shall be in accordance with MIL-STD-453, except where noted in Appendix C. The complete armor inserts shall pass the requirements specified in 3.6.6.

4.8.7 Adhesion test of rubber edging. The rubber edging shall be tested for adhesion by application of a 5 pound minimum static shear load. The 5 pound load shall be applied to the rubber edging using a clamp device conforming to that shown on Figure 1. With the armor insert vertically suspended or secured, the clamp shall be adjusted such that the contact points evenly make contact with the top edges of the rubber edging, see Figure 1. The clamp shall not come in contact with the spall cover or fiberglass laminate surface of the armor insert. The load shall be applied to all four sides of the back armor insert and the front insert in the approximate center of each side. Each location shall be tested separately and the load shall be applied for a minimum of 10 minutes. The adhesion of the rubber edging shall pass the requirements specified in 3.6.7.

4.8.8 Adhesion test for spall cover. The sample for this test may be made from an armor insert which has been tested ballistically using an undamaged area, or a small test specimen made identically to the armor insert with respect to surface preparation, adhesive application, and bonding. Make parallel cuts through the spall covering 4 inches long and 1 inch apart along the weave. At one end of the cut, make a cut at a right angle so that a 1-inch wide by 2-inch long tab can be peeled from the armor insert. Attach a 2-pound weight to this tab so that the resultant peel force is normal to the plane of the armor insert. Make gage marks on the specimen for the measurement of the amount of peeling during the test. Allow the weight to hang



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for 4 hours minimum at room temperature (70° to 90°F). The adhesion of the spall cover shall pass the requirements specified in 3.6.8.

## 5. PACKAGING

5.1 Preservation. Preservation shall be level A or Commercial as specified (see 6.2j).

### 5.1.1 Level A.

5.1.1.1 Unit preservation. The hard body armor insert(s) shall be inserted in the appropriate pocket and the flaps securely fastened. Each hard body armor shall be completely wrapped in not less than 1-inch cushioning material conforming to type II, class B of A-A-1898 or padding conforming to type I, grade A, class 1 or 2 of CCC-P-91. The cushioning or padding material shall be secured with pressure-sensitive tape or by means of cross-tying with cotton tape or twine. The inserts shall have the respective concave sides facing the pad and be alternately reversed top to bottom. The pad shall conform to type CF (variety TW), class domestic of PPP-F-320. The inserts shall be secured to the pad by cross-banding with filament reinforced pressure-sensitive tape or by cross-tying with cotton tape or twine.

5.1.1.2 Intermediate preservation. Two hard body armors of one size only, unit preserved as specified in 5.1.1.1, shall be further packed flat in a snug-fitting intermediate fiberboard box conforming to style RSC-L, grade V3c of PPP-B-636. The inside of each box shall be fitted with a box liner and top and bottom pads conforming to type CF (variety TW), class domestic of PPP-F-320. The height of the box liner shall be the inside depth of the box less the combined thicknesses of the top and bottom pads. The top and bottom pads shall measure 1/4 inch less than the inside length and width dimensions of the box. All void spaces around the hard body armor shall be filled with the same cellulosic cushioning or padding specified in 5.1.1.1 in a manner to immobilize the contents from movement while in transit. Each fiberboard box shall be closed and water-proofed with tape in accordance with the appendix of PPP-B-636.

5.1.2 Commercial. Hard body armors shall be preserved in accordance with ASTM D 3951.

5.2 Packing. Packing shall be level A, B or Commercial as specified (see 6.2j).

5.2.1 Level A. Eighteen hard body armors of one size only, preserved as specified in 5.1, shall be packed in a snug-fitting shipping container conforming to overseas type, style A or I, grade A or B, type 2 load of PPP-B-601. Level A intermediate packs shall be packed flat, three in length, one in width, and three in depth within a shipping container. Each shipping

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container shall be provided with skids as specified in the container specification. Each shipping container shall be closed and reinforced in accordance with the appendix of PPP-B-601. Toward the end of the contract or when there are less than the required amount per container of the same size, mixed sizes may be packed with the same container.

5.2.2 Level B. Eighteen hard body armors of one size only, preserved as specified in 5.1, shall be packed in a snug-fitting shipping container conforming to domestic type, style A or I, grade B, type 2 load of PPP-B-601. Level A intermediate packs shall be packed flat, three in length, one in width, and three in depth within a shipping container. Each shipping container shall be provided with skids as specified in the container specification. Each shipping container shall be closed and reinforced in accordance with the appendix of PPP-B-601. Toward the end of the contract or when there are less than the required amount per container of the same size, mixed sizes may be packed within the same container.

5.2.3 Commercial. Hard body armors, preserved as specified in 5.1, shall be packed in accordance with ASTM D 3951.

5.3 Marking. In addition to any special marking required by the contract or purchase order (see 6.2k), intermediate packs and shipping containers shall be marked in accordance with MIL-STD-129 or ASTM D 3951, as applicable.

5.3.1 Special marking. Each intermediate pack and shipping container shall be provided with fragile labels in accordance with MIL-STD-129 and in addition, the top panel of each package and container shall be printed or stenciled in black ink with the following legend:

"DO NOT DROP"

5.3.2 Labels, mixed sizes. Each shipping container packed with mixed sizes shall have securely attached to the end and side, directly under the printing or stenciling, a white paper label 5 by 4 inches with the words "MIXED NSNs" plainly stamped or printed thereon and under these words shall be legibly printed the correct quantity of NSNs contained therein.

## 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 hard body armor covered by this specification is intended to be worn by helicopter aircrewmen to provide small arms ballistic protection.

6.2 Acquisition requirements. Acquisition documents should specify the following:

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- a. Title, number, and date of this specification, including any amendments.
- b. Applicable drawings, including revisions.
- c. Quantity and size desired.
- d. Issue of DODISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1.1 and 2.2).
- e. Whether first article inspection is waived (see 4.4.1).
- f. Name and address of the first article inspection facility (see 4.4.1); and the name and address of the Government activity responsible for conducting the first article inspection program (see 4.4.2.)
- g. The minimum lot size for the initial production lot (see 4.5.1.2).
- h. Whether certification of compliance is required (see 4.5.2)
- i. Location for testing of liquid penetrant on the ceramic component (see 4.8.1.1).
- j. Selection of applicable levels of preservation and packing (see 5.1 and 5.2).
- k. Whether any special markings are required (see 5.3.1).
- l. Items of data required (see 6.3).

