

PURCHASE DESCRIPTION

**PERSONAL ARMOR
E SMALL ARMS PROTECTIVE INSERT (ESAPI)**

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

1. SCOPE

1.1 Scope. This purchase description covers the Enhanced Small Arms Protective Insert (ESAPI) worn by ground troops. When placed in the Outer Tactical Vest (OTV) / Improved Outer Tactical Vest (OTV / IOTV) or Soldier Plate Carrier System (SPCS) (as a component of the Interceptor Body Armor (IBA) system) the insert will provide ballistic protection from specific 5.56 mm and 7.62 mm rifle rounds. The systems identified above is designated a critical safety item (CSI).

1.2 Classification. The inserts shall be of one type and in the following sizes:

X-Small, Small, Medium, Large, and X-Large (see 6.9)

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this performance requirement. This section does not include documents cited 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.

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 paragraph 6.2).

SPECIFICATIONS

FEDERAL

MIL-DTL-32075 - Label: For Clothing, Equipage, and Tentage (General Use).

DEPARTMENT OF DEFENSE

TOP 10-2-210 - Ballistic Testing of Hard Body Armor Using Clay Backing
FQ/PD 07-05 - Body Armor, Multiple Threat, Improved
MIL-STD-662F - V₅₀ Ballistic Test for Armor (18 DEC 97)
MIL-STD-810(G) - Environmental Engineering Considerations and Laboratory Tests
MIL-STD-130 - DoD Standard Practice – Identification Marking of US Military Property

(Unless otherwise indicated, copies of the above specifications, standards, and handbooks are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094).

2.2.2 Other Government documents, drawings and publications. The following other Government documents, drawings and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

Department of Defense (DoD) Testing Protocols:

Hard Body Armor Standard for Ballistic Testing – 27 April 2010

Standard for Lot Acceptance Ballistic Testing of Hard Body Armor – 02 July 2010

DRAWINGS

Drawing Numbers:

2-6-0588; Enhanced Small Arms Protective Insert, Size; X-small
2-6-0589; Enhanced Small Arms Protective Insert, Size; Small
2-6-0590; Enhanced Small Arms Protective Insert, Size; Medium
2-6-0591; Enhanced Small Arms Protective Insert, Size; Large
2-6-0592; Enhanced Small Arms Protective Insert, Size; X-large

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 that are DoD adopted are those listed in the issue of the DODISS cited in the solicitation (see paragraph 6.2).

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME Y14.5M - Dimensioning and Tolerancing (DoD adopted)
(Application for copies should be addressed to the American Society of Mechanical Engineers,
345 East 47th Street, New York, NY 10017-2392).
AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- ASTM D-792 - Specific Gravity and Density of Plastics by Displacement
- ASTM D-2563 - Standard Recommended practice for Classifying Visual Defects
in Glass Reinforced Plastic Laminate Parts
- ASTM D-2584 - Ignition Loss of Cured reinforced resins
- ASTM D-2863 - Measuring the Minimum Oxygen Concentration to Support
Candle Like Combustion of Plastics (Oxygen Index)
- ASTM D-3951 - Standard Practice for Commercial Packaging
- ASTM E29 - Standard Practice for Using Significant Digits in Test Data to
Determine Conformance with Specifications

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

AMERICAN NATIONAL STANDARD/AMERICAN SOCIETY FOR QUALITY (ANSI/ASQ)

ANSI/ASQ Z1.4-2008 – Sampling Procedures and Tables for Inspection by Attributes

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 over TOP and TOP takes precedence over MIL-STD-662F. However, for V_{50} testing, MIL-STD-662F takes precedence over TOP. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 First Article. When specified (see paragraph 6.2), samples shall be subjected to first article inspection (see paragraph 6.3) in accordance with paragraph 4.2.1.

3.2 Standard Sample. Standard color samples, when furnished, are solely for guidance and information to the contractor (see paragraph 6.4).

3.3 Construction. The materials selected by the contractor shall be capable of meeting all the performance, operational and environmental requirements specified herein.

3.3.2 ESAPI Cover. ESAPI cover materials used to mitigate frontal spall, increase durability and decrease environmental deterioration of the underlying components, shall be in a configuration as to cover the entire front and back outer surface and sides. There should be no visible peeling of the cover before or after any operating environment conditioning.

3.3.3 Assembly of Components by Bonding. There shall be no evidence of under adhered areas or components. No excess bonding agent will smear, clump or be visible on the exposed surfaces of the finished ESAPI.

3.4 Production Data. The following information determined during production shall be made a matter of record and shall be furnished on request to the contracting official. This data shall be identified with the serial number of the body armor.

a. Data generated during inspection or other protocols per quality system/quality validation plan. This includes, but is not limited to, weight, thickness and dimensional measurements.

b. Supplier lot information and traceability for all component parts identified in the technical data package. This shall include material compliance forms signed by the contractor, each sub-contractor or material supplier.

c. Operational, ownership and environmental test data generated by the contractor on the ESAPI.

d. Ballistic performance test data generated under all first article, conformance and validation testing as described in paragraph 4.9.

e. For traceability every ESAPI must be durably marked in such a fashion as to be traceable from production through to the ballistic test records for that lot of ESAPIs. The serial number will be marked on the outside face within 1 inch of the lower edge of the ceramic component before it is fired. It will be marked by inscribing, embossing, or with high temperature resistant inorganic ink or after firing with permanent marking to a maximum depth of 0.010 inch so that the serial number will be legible when the spall cover is stripped mechanically or by the use of a solvent. Solvents, fuels and other liquids shall not affect the serial number markings. It is desirable to have the ceramic cores marked to be traceable by radiographic analysis as well. If inscribed, it will be done on the outer 0.25 inches of the plate.

3.5 Workmanship. The finished ESAPI shall conform to the quality of product established by this performance specification. Utmost care shall be taken during fabrication to ensure quality workmanship and safety of the service person using the item. All materials to be used in the construction of the ESAPI shall conform to all material requirements in this purchase description and internal specifications, unless otherwise specified. Manufacturing practices shall be capable of consistently yielding product that conforms to all requirements in this purchase description and internal specifications for the body armor and their components. Continual improvement shall also be a constant focus of the manufacturing practices. All component materials shall be properly marked and identified, and also protected properly during storage. Materials shall be produced and integrated to extend durability and provide consistency of appearance throughout plate life. 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(s) shall be applied uniformly over the entire contact areas of the components to be joined to eliminate delamination between materials. The ESAPI outer cover shall be properly fitted to preclude lift, separation, or other signs of poor adhesion. Material layers shall be free of contaminants (such

as, but not limited to: Foreign Object Debris (FOD) (media not associated with the technical data package), loose fragments of component materials, operator elements not part of component materials. The ESAPI ceramic must be free of cracks. Defective conditions within the ESAPI shall not exceed the limits identified in Table II. This section is applicable to all material or components of the ESAPI whether furnished by the Prime Contractor or by any of their suppliers or sub-contractors. In any case of material, process, or equipment change desired to be made by the Contractor, the written consent of the Government shall be obtained before making the change. Additional testing may be required prior to implementation of the change to verify product performance. (See section 4.9.10 for verification)..

3.6 Operating Requirements. Each ESAPI will satisfy the following user-oriented requirements (see paragraph 4.6).

3.6.1 Ease of Insertion. The ESAPI shall be able to easily slide into and out of the Body Armor, Multiple Threat; CO/PD 00-02, Outer Tactical Vest (OTV) ,FQ/PD 07-05, Improved Outer Tactical Vest (IOTV) or AR/PD 10-04 Soldier Plate Carrier System. No obtrusive or abrasive coverings shall be applied to any of the ESAPI surfaces. No special training, equipment or tools will be required to insert the ESAPI into the carrier pouch (see paragraph 4.6.1).

3.6.2 Weight. The finished ESAPI will not exceed the following weights;

The threshold maximum weights:

- a. X-Small: 3.80 lbs.
- b. Small: 4.75 lbs.
- c. Medium: 5.45 lbs.
- d. Large: 6.25 lbs.
- e. X-Large: 7.10 lbs.

The objective maximum weights (10% lighter):

- a. X-Small: 3.42 lbs.
- b. Small: 4.28 lbs.
- c. Medium: 4.91 lbs.
- d. Large: 5.63 lbs.
- e. X-Large: 6.39 lbs.

3.6.3 Dimensional measurements. The ESAPI shall conform to all measurements, tolerances, radius and edge chamfers cited in drawings from paragraph 2.2.2 (see paragraph 4.6.3 and 4.6.4).

3.6.4 Thickness. The ESAPI in finished form will have uniform thickness throughout. The tolerance of the thickness shall not exceed 1/8 inch between any two measurements (para. 4.6.4).

3.6.5 ESAPI Color. All areas of the ESAPI shall be colored Foliage Green 504 as specified in paragraph 4.6.5.

3.6.6 Labels/markings. (See paragraph 4.6.6)

3.6.6.1 Orientation Labels. Permanent labels or markings shall be placed on the back-face of the ESAPI clearly displaying the “TOP” orientation. Orientation marking will be 1.25 ± 0.25 inches from its respective edge. A permanent label or marking shall be centered on the front of the ESAPI, 3.0 ± 0.25 inches from the top clearly displaying “STRIKE FACE”. All characters will be 0.50 inch height (see Figure A and B below and paragraph 4.6.6).

3.6.6.2 Performance Labels. A permanent label or marking shall be displayed on the back-face clearly displaying “ESAPI - Rev. G” with 0.25 inch height characters. The marking will be displayed on the center of the ESAPI, 2.5 ± 0.25 inches from the top edge (see Figure A and B below and paragraph 4.6.6).

3.6.6.3 Complete ESAPI Markings. The manufacturer’s contract number and nomenclature shall be permanently and legibly marked on the upper mid-center back face. The letters “U.S.” shall be applied 4.0 ± 0.25 inches below the top edge and centered on the ESAPI in characters 1.0 inch high. The size identification of the ESAPI shall be clearly displayed centered on the front surface 1.5 inches below the top edge in all capital characters 0.5 inch high (i.e. MEDIUM). The words “HANDLE WITH CARE” shall be printed in characters 0.5 inch high at 6.5 ± 0.25 inches below the top edge and centered on the front face surface. All markings shall conform to type IV, class 9 of MIL-DTL-32075. The fastness for the class 9 label shall be as specified for class 5 labels. A list in duplicate of the serial numbers used for each ESAPI production lot shall be furnished to the contracting officer at the time of delivery. The front side of the ESAPI shall have a letter height to width ratio of approximately 1:0.75 (see paragraph 4.6.6).

A Unique Identification (UID) label will conform to the specifications below:

The manufacturer is required to comply with the current versions of Military Standard 130 and the Department of Defense Guide to Uniquely Identifying Items, and the following criteria.

1. Color: Label/Tag will be black with white Human Readable and Machine Readable Information (HRI) and (MRI).
2. HRI shall consist of: Commercial and Government Entity (CAGE) code of activity applying the tag/label, Lot Number, Serial Number, Date of Production, National Stock Number (NSN) and Design Code. HRI will meet requirements of the latest version of MIL-STD-130.
3. MRI shall consist of one ECC 200 compliant Data Matrix code containing: CAGE code of activity applying the tag/label, Lot Number, Serial Number, Date of Production, NSN, and Design Code. The tag/label shall comply with the latest version of MIL-STD-130, ANSI MH10.8.2, and Items #4 and #5 below. To prevent automated read errors, the Government will not allow other 1D or 2D codes to be printed on this label. This does not restrict contractor from using other HRI and MRI on labels not associated with the UID label/tag.

4. Data Matrix Construct: The Data Matrix shall be encoded per MIL-STD-130 using only the data identifiers (DI) and criteria shown below. The following DI sequence shall be maintained in the order listed below:

Cage=17V followed by cage code

Lot=1T followed by lot number

Serial number=S followed by serial number

Date of production = 16D followed by production date, YYYYMMDD

National stock number=N followed by the NSN.

