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**JOINT APPLIED PROJECT**

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**DRAGON SKIN—HOW IT CHANGED  
BODY ARMOR TESTING IN THE  
UNITED STATES ARMY**

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**September 2015**

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**DRAGON SKIN—HOW IT CHANGED BODY ARMOR TESTING IN THE  
UNITED STATES ARMY**

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Submitted in partial fulfillment of the requirements for the degree of

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September 2015**

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## **ABSTRACT**

On February 9, 2009, Mr. Dean G. Popps, Acting Assistant Secretary of the Army (Acquisition, Logistics, Technology), issued a memorandum directing that all first article and lot acceptance testing of interceptor body armor (IBA) would be conducted by the Army Test and Evaluation Command (ATEC). Prior to the directive, the majority of IBA testing was conducted at National Institute of Justice (NIJ)-certified ballistics laboratories. The rationale for this change, as stated in the memorandum, was that recent internal and external reviews indicate that the testing process for personal protective equipment needed to be improved. This joint applied project examines the reasons why the decision was made, as articulated in the Popps memorandum, what improvements to IBA testing were made by ATEC, and impacts of the changes, positive and negative. Although the scope of the project is limited to IBA hard armor ballistic inserts, the goal is to provide the current and future leadership of Program Executive Office (PEO) Soldier and other stakeholders a better understanding of key events and decisions regarding body armor testing and the impacts of those events and decisions, to inform future decisions.

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## LIST OF ACRONYMS AND ABBREVIATIONS

AFRL	Air Force Research Lab
AP	armor piercing
ATC	Aberdeen Test Center
ATEC	Army Test and Evaluation Command
BFD	back face deformation
CP	complete penetration
DCIS	Defense Criminal Investigative Service
DOD	Department of Defense
DOT&E	Director, Operational Test and Evaluation
ESAPI	enhanced small arms protective inserts
ESBI	enhanced side ballistic inserts
FAT	first article test
FSAPV-E	Flexible Small Arms Protective Vest-Enhanced
FSAPV-X	Flexible Small Arms Protective Insert-X level
GAO	Government Accountability Office
HASC	House Armed Services Committee
IBA	interceptor body armor
IED	improvised explosive device
LAT	lot acceptance testing
LFT&E	Live Fire Test and Evaluation
LTG	Lieutenant General
NIJ	National Institute of Justice
NLECTC	National Law Enforcement and Corrections Technology Center
OSI	Office of Special Investigations
PD	purchase description
PDM	Preliminary Design Model
PdM SPE	Product Manager Soldier Protective Equipment
PEO	Program Executive Office
PM SEQ	Project Manager, Soldier Equipment
PM SPIE	Project Manager Soldier Protective and Individual Equipment

PPE	personal protective equipment
R&D	research and development
RFP	request for proposal
TOP	test operating procedure
U.S.	United States
USCENTCOM	United States Central Command
XSAPI	Small Arms Protective Insert-X level

## I. INTRODUCTION

### A. BACKGROUND

The Government Accountability Office (GAO) issued a report, *Review of Body Armor* (GAO-07-662R) on April 26, 2007. The subject of the report as stated is *Defense Logistics: Army and Marine Corps's Individual Body Armor Issues*. Enclosure I, slide 5 of this document provides a good synopsis of the concerns over body armor from 2005–2007. The concerns were as follows:

- In February 2005, an Armed Forces Institute of Pathology report found that body armor did not provide side protection.
- In April 2005, GAO reported that there were shortages in body armor due to material shortages, production limitations, and in-theater distribution problems.
- In May 2005, Marine Corps recalled body armor because it concluded that the fielded body armor failed to meet contract specifications; public concern raised.
- In November 2005, Army and Marine Corps recalled 14 lots of body armor that failed original ballistic testing, but were accepted by DOD.
- In January 2006, a *New York Times* article reported on the Institute of Pathology report and the recalls, raising public concern again.
- Congress has expressed strong interest in assuring body armor protects ground troops including the amount and level of ballistic protection, testing of body armor before and after fielding, and coordination of requirements and testing between the Army and Marine Corps.
- GAO has conducted prior and ongoing work concerning force protection for ground forces, including truck armor to protect forces from Improvised Explosive Devices (IEDs).
- GAO began a review of body armor as part of its review of protection of ground forces. (Solis, 2007, pp. 5–6)

The *New York Times* article referenced above and written by Michael Moss is titled, “Pentagon Study Links Fatalities to Body Armor” (Moss, 2006). A similar article

was published on the same day in another major newspaper, *The Washington Post*, written by Ann Scott Tyson. The title was a better description of the issue at hand, “Body-Armor Gaps Are Shown to Endanger Troops” (Tyson, 2006). The issue was that gaps in hard armor plate coverage and soft armor coverage of certain extremities resulted in lethal torso wounds that may have been preventable with additional coverage. These gaps ultimately resulted in side hard armor plates and additional soft armor protection for the neck and shoulders.

Shortly after the release of the GAO report, *NBC News* commissioned a private ballistics laboratory in Germany, Beschussamt Mellrichstadt, to do a comparative test between the Army’s interceptor body armor (IBA) system, and a commercial body armor called Dragon Skin. The test was conducted on May 3, 2007, and was the subject of a *Dateline NBC* report that aired on May 20, 2007. The report received a great deal of attention from the public, media, and eventually Congress. The results of the test seemed to confirm that Dragon Skin flexible body armor provided superior ballistic protection compared to the Army and Marine Corps issued IBA.