**6.3 Consideration of data requirements.** The following data requirements should be considered when this specification is applied on a contract. The applicable Data Item Descriptions (DID's) should be reviewed in conjunction with the specific acquisition to ensure that only essential data are requested/provided and that the DID's are tailored to reflect the requirements of the specific acquisition. To ensure correct contractual application of the data requirements, a Contract Data Requirements List (DD Form 1423) must be prepared to obtain the data, except where DOD FAR Supplement 27.475-1 exempts the requirements for a DD Form 1423.

<u>Paragraph</u>	<u>DID Number</u>	<u>DID Title</u>	<u>Tailoring</u>
4.4.2	DI-NDTI-80809	Test reports	Use contractor format
4.5.2	DI-E-2121	Certificate of Compliance	Use contractor format

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The above DID's were those cleared as of the date of this specification. The current issue of DOD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL), must be researched to ensure that only current, cleared DID's are cited on the DD Form 1423.

6.4 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in the applicable Qualified Products List whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. The activity responsible for the Qualified Products List is the Commander, Naval Air Systems Command, Department of the Navy, Washington, DC 20361; however, authorization for qualification of products may be obtained from the Commanding Officer, Naval Air Warfare Center Aircraft Division Warminster, (Code 6031), Warminster, PA 18974-0591.

6.5 First article. When first article inspection (see 3.2) is required, the contracting officer should provide specific guidance to offerors whether the item(s) shall be first article sample, a first production item, or a standard production item from the contractor's current inventory, and the number of items to be tested shall be as specified in 4.4.1. The contracting officer should include specific instructions in acquisition documents regarding arrangements for examinations, approval of first article test results and disposition of first articles. Invitation for bids should provide that the Government reserves the right to waive the requirement for samples for first article inspection 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. Bidders should not submit alternate bids unless specifically requested to do so in the solicitation.

6.6 Patterns and drawings. For access to patterns and drawings, address the acquiring activity issuing the invitation for bids.

6.7 Recycled material. It is encouraged that recycled material be used when practical as long as it meets the requirements of this document (see 3.3).

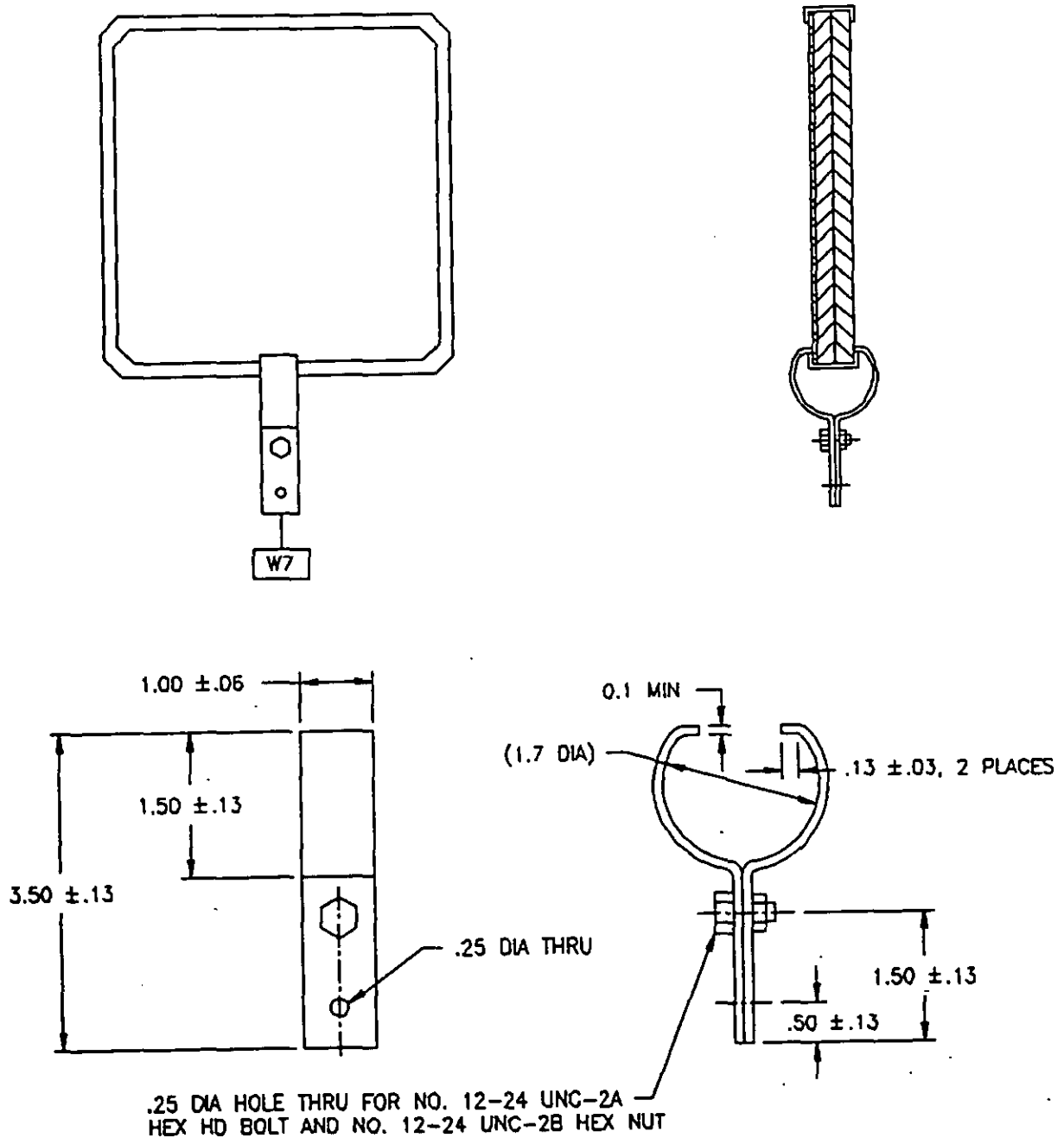
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6.8 Subject term (key word) listing.