Part number = 1P followed by design code (the design code may be up to 13 alpha-numeric characters (plus only dashes "-" as special characters))

Construct Example:

]>RS06GS17V52969GS1TE034GSS328185GS16D20080215GSN8470-01-520-7370GS1PABC-123RSEOT

5. Data Matrix Geometry: Data Matrix codes shall be a square ECC200 matrix per ISO 16022. Individual Cell size (element size) of the code shall be between 0.020 and 0.023 inches. A quiet zone of 0.5 inches of Black label/tag material is required around the Data Matrix code.
6. Verification: Data Matrix code quality will be graded to ISO 15415 with a certified verifier and meet a minimum passing grade per the latest release of MIL-STD-130. AS9132 and AIM DPM grading platforms will not be allowed for this project. Contractor must provide the contracting officer with at least two verification reports per plate size for each FAT and LAT. Verification shall be on the end item, not a standalone label. If using laminates or overcoats the label must be verified after placing the laminate or overcoat on the label or tag. No exceptions are allowed. Proof of Verification is subject to inspection at the time of shipment.
7. Validation: Validation checks of the UID must be performed on a routine basis. Contractor is responsible for encoding the UID per above guidelines (#4 and 5) and the latest revision of MIL-STD-130. Proof of Validation is subject to inspection at the time of shipment.
8. Placement of the UID label/tag: The center of the Data Matrix code on an x and y axis will hereinafter be referred to as the centerline of the UID label/Tag. The UID label/tag will be placed on the back side (opposite the strike face) of the item. The centerline of the UID label/tag will be left-right centered on the item, positioned 2 inches from the bottom edge. A tolerance of ± 0.25 inches in each direction will be allowed. The entire plate area within 3.0 inches of the bottom of the plate must be clear of any other labels or markings at all times. Additional non UID information and logos required by this product description must appear above the 3-inch featureless zone. Placement of a sample label is shown below.

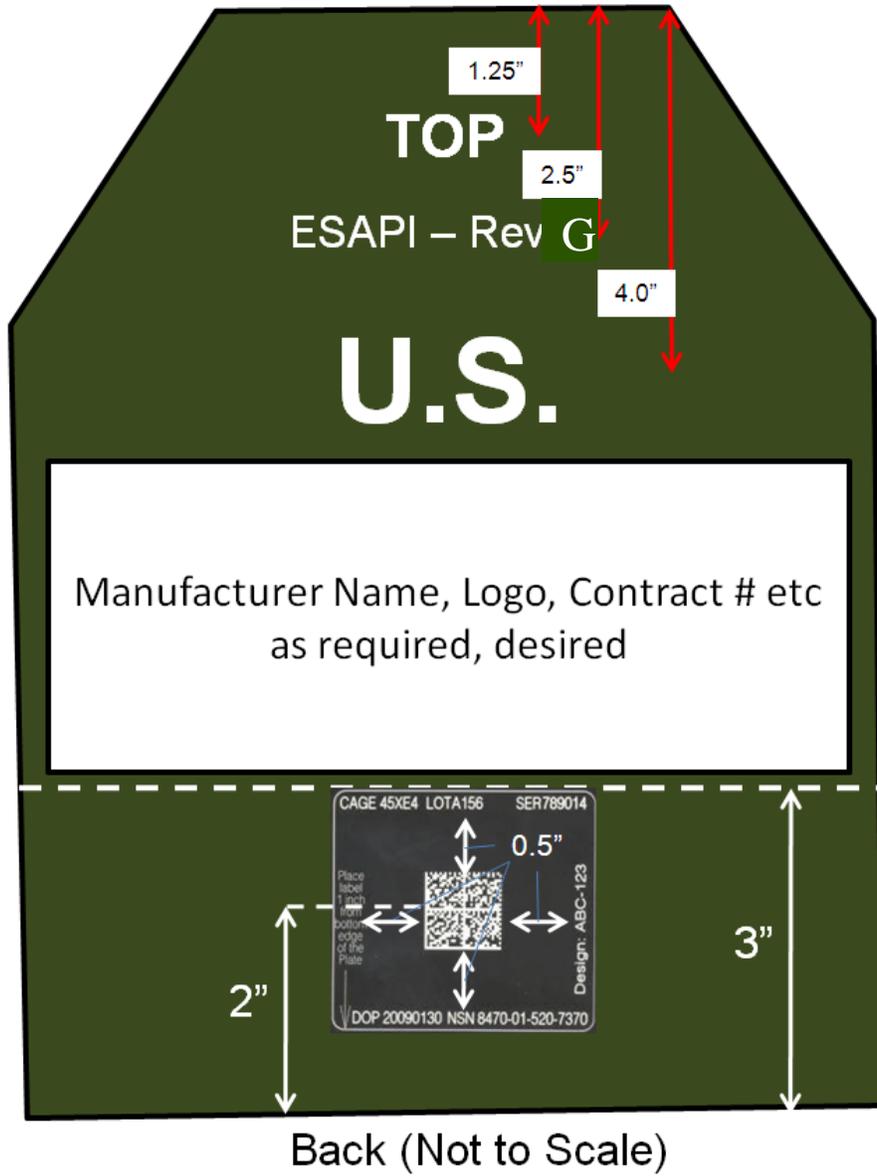


FIGURE A: Back Side Label and UID placement with “quiet zone” distances

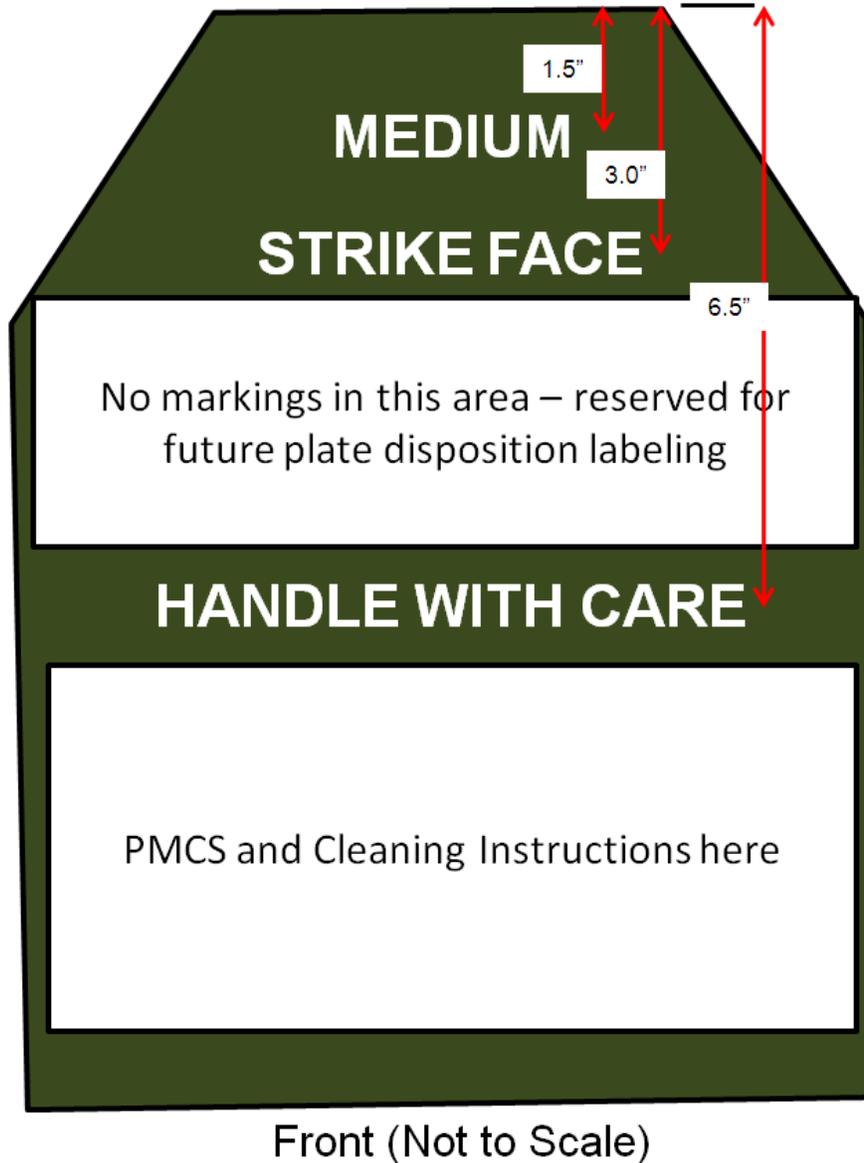


FIGURE B: Front Side Label Placement

PMCS and Cleaning instructions, in a font no smaller than Arial size 8, will be printed on a label located as on the above drawing and will read as below:

Preventative Maintenance Checks and Services (PMCS): The ESAPI plate is considered to be unserviceable if any of the following conditions are present:

1. Outer Cover is damaged exposing the ceramic tile material
2. Plate is cracked and you hear loose pieces rattling around when shaken
3. Creaking or squeaking of ceramic tile heard when plate twisted by hand
4. Composite backing is delaminating (backing material plies are separating)

5. Cracking of the ceramic tile is felt or heard as you firmly pinch the outer 1/2” perimeter of the plate
6. Plate has been hit by a bullet or fragment

Cleaning Procedures

CAUTION: Do not machine wash or dry. Failure to follow these instructions may degrade your plate’s (XSAPI/ESAPI/ESBI) performance against ballistic threats.

1. Remove loose dirt and lint from the outer surface of the plate using a cloth or soft bristle brush (Never use a stiff bristle brush)
2. Wet the plate in a sink or shower using warm, not hot, water
3. Apply mild detergent to the soiled areas and scrub with a cloth or soft bristle brush. Badly soiled areas may be scrubbed with hand soap. Scrub only long enough to remove soil.
4. Heavy grease/oil stains may be pre-spotted with a dry cleaning solvent and detergent mixture and scrubbed with a soft brush
5. Rinse the plate with warm water until all suds are completely gone
6. Let the insert air dry away from heat or open flame

3.6.7 Health and Safety. The ESAPI will be non-hazardous (non-explosive and have no toxicological or electromagnetic radiation effects) to the individual wearing the ESAPI or troops in the surrounding area (see paragraph 4.6.7).

3.6.7.1 Flammability. Demonstrate that ESAPIs will not combust, explode or drip melted materials when impacted with defined threats or when subjected to elevated temperatures of 250 degrees Fahrenheit for ten (10) minutes (see paragraph 4.6.7.1).

3.6.7.2 Personnel Hazard Inspection. Visually inspect that ESAPIs are free of sharp edges, foreign materials, burrs or any other conditions that may cause an injury to the user. Demonstrate that the ESAPI will not cause injury to the user or surrounding troops when ballistically tested (see paragraph 4.9). Any component of the ESAPI that can cause personnel injury will not be acceptable (see paragraph 4.6.7.2).

3.6.7.3 Magnetic Influence. There shall be no magnetic influence on a compass at any distance from the ESAPI (see paragraph 4.6.7.3).

3.7 Ownership and Support. (See paragraph 4.7)

3.7.1 Durability. The ESAPI will be able to withstand two drops using a moment arm fixture (See Figure 1) at a height of 48.0-inches onto a concrete surface without any detrimental effects to ballistic performance, major surface characteristics or physical properties. A 10.0 ± 0.1 lbs weighted object shall be attached to the rear surface of the ESAPI/shoot pack sample (see paragraph 4.7.1). The weight of the moment arm and straps shall be 8.5 ± 0.5 lbs.

3.8 Operating Environment Requirements. Unless otherwise stated ballistic validation testing will be performed with threat “d” and/or “e” in paragraph 3.9.3. Ballistic performance will not be degraded from exposure to the environmental conditions specified in paragraph 4.8.

3.8.1 Weatherometer Resistance. The finished ESAPI after being subjected to the weatherometer resistance testing shall exhibit no evidence of cracking, blistering, color change, separation of edging (if used) or ballistic degradation (see paragraph 4.8.1).

3.8.2 Temperature extreme. The ESAPI shall be both structurally and ballistically functional within the temperature ranges of -55 ± 5 degrees to $+155 \pm 5$ degrees Fahrenheit. (see paragraph 4.8.2).

3.8.3 Fluid Resistance. The ESAPI shall maintain structural and ballistic integrity after contamination with Jet Propellant 8 (JP-8), oil, and immersion in salt water for a period of two (2) hours each at 70 degrees \pm 10 degrees Fahrenheit (see paragraph 4.8.3.).

3.8.4 Altitude. The ESAPI shall meet all performance requirements from sea level to 15,000-foot equivalent pressure altitude. No structural, visible, operational degradation or safety hazard shall occur when the insert is exposed to a pressure change equivalent to a change in altitude from 40,000 to 15,000-feet at a rate of 1500-2000 ft/min (see paragraph 4.8.4).