The *Dateline NBC* report, subsequent Army responses, and resulting Congressional hearings are what ultimately led to Mr. Dean G. Popps, the Acting Assistant Secretary of the Army (Acquisition, Logistics, Technology), to issue a memorandum directing that all first article test (FAT) and lot acceptance testing (LAT) of interceptor body armor (IBA) would be conducted by the Army Test and Evaluation Command (ATEC).

## **B. PURPOSE**

The section entitled Body Armor and Rifles Remain a Popular Media Topic, in the Program Executive Office (PEO) Soldier FY09 historical report, states:

Because these items represent a Soldiers two most important actions; offense and defense, they remain, in BG Fuller’s words, “lightning rods” of media and public attention. For as long as American Soldiers will go in harm’s way, the Army should get in front of the certain bow wave of press reports finding fault with acquisition of these items. (Sahlin, 2010, p. 6)



This statement is as true today for body armor as it was in 2009, and no doubt remains that it will continue to be true into the future.

The purpose of this research effort is to provide analysis and insight for the current and future leadership of PEO Soldier and other stakeholder organizations to assist in future decision making regarding the test and evaluation of body armor.

### **C. RESEARCH QUESTIONS**

The primary research question for this joint applied project is what are the impacts, positive and negative, of the decision to conduct IBA hard armor ballistic insert testing through the ATEC?

The following subsidiary research questions are also addressed:

- What were the reasons for the decision to conduct all IBA hard armor ballistic insert testing through ATEC versus National Institute of Justice (NIJ) certified laboratories?
- Who were important stakeholders in the decision-making process, and what did they have at stake regarding this decision?
- What was the cost of FAT and LAT testing at the NIJ laboratories compared to the cost of testing at ATEC?
- What improvements to body armor testing and unintended consequences emerged in the years following the Poppo memorandum?

### **D. SCOPE**

The scope of this research effort is limited to published works and documented meetings and events. Body armor testing in the United States (U.S.) Army is still an emotional subject for many in the materiel development and test communities. This research effort examines the larger issues, and provides objective analysis. The scope is also limited to hard armor ballistic testing to provide context in answering the research questions. Body armor testing is a complicated process, and therein lies much of the problem. It is difficult to distill the processes and associated disciplines, such as ballistics, to a level easily understood by those without training and experience in these areas. Limiting the technical scope of research accomplishes the purpose without overcomplicating the material, and overwhelming the reader with technical detail.

Additionally, to avoid potentially sensitive and/or classified material, this research effort limits the discussion of specific methodologies and requirements, both test and material, to overview for general understanding and context. In certain instances, test and material requirements require closer examination, as they play a key role in answering the research questions, and subsequent conclusions. In those instances, sensitive and/or classified aspects are not included.

## **II. IBA BALLISTIC INSERT TEST OVERVIEW**

### **A. GENERAL**

The purpose of this chapter is to give the reader a sense of the technical complexity of testing body armor. A test operating procedure (TOP) governs the live-fire testing of IBA ballistic inserts for use by the United States Army and Marine Corps. TOPs are frequently updated to account for procedural changes related to issues that have occurred during testing, the introduction of new test technology (such as fixtures and instrumentation), and new discoveries resulting from previous testing. For the purposes of this research, the TOP referenced in describing hard armor test is U.S. Army Developmental Test Command TOP 10-2-210, dated October 1, 2008—Change 4 with multiple update pages (May 21, 2009, June 16, 2009, September 10, 2009, and April 21, 2010). This document governed hard armor testing during the formative period of transition to testing all body armor at the Aberdeen Test Center (ATC). This TOP was not published until after the first directed test of body armor at ATEC.

Live-fire body armor testing is conducted on the Light Armor Range Complex (LARC) at ATC. All the major components (hard armor, soft armor, and helmets) of personal protective equipment (PPE) are tested at this location using separate ranges outfitted with fixtures and instrumentation specific to the item being tested.

### **B. REQUIRED TEST CONDITIONS**

The required test conditions for hard armor ballistic inserts are described in TOP 10-2-210 (U.S. Army Aberdeen Test Center, 2008) [redacted where necessary and paragraphs deleted for brevity]:

#### **3.3 Test Set-Up.**

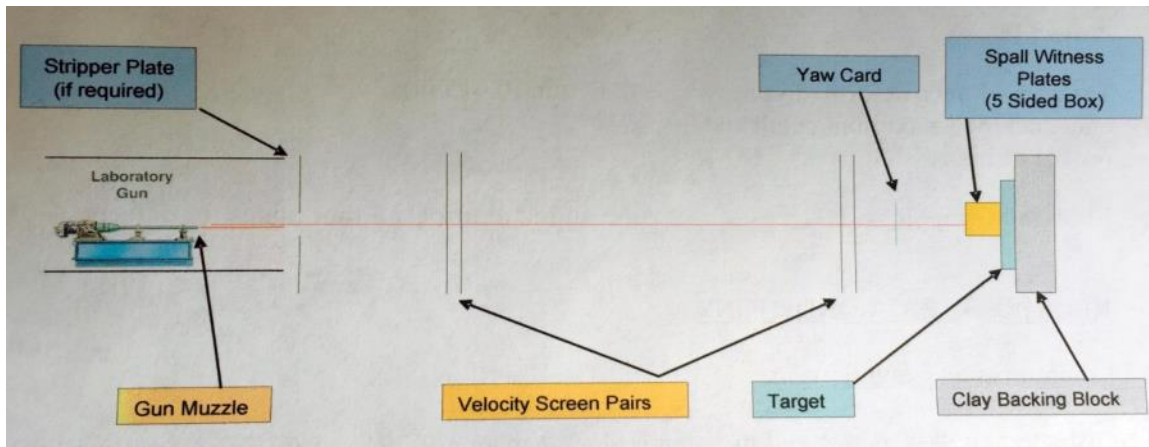
A typical test set-up is shown in Figure 1. Equipment includes the following: 1) a stripper plate to keep sabot petals away from the target and/or instrumentation if required; 2) Doppler radar or velocity screens to measure the penetrator striking velocity; 3) a yaw card or orthogonal high speed video cameras to check the striking yaw of the penetrator; 4) witness plates to identify spall coming off the front of the armor target.