Aircrewmen protection  
Ballistic protection  
Ceramic  
Helicopter aircrewman  
Protection, projectile

Preparing Activity  
NAVY-AS  
(Project No. 8470-N157)

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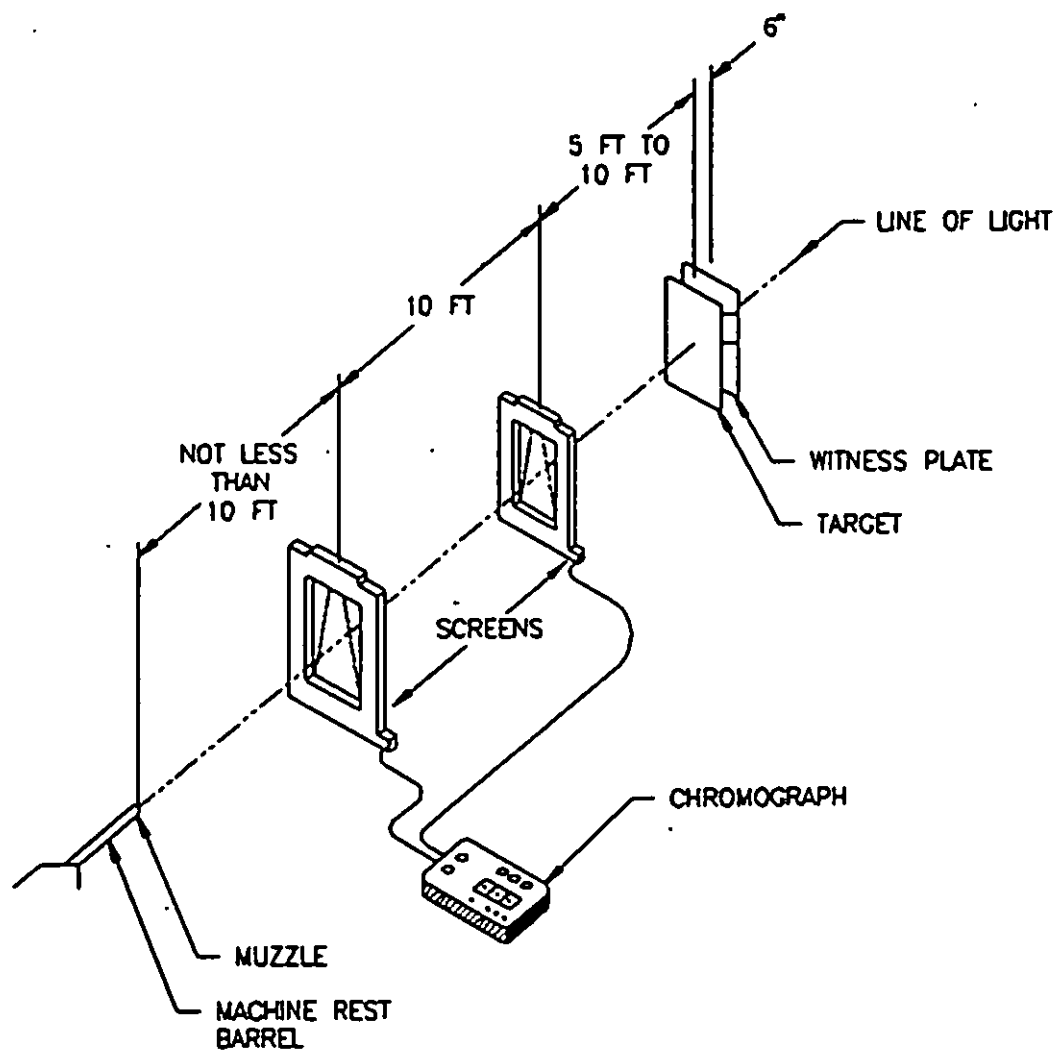
## NOTE:

THE TYPE OF MATERIAL FOR THE CLAMP IS OPTIONAL, THE DIAMETER OF THE CLAMP OPENING DEPENDS UPON THE OVERALL THICKNESS OF THE ARMOR BEING FURNISHED. A DIFFERENT TYPE AND SIZE OF BOLT AND NUT MAY BE USED AT THE SUPPLIER'S OPTION.

FIGURE 1. Clamp for application of weight in preforming rubber edging adhesion test, aircrewman's body armor.



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NOTE:  
MEASUREMENTS TO BE TAKEN TO THE NEAREST 0.01 FOOT

FIGURE 2. Ballistics facility layout.

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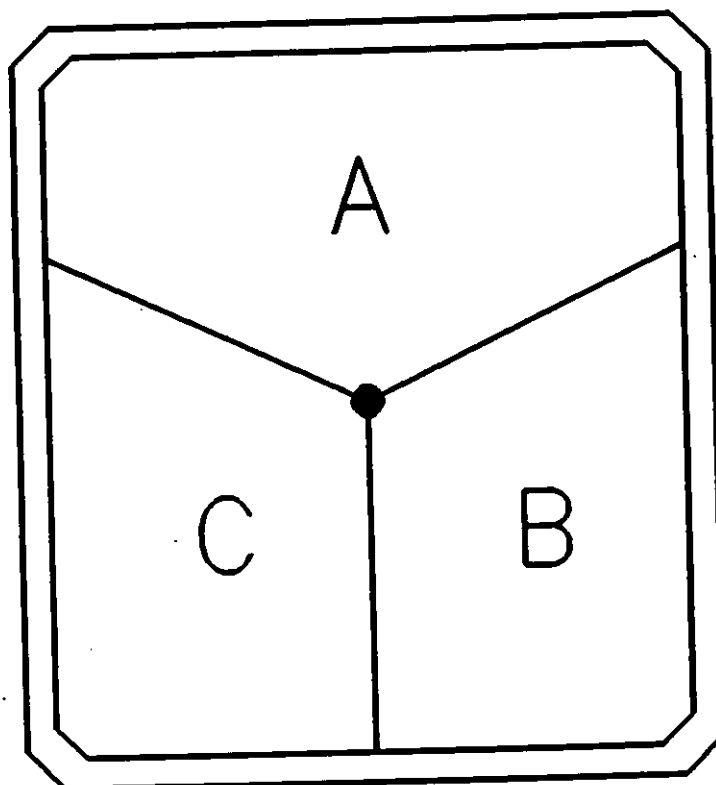


FIGURE 3. Ballistic test sample for marking.

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TABLE I. Component parts.

Material	Nomenclature of Component Parts	Cut Parts
Cloth, duck, textured nylon (MIL-C-43734, Class 3)	Encasement, front	1
	Encasement, back	1

TABLE II. Qualification inspection (see 4.3).