3.8.5 Fungus. The ESAPI shall neither support fungus growth nor experience damage due to the presence of fungus spores or adjacent fungus growth (see paragraph 4.8.5).

3.8.6 Temperature Shock. The ESAPI shall meet all performance requirements after exposure to temperature changes between the high and low operating temperature extremes within a 5-minute period (see paragraph 4.8.6).

3.8.7 Vibration. The ESAPI shall not experience any structural, visible or operational degradation when subjected to vibration. Vibration testing shall be conducted in accordance with 4.8.7.

3.9 Performance Requirements. (See paragraph 4.9)

3.9.1 Area of Coverage. The ESAPI will provide uniform materials coverage throughout the entire surface area of the ESAPI. If backing materials are used, the backing materials must extend from edge to edge to provide uniform thickness throughout the entire surface area of the ESAPI. The ESAPI shall have uniform areal density throughout the entire surface area. The only exception is if edge materials are used to protect the plate from side impact (i.e. foam) to increase the durability. Material no thicker than 0.10” can be used for this purpose. “Patches”, “clamps”, materials with partial coverage of the ESAPI surface area shall not be acceptable. Any cuts with open gaps and/or slits on any materials are not allowed. The government has the option to reject plates with imperfections visible in radiographic images (x-rays). If ceramic materials are used, the ceramic shall have uniform edges without “edge breaks” or “chamfers”. To reduce sharp edges, sand paper or a scouring pad may be used to clean the edges in production.

3.9.2 Required V_{50} Ballistic Limit. The ESAPI will yield the minimum V_{50} ballistic limit measurements at 0-degree obliquity with the specified test projectiles as per Appendix A.

3.9.3 V_0 Ballistic Resistance. The ESAPI, when tested in conjunction with the simulant (see paragraph 6.10), will provide ballistic resistance as specified in Appendix A.

3.9.4 Back Face Deformation. The ESAPI back face deformation shall be tested in accordance with and meet the requirements of paragraph 4.9.9.2, 4.9.9.3 and 4.9.9.4.

3.9.5 Spall, Debris and Residual Penetrator. The ESAPI will be designed to mitigate injury to the wearer or surrounding individuals from frontal spall, penetrator and/or armor debris ejecta when tested against the required threats (see paragraph 4.9.9.5).

4. VERIFICATION

4.1 Verification Alternatives. Alternative test methods, techniques or equipment including the application of cost effective sampling procedures may be proposed by the contractor. Acceptable alternative verification approaches shall be identified in the contract or amended into the contract.

4.2 Classification of Testing. The testing requirements specified herein are categorized as First Article Testing (FAT) and Lot Acceptance Testing (LAT) as specified in Table I.

4.2.1 First Article Testing (FAT). Unless otherwise specified in the contract or purchase order, the ESAPI supplier is responsible for all FATs and LATs herein. The government reserves the right to perform any of the tests set forth in this specification where such tests are deemed necessary to ensure supplies and services conform to prescribed requirements. When a FAT is required, it includes all of the verifications listed in paragraphs 4.6, 4.7, 4.8, and 4.9 (see Table I) unless otherwise specified in the contract.

4.2.2 Lot Acceptance Testing (LAT). LAT of ESAPI shall include those applicable examinations and tests from paragraphs 4.6 and 4.9 as defined in the contract or by the procuring activity (see paragraph 6.2). See Table I, "Requirements and Verifications" for requirements and frequencies of inspection.

4.2.3 First Article Testing (FAT) and Lot Acceptance Testing (LAT).**Table I. Requirements and Verifications**

CHARACTERISTICS	REQUIREMENT PARAGRAPH	VERIFICATION PARAGRAPH	First Article Testing (FAT)	Lot Acceptance Testing (LAT)
Operating Requirements	3.6	4.6		
Ease of Insertion	3.6.1	4.6.1	X	X**
Weight	3.6.2	4.6.2	X	X**
Dimensional measurements	3.6.3	4.6.3	X	X**
Thickness	3.6.4	4.6.4	X	X**
ESAPI Color	3.6.5	4.6.5	X	CoC
Labels/markings	3.6.	4.6.6		
Orientation Labels	3.6.6.1	4.6.6	X	X**
Performance Labels	3.6.6.2	4.6.6	X	X**
Complete Insert Markings	3.6.6.3	4.6.6	X	X**
Health and Safety	3.6.7	4.6.7		
Flammability	3.6.7.1	4.6.7.1	X	CoC
Personnel Hazard	3.6.7.2	4.6.7.2	X	CoC
Magnetic Influence	3.6.7.3	4.6.7.3	X	X**
Ownership and Support	3.7	4.7		
Durability	3.7.1	4.7.1	X	NA
Operating Environment Requirements	3.8	4.8		
Weatherometer Resistance	3.8.1	4.8.1	X	NA
Temperature extreme	3.8.2	4.8.2	X	NA
Fluid Resistance	3.8.3	4.8.3	X	NA
Altitude	3.8.4	4.8.4	X	NA
Fungus	3.8.5	4.8.5	CoC***	NA
Temperature Shock	3.8.6	4.8.6	X	NA
Vibration	3.8.7	4.8.7	X	NA
Performance Requirements	3.9	4.9		
Area of Coverage	3.9.1	4.9	X	NA
Req. V ₅₀ Ballistic Limit	3.9.2	4.9	X	NA
V ₀ Ballistic Resistance	3.9.3	4.9	X	X
Transient (Back-face) Deformation	3.9.4	4.9	X	X
Spall, Debris and Residual Penetrator	3.9.5	4.9	X*	NA

Notes:

X - testing required

CoC - certificate of conformance to include data

* - government reference

** - test or inspection to be performed at vendor facility

*** - the government may elect to perform testing at their discretion

NA - not applicable

4.3 Order of Testing. Performing the various testing (operating, ownership & support, operating environment, and performance) can occur in any order.

4.4 Verification Methods. The types of verification methods included in this section are visual inspection, dimensional measurements, sample tests, component properties analysis and similarity to previously approved or previously qualified designs.

4.4.1 Verification Using Standard Samples. Use standard samples to verify colors with visual inspections.

4.5 Responsibility for Compliance. Production items shall meet all requirements specified in section 3. The supplier shall establish and maintain documented procedures for inspection and testing activities in order to verify that the specified requirements for the product are met. The required inspection, testing and the records to be established shall be detailed in a quality plan available to the government as specified in the contract or procuring activity. The inspection set forth in this specification shall become part of the contractor's overall inspection procedures or quality system. The absence of any inspection requirements in the specification 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 the 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 accept defective material.

4.6 Operating Requirements. Complete each test in this paragraph.

4.6.1 Insertion. One barehanded person shall demonstrate insertion of the ESAPI into the OTV or IOTV front or back pocket without tools or special aids. Perform insertion into Government furnished carrier in a maximum of 30 seconds.

4.6.2 Weight. Take physical weight measurements of all ESAPI s to ensure that weights do not exceed those presented in paragraph 3.6.2. The finished ESAPIs shall be weighed to the nearest 0.01 pound.

4.6.3 End Item Dimensions. Take physical measurements of all ESAPI to show that all measurements conform to dimensions and tolerances in Drawings (Para. 2.2.2). Two length and two width measurements shall be made and conform to the tolerances specified in the drawings. The measurements specified herein shall be made for each ESAPI. The length measurements should be taken at the two chamfered edges. The first width measurement shall be no further than 1.0 inches away from the bottom edge. The second width measurement shall be no closer than 7.0 inches from the first measurement location.

4.6.4 Thickness. Measure thickness in seven locations, approximately near the center (at least 3.5 inches from any edges) and near each of the six corners (1/4 to 1 inch from the edge) with a deep throat micrometer and record to the nearest 0.01 inch. (see paragraph 2.2.2 and paragraph 3.6.4).

4.6.5 ESAPI Color. Visually inspect the ESAPIs for similarity to the standard sample color of Foliage Green 504 as specified by the contract.

4.6.6 Instruction labels. Visually inspect for legible, permanent labels on the front and back face surfaces. Visually inspect that labels contain written instructions and/or orientation directions.

4.6.7. Health and safety. Complete the verifications in this paragraph.

4.6.7.1 Flammability. Observe that the ESAPI does not melt, drip, combust or explode when impacted in ballistic testing. Ballistic testing at the elevated temperature is reserved for first article testing when required.

4.6.7.2 Personnel Hazard. Visually inspect that the items are free of conditions that will cause potential injury to the user. All the material comprising the end item shall be examined by the Government to assess non-explosive, toxicological, and electromagnetic radiation effects. The Contractor shall provide Material Safety Data Sheets (MSDS) to the Government for all materials comprising the end item.

4.6.7.3 Magnetic Influence. The ESAPI shall be tested for magnetic influence using magnetic and lensatic compasses. The ESAPI shall not cause any deviation of the compass needle.

4.7 Ownership and Support Requirements. Perform the verification in this paragraph.

4.7.1 Durability. Demonstrate durability by performing drop test analysis. Attach ESAPI/shoot pack with a strap, belt or other non-obstructive retaining device to the front surface of a 10.0 ± 0.1 lb. weighted object. The weight of the moment arm and straps shall be $8.5 \text{ lbs} \pm 0.5 \text{ lbs}$. The weighted object (clay is a recommended material) will be contoured to the back ESAPI/shoot pack surface. The shoot pack, as described in paragraph 6.10, shall be placed in between the ESAPI and weighted object. A fixture similar to that in Figure 1 has shown to provide accurate and reproducible results and should be securely mounted to the floor. The drop height shall be 48.0 ± 0.5 inches. (90 degrees from horizontal) (approx. 16 ft/sec) from the flat hardened surface (stiffness of at least 3×10^6 psi and a mass much greater than the moving components (e.g. concrete slab)) and with the ESAPI strike face pointing down, drop the weighted fixture two (2) times. Impacts will occur as near as possible to the center of the ESAPI strike face (not an edge). A radiographic image of the ESAPI will be inspected to identify any cracks, delaminations or indentations on the ESAPI surface. Perform ballistic testing in accordance with paragraph 3.9.3 for threat "d" or "e". The first test shot will be taken at the most severely damaged area of the ESAPI specimen as identified by the x-ray image no closer than 1.5 inches from any edge. If no damage is visible the first shot will be taken vicinity of the impact location (center of the strike face). The second test shot will be located $1.5 + 0.75$ inches from any edge and 5.0 to 6.0 inches from the first impact.

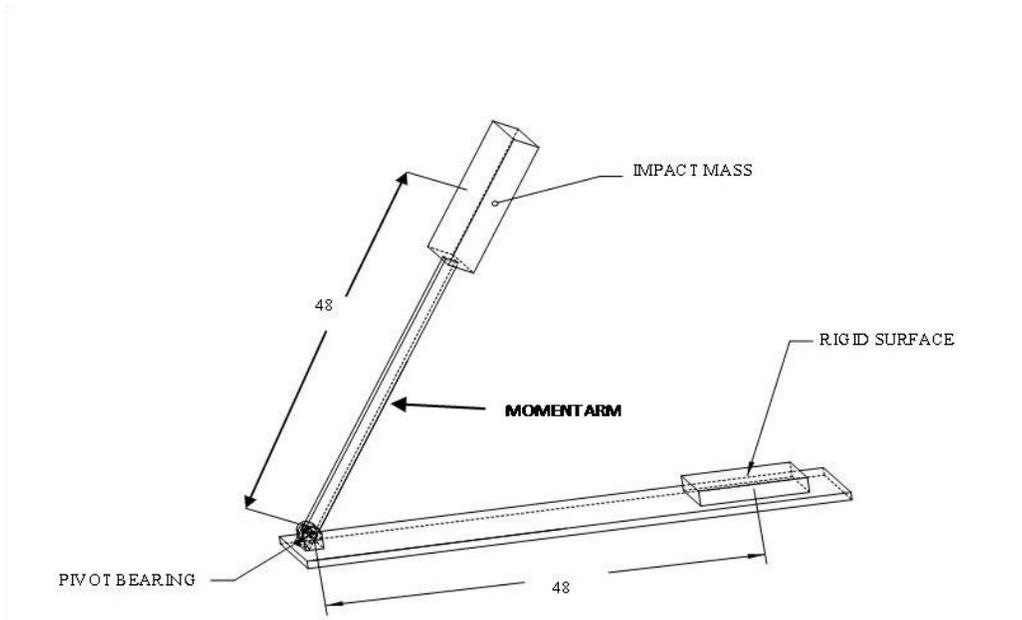


Figure 1. Proposed Durability Apparatus

4.8 Operating Environment Requirements. Perform each verification in this paragraph then perform ballistic testing in accordance with paragraph 3.9.3 with threat “d” or “e”. The number of tests required for this demonstration will be specified in the contract as a pre production item.