Approved calibration procedures and standards will be used for a instrumentation and documented as part of the test record. Any test shot for which yaw is determined to be greater than 3 degrees will be scored as an unfair hit (results excluded for analysis) and shall be identified as such in the database. Air drag correction calculations will be used to calculate the final striking velocities.

### 3.3.1 Range Preparation.

Test equipment will be arranged per Figure 1, with the test sample mounted [redacted] m from the test barrel being used to fire test rounds. The distance may need to be adjusted for different threat rounds to minimize the possibility of excessive yaw at impact or to achieve desired impact location accuracies.

Figure 1. Typical Indoor Range Setup for Body Armor V50/V0 Testing



### 3.3.2 Test Target Fixture.

The clay backing material, upon which the test sample will be mounted, will be contained by a rigid (i.e. metal) frame with wood backing. The clay backing material packed into the rigid frame with wood backing forms the clay backing block which must be firmly held in place by a suitable test stand. The test stand should several locking degrees of freedom that would allow the clay backing block (with attached target) to be shifted vertically / horizontally such that the entire assembly is within the test barrel's aim point. See paragraph 3.6.2 for details on the clay backing block.

### 3.3.3 Target Obliquity.

The obliquity of the target relative to projectile line of flight shall be set at the required obliquity [with redacted degree of accuracy].

### 3.3.4 Test Projectiles.

Threat projectiles, as specified in the governing requirements documentation, will be hand loaded into cartridges by a qualified ammunition loader during testing. Propellant must be carefully measured and hand-loaded to ensure test rounds fired achieve the desired velocity [redacted] for V50 testing. For V0 testing the test rounds shall achieve the required reference velocity [redacted] for the specific threat projectiles being fired as specified in the governing requirements documentation.

Note: Experience has shown that controlling humidity in the ammunition loading facility is essential for maintaining desired projectile impact velocities.

### 3.3.5 Test Barrels.

Test barrels used to fire the test rounds shall be ANSI/SAAMI unvented velocity test barrels.

### 3.3.6 Test Barrel Fixtures.

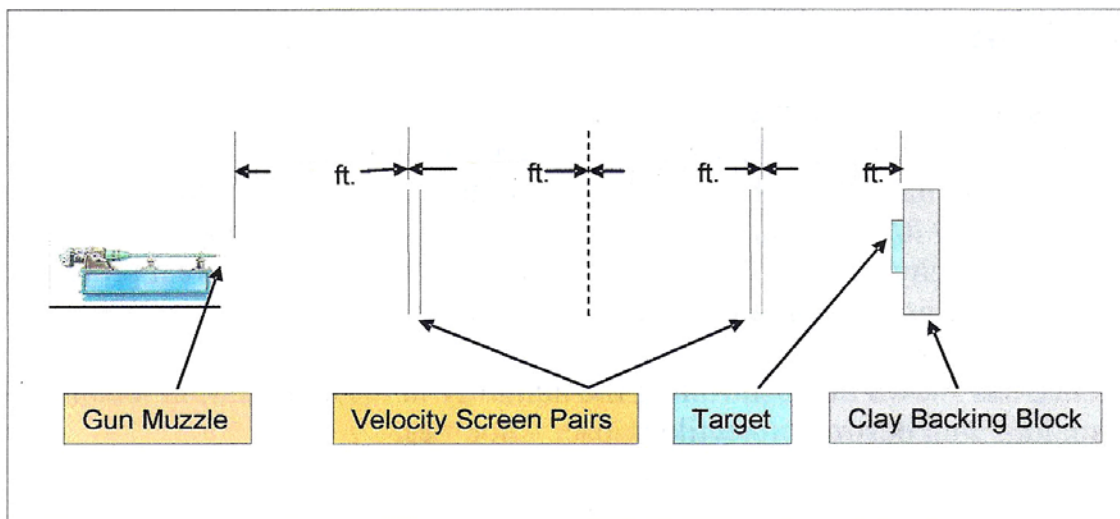
The test barrel fixture used to fire test rounds shall be an ANSI/SAAMI Universal Receiver or similar. The fixture shall be attached to a table or other fixture, with the capability to adjust elevation, with sufficient restraint and mass to ensure accurate targeting for repetitive firing of rounds.