Inspection	Method	Sample Number
Visual examination	4.8.1.1 thru 4.8.1.4 and 4.8.1.5	Every Assembly
Dimensions	4.8.1.5	Every Assembly
Liquid penetrant	4.8.1.1	Every Assembly
Resin content (percent)	4.8.2.1	Every Assembly
Flame resistance	4.8.2.2	Every Assembly
Areal density	4.8.3	Every Assembly
Ballistic resistance test	4.8.4	Every Assembly
Temperature extremes test	4.8.5	Every Assembly
Radiographic examination (end item), initial production lot	4.8.5	Every Assembly
Radiographic examination (end item), subsequent production lots	4.8.6	Every Assembly
Adhesion test of rubber edging	4.8.7	Every Assembly
Adhesion test for spall cover	4.8.8	Every Assembly
Packaging	4.8.1.7	Every Assembly

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TABLE III. First article inspection (see 4.4).

Inspection	Method
Visual examination	4.8.1.1 thru 4.8.1.4 and 4.8.1.6
Dimensions	4.8.1.5
Liquid penetrant	4.8.1.1
Resin content (percent)	4.8.2.1
Flame resistance	4.8.2.2
Areal density	4.8.3
Ballistic resistance test	4.8.4
Temperature extremes test	4.8.5
Radiographic examination (end item), initial production lot	4.8.6
Radiographic examination (end item), subsequent production lots	4.8.6
Adhesion test of rubber edging	4.8.7
Adhesion test for spall cover	4.8.8
Packaging	4.8.1.7

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TABLE IV. Quality conformance inspection.

Inspection	Method	Sample Size	Acceptance Criteria
Visual examination	4.8.1.1 thru 4.8.1.4 and 4.8.1.6	Every ceramic component and composite armor insert for the critical and minor defects  Inspection level II 1/ for hard body armors (end item)	Reject all units with any critical defects or four minor defects 2/  An acceptable quality level of 4.0 defects per hundred units
Dimensions	4.8.1.5	Inspection level S-3 1/	An acceptable quality level of 4.0 defects per hundred units
Liquid penetrant	4.8.1.1	Every ceramic component for critical and minor defects	Reject all units with any critical defect or four minor defects 2/
Resin content (percent)	4.8.2.1	Inspection level II 1/	Acceptance number zero, rejection number 1
Flame resistance	4.8.2.2	Inspection level II 1/	Acceptance number zero, rejection number 1
Areal density	4.8.3	Inspection level S-1 1/	An acceptable quality level of 6.5 defects per hundred units
Ballistic resistance test	4.8.4	Inspection level S-1 1/	An acceptable quality level of 6.5 defects per hundred units
Temperature extremes test	4.8.5	Inspection level S-1 1/	An acceptable quality level of 6.5 defects per hundred units
Radiographic examination (end item, initial production lot)	4.8.5	Every completed armor insert	Reject all units with any critical defects or three minor defects

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TABLE IV. Quality conformance inspection - Continued.

Inspection	Method	Sample Size	Acceptance Criteria
Radiographic examination (end item, subsequent production lot)	4.8.6	Inspection level II 1/	An acceptable quality level of 0.25 percent defective units
Adhesion test of rubber edging	4.8.7	Inspection level S-1 1 1/	An acceptable quality level of 4.0 defects per hundred units
Adhesion test for spall cover	4.8.8	Inspection level S-1 1 1/	An acceptable quality level of 4.0 defects per hundred units
Packaging	4.8.1.7	Inspection level S-2 2 1/	An acceptable quality level of 2.5 defects per hundred units

- 1/ The sample size shall be based only on the applicable sample size code letter corresponding to the specified inspection level of MIL-STD-105.
- 2/ For the initial production lot, the acceptance criteria shall be "Reject all units with critical defects or three minor defects."



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TABLE V. Quality conformance verification inspection (see 4.6).

Inspection	Method	Sample Number
Visual examination	4.8.1.1 thru 4.8.1.4 and 4.8.1.6	Every Assembly
Dimensions	4.8.1.5	Every Assembly
Liquid penetrant	4.8.1.1	Every Assembly
Resin content (percent)	4.8.2.1	Every Assembly
Flame resistance	4.8.2.2	Every Assembly
Areal density	4.8.3	Every Assembly
Ballistic resistance test	4.8.4	Every Assembly
Temperature extremes test	4.8.5	Every Assembly
Radiographic examination (end item), initial production lot	4.8.6	Every Assembly
Radiographic examination (end item), subsequent production lots	4.8.6	Every Assembly
Adhesion test of rubber edging	4.8.7	Every Assembly
Adhesion test for spill cover	4.8.8	Every Assembly
Packaging	4.8.1.7	Every Assembly

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TABLE VI. Classification of defects for the visual and radiographic examination of the hard body armor 1/

Defect	Critical	Minor
CERAMIC COMPONENT		
a. Edge crack (filled or unfilled) greater than 1-1/2 inches in length and through thickness of plate <u>2/</u> , <u>4/</u> , <u>10/</u>	X	
b. Edge crack (unfilled) greater than 3/4 inches in length and not through thickness <u>2/</u> , <u>4/</u> , <u>5/</u> , <u>10/</u>		X
c. Edge crack (unfilled) less than 3/4 inches in length and through thickness <u>2/</u> , <u>4/</u> , <u>5/</u> , <u>10/</u>		X
d. Any crack (unfilled) over 1/2 inch in length other than edge crack <u>2/</u> , <u>4/</u> , <u>10/</u>	X	
e. Any crack (filled) other than edge crack and over 1/2 inch in length <u>7/</u> , <u>8/</u>	X	
f. Laminar crack along edge greater than 3/4 inch in length <u>10/</u> , <u>13/</u>		
g. Shrinkage, filamentary type, (filled or unfilled) indications: <u>4/</u> , <u>7/</u> , <u>8/</u> , <u>12/</u>		
(1) Three or less such defects in any 2 inch diameter circle anywhere on the plate whose combined length, when measured from end to end in a straight line, is greater than 1 linear inch		
(2) Four or more such defects regardless of length in any 2 inch diameter circle anywhere on the plate		
h. Sponge area (unfilled) - over 0.2 inch <sup>2</sup> (1/2 diameter circle) per any 2 inch diameter circle <u>4/</u> , <u>7/</u> , <u>8/</u>	X	

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TABLE VI. Classification of defects for the visual and radiographic examination of the hard body armor - Continued 1/