4.8.1 Weatherometer Resistance. The ESAPI shall be tested for weather resistance in accordance with AATCC Test Method #169 with the following modifications. Upon completion of the test, the ESAPI shall be visually examined and failure to meet any of the requirements in paragraph 3.8 shall constitute a test failure.

Modifications to AATCC Test Method # 169:

The test apparatus shall be either a test chamber type 1A or 1B. Type 1B shall be equipped with a three-tiered inclined specimen rack. The apparatus shall be equipped with an automatic light monitor and shall be capable of automatically controlling irradiance, temperature, and humidity. The apparatus shall be maintained in accordance with manufacturer’s recommendations.

The weathering test cycle shall be 40 minutes of light, 20 minutes of light with water spray on the specimen, 60 minutes of light, 60 minutes of darkness with no spray. The test cycle shall be repeated until the total energy exposure is equal to 100 kilojoules per square meter.

The irradiance level shall be 0.55 ± 0.01 watts/square meter/nanometer (W/sq.m/nm) bandpass at 340 nanometers.

The glass filter combination shall be quartz inner filter and a borosilicate type “S” outer filter.

The relative humidity shall be 50 ± 5 percent during the light cycle and not lower than 95 percent during the dark cycle.

The control set points shall be as follows:

	Dark Cycle	Light Cycle
Black Panel	38°C	77°C
Conditioning Water	40°C	53°C
Wet bulb depression*	0°C (95%+RH)	10°C (50%RH)
* As a guide only; adjust to achieve required relatively humidity		

The test specimens (ESAPI) shall be mounted on the outside of the rack. After the required exposure period, the specimen shall be removed from the apparatus and allowed to dry and condition at ambient conditions.

After the ESAPI have been tested in the weatherometer and after passing visual examination tests, the ESAPI shall be tested to establish a V_0 ballistic resistance against threat d at 0 degree obliquity within 24 ± 0.50 hours after removal from the weatherometer. Testing shall be conducted in accordance with paragraph 3.9.3 with threat “d” or “e”.

4.8.2 Temperature Extreme. The finished ESAPI shall be heated in an oven operating at 155 ± 5 degrees Fahrenheit for a minimum of 6 hours (Ref. MIL-STD-810G). Pre-conditioning and post-conditioning radiographic images shall be taken of the ESAPI samples. The test specimen shall then be ballistically tested in accordance with paragraph 3.9.3 for threat “d” or “e”. Subject ESAPI (different to those subjected to high temperatures) to cold exposure at minus (-) 55 ± 5 degrees Fahrenheit for minimum 6 hours then ballistically test in accordance with paragraph 3.9.3 for threat “d” or “e”. After each exposure, the ESAPI will be examined for evidence of delamination, component separation, blistering or any other visual defects. The ballistic tests shall be completed within 30 minutes after each exposure.

4.8.3 Fluid Resistance. Conduct this test at fluid and ambient temperatures between 60 - 80 degrees Fahrenheit. Contaminate ESAPI in one of the following containers of fluid. At least one ESAPI will be subjected to contamination to each of the three fluids; 30 weight lubricating oil of commercial grade SE or better, commercial grade JP-8 and salt water. For lubricating oil and JP-8, place the ESAPI strike face down in a pan filled with 0.50-inch of fluid for two (2) hours (+15 min) with a twenty (20) pound weighted object on top of the ESAPI. For salt-water contamination test, submerge the ESAPI in a container for two (2) hours (+15 min). ESAPIs shall be held vertically to drip dry for 5 minutes. Pre-conditioning and post-conditioning digital x-rays shall be taken of the ESAPI samples. The test specimen shall be ballistically tested in accordance with paragraph 3.9.3 with threat “d” or “e” within 30 minutes after each exposure.

4.8.4 Altitude Test. Place the ESAPI in an ambient air pressure chamber to simulate a 40,000-foot altitude. The air pressure then shall be changed to simulate a 15,000-foot altitude. When

the air pressure reaches the simulated 15,000-foot level, a complete visual inspection will be performed. The change rate of the ambient air pressure is 1,500 to 2,000 ft/min. The test specimen shall be ballistically tested in accordance with paragraph 3.9.3 with threat “d” or “e”.

4.8.5 Fungus Test. Verification of compliance with the fungus requirement will be performed through the use of certified materials and coupon sampling. A fungus test may be performed on all non-certified materials at the discretion of the government. The results of those tests will be for government reference but the government reserves the right to fail the ESAPI design due to excessive fungus growth. Tests will be performed in accordance with Method 508.6 of MIL-STD-810G. A sample of each non-certified material will be placed in the fungus test chamber for 28 days. No ballistic tests are required. The amount of fungus growth should support a grade of 2.5 or less, as specified in MIL-STD-810G.

4.8.6 Temperature Shock. Tests will be performed in accordance with method 503.5 of MIL-STD-810G Procedure I-A (ambient, cold, hot, ambient) using -25 and +120 degrees Fahrenheit for the extreme temperatures. Pre-conditioning and post conditioning digital x-rays shall be taken of the ESAPI samples. The test item will be stabilized at the appropriate temperature for a minimum of two hours before cycling to the other temperatures. The test specimen shall be ballistically tested in accordance with paragraph 3.9.3 for with “d” or “e”.

4.8.7 Vibration Test. Testing shall be conducted in accordance with MIL-STD-810G, Method 514.6, Procedure II for Loose Cargo with modifications. The vibration test shall approximate the various environments in which the ESAPI shall be subjected. Pre-conditioning and post conditioning digital x-rays shall be taken of the ESAPI. The ESAPI shall be positioned strike face down and have the top and bottom of the plate parallel to the y axis. The ESAPI shall be placed in a wooden box 25.4 mm larger than the plate in all directions which is then mounted to the vibration table. The simulation of the loose cargo environment requires the use of a package tester that imparts a 25.4 mm peak-to-peak, circular synchronous motion to the table at a frequency of 5 Hz for 1 hour. After conditioning the test specimen shall be ballistically testing in accordance with paragraph 3.9.3 with threat "d".

4.9 Performance Requirements. Complete each test in this paragraph.

4.9.1 Ballistic Test Criteria. For all V_{50} BL and V_0 acceptance tests the following minimum information is required by the government to validate performance:

1. Armor description including Design code, size, dimensions, thickness, weights of all components of the ESAPI system.
2. Test projectile threat code, weight and reference weight.
3. Temperature and humidity measurements.
4. Yaw angle.
5. Angles of target obliquity.
6. All velocity measurements of each test shot used to test the ESAPI (regardless of whether that particular velocity was used in the V_{50} or V_0 determination). Ensure proper drag table for each threat is used to calculate impact velocity.

7. PP (Partial Penetration; with shoot pack ply count as applicable) and CP (Complete Penetration) next to each shot velocity as determined.
8. Back Face Deformation measurements in mm with significant digits recorded only to the accuracy of the measuring device.
9. Spall/debris ejection count (when required).
10. Name of organization/company performing tests.
11. Type of gun barrel, caliber, propellant type, propellant weight, twist rate, and gun barrel serial number.
12. Calculated V_{50} BL. In a situation where the V_{50} BL or V_0 data sheet would compromise the Security Classified Guide for Armor Materials, the data sheet should exclude the specific projectile used during testing.
13. Shoot pack or specified soft armor backing design, weight and total ply count.
14. Clay type, drop temperatures, locations, depth, and clay box number.
15. Remarks or Notes for all testing anomalies, unfair hits, etc.
16. All shot locations.
17. Revision #/level of all ballistic test software used by test lab (i.e. FARO software including smoothing function, drag calculation software, etc)
18. Time and date of clay calibration drops and ballistic shots.
19. Photos of clay calibration drop locations, ballistic impact locations on the plate, and any anomalies.

4.9.2 Projectile Velocity Determination. Projectile velocity measurements methods that utilize either contact screens or radar will be used. Contact screen methods that employ either high velocity lumiline screens or electrical contact screens activated by a passing projectile opening or closing a circuit are preferred. An electric counter type chronograph calibrated to microseconds, will also be used in conjunction with the contact screen method. Doppler radar capable of accurately measuring the projectile striking and residual velocities can also be used. Personnel conducting ballistic testing should be properly trained in velocity measurement determination using the Doppler radar equipment. Radiographic equipment calibrated to capture the projectile at calibrated time intervals of flight may also be used.

4.9.3 Weapon Mounting Configuration. The spacing from the weapon muzzle to the first pair of triggering devices shall be sufficient to prevent damage from muzzle blast and obstruction from smoke in case optical devices are used. Recommended distances can be found in USATECOM TOP 4-2-805. Spacing between triggering devices is a function of the expected velocity of the projectile being fired. In many instances, physical restriction, such as short overall distance from muzzle to test sample dictates the spacing of the triggering devices. The last pair of triggering devices shall be placed at least four (4) ft (122 cm) in front of the test sample and should be protected from possible damage resulting from fragments.

4.9.4 Environmental Test Conditions. All ballistic tests shall be performed in a standard atmosphere of 68 ± 10 degree Fahrenheit and $50 \pm 20\%$ relative humidity. Temperature and humidity measurements shall be recorded before the beginning of days test firings and a minimum of every two hours thereafter.

4.9.5 Projectile Yaw. Projectile yaw shall be measured for each firing by yaw cards, flash x-ray or photography. Any round for which yaw is determined to be greater than 3.0 degrees shall be disregarded in the calculation of the ballistic limit. The measurement system employed should be capable of measuring yaw within an accuracy of 1.0 degree.

4.9.6 V₅₀ BL. See Appendix A.

4.9.7 PP and CP for V₅₀. Complete and partial penetrations will be determined based on the definitions provided in paragraph 6.6.

4.9.8 V₅₀ Test Sample Mounting. Unless otherwise stated the following conditions shall be performed during V₅₀ testing. The ESAPI shall be secured to the clay-mounting block with the impact side perpendicular to the line-of-flight of the projectile. Testing will be performed in accordance with MIL-STD-662F except partial and complete penetrations will be determined based on definitions provided in paragraph 6.6.

4.9.9 Ballistic V₀ Testing. Ballistic V₀ testing of ESAPI shall be conducted on a recurring basis per paragraph 3.9.3 and procedures specified in the contract (see paragraph 6.2).

4.9.9.1 V₀ Determination for Acceptance. For V₀, the minimum velocities as stated in Appendix A will be the requirement.

4.9.9.2 Impact Location. See Appendix A.

4.9.9.3 Back Face Deformation (BFD) Measurement.

The back of the ESAPI test specimen will be attached to a block of non-hardening, oil-based modeling clay so that no movement of the test samples occurs before, during or after the ballistic event. The clay material fixture shall be in the form of a single block at least 5.5 inches thick and 24 x 24 inches in length and height with 0.75 inch plywood backing. The clay shall be conditioned for at least 3.0 hours and worked thoroughly to remove any voids. A new clay conditioned block shall be used for each ESAPI sample. The clays consistency shall be such that depression of 25 ± 3 mm in depth is obtained when a $1 \text{ kg} \pm 10 \text{ gm}$ ($2.2 \text{ lb} \pm 0.35 \text{ oz}$) cylindrical steel mass, $44.5 \pm 0.5 \text{ mm}$ ($1.75 \pm 0.02 \text{ in}$) in diameter and having a hemispherical striking end, is dropped from a height of $2 \text{ m} \pm 2 \text{ cm}$ ($6.56 \text{ ft} \pm 0.8\text{-in}$) onto one of its square faces. During the three drop tests for each block, the center of each impact location shall be at least 4.0 inches from any previous impact site and from any edge of the clay block. A guide tube or other means may be used as required to assure that the striking end of the cylindrical mass impacts the backing material squarely at the desired location. Depressions and BFDs will be measured with instruments capable of ± 0.4 mm accuracy. The calibration drop indentations will be filled with temperature conditioned clay prior to conduct of the V₀ test shots. The clay boxes will be numbered so as to be recognized by an overhead camera. Any portion of the clay “chest mold” will not be adhered to any portion of the clay block that has last been smoothed or worked with a “putty knife” or “flexible blade.”