### 3.3.7 Velocity Management.

Two independent sets of instrumentation are required for velocity management. Examples of acceptable types of instrumentation for velocity management include photo electric light screens, ballistic radar, printed make circuit screens, and printed break circuit screens. Fair velocity measurements are individual measurements within [redacted] of each other. Recorded velocity shall be the arithmetic mean of all fair velocity measurements. If chronographs are used with trigger screens, the screens should be centered at [redacted] in front of the armor test sample mounting fixture. Screens must be securely mounted to maintain required position and spacing. Prior to the start of testing, sufficient time must be allowed for instrumentation to warm-up and achieve stability. When using velocity screens to measure striking velocity, two pairs of screens are used in a double-base configuration. This configuration provides redundant

measurements at the same point along the trajectory of the projectile. Instrument velocity measurements will be translated into striking velocity at the target in accordance with procedures set forth in the International Test Operations Procedure (ITOP 4-2-805). Figure 2 provides an example of a typical velocity measurement set-up when velocity screens are used. Note: The velocity screen set-up in Figure 2 is a compromise (from longer distances between velocity screens) to balance velocity measurement accuracy with the need to keep gun muzzle to target distance short enough to achieve adequate shot impact location accuracy.

Figure 2. Typical Velocity Measurement Set-up  
(when velocity screens are used)



3.4 Fluid Conditioning. [Redacted]

3.5 Threat Munitions.

Test samples will be subjected to threat munitions as specified in the governing requirement document (e.g., purchase description, or system specification as applicable). (U.S. Army Aberdeen Test Center, 2008, pp. 3–6)

## C. PREPARATIONS FOR TEST EXECUTION

Preparations for test execution on hard armor ballistic inserts are described in TOP 10-2-210 [redacted where necessary and paragraphs deleted for brevity]:

3.6 Preparations for Execution.

3.6.1 Velocity Curve.

Prior to testing body armor, a propellant charge versus velocity curve shall be established for the combination of threat projectile, barrel, shell casing, and propellant being used. The required velocity shall be within a tolerance level of [redacted]. Prior to the start of record V0 test firing, at least three warm-up rounds will be fired to verify the striking velocity is stabilized within [redacted] of the reference velocity for specific threat projectiles being fired as specified in the governing requirements documentation. Warm-up rounds also confirm impacts are placed accurately enough to provide fair hit locations (see paragraph 4.6) in accordance with the specific test requirements. If there is a pause in testing of more than one hour, additional warm-up rounds will be fired prior to continuing the ballistic test record shots on body armor test samples.

### 3.6.2 Clay Backing.

a. Clay Backing Block. The back of the armor test specimen will be placed against a block of non-hardening, oil based modeling clay [specific type redacted]. The clay material will be in the form of a single block measuring [redacted] in length and width, with a depth of [redacted]. A rigid (i.e., metal) frame will be used to hold the clay and it will have [redacted] removable wood or plywood backing. [Redacted] clay come in bricks of [redacted] each. It requires approximately [redacted] bricks to fill a [redacted] rigid frame. An aluminum frame with the plywood backing weighs approximately [redacted] without the clay and approximately [redacted] with the clay.

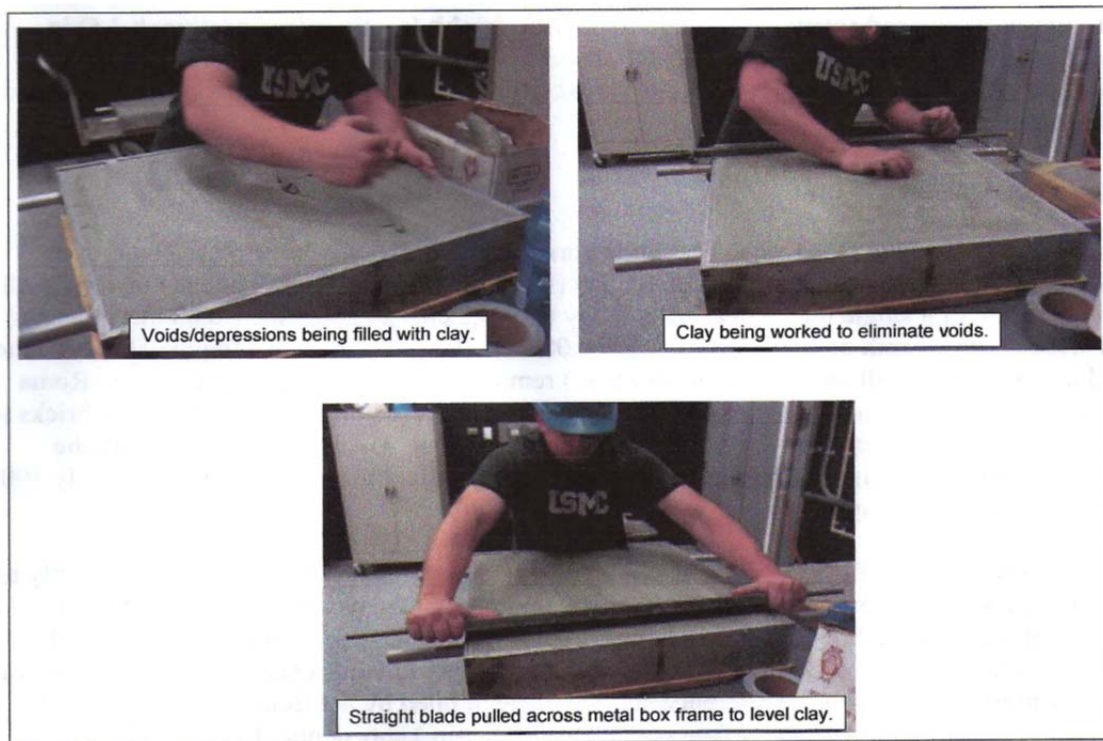
b. Preparation of the Clay Backing Block. The clay bricks must be worked thoroughly to remove any voids to form one solid block with a smooth, flat front surface for accurate and consistent measurement of depression depths. After the clay has been worked into the rigid frame, the clay backing block shall be X-rayed to verify that no voids exist. The front surface of the clay must be even with the reference surface plane defined by the front edges of the rigid frame to obtain an original flat surface with a [redacted] clay depth. Leveling devices of sufficient length shall be used to ensure the reference surface is established using the edges of the clay box frame as index points. Figure 3 illustrates the process described here.