Defect	Critical	Minor
i. Silicon rich area - over 0.2 inch <sup>2</sup> (1/2 diameter circle) per any 2 inch diameter circle 4/, 7/, 8/, 12/	X	
j. Any internal void or unfilled area greater than 0.2 inch <sup>2</sup> per any 2 inch diameter circle 4/, 10/, 12/	X	
k. Pit greater than:		X
(1) 0.030 inch in depth and diameter but not more than 0.060 inch in depth 10/	X	
(2) 0.030 inch in diameter but not more than 0.060 inch in depth 10/		X
(3) 3/16 inch in the longest lateral direction but not more than 5/16 inch in 0.030 inch or less in depth 5/, 6/, 10/	X	
(4) 5/16 inch in the longest lateral direction and 0.030 inch or less in depth 10/	X	
l. Rivelet over 1-1/2 inch in length 2/, 11/	X	
m. Edge chip on either surface beyond 1/8 inch outer boundary:		
(1) Greater than 3/8 inch in any lateral direction but not more than 3/4 inch and 1/16 inch or less in depth 5/, 10/		X
(2) Greater than 3/4 inch in any lateral direction and 1/16 inch or less in depth 10/, 12/	X	
(3) Greater than 1/16 inch in depth but not more than 1/8 inch 5/, 10/, 12/		X

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TABLE VI. Classification of defects for the visual and radiographic examination of the hard body armor - Continued 1/

Defect	Critical	Minor
(4) Greater than 1/8 inch in depth <u>10/</u> , <u>13/</u>	X	
n. Edge chip on either surface within the 1/8 inch outer boundary greater than 3/16 inch in depth <u>10/</u> , <u>13/</u>	X	
o. Scratch or gouge:		
(1) 0.030 to 0.050 inch in depth <u>5/</u> , <u>6/</u> , <u>10/</u> , <u>13/</u>		X
(2) Greater than 0.060 inch in depth <u>10/</u> , <u>13/</u>	X	
p. Any mend or patch <u>10/</u> , <u>11/</u> , <u>13/</u>	X	
q. Markings (serial number) omitted, not located or applied as specified <u>10/</u> , <u>11/</u> , <u>13/</u>		X
	X	
FIBERGLASS LAMINATE COMPONENT		
a. Any delamination from the ceramic component: <u>10/</u> , <u>11/</u> , <u>13/</u>		
b. Exposed fibers on edge <u>10/</u>		X
c. Any blister, crack, torn fabric, crazing, dents or surface roughness <u>10/</u> , <u>11/</u> , <u>13/</u>		X
d. Any delamination of fiberglass plies <u>10/</u> , <u>11/</u> , <u>13/</u>		X

- 1/ Radiographic examination shall be performed using the composite armor insert.
- 2/ Edge cracks are defined as those within the 1-1/2 inch boundary around the periphery of the ceramic component.
- 3/ Cracks other than edge cracks are defined as those beyond the 1-1/2 inch edge boundary or those that start within the

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1-1/2 inch boundary and extend beyond the 1-1/2 inch boundary.

- 4/ For the purposes of radiographic examination and interpretation, the following definitions or descriptions shall apply (see 6.8):

Cracks. Well-defined line or lines having sharp terminal points indicating a break in the ceramic material.

Shrinkage filamentary type indications. Sharply defined wavy or irregular line or lines usually less than 3/4 inch in length occurring within the ceramic material and indicating an internal discontinuity.

Internal voids or unfilled areas. Round or elongated, smooth edged, dark spots occurring individually or randomly distributed within the ceramic material.

Sponge. Dark localized area or areas occurring within the ceramic and indicating low ceramic density or high porosity.

Silicon Rich Area. A lighter localized area or areas indicating a high concentration of silicon within the ceramic.

- 5/ All such surface minor defects so identified in the visual and liquid penetrant examinations shall be described, located, and annotated so that they will not be identified as internal voids or unfilled areas (defect h) when and if the ceramic component is subjected to radiographic examination.
- 6/ Any two minor defects on the surfaces of the ceramic component, except within the 1-1/2 inch edge boundary, less than 3/8 inch apart shall be classified as a major defect.
- 7/ Applies to silicon carbide type only.
- 8/ Applies to boron carbide/silicon carbide/silicon type only.
- 9/ Applies to boron carbide type only.
- 10/ Applies to all classes of ceramic.
- 11/ Does not apply to liquid penetrant examination.
- 12/ Applies only to radiographic examination.
- 13/ Does not apply to radiographic examination.

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TABLE VII. End item visual defects

Examine	Defect
Spall cover	Cut, hole, tear or abraded area Any wrinkle or crease Any mend or patch Any areas not bonded to ceramic component exceeding 1/4 inch in longest lateral direction
Rubber edging	Not continuous Any dimension on height of edging, size and depth of cut-outs at radii points, or space between butted ends exceeding requirements Torn or cut except where permitted Does not overlap peripheral edge of armor as specified Any area of non-adherence in excess of 1/2 inch
Webbing or Tape	Any cut edge not seared or any sharp edge formed by the searing
Fabric	Any hole, cut, tear, smash, or broken or mission yarn Any abrasion mark Misplaced, not serving the intended purpose
Fastener tape, hook and pile	Any cut, hole, or tear missing hooks Hooks flattened
Open seams	Up to and including 1/2 inch More than 1/2 inch  NOTE: A seam shall be classified as an open seam when one or more stitches joining a seam are broken, or when two or more consecutive skipped or runoff stitches occur.
Run-offs (see open seams)	
Raw edges (except where required)	More than 1/2 inch when securely caught in stitching  NOTE: Raw edges not securely caught in stitching shall be classified as open seams
Seam and stitch type	Wrong seam or stitch type



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TABLE VII. End item visual defects - Continued

Examine	Defect
Stitching	Loose, resulting in loose bobbin or top thread; tight, resulting in tightness or puckering of fabric on seams
Stitches per inch	One stitch less than minimum specified Two or more stitches less than minimum specified One or more stitches in excess of maximum specified  NOTE: Variation in the number of stitches per inch caused by operator speeding up the machine and pulling the fabric in order to sew over heavy places, or in turning corners shall be classified as follows:  (a) within the minor B defect Classification - no defect (b) within the minor A defect Classification - Minor B defect
Stitching margins, stitching gage	Not as specified
Stitching ends	Not backstitched as specified, except where ends are turned under in a hem or held down by other stitching Less than five tying, overlapping, or backstitching in cross box stitching or W-W stitching (when performed on automatic machine)
Thread breaks	On stitching other than W-W stitching, overstitched less than 1 inch in each direction beyond defective stitching area On W-W stitching, overstitched less than 1/2 inch in each direction beyond the defective stitching area  NOTE: Thread breaks not backstitched shall be classified as open seams