Before ballistic testing the clay material will be contoured to the back face curvature provided by the ESAPI. This buildup will use additional clay backing material conditioned in the same

manner as the clay material fixture. Both the shoot pack and ESAPI will be strapped or taped to the curved surface of the clay material. For FAT part A, back face deformations in the clay will not exceed 44.0 mm max, without incurring a minor defect when measured from the original undisturbed surface of the clay backing material to the post-impact surface with the reference direction perpendicular to the front surface (facing the line-of-fire) of the box. All BFD measurements will be conducted at 0 degree obliquity only. Indentation measurements will utilize laser scanner measurement instruments, which provide a means to accurately establish the difference between the original undisturbed clay surface and the post-impact surface. The BFD measurement is the maximum-distance-length, which is the length of the longest line segment parallel to the reference direction between the pre-impact clay surface and the post-impact (BFD) clay surface, where the reference direction is defined to be perpendicular to the front surface (facing the line-of-fire) of the box containing the clay backing material. Deformations will be recorded in mm to the nearest tenth digit following standard ASTM E29 “Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications” (“Five-even” rule)(Rounding Method) (i.e. 44.050 = 44.0, 44.051 = 44.1 and 47.950 = 48.0).

The laser scanner measurement instruments and associated software must be approved for use by ATEC. Changes to this software will be managed by a Configuration Control Board (CCB) which will certify each change. The software package must be capable of meeting the following requirements:

- Uniform sample: 0.5mm
- Wrap with Auto Noise Reduction
- Clean function w/ smooth option
- Fill holes (curvature based hole filling)
- Remove intersecting triangles
- Remove spikes at 10%
- 3D Compare to find deepest point

The software package must be able to remove and fill cracks in the clay if the deepest point falls within a crack with an area < 0.7 mm x 0.7 mm.

4.9.9.4 Test Sample Mounting. The framed clay block shall be rigidly fixtured in a manner which will resist, without movement, the anticipated force of the ballistic impacts. The ESAPI test sample shall be secured in the vertical position, perpendicular to the projectile line of flight. The frame supports must be capable of retaining the sample and withstanding shock resulting from ballistic impact by all specified threats on the test sample. The test sample mounting shall be capable of adjustment for moving the sample in the vertical or horizontal positions so that the point of impact can be located anywhere on the sample and rotation on the vertical axis so that zero degree and thirty degree obliquity impacts can be achieved anywhere on the sample. Mark intended shot locations on the actual plate. Small “windows” shall be cut in the shoot pack’s front Cordura cover to expose the aim points marked on the actual plate. Edge “witness” strips (or similar) shall be used on all threat “d” and “e” V₀ edge shots. Edge “witness” strips may be adhered to the ESAPI prior to environmental conditioning if necessary (exceptions can be made if the edge strip fails to adhere to the plate, especially on environmentally conditioned samples). The witness strip edge closest to the center of the ESAPI shall be placed 0.60 inches from the edge of the ESAPI (at the ESAPI surface) to account for ½ diameter of the 0.30 caliber projectile

as the “point of impact” (projectile tip) can be no closer than 0.75 inches from the edge. There shall be a minimum 3.0 inch radius of unpenetrated (no yarns broken) soft armor backing (shoot pack) around the intended point of impact.

4.9.9.5 Spall, Debris and Residual Penetrator. Witness sheets for determining potential injuries to the wearer will be mounted around the front, sides, top and bottom of the ESAPI test sample. The witness inserts shall be a 2024-T3 or 2024-T4 aluminum alloy sheet, 0.020-inch thick and approximately 12.0 x 12.0 inches size. The witness sheets should be assembled into a box configuration with the open ended side placed within 0.50 inch from the front of the ESAPI sample. The front sheet will be placed 12.0 to 14.0 inches away from the front of the ESAPI sample. A hole at least 3.0-inches diameter will be made in the front sheet to allow for undisturbed passage of the projectile. The ESAPI will be placed in the carrier or a representative carrier fabricated with the same material before spall testing. The projectile impact point should be no closer than 6.0 and no further than 7.0 inches from any witness sheet surface. The witness sheet box shall be repositioned after each shot. Perforations in the surrounding witness sheets will be counted and documented. The only spall perforations counted will be those closer to the ESAPI specimen than the lines created by a 60 degree angle as measured from perpendicular to the point of impact to the witness sheet box. A perforation is any crack or hole which permits light passage when a 60 watt, 110 volt bulb is placed behind the witness panel. The spall count will be recorded for Government reference.

4.9.10 Worksmanship and Areal Density. Dry Lay ups for each design will be examined prior to production of any test plates or production plates to visually ensure the plates exhibit uniform areal density (no unnecessary overlap/underlay, uniform material lengths and thicknesses, etc). Radiographic images (x-rays) of complete end items will be taken digitally or by the use of x-ray film. Radiography shall include the entire strike face area of the plate with the radiograph taken from a frontal or rear view. The complete ESAPI shall pass the requirements specified in Table II. The Government reserves the right to change the shot pattern to target any and all anomalies, defective conditions or contaminants highlighted in x-ray. If a failure is observed when tested in accordance with sections 4.7, 4.8, and 4.9 the items shall be rejected regardless of requirements specified in Table II. Visual end item inspection shall take place to ensure the entire plate is covered completely with a spall cover, with no rips, tears, cuts, blistering or separation between the materials.

Table II. Classification of Defects for the radiographic examination of ESAPI

Defect	Critical	Minor
<i>Ceramic component</i>		
Any Crack	X	
Pit or void greater than: 0.060 inch in depth or diameter	X	
Pit or void less than or equal to 0.060 inch in depth and diameter		X
Rivulet, pit or void over 2.5 inches in length.	X	
Rivulet , pit or void greater than 0.75 inch in length but no more than 2.5 inch with max width and max depth no greater than 0.060 inch		X
Edge chip greater than 1/2 inch in the face or width of ceramic	X	
Edge chip greater than 1/16 inch but not more than 1/2 inch in the face or width of ceramic		X

Edge chip greater than 1/8 inch in depth of ceramic	X	
Edge chip greater than 1/16 inch in depth of ceramic but not more than 1/8 inch		X
<i>All components to include laminate behind the strike face</i>		
Any delamination areas larger than 0.20 inch ²	X	
Any delamination areas less than or equal to 0.20 inch ²		X
<i>Other</i>		
Any foreign object debris or defect identified that is not associated with the Technical data package		
Any Item larger than 0.04 inch in any dimension	X	
Any item equal to or less than 0.04 inch in any dimension		X

Table II Definitions:

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

Void. Round or elongated, smooth edged spots occurring individually or randomly distributed within the ceramic indicating regions of missing material.

Pit. A region of missing material, or void, on the surface of the ceramic

Rivulet. Rounded void with gradual, river like meandering, which make it distinguishable from cracks

Delamination. A region where there is no bond or material separation between single or multiple layers of the plate components, creating a gap in the materials.

Table II Notes:

- Reject all plates with any critical defects or 3 or more minor defects.
- Any two minor defects less than 3/8 inch apart shall be classified as a critical defect.
- If any defect falls into two categories of defects, the more severe defect category will apply and only be considered one defect.
- If applicable, this requirement should not supersede more stringent vendor internal requirements.

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.

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 body armor ESAPI is intended for use by ground combat troops. The ESAPI when inserted into the fragment protective vest carrier will provide protection from certain small arms fire. The ESAPI is part of a protective system, which includes a soft fragmentation and handgun tactical vest. The ESAPI shall be used in conjunction with the soft under garment as a total armor ensemble.

6.2 Acquisition Requirements. Acquisition documents must specify the following:

- a. Title, number and date of this specification and amendments.
- b. Special provisions for verification inspection of equipment (see paragraph 1.1).
- c. Issue of DODISS to be cited in the solicitation and if required the specific issue of individual documents (see paragraph 2.3).
- d. When first article is required (see paragraphs 3.1, 4.2.1 and 6.3).
- e. Packaging requirements (see paragraph 5.1).
- f. Contractually approved ballistic packages / design code to include package name, complete description, and FAT acceptance letter.
- g. FAT and LAT requirements.

6.3 First article. When a first article is required, it shall be inspected and approved under the appropriate provisions of FAR 52.209. The first article shall be a pre-production sample. The contracting officer shall specify the appropriate type of first article and the number of units to be furnished. The contracting officer should also include specific instructions in acquisition documents regarding arrangements for selection, inspection, and approval of the first article.

6.4 Standard Color Samples. Standard color samples are available from the contracting officer.

6.5 Acceptance criteria. Acceptance criteria shall be as specified in the contract or purchase order.

6.6 Definitions. The following definitions are provided to assist in understanding the test procedures;

Over-Velocity. Striking velocity that is higher than the specified threat requirement.

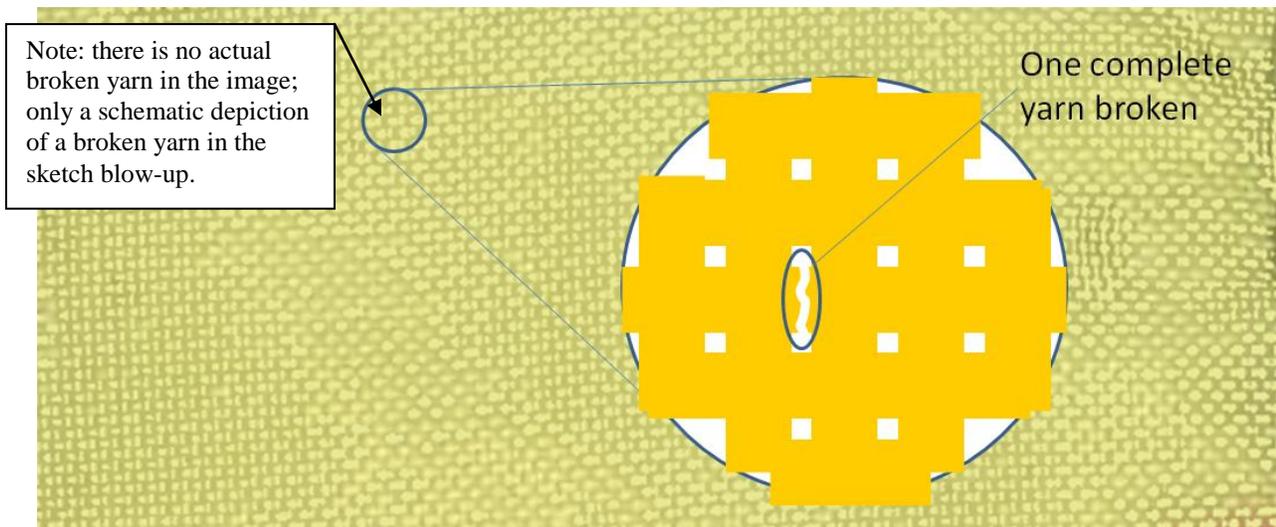
Under-Velocity. Striking velocity that is lower than the specified threat requirement.

Fair Impact. Impact of an unyawed bullet of the specified bullet type, velocity and obliquity (± 3 degrees) except an impact which violates shot spacing or edge distance (see Appendix A) shall be an unfair impact.

Complete Penetration (CP) for V_{50} Testing. A complete penetration occurs when the impacting projectile or any fragment thereof, or any fragment of the test specimen perforates the rear surface of the ESAPI.

Complete Penetration (CP) for V_0 Testing. There are two categories: a “Plate complete” in which the armor plate is completely penetrated and a “System complete” in which the entire body armor system is completely penetrated (hard armor (plate) and soft armor (carrier/shoot pack)).

1. Plate complete. Complete penetrations of the plate will have occurred when the projectile, fragment of the projectile or fragment of the armor material penetrates the entire plate and is imbedded or passes into the soft under garment used directly behind the impact point on the ESAPI, resulting in the penetration of the first ply of the soft armor component (minimum of one complete yarn broken of the first ply – see below schematic). Paint or fibrous material that are emitted from the back of the test specimen and rests on the outer surface of the under garment are not considered complete penetrations.