Note: Forming the clay into the rigid frame is easier if the clay is heat conditioned. A pneumatic or electric tamper may be used to condition the new clay when it is placed in the rigid frame. The clay shall be replaced at least annually or as required if spall becomes embedded in the clay or a round passes through the clay.

c. Preparation of Additional Clay Backing for Non-Planar Body Armor.

(1) For non-planar body armor (i.e. curved rigid plates) that do not make full contact with the flat clay surface, additional clay backing material shall be built up on the front surface of the clay block to conform to the shape of the non-planar armor. The added clay shall be conditioned at the same temperature as the clay backing material used in the clay block. Molds are used to shape the clay used for the built-up area on the front of the clay block (the area under the curved ceramic armor plate). The curvature of the molds match the dimensions specified in the reference drawings contained in the body armor purchase descriptions. Temperature conditioned clay is placed in the mold cavity and tamped as the mold is filled to remove any voids and to form one solid block of clay. Once the mold is filled, a taught wire on a low frame is used to cut the clay even with the top surface of the mold.

Figure 3. Process Used to Prepare the Clay Backing Pack



Any significant voids/tears at the cut clay surface are filled and a taught wire is used again to cut the clay even with the top surface of the mold. The clay form is then removed from the mold.

(2) The ceramic armor test plate is now placed into the empty mold cavity and a flat metal plate is placed on the ceramic armor plate such that the



metal plate touches the corners of the ceramic armor plate. Next, guide plates attached to the mold sides are raised until they are in contact with the metal plate on top of the ceramic armor plate, and the guide plates are locked in place. The edges of the guide plates now establish a plane [redacted] above the corners of the ceramic armor plate. At this point the flat metal plate is removed, and the curved clay form is placed against the rear surface of the ceramic armor plate and rolled to press the clay firmly against the ceramic armor plate. The edges of the clay form are now trimmed flush with the edges of the ceramic armor plate. The taught wire is then drawn across the guide plates on the mold to cut the clay form at the proper thickness. The clay form is now custom fitted for that specific ceramic armor panel, and is removed for temperature conditioning as necessary.

(3) The process for mounting the clay form to the clay backing block starts by pressing one edge of the flat side of the clay form against the front side of the flat clay block. The clay form is then laid out against the clay block (in a forward rolling motion), with the clay form being pressed against the clay block as contact between the two occurs. This is done after the clay block has passed the drop test trials that confirm the clay consistency (see discussion in the paragraph e. below). A thin strip of temperature conditioned clay material is then pressed along the edge of the curved clay form at the surface of the flat clay backing pack to reinforce the joint area. At this point the clay backing is ready for the body armor to be mounted for ballistic testing.

d. Clay Conditioning. The clay will be placed in the rigid frame and worked thoroughly to remove any voids prior to being placed in the conditioning chamber. The clay backing block for each test will have been conditioned at a uniform temperature to enable the clay to pass the drop test. Additional clay material will be simultaneously conditioned for use in filling depressions created by the drop testing and building up areas to fit non-planar body armor test samples. An alternate conditioning method that may be used in conjunction with temperature adjustment is cold working. During cold work, mechanical energy is imparted to the clay by some means (i.e. a pneumatic tamper, a mallet). This will soften the clay in order to allow it to pass the drop calibration test.

e. Clay Consistency Measurement. The consistency of the clay backing material will be measured via a drop test prior to using the clay block for a sequence of ballistic tests. Unless otherwise specified differently in the governing system requirements documentation, the clay consistency shall be such that a depression of [redacted] in depth is obtained when a [redacted] cylindrical steel mass (see Figure 4.), [redacted] in diameter and having a hemispherical striking end, is dropped from a height of [redacted] onto the flat clay surface. 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 (see Figure 5.). Three or more individual drop trials (example show in Figure 6.) shall be executed. The edge of each dimple created by the impact shall be at least [redacted] from an edge and the distances between impact dimple centers shall be at least [redacted.] Drop test impact locations should not be near planned test shot impact locations. The depressions will be measured using the original flat surface as measurement reference with a device capable of [redacted] accuracy, using a bridge that rests on two parallel sides of the clay backing block rigid frame. Each drop test depression is required to meet the [redacted] depth criteria. Before each measurement, the measuring device will be zeroed using the edge of the rigid frame to reference the original flat surface of the clay. The drop test indentations will be filled with temperature conditioned clay prior to use of the clay block for ballistic tests. In the event the clay backing material drop test results do not meet the depression depth criteria, the clay backing shall be repaired with temperature conditioned clay and the drop trials shall be repeated after adequate reconditioning of the clay backing block. For example, if the failure of the drop test was due to one or more shallow depressions, then clay backing block should be heated uniformly, or cold worked, or some combination of the two methods. On the other hand, if the clay drop test failure occurred due to one or more deep depressions, the clay backing block should be allowed to cool uniformly. If, after reconditioning, the clay backing does not meet the drop test depression criteria on the second attempt, the clay backing shall be replaced with another clay backing block and the clay consistency measurement process shall be repeated. Measurement of clay consistency is not required again post-test; however, a 45-minute time limit will be imposed on the use of the clay block starting from the impact of the last passing pre-test drop until the impact of the last record projectile against the armor under test.