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TABLE VII. End item visual defects - Continued

Examine	Defect
Stitching rows	One or more required rows of stitching omitted: - seriously affecting serviceability - affecting serviceability but not seriously
"W" stitching	Height of "W" stitching less than specified by more than 1/8 inch
Components and assembly	Any component or required operation omitted (unless otherwise classified herein) Needle chews Seams pleated or badly puckered Mends, darns, or patches
Hems	Less than specified width on hems required to finish less than 3/4 inch Less than specified width by more than 1/8 inch on hems required to finish 3/4 inch or more
Bartacks	One or more bartacks omitted Any bartack not as specified or not in specified location
Reinforcements	Omitted or mislocated
Marking	Omitted, incorrect, illegible, misplaced, or size of characters not as specified
Instruction label	Omitted, illegible, misplaced, or not type and class specified
Cleanness	Grease or oil stains clearly noticeable Adhesive smeared on spall cover or rubber edging (except where allowable)
Construction and workmanship	Any component missing or not assembled as specified (unless otherwise classified herein)
Identification markings	Not as specified, missing, of improper size, or illegible

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TABLE VII. End item visual defects - Continued

Examine	Defect
"W" stitching	Height of "W" stitching less than specified by more than 1/8 inch
Components and assembly	Any component or required operation omitted (unless otherwise classified herein) Needle chews Seams pleated or badly puckered Mends, darns, or patches
Hems	Less than specified width on hems required to finish less than 3/4 inch Less than specified width by more than 1/8 inch on hems required to finish 3/4 inch or more
Bartacks	One or more bartacks omitted Any bartack not as specified or not in specified location
Reinforcements	Omitted or mislocated
Marking	Omitted, incorrect, illegible, misplaced, or size of characters not as specified
Instruction label	Omitted, illegible, misplaced, or not type and class specified
Cleanness	Grease or oil stains clearly noticeable Adhesive smeared on spall cover or rubber edging (except where allowable)
Construction and workmanship	Any component missing or not assembled as specified (unless otherwise classified herein)
Identification markings	Not as specified, missing, of improper size, or illegible

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TABLE VIII. Packaging examination

Examine	Defect
Marking (exterior and interior)	Omitted; incorrect; illegible; of improper size, location, sequence, or method of application
Materials	Any component missing, damaged, or not as specified
Workmanship	Inadequate application of components such as: incomplete closure of container flap, loose strapping, inadequate stapling, or improper taping. Bulged or distorted container
Content	Number per container is more or less than specified

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APPENDIX A

Liquid Penetrant Requirements for the Examination of Ceramic  
Body Armor Inserts

10. SCOPE

10.1 Scope. This appendix details the liquid penetrant inspection process to be used for the examination of ceramic body armor materials. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

20. APPLICABLE DOCUMENTS

20.1 Government documents.

SPECIFICATION

MILITARY

MIL-I-25135 - Inspection Materials, Penetrant.

20.2 Other publications.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E165 - Liquid penetrant inspection

30. REQUIREMENTS

30.1 Application. Liquid penetrant inspection is applicable for the detection of surface discontinuities and shall be performed prior to radiography.

30.2 Equipment. The equipment required shall be capable of performing uniform controlled operation using ASTM test procedures A1 and B3 per ASTM E165.

30.3 Penetrant materials. For procedure A1 per ASTM E165, Magnaflux ZL-17B penetrant shall be used for procedure B3 per ASTM E165, Magnaflux SKL-HF penetrant shall be used. Equivalent materials complying with MIL-I-25135 may be used.

30.4 Test method. The test procedures as outlined in ASTM E165 (procedure A1 for silicon carbide, high purity and modified boron carbide and procedure B3 for aluminum oxide) shall be used. All discontinuities detected shall be marked for further evaluation or disposition. A ten power magnifying lens with or without illumination shall be used as necessary to assure accurate detection of indications.

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APPENDIX B

Visual inspection requirements for the examination of ceramic  
body armor inserts

10. SCOPE

10.1 Scope. This appendix details the visual inspection process to be used for the examination of ceramic body armor materials. This appendix is a mandatory part of the specifications. The information herein is intended for compliance.

20. APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

30. REQUIREMENTS

30.1 Application. Visual inspection is applicable for the detection of surface discontinuities and shall be performed prior to any other nondestructive test.

30.2 Equipment. The equipment for visual inspection shall consist of the following items:

- a. Suitable work bench.
- b. Ten-power magnifier.
- c. Suitable lighting (can be part of magnifier).
- d. Marking pens or crayons.
- e. Scales or graduated magnifiers for recording diameter of flaw.
- f. Suitable gage for measuring depth of flaw.

30.3 Test method. Each ceramic insert shall be carefully examined visually using ten power magnification where necessary. Flaw type indications shall be identified and measured. All discontinuities detected shall be marked for further evaluation or disposition.

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APPENDIX C

Radiographic requirements for examination of ceramic  
body armor inserts

10. SCOPE

10.1 Scope. This appendix details radiographic inspection process to be used for the examination of ceramic body armor materials. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

20. APPLICABLE DOCUMENTS

20.1 Government documents.

SPECIFICATIONS

MILITARY

MIL-R-11470 - Radiographic inspection: Qualification  
of equipment operators and  
procedures

STANDARDS

MILITARY

MIL-STD-453 - Inspection, Radiographic

30. REQUIREMENTS

30.1 Application. Radiographic inspection is applicable for the detection of internal discontinuities in ceramic body armor inserts and concurrently providing a permanent and ready future reference of internal conditions.

30.2 Equipment. Equipment for radiographic inspection shall consist of the following items:

- a. 150 kv X-Ray Equipment.
- b. Transmission Densitometer.
- c. Penetrameters and Stepwedges.
- d. Fine grain film and film envelope.
- e. Lead letters and numerals for X-ray film/part identification
- f. Sheet lead 1/8 inch thick to conform to ceramic armor insert.
- g. High intensity radiographic viewer.
- h. 10X magnifier and film processing facilities.