2. System complete. Complete penetrations of the system will have occurred when the projectile, any fragment of the projectile or any fragment of the test specimen penetrates the entire plate and all plies of the shoot pack and is imbedded or passes into the clay backing used directly behind the impact point on the ESAPI and soft armor/shoot pack.

Crown. Location of the intersection of three different curvatures vicinity the center of the upper third of the plate.

Partial Penetration (PP). Any fair impact that is not a complete penetration shall be considered a partial penetration.

Areal Density (AD). A measure of the weight of the armor per unit area, usually expressed in pounds per square foot (lb/ft^2) or kilograms per square meter (kg/m^2) of surface area.

Obliquity. The angle, in degrees, between the line-of-flight of the bullet and a line perpendicular to the front surface (facing the line-of-fire) of the clay box. A projectile's line-of-flight which is perpendicular to the surface of the clay box strikes at zero (0) degrees of obliquity.

Spall. Fragmentation of the bullet or target material which is projected from the impact surface or rear surface of the target.

Yaw. Projectile yaw is the angular deviation of the longitudinal axis of the projectile from the line of flight at a point as close to the impact point on the target as is practical to measure.

V₅₀ Ballistic Limit (BL). In general, the velocity at which the probability of penetration of an armor material is 50 percent.

6.7 Government Loaned Property. Contact the contracting official for the loan of the property listed in paragraph 3.6.1.

6.8 Drawings and Materials. See Paragraph 2.

6.9 National Stock Numbers.

X-SMALL	8470-01-520-7360
SMALL	8470-01-520-7370
MEDIUM	8470-01-520-7373
LARGE	8470-01-520-7385
X-LARGE	8470-01-520-7382

6.10 Simulant/Surrogate Shoot Pack. A Simulant/Surrogate Shoot Pack system of fielded body armor may be used to represent the ballistic resistant materials of the OTV, IOTV or SPCS (see CO/PD 00-02, FQ/PD 07-05, AR/PD 10-04). The surrogate shoot pack system will consist of (1) a ballistic filler packet specified by the contract and (2) a ballistic filler carrier with ESAPI pocket. The baseline ballistic filler packet will be 15 x 15 inches in size consisting of an approved ballistic shoot pack package. The ballistic packet will be stitched diagonally across the 4 corners with a 5-inch line of 50 TEX Aramid thread at 5 to 10 stitches per inch. The ballistic filler carrier will have an ESAPI pocket capable of holding the largest ESAPI stitched on the face fabric. Both the face fabric and the pocket cover will consist of 500 denier 7.5 oz. / sq. yd. urethane back coated, textured nylon, Cordura. The ESAPI pocket will be stitched on three sides to the face fabric with nylon or polyester thread. The top edge of the pocket will have a minimum of 5 inches of not less than 0.5 inch wide hook and loop fastener centered and stitched at the top. The ballistic filler carrier back cover will consist of 500 denier, 7.5 oz. / sq. yd. urethane back coated, textured nylon, Cordura. The front and back filler carrier covers will be stitched together on 3 sides with nylon or polyester thread to form a pocket to hold the ballistic filler packet. The fourth side will remain unstitched but will have a minimum of 5 inches of not less than 0.5 inch hook and loop fastener centered and stitched to the top.

Appendix A

V₅₀ Ballistic Limit Measurements

V₅₀ ballistic limit testing of ESAPIs shall be conducted as per paragraph 3.9.2 and 4.9 of this CO/PD and procedures specified in the contract (see paragraph 6.2) and MIL-STD-662. The ESAPI will yield the minimum V₅₀ ballistic limit measurements at 0 degree obliquity with the specified test projectiles as listed in Table I below. For “d” threat, the 1st, 2nd and 3rd shots will yield separate V₅₀ ballistic limit measurements at 0-degree obliquity with the specified test projectiles as listed in Table I below for government reference. The suggested starting velocities for the 2nd and 3rd shot V₅₀ ballistic limit measurements will be those listed in Table I.

Ballistic limit measurements will be performed on the actual ESAPI (three (3) shots maximum per ESAPI in accordance with MIL-STD-662F). Shot spacing should be no closer than 0.75 inches from an edge and each subsequent shot shall be spaced at least 5.0-inches from any previous shot. Second and third shots should be placed in an area unaffected by any previous shot. The V₅₀ will be determined when tested in conjunction with the simulant (see paragraph 6.10).

V₅₀ Calculation: The arithmetic mean of three (3) Partial Penetration (PP’s) and three (3) Complete Penetrations (CP’s) within a 125 ft/sec velocity spread or four (4) Partial Penetration (PP’s) and four (4) Complete Penetrations (CP’s) within a 150 ft/sec velocity spread yield the minimum allowable V₅₀ BL determination that will be accepted as reliable test results. If 6 partial penetrations occur that are above the minimum V₅₀, the plate demonstrates a V₅₀ above the minimum, the plate passes, and that V₅₀ test is terminated. All shots’ velocities are recorded.

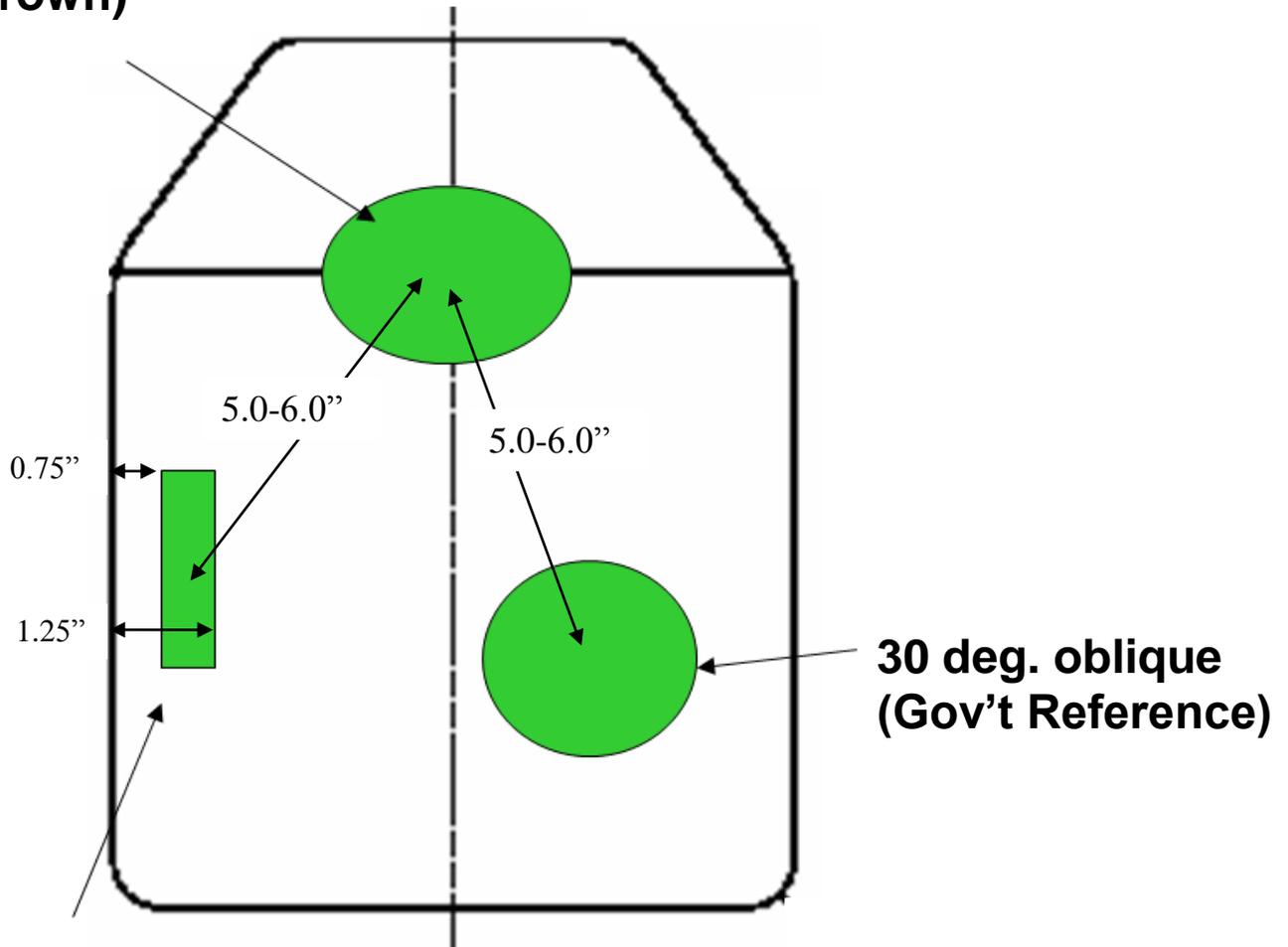
V₀ Ballistic Resistance

Ballistic V₀ testing of ESAPI shall be conducted on a recurring basis per paragraph 3.9.3 and 4.9.9 and procedures specified in the contract (see paragraph 6.2). For V₀, the minimum velocities as in Table II below will be the requirement. The ballistic V₀ testing of ESAPI shall have a minimum of 3 impacts (2 impacts at 0 degree obliquity and 1 impact at 30 degree obliquity). The first two shots must be fired at 0 degree obliquity and the third shot at 30 degrees obliquity for all threats. For the 30 degree obliquity shots, the direction of the obliquity depends on which side of the centerline is the intended impact point. If on the right, that side shall be rotated up-range (toward the gun barrel); if left, that side shall be rotated up-range.

An “Edge” fair hit impact (0 degree obliquity) shall be between 0.75 to 1.25 inches from any edge. A “Crown” impact (0 degree obliquity) will be 5.0-6.0 inches from any edge shot impact location and located at the ballistically weakest point of the insert (e.g. triple point or seam, if any) (see Figure A-1). The distance between second and all subsequent shots will be between 5.0–6.0 inches (see Figure A-1). All shots after the first shot must be a minimum of 1.5 inches from any edge (except for DoD protocol shot pattern (FAT part B) which alternates between edge shot first, crown shot second and crown shot first, edge shot second). Back face

deformation measurements, per paragraph 3.9.4 and 4.9.9.3, will only be taken for shots taken at 0 degrees obliquity.

(Crown)



(Edge)

Figure A-1: General shot pattern

Figure above: General V_{50} and V_0 testing shot patterns for uniform material design (other patterns IAW the shot spacing requirements above are possible at the discretion of the government – i.e. mirror image opposite the vertical centerline, etc).

Complete and partial penetrations for V_0 testing – see 6.6 for complete definitions.

Ballistic test results will be scored per FAT Protocol (Appendix B and D) and LAT Protocol (Appendix E) for each shot on the ESAPI.

Table I: Threat Codes, Descriptions, and Required Velocities

Threat Code	V ₅₀ Minimum Required Velocity (ft/s)	V ₀ Required Velocity and Tolerance (ft/s)	Shots (V ₀)	Obliquity (V ₀)
a	No less than 2,850 (combined V ₅₀)	2,750 +50	3	1-2 0 degree 3 rd 30 degree
b	No less than 2,850 (combined V ₅₀)	2,750 +50	3	1-2 0 degree 3 rd 30 degree
c	No less than 3,350 (combined V ₅₀)	3,250 +50	3	1-2 0 degree 3 rd 30 degree
d	Gov't Reference (1 st , 2 nd , 3 rd shot individual V ₅₀ S)	2,850 +50	3 (3 rd Government reference)	1-2 0 degree 3 rd 30 degree
e	NA	2,700 +50	3 (3 rd Government reference)	1-2 0 degree 3 rd 30 degree
y	N/A	3,350 + 50	3 (3 rd Government reference)	1-2 0 degree 3 rd 30 degree

V₅₀ 1st, 2nd, and 3rd shot velocities are for government reference only.