Figure 4. Cylindrical Steel Mass Used for Drop Tests on Clay



Figure 5. Plastic Guide Tube Used during Drop Tests to Verify Clay Consistency

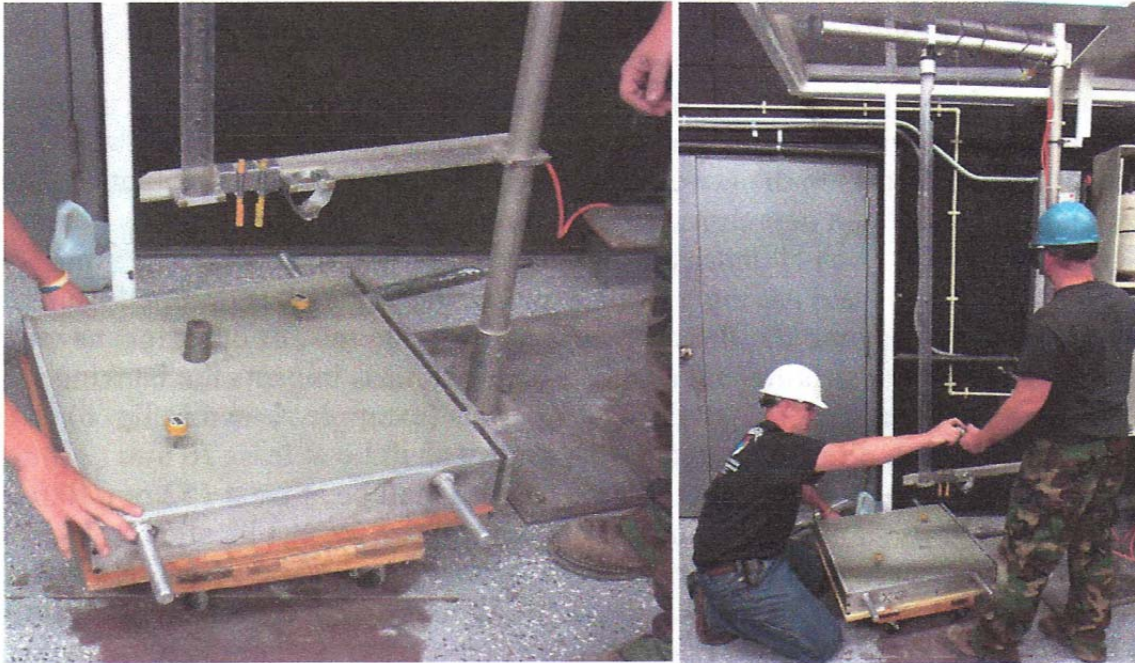
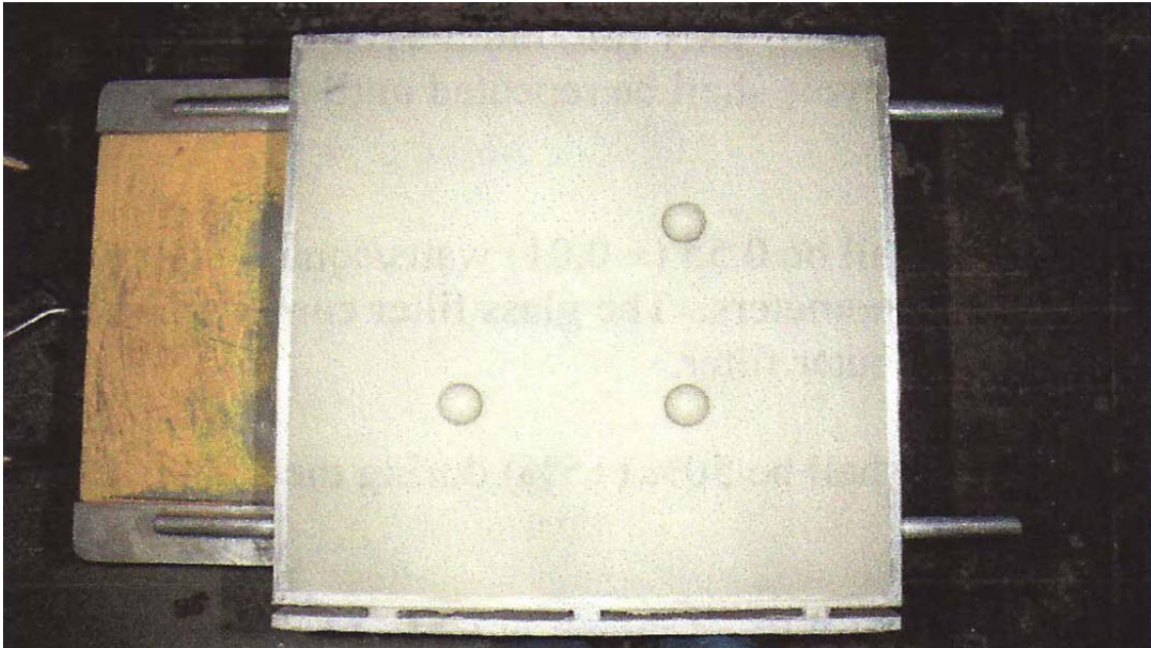


Figure 6. Typical Drop Test Indentation Pattern in Clay Backing Material



#### 3.6.3 Test Sample Accountability.

All test samples will be documented in an armor custody tracking system, which will be updated on an as needed basis. This system will provide documentation accurately tracking the location of all test samples from the time of receipt until final disposition. The armor custody tracking system will also document the manufacturer and configuration of each test sample.