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30.3 Test Method. Unless otherwise specified, all radiographic test equipment and procedures shall conform to the requirements of MIL-R-11470 and MIL-STD-453. When other inspection methods are used in addition to X-ray, the X-ray inspection shall be performed prior to more expensive methods and subsequent to less expensive methods. Parts or material showing evidence of inadequate visual or penetrant inspection or parts not in a suitable condition for radiographic inspection shall not be inspected unless properly prepared and recycled.

30.4 Radiograph identification. Each radiograph shall be permanently marked with the name of the test laboratory, X-ray control or test number, part serial number, if any, and view number. All identification markings shall be outside of the area being inspected whenever practical. Each radiograph envelope shall contain no more than 12 radiographs and shall list plate serial numbers of the radiographs contained therein. Each envelope shall also bear a rubber stamp image outlining exposure factors and technique employed.

## RADIOGRAPHIC TEST RECORD

Date \_\_\_\_\_ Material \_\_\_\_\_ Thickness \_\_\_\_\_  
 Kilo Voltage \_\_\_\_\_ M.A. \_\_\_\_\_ Exp. Time \_\_\_\_\_  
 Film Type \_\_\_\_\_ Screens \_\_\_\_\_  
 FF Distance \_\_\_\_\_ Equipment \_\_\_\_\_  
 H&D Density \_\_\_\_\_ No. of Exp. \_\_\_\_\_  
 Remarks \_\_\_\_\_

30.5 Radiographic coverage. Two radiographs, each representing at least half of each ceramic plate, shall be made to effect 100 percent radiographic coverage. In order to avoid image distortion, each exposure shall be made with the ceramic plate angulated or propped so as to be as normal as possible to the X-ray beam.

30.5.2 Radiographic technique. A standard X-ray technique for each ceramic material and type or design shall be established subject to the approval of the procuring agency. All radiographs shall be in the H&D density range of 1.5 - 2.2 + 0.20. The radiographic quality level shall be 2-2T. Radiographic equivalence systems shall be permitted using stopwedges and penetrameters exhibiting the same radiographic attenuation properties as ceramic armor materials. The suggested X-ray techniques for high purity boron carbide ceramic armor materials and composites shall be as follows:

Ceramic Plate only - 50 kv, 15 Ma, 40"FFD, 2'0", Kodak M, NS



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**Complete Composite - 70 kv, 5 Ma, 40"FFD, 1'45", Kodak M, NS**

**The suggested X-ray techniques for modified boron carbide ceramic armor materials and composites shall be as follows:**

**Ceramic Plate only-60 kv, 18 Ma, 40"FFD, 1'50", Kodak M, NS**

**Complete Composite-70 kv, 15 Ma, 40"FFD, 1'35", Kodak M, NS**

**The suggested X-ray techniques for silicon carbide ceramic armor composites shall be as follows:**

**Complete Composite-80 kv, 10Ma, 40"FFD, 1'30", Kodak M, NS**

**The suggested X-ray techniques for aluminum oxide ceramic armor composites shall be as follows:**

**Complete Composite-80 kv, 10 Ma, 40"FFD, 1'30", Kodak M, NS**

**Penetrameters shall be placed so as not to obscure X-ray images. Penetrameter holes and outlines shall be as specified in MIL-STD-453.**

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## APPENDIX D

Ballistic Test

## 10. SCOPE

10.1 Scope. This appendix details the procedure to be used in determining the ballistics resistance of ceramic faced armor materials with caliber .30 AP M2 projectiles. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

## 20. APPLICABLE DOCUMENTS

20.1 Government documents.

## DRAWINGS

Frankford Arsenal

C6138195 - Bullet

## 30. REQUIREMENTS

30.1 Equipment. Equipment for ballistic testing shall consist of the following items:

a. Gun Mount - The gun mount shall be suitable for firing the caliber .30 gun to muzzle velocity of at least 3000 ft/sec.

b. Test Sample Mounting - The armor test sample shall be mounted in a frame which is suspended from overhead by means of steel cables and wires. The sample shall be secured in the vertical position perpendicular to line-of-flight projectile, using quick release clamps. The frame supports and clamps must be capable of retaining the sample withstanding shock resulting from ballistic impact by caliber .30 AP M2 projectile (kinetic energy approximately 3500 ft. - lbs.) on the test sample. The test sample mounting shall be capable of adjustment for moving the sample in the vertical or horizontal directions so that the point of impact can be located anywhere on the sample, and rotation on the vertical axis so that zero degree obliquity impacts can be achieved anywhere on the sample.

c. Weapons - A caliber .30 weapon shall be used.

d. Projectile - The projectile to be used is the caliber .30 AP M2 standard service projectile (bullet) conforming to Frankford Arsenal Drawing C6138195.

e. Witness Plate - The witness plate shall be a 2024-T3 or 2024-T4 aluminum alloy sheet, 0.020 inch thick and shall be a minimum of 11 inches by 14 inches in size.

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## f. Velocity measuring equipment.

1. Chronograph - an electronic counter type chronograph measuring to the nearest microsecond or as a minimum to the nearest 10 microseconds.

2. Detectors - Either high-velocity luminiline screens, or electrical contact screens which either open or close an electric circuit by passage of the projectile through the detector. Contact screens may consist of metallic foils separated by a thin insulating layer, or may consist of a circuit printed on paper with the circuit spacing such that the projectile passing through the screen will "break" the circuit.

g. Propellant - Any propellant which is standard for the weapon may be used, however, when other than a standard propellant is used, extreme care must be exercised in selecting the charge weight. A projectile velocity - propellant charge curve for the weapon shall be determined before any testing is performed. This curve is required to provide a basis for selecting a powder charge to achieve a desired velocity. It is recommended that the propellant storage and weighing area be maintained at  $72^{\circ} \pm 5^{\circ}\text{F}$  and  $50 \pm 5$  percent relative humidity.