-Suggested starting velocities for d threat 2nd and 3rd shot respectively: 3000, 3300

Appendix B

First Article Test (FAT) Protocol – ESAPI - Part A

Test	Threat a	Threat b	Threat c	Threat d	Threat e	Threat y	Number of Items
V ₅₀	1 XS, 1 MED, 1 LG	1 XS, 1 MED, 1 LG	1XS, 1 MED, 1 LG	2 XS, 2 SM, 2 MED, 2 LG, 2 XL	N/A	N/A	19
V ₀ Ambient	1 SM	1 XS	1 SM	3 XS, 2 SM, 3 MED, 3 LG, 2 XL	PART B	4 XS, 4 SM, 5 MED, 5 LG, 4 XL	38
Impacted V ₀	N/A	N/A	N/A	1 MED	N/A	N/A	1
Oil V ₀	N/A	N/A	N/A	1 SM	N/A	N/A	1
JP-8 V ₀	N/A	N/A	N/A	1 XL	N/A	N/A	1
Saltwater V ₀	N/A	N/A	N/A	1 LG	N/A	N/A	1
Weathered V ₀	N/A	N/A	N/A	1 XS	N/A	N/A	1
High Temp V ₀	N/A	N/A	N/A	1 XL	N/A	N/A	1
Low Temp V ₀	N/A	N/A	N/A	1 SM	N/A	N/A	1
Temp Cycle V ₀	N/A	N/A	N/A	1 XL	N/A	N/A	1
Altitude V ₀	N/A	N/A	N/A	1 LG	N/A	N/A	1
Vibration V ₀	N/A	N/A	N/A	1 MED	N/A	N/A	1

*If all six shots exceed V50 minimum requirements, with no complete penetrations occurring, the requirement is considered met.

The Contractor shall provide a total of **92 FAT ESAPI samples** to the Government for First Article Testing as indicated below and a minimum of two UID verification reports per plate size.

67 samples: First Article Testing	XS: 19
15 samples (three of each size): FAT contingency / spares	S: 17
5 samples (one of each size): Government record (DCMA)	M: 20
5 samples (one of each size): Government record (PM SPE/TMD)	L: 20
	XL: 16
92 FAT Samples	

Government samples will be retained as the manufacturing standard.

FAT is based on ANSI/ASQ Z1.4.2008. Zero (0) critical defects are allowed. Defects are divided into “critical” defects and “minor” defects as explained below. Given the sample size of 48 ESAPI plates V_0 tested with all threats, the accept/reject criteria is interpolated from Table II-A as shown below which correlates to a FAT rejection at a minor defect rate of 14. The Fair Hit criteria for part FAT Part A only, is identified in Appendix C (V_0 Test Contingency Matrix). The government reserves the right to perform additional testing beyond what is outlined in this PD. If additional testing is required, the acceptance criteria will be updated according to ANSI/ASQ Z1.4.2008 using the same Acceptable Quality Limits.

Definitions (V_0 testing):

Critical defects for threat a, b, c and y:

- Complete penetration of both hard armor (ESAPI) and soft armor (IOTV or shoot pack) on any shot
- Back face deformation ≥ 48.0 mm on any shot

Minor defects for threat a, b, c and y:

- Complete penetration of hard armor (ESAPI) and partial penetration of soft armor (IOTV or shoot pack) on any shot
- Back face deformation > 44.0 mm on any shot

Critical defects for threat d and e:

- Complete penetration of both hard armor (ESAPI) and soft armor (IOTV or shoot pack) on 1st shot
- Back face deformation ≥ 48.0 mm on 1st shot

Minor defects for threat d and e:

- Complete penetration of hard armor (ESAPI) and partial penetration of soft armor (IOTV or shoot pack) on 1st shot
- Complete penetration on both hard armor (ESAPI) and soft armor (IOTV or shoot pack) on 2nd shot (weighted 1.5 times for each occurrence)
- Back face deformation > 44.0 mm on any shot

Accept / Reject criteria:

- (1) One or more critical defects during V_0 testing constitutes FAT rejection.
- (2) A minor defect rate of 14 or higher constitutes FAT rejection (as per AQL of 15 – see below Table II-A). Truncate after the decimal point of the cumulative minor defect rate (e.g. a minor defect rate of 13.5 would equate to 13 and would pass).

Successful completion of FAT Part “A” shall be followed by additional testing as outlined in Appendix D: DoD Hard Body Armor Standard for Ballistic Testing FAT Part B. In order to gain FAT approval, a submitted design must successfully pass the requirements outlined in both FAT Part A and Part B.

The government reserves the right to allow ESAPI plate size substitution within the FAT Part A matrix if necessary. Technical Data Package, Dry Lay-up (size Medium), and final end item government record plates must be provided to the Government in order to gain approval to conduct FAT.

Table II-A—Single sampling plans for normal inspection (Master table)

(See 9.4 and 9.5)

Sample size code letter	Sample size	Acceptance Quality Limits, AQLs, in Percent Nonconforming Items and Nonconformities per 100 Items (Normal Inspection)																									
		0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
		Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re
A	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
B	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
C	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
D	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
E	13	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
F	20	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
G	32	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
H	48	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
I	63	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
J	80	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
K	125	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
L	200	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
M	315	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
N	500	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
P	800	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Q	1250	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
R	2000	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑

FAT

- ↓ = Use the first sampling plan below the arrow. If sample size equals, or exceeds, lot size, carry out 100 percent inspection.
- ↑ = Use the first sampling plan above the arrow.
- Ac = Acceptance number.
- Re = Rejection number.

ANSI / ASQ Z1.4 - Acceptable Quality Limits

11

SINGLE
NORMAL
PLANS

Appendix C V₀ Test Contingency Matrix

			Shot 1								
Velocity		→ Over	Over	Over	Fair	Fair	Fair	Under	Under	Under	
	↓	Result	Critical Defect	Minor Defect	No Minor Defect	Critical Defect	Minor Defect	No Minor Defect	Critical Defect	Minor Defect	No Minor Defect
Shot 2	Over	Minor Defect	1	1	1	2, 4	2, 6	2, 3	2, 4	2, 6	1
	Over	No Minor Defect	1	1	1	2, 4	2, 4	2, 4	2, 4	2, 5	1
	Fair	Minor Defect	1	1	1	2, 4	2, 4	2, 4	2, 4	2, 5	1
	Fair	No Minor Defect	1	1	1	2, 4	2, 4	2, 4	2, 4	2, 5	1
	Under	Minor Defect	1	1	1	2, 4	2, 5	2, 5	2, 4	2, 5	1
	Under	No Minor Defect	1	1	1	2, 4	2, 5	2, 5	2, 4	2, 5	1

LEGEND:

1. No second shot; re-test on new plate
2. Continue with second shot
3. Wait until end of testing and tally total points. If vendor fails, re-test. If vendor passes then no need to re-test.
4. Data valid
5. Shoot second plate and compare total penalty points with first plate. Pick plate with most minor defects or any critical defects.
6. Shoot second plate and add points. Only consider 1st shot minor defects on first plate, compare 1st plate to 2nd plate total minor defects and pick plate with most minor defects or any critical defects.

NO TESTS:

1. If the “edge strip” is impacted by the incoming projectile (indicating a shot too close to the edge), the plate will be a “No test” (rationale – the plate can only pass)
2. If the 2nd shot is not within the specified shot spacing the plate will be a “No test” (rationale – the plate can only pass)
3. If the clay sticks to the shoot pack in the BFD location as the shoot pack is removed and the BFD result is above 44.0 mm, test shall be considered a “No test”. Rationale: Resulting BFD would inadvertently result in a deeper reading due to clay removal from the surface. If the testing is using statistical sampling of BFDs, all instances of clay sticking to the shoot pack and creating a deeper BFD should be noted and if the plate design fails due to high BFD, these cases need to be retested.

NOTES:

1. If silicon spray is used, remove immediately afterwards (scrape off and dispose surface clay).

Appendix D

DoD Hard Body Armor Standard for Ballistic Testing

FAT Part B

Once an ESAPI design passes Part A of the FAT protocol prescribed in Appendix B, the ESAPI design will be tested to the DoD Protocol listed in Table 1 below with threat “e”.

Table 1: DoD FAT Protocol

Environment		
	1 st Shot Edge	1 st Shot Crown
Ambient (Unconditioned)	XS, L, XL	S, M, XL
Temperature Cycling	M, L, XL	XS, S, M
JP-8 Soak	XS, S, M	M, L, XL
Oil Soak	S, M, L	XS, S, XL
Salt Water	XS, M, XL	XS, S, L
Weathered	S, M, XL	XS, L, XL
High Temperature	S, L, XL	XS, M, L
Low Temperature	XS, S, XL	S, M, L
Altitude	XS, M, L	S, L, XL
Total	27	27
Impacted*	2 XS, S, L, M, XL	
Total	60	

For all ambient and environmentally conditioned plates, two shots per plate will be taken as indicated in the graphic below: one edge shot and one crown shot (the point at which three curvatures of ballistic plate converge) shot. For Impact-Conditioned plates, two shots per plate will be taken as indicated in the below right graphic: first shot is at the location of the most severe crack, as determined by x-ray. If a crack is not visible after x-ray of the plate, the 1st shot will be taken at the center of the plate (impact location). The second shot is at any edge.

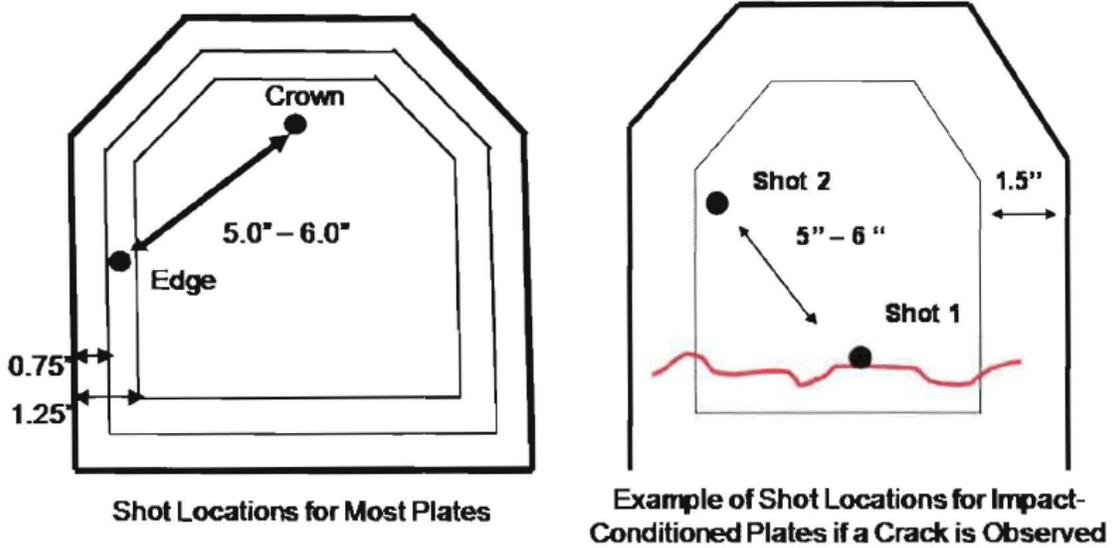


Figure 1: Shot locations ESAPI plates

Statistical Confidence in Test Results: Table 2 below represents the resistance to penetration and back face deformation statistical analysis required for FAT testing. For resistance to penetration, the lower confidence level for the probability of no penetration $P(nP)$ is the statistic of interest and the result compared against a 90% probability of no penetration for first shot and a 70% probability of no penetration for the second shot. For back-face deformation (BFD), the Upper Tolerance Limit will be computed using back-face deformation as a continuous normal random variable and the result compared against the requirement.

Table 2: Statistical Analysis Method

1 st shot	2 nd shot
Resistance to Penetration	
90% Prob. of No Penetration ($P(nP)$), 90% Confidence	70% Prob. of No Penetration ($P(nP)$), 90% Confidence
Back Face Deformation ($\leq 44.0\text{mm}$)	
90% Upper Tolerance Limit / 90% Confidence	80% Upper Tolerance Limit / 90% Confidence

Analysis Methodologies:

For each valid test shot, the result is determined to have experienced either a system complete penetration or a system partial penetration (no penetration of the system). The numbers of complete penetrations and no penetrations are the basis for calculating the 90% LCL for $P(nP)$

via the exact Clopper-Pearson method,¹ with the numerical result truncated by applying the “floor function” to two-decimal place precision. The LCL for P(nP) is calculated for the 1st and 2nd shots by combining shot locations, plate sizes, and environmental conditions. The LCL must meet or exceed the requirement specified in Table 2. For example, if the 90% LCL for the P(nP) associated with a set of second shot data from FAT were calculated to be 0.699987, the reported result would be 0.69 and the outcome would be considered to be non-compliant with the prescribed criterion of 0.70.