#### 3.6.4 Grouping and Randomization.

When applicable, such as for source selection or some types of “Blind Testing,” test grouping and randomization concepts will be followed to eliminate any bias in test conditions. (U.S. Army Aberdeen Test Center, 2008, pp. 6–11)

### **D. TEST PROCEDURES**

Test procedures for testing hard armor ballistic inserts are described in TOP 10-2-210 (U.S. Army Aberdeen Test Center, 2008) [redacted where necessary and paragraphs deleted for brevity]:

#### 4.1 Ballistic Test Requirements.

Body armor test samples must successfully complete both V0 and V50 ballistic performance test series. The V0 test requires the body armor sample to consistently demonstrate ballistic resistance to perforation and excessive blunt force trauma (represented by the back face deformation following impact of a threat round). The V50 test series is designed to provide a statistical approximation of resistance to penetration performance. V50 is the velocity at which there is a 50% probability of a threat round completely penetrating the body armor sample. Additional testing should be conducted to ensure that hard body armor plates do not exhibit shatter gap phenomena.

(Author note: The V50 test series is only required for First Article Testing (FAT) for design qualification. It is not required once a design is qualified; a contract is executed between the Government and a vendor; and Lot Acceptance Testing (LAT) is commenced. The V50 portion of test procedures will not be included as it is not crucial to gaining an understanding of the material.)

#### 4.2 Test Sample Mounting.

Immediately prior to testing, the subject test sample will be visually inspected. The hard armor plate is then inserted into the carrier (vest or shoot pack), the carrier is closed, and the armor plate is positioned so that the lower edge of the armor plate contacts the bottom of the carrier. Next, to define a clearly visible fair impact area of the target, the outline of the armor plate (outer edge) is traced onto the front of the carrier along with the ballistic test fair impact boundaries specified in the governing system requirements documentation. After all target markings have been made, the plate is then removed (environmentally conditioned if the protocol requires) and fitted with a rubber edge strip which serves as the fair hit witness for the edge shot (see section 4.6 for detail). The plate will then be placed back inside the carrier, the carrier closed, and the plate aligned with the previously marked armor plate outline. To prevent clay from adhering to the fibers on the rear surface of the vest or shoot pack, silicone lubricant may be applied to the rear surface of the vest or shoot pack. Samples will then be securely strapped onto the clay block mounting frame, prepared as described in paragraph 3.6.2. Figure 7 shows a typical vest sample properly mounted for test execution (Note: most tests are conducted using shoot packs vs. actual IBA vests). The armor test sample will be securely strapped in a position that will provide the required target impact obliquity and aim point for each shot. The straps used to secure the armor sample to the clay box shall be placed so that the straps are at least [redacted] from the aim point of the target if possible (far enough away to prevent spall from the front surface of the armor from damaging the straps. The clay



block will be rigidly held by a suitable stand capable of withstanding the shock force of the threat round impact. Post-test, surface areas of the clay backing that may have been in contact with the silicon spray applied to the vest or shoot pack will be removed to prevent contamination of the clay backing used for subsequent testing.

Note: When shoot packs (ballistic test surrogate pouches made out of the soft fragmentation material) are utilized with hard armor panels in lieu of tactical vests, the shoot pack should be positioned such that approximately [redacted] of shoot pack material extends beyond the intended impact point on the hard plate. When shoot packs are configured to represent the size and shape of tactical vest panels, it is not necessary to have [redacted] if shoot pack material extend beyond the intended impact points. The shoot pack configuration is typically described in the purchase description for the armor plates.

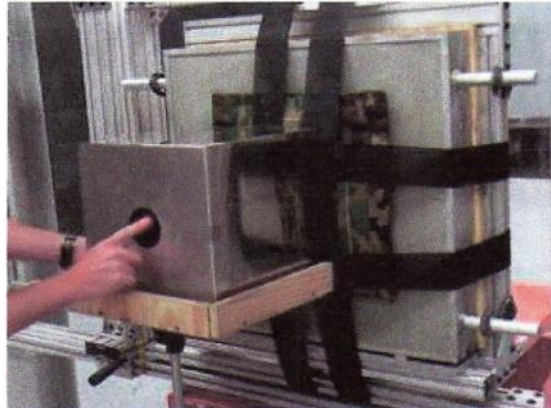
Figure 7. Test Sample Mounted on a Clay Block for Ballistic Testing



#### 4.3 Spall and Debris Determination.

Witness sheets for determining potential injuries to the wearer will be mounted around the front of the armor test sample. The witness sheets shall be [redacted] in size. The witness sheets should be assembled into a box configuration with the open ended side placed within [redacted] from the front of the test armor sample (see Figure 8). A hole at least [redacted] in diameter will be made in the front sheet to allow for undisturbed passage of the projectile. The projectile impact point should be no closer than [redacted] and not further than [redacted] 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.