30.2 Set-up. The required set-up for the ballistic equipment is shown in Figure 2.

30.3 Data sheet. Data sheets shall be provided and shall contain the following information:

- a. Item document number.
- b. Material description (including physical characteristics if required).
- c. Material identification number for each test sample.
- d. The areal density of each test sample.
- e. Temperature and humidity of the test facility.
- f. Date.
- g. Personnel conducting test and any witnesses.
- h. Weapon used.
- i. Projectile used.
- j. Projectile weight, grains.
- k. Type of propellant.
- l. Weight of propellant for each shot, grains.
- m. Impact velocities used in computing  $V_{50}$ 's with highest partial penetration, lowest complete penetration, range (spread), and velocities of rounds all being listed.
- n. Witness plate characteristic, partial or complete.
- o. Calculated ballistic limit ( $V_{50}$ ).
- p. Any remarks pertinent to the conduct of the

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test, or behavior of the material.

### 30.4 Procedure.

30.4.1 Marking, samples. Areal density must have been previously determined on the test samples before they are tested ballistically. Each test sample will be marked in the following manner: (See figure 3)

- a. The approximate center of the test sample will be located.
- b. From the center of the test sample, a line is drawn to the center of the bottom of the test sample.
- c. From the center of the test sample, lines are drawn on both sides of the test sample to the nearest edge portion of the test sample. (see Figure 3)
- d. The upper area is marked A, the lower right area B, and the lower left area C, respectively.
- e. The first test sample will be impacted in area A, the second test sample in area B, and the third test sample in area C. Each successive test sample will be fired in the same order, i.e. area A, B, and C. Only one shot will be fired in each test sample. All shots shall be fired at the approximate center of the area to be impacted.

30.4.2 Velocity, projectile. A test round will be fired through a witness plate to determine the exact position of impact. Three additional rounds shall be fired using the appropriate projectile velocity - propellant charge curve for the weapon being used, and selecting propellant weights to achieve a velocity of approximately 2850 ft/sec. The last three of these rounds shall be within the range of 2850 to 2900 ft/sec (hereinafter designated the "reference velocity"). If it is not, additional rounds shall be fired and the projectile velocity - propellant charge curve corrected until reference velocity is achieved. The propellant charge for the last warm-up round shall be considered the reference charge for the test. From the curve, the increments to and decrements from the reference charge for the test. From the curve, the increments to and decrements from the reference propellant charge to yield approximate velocity changes at the reference velocity of 100 ft/sec shall be determined and recorded. These shall be the only increments used during the test. The reference charge and propellant increments and decrements may be redetermined between tests whenever difficulty is experienced in completing the last test. The entire procedure must then be repeated. All reference velocities, and propellant charges, and increments and decrements of propellant weights developed for a test or utilized from a previous test shall be recorded. All the records for the procedure shall be recorded with the test that immediately follows. This procedure must be repeated for succeeding tests if the weapon has not been fired within two hours previous to the test.

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30.4.3 Mounting, sample. The sample will be mounted as specified in 30.1 b, Test Sample Mounting. The point of impact will be located on the test sample as specified in 30.4.1 and will be positioned to line up with the previously determined line of flight. The point of impact is now checked for obliquity. The obliquity shall be  $0 \pm 5$  degrees. The angle of obliquity is determined by the angle formed by a perpendicular to a plane tangent to the point of impact and line of flight of the projectile. The obliquity can be determined by any suitable method, however, it is important that the obliquity is determined with respect to the line of flight, and not any other reference. Once the point of impact has been determined on the test sample, and the obliquity fixed, the gun and velocity screen distances must not be changed until the test has been completed.

30.5 Testing.

30.5.1 Test, ballistic. The first round shall be loaded with the reference propellant charge and fired into the sample, and the reading on the chronograph recorded. The velocity shall be computed and recorded. The witness plate shall then be examined for penetration. A complete penetration is recorded when the witness plate is held up to a light and any penetration is noted, regardless of what has penetrated the witness plate. If no light is visible through the witness plate, a partial penetration is recorded. If the first round fired yields a complete penetration, for the second round use a propellant charge equal to that of the first minus the propellant decrement of 50 to 100 ft/sec in an attempt to obtain a partial penetration. If the first round yields a partial penetration, use a propellant charge for the second equal to that of the first complete penetration. A propellant increment or decrement, as applicable, for at least 50 ft/sec should be used until one partial and one complete penetration are obtained. After obtaining a partial and complete penetration, the propellant increment or decrement for 50 ft/sec should be used. Continue firing using this up (on a partial penetration) and down (on a complete penetration) method until at least 3 complete and 3 partial penetrations having a velocity spread not greater than 125 ft/sec is obtained (see 30.5.2). This up-and-down method firing must be followed in order to achieve an acceptable ballistic limit ( $V_{50}$ ). No further testing shall be conducted on the sample unit as soon as this condition has been achieved. A  $V_{50}$  protection ballistic limit shall be determined from single round fair impacts on each of at least 6 complete armor inserts of the ballistic sample unit. A fair impact results when an unyawed projectile strikes an unsupported area of the ballistic test plate at least 1 1/2 inches from the outside edge of the ceramic component. (The impacted area shall contain no belts, buckles, webbing, etc.)

30.5.2 Calculation of ballistic limit. The ballistic limit ( $V_{50}$ ) is calculated by taking the arithmetic mean of the 3 lowest

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velocities producing complete penetration and the 3 highest velocities producing partial penetration, provided the velocity spread for the 6 rounds is not greater than 125 ft/sec. If, after all samples in the sample unit have been tested and it was not possible to obtain the 3 lowest velocities for complete penetrations and the 3 highest velocities for partial penetration within a spread of 125 ft/sec, then the ballistic limit ( $V_{50}$ ) calculation shall be based on one of the following two alternatives. First, the 3 lowest velocities for complete penetration and the 3 highest velocities for partial penetration within a spread of 150 ft/sec; and second, if the first alternative cannot be applied, the 2 lowest velocities for complete penetration and the 2 highest velocities for partial penetration with a 150 ft/sec spread. If none of the preceding ballistic limit ( $V_{50}$ ) calculation stipulations regarding test velocity spreads apply, then all the valid test velocity values shall be examined to determine whether there are at least 3 partial penetration velocities above 2850 ft/sec. If these conditions are satisfied, the sample unit will be considered to have met the ballistic limit ( $V_{50}$ ) requirement. If none of the acceptable calculation procedures can be applied, and if the analysis of the individual test velocities show that they do not meet the requirement for partial penetration velocities higher than 2850 ft/sec and no complete penetration velocities lower than 2850 ft/sec, then the sample unit shall be considered to have failed the ballistic limit ( $V_{50}$ ) requirement. The ballistic limit ( $V_{50}$ ) must be at least 2850 ft/sec in order to pass the ballistic test requirement.

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