For back face deformation, the metric of merit is a one-sided Upper Tolerance Limit (UTL) based on the assumption of normally distributed BFD data; the UTL to be calculated is specified in Table 2. The BFD UTLs are calculated for the first and second shots by combining shot locations, plate sizes, and environmental conditions.

Validated one-decimal place BFD measurements, for tested hard armor inserts that did not experience complete penetrations, are the basis for any UTL calculation. The UTL is defined² as $Y_u = \bar{Y} + ks$, where \bar{Y} is the mean of all valid BFD measurements, k is a look-up constant³ (varying with the sample size, UTL percentage, and confidence percentage), and s is the sample standard deviation. The UTL is reported to one decimal place precision after adjusting upwards via the “ceiling function” – ensuring that a conservative UTL is reported. For example, calculated results of 38.1349 mm and 38.1999 mm are each reported as 38.2 mm. Compliance with the BFD requirement is achieved only if the associated UTL is less than or equal to 44.0mm.

When calculating the sample average (mean) and standard deviation in order to compute the UTL, calculate both the mean and standard deviation to six significant digits. This is to avoid the rounding of these intermediate quantities affecting the reported UTL. The final result (the UTL) is then reported to one decimal place as specified above.

¹
$$\frac{1}{1 + \frac{n-x+1}{x} F_{2(n-x+1), 2x, \alpha/2}} \leq p \leq \frac{\frac{x+1}{n-x} F_{2(x+1), 2(n-x), \alpha/2}}{1 + \frac{x+1}{n-x} F_{2(x+1), 2(n-x), \alpha/2}}$$
 Where $F_{v1, v2, \alpha}$ is the upper α cutoff from an F distribution with v1 and v2 degrees of freedom. (Clopper Pearson Formula from Casella, George and Roger Berger: Statistical Inference 2002 Duxbury / Thomson Learning Inc, Pacific Grove, CA p 454.)

² NIST/SEMATECH e-Handbook of Statistical Methods <http://www.itl.nist.gov/div898/handbook/prc/section2/prc263.htm>

³ $k = \frac{z_{utl} + \sqrt{z_{utl}^2 - ab}}{a}$ where $a = 1 - \frac{z_{conf}^2}{2 \cdot (N-1)}$, $b = z_{utl}^2 - \frac{z_{conf}^2}{N}$ and z_{utl} is the critical value from the standard normal distribution associated with the UTL percentage. z_{conf} is the critical value from the standard normal distribution associated with the Confidence percentage and N is the total sample size for the data of interest.

For impact velocity anomalies, Table 3 identifies the standard fair/no test criteria for this hard body armor standard. In the case of an under-velocity shot which results in either a system complete penetration (CP) or a BFD greater than 44.0mm, the shot result will be included in the analysis. If the under-velocity shot occurs on the first shot, the plate will be replaced with a contingency plate to ensure a completed test matrix.

Table 3: Fair Hit/No Test Criteria for Velocity Anomalies

Impact Velocity	Test Result		Evaluator Accepts or Rejects for Inclusion in Analysis		Proceed to next data point for that plate?
	Penetration	BFD	Penetration	BFD	
Acceptable	No Penetration (PP and CP)	Measured	Include as success	Include	Yes
Acceptable	Complete System Penetration (CC)	Not measured	Include as failure	Not measured	Yes
Too High	No Penetration (PP and CP)	Measured	Not included	Not included	No
Too High	Complete System Penetration (CC)	Not Measured	Not included	Not included	No
Too Low	No Penetration (PP and CP)	Measured	Not included	Not included if $\leq 44.0\text{mm}$ Included if $> 44.0\text{mm}$	No
Too Low	Complete System Penetration (CC)	Not measured	Include as failure	Not measured	No

Appendix E

ESAPI Lot Acceptance Test (LAT) Protocol

LAT REQUIREMENTS (all testing with threat “e”)

Table 1: LAT Protocol Sampling Rate

Lot size	ANSI/ASQ Z1.4 Code Letter	Sample Size	Contingencies	Total Plates
91-150	D	8	3	11
151- 500	E	13	3	16
501-1200	F	20	4	24
1201-3200	G	32	6	38

Sample size based on ANSI/ASQ Z1.4 Special Inspection Level “S-4”. Switching rules do not apply unless authorized by the Government. A lot shall consist of only one size. The contractor shall provide a minimum of two UID Verification reports for each LAT. Testers will cut small “windows” in the shoot pack cover to expose the actual aim point on the ESAPI. All LATs shall be 3-shot, V0 Testing of each insert – 3rd shot (30 degree obliquity) is for government reference only.

Figure 1 depicts shot locations for LAT plates. For all plates, two shots per plate will be taken as indicated in the below graphic: one edge shot and one crown (the point at which three curvatures of a ballistic plate converge) shot. The shot pattern will alternate between first shot edge, second shot crown, and first shot crown, second shot edge for each threat until all sampled plates are tested. A third shot will be taken as government reference and will follow the pattern outlined in Appendix A for V₀ testing.

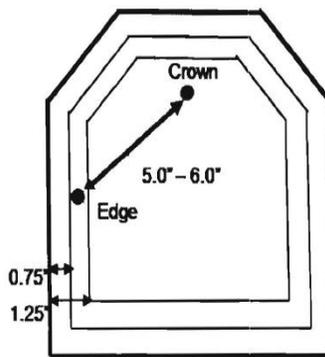


Figure 1: Intended Shot locations

Statistical Confidence in Test Results: Table 2 displays the resistance to penetration and back face deformation criteria required for this lot acceptance test protocol. For resistance to penetration, no first shot penetrations of threat “e” is acceptable. The second shot acceptable

quality level is 10 percent; the corresponding accept/reject numbers are provided in Table 3 through Table 5.

Table 2: Statistical Analysis Methodologies

1st shot	2nd shot
Resistance to Penetration	
No 1 st shot Penetration allowed for any lot size	10% Acceptable Quality Level
Back Face Deformation (≤44.0mm)	
80% Upper Tolerance Limit with 90% Confidence	70% Upper Tolerance Limit with 90% Confidence

For back face deformation, the metric of merit is a one-sided Upper Tolerance Limit (UTL) based on the assumption of normally distributed BFD data; the UTL to be calculated is specified in Table 2. The BFD UTLs are calculated for the first and second shots by combining shot locations.

Validated one-decimal place BFD measurements, for tested hard armor inserts that did not experience complete penetrations, are the basis for any UTL calculation. The UTL is calculated as specified in Appendix D. Compliance with the BFD requirement is achieved only if the associated UTL is less than or equal to 44.0mm.

Table 3: Penetration Allowances Overall

Lot size	ANSI/ASQ Z1.4 Code Letter	Sample Size	First Shot Complete Penetration		Second Shot Complete Penetration	
			Accept	Reject	Accept	Reject
91 - 150	D	8	0	1	2	3
151- 500	E	13	0	1	3	4
501-1200	F	20	0	1	5	6
1201 - 3200	G	32	0	1	7	8

DEFINITIONS:

Complete Penetration:

- Complete penetration of hard armor (ESAPI) and soft armor (IOTV or shoot pack), otherwise known as system complete as defined in section 6.6.

Reject Criteria

- One or more complete penetrations on 1st shot constitutes LAT rejection
- For 2nd shot, an overall defect rate higher than allowed by Table 5 (derived from Table II-A using AQL of 10) constitutes LAT rejection.
- 80% Upper Tolerance Limit with 90% Confidence > 44.0mm on 1st shot constitutes LAT rejection
- 70% Upper Tolerance Limit with 90% Confidence > 44.0mm on 2st shot constitutes LAT rejection

LAT ACCEPTANCE / REJECTION CRITERIA

Table II-A—Single sampling plans for normal inspection (Master table)

(See 9.4 and 9.5)

Sample size code letter	Sample size	Acceptance Quality Limits, AQLs, in Percent Nonconforming Items and Nonconformities per 100 Items (Normal Inspection)																											
		0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000		
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	
A	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31		
B	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45		
C	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45		
D	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45	↑	↑		
E	13	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45	↑	↑		
F	20	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45	↑	↑		
G	32	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑		
H	50	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑		
J	80	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑		
K	125	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑		
L	200	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑		
M	315	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑		
N	500	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑		
P	800	↓	0 1	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑		
Q	1250	0 1	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑		
R	2000	↑	↑	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑		

LAT
2nd
shot

- ↓ = Use the first sampling plan below the arrow. If sample size equals, or exceeds, lot size, carry out 100 percent inspection.
- ↑ = Use the first sampling plan above the arrow.
- Ac = Acceptance number.
- Re = Rejection number.

ANSI / ASQ Z1.4 - Acceptable Quality Limits

CODE
LETTERS

Table I—Sample size code letters

(See 9.2 and 9.3)

Lot or batch size	Special inspection levels				General inspection levels		
	S-1	S-2	S-3	S-4	I	II	III
2 to 8	A	A	A	A	A	A	B
9 to 15	A	A	A	A	A	B	C
16 to 25	A	A	B	B	B	C	D
26 to 50	A	B	B	C	C	D	E
51 to 90	B	B	C	C	C	E	F
91 to 150	B	B	C	D	D	F	G
151 to 280	B	C	D	E	E	G	H
281 to 500	B	C	D	E	F	H	J
501 to 1200	C	C	E	F	G	J	K
1201 to 3200	C	D	E	G	H	K	L
3201 to 10000	C	D	F	G	J	L	M
10001 to 35000	C	D	F	H	K	M	N
35001 to 150000	D	E	G	J	L	N	P
150001 to 500000	D	E	G	J	M	P	Q
500001 and over	D	E	H	K	N	Q	R

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ANSI / ASQ Z1.4 Inspection Levels - Sample Size Code Letters

SUBMISSION, REVIEW, ACCEPTANCE/REJECTION OF LATs

- All lot test samples that are selected by the onsite DCMA QAR will be sent by the DCMA QAR to the third party testing facility using DD Form 1222, Request For and Results Of Tests.
- Upon completion of the required ballistic testing, the results will be provided to the vendor and to COTR and their designated representatives for review and acceptance/rejection IAW the above criteria. No production lot will be released for shipment by the vendor until approval by the COTR or their representative.
- The acceptance, additional testing requirement, or rejection of each lot will be provided to the DCMA QAR, who will take the appropriate action.

**Appendix F
PDM Test Protocol**

TEST	Threat d V ₀ 2850+50	# of Items
Ambient V ₅₀	3S, 3M, 3L, 1XL (gov't ref. – separate shot V50s)	10
Ambient V ₀	1XS, 3S, 4M, 3L, 2XL	13

The Contractor shall provide a total of **33 PDM ESAPI samples** to the Government for First Article Testing as indicated below.

23 samples: PDM Testing	XS: 3
5 samples (three of each size): PDM contingency / spares	S: 8
5 samples (one of each size): Government record (PM SPE/TMD)	M: 9
	L: 8
33 total PDM Samples	XL: 5

Government samples will be retained as the manufacturing standard. Upon satisfactory completion of PDM, all PDM samples will be returned to the Contractor – except Government record plates.

PDM is based on ANSI/ASQ Z1.4 Special Inspection Level “S-3” single sampling plan (normal inspection), with the following deviations: Switching rules do not apply, and zero (0) critical defects allowed. Defects are divided into “critical” defects and “minor” defects as explained below. Given the sample size of 13 ESAPI plates V₀ tested with threat “d,” the accept/reject criteria are extrapolated from Table II-A as shown below which correlates to a PDM rejection at a minor defect rate of 8.

Definitions (V₀ testing):

Critical defects for threat d:

- Complete penetration of both hard armor (ESAPI) and soft armor (IOTV or shoot pack) on 1st shot
- Back face deformation ≥ 48.0 mm on 1st shot

Minor defects for threat d:

- Complete penetration of hard armor (ESAPI) and partial penetration of soft armor (IOTV or shoot pack) on 1st shot
- Complete penetration on both hard armor (ESAPI) and soft armor (IOTV or shoot pack) on 2nd shot (weighted 1.5 times for each occurrence)
- Back face deformation > 44.0 mm on any shot

Accept / Reject criteria:

- (1) One or more critical defects during V_0 testing constitutes PDM failure.
- (2) A minor defect rate of 8 or higher constitutes PDM failure (as per AQL 25 – see below Table II-A). Truncate after the decimal point of the cumulative minor defect rate (i.e. a minor defect rate of 7.5 would equate to 7 and would pass).