Figure 8. Aluminum Spall Plate Box Placed in Front of the Target



#### 4.4 Projectile Yaw Determination.

Projectile yaw will be checked for each firing by perpendicular high-speed video cameras or by means of a yaw card placed approximately [redacted] in front of the target location perpendicular to the shot line. After firing, yaw cards will be overlaid with a GO/NO GO template showing the profile for a [redacted] yaw projectile. Any round for which yaw exceeds [redacted], as evidenced by the round passing through the yaw card outside of the acceptable template borders, shall be considered an unfair hit.

#### 4.5 Partial and Complete Penetration.

The definition of a complete penetration and a partial penetration are as follows (see Figure 9 for illustrations):

##### 4.5.1 Complete Penetration (CP).

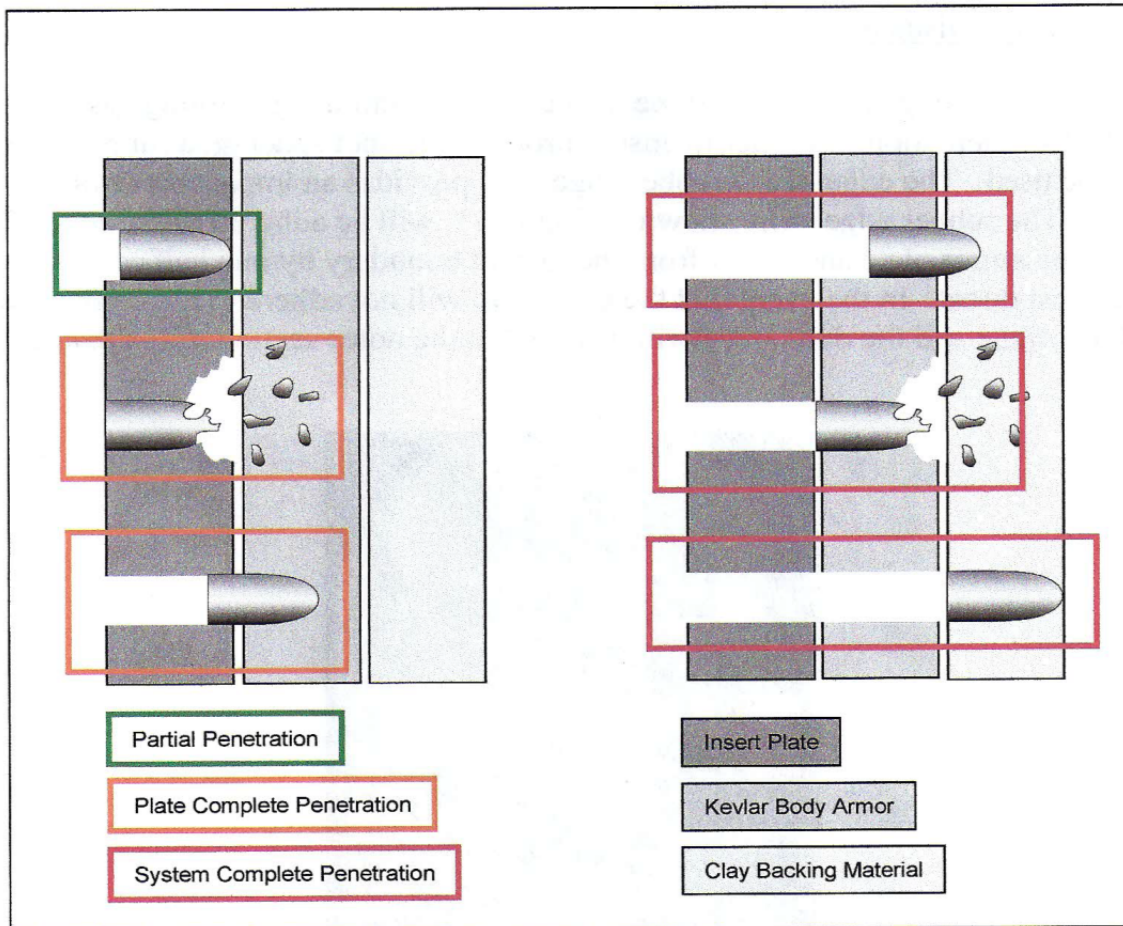
The complete penetration of an armor sample or panel occurs when a test bullet, or fragment of the bullet or a fragment of the armor sample itself, is present in the soft ballistic shoot pack, or creates a hole which passed through the armor and/or soft ballistic shoot pack. If a bullet or fragment can be seen in or passes through the rear panel of the vest or shoot pack, it is a complete penetration. There are two categories of CP, a plate CP in which the armor plate is completely penetrated, and a system CP in which the entire body armor system is completely penetrated (armor plate and carrier/shoot pack). A system CP by definition will also always be a plate CP; however, a plate CP in which the round does not completely perforate the carrier/shoot pack will not be considered a system CP. This is an important distinction particularly when the item under test is a removable armor panel or plate and not the entire system. Paint or fibrous materials

that are emitted from the back of the test specimen and rest on the outer surface of the clay backing are not considered complete penetrations.

#### 4.5.2 Partial Penetration (PP).

Any impact that is not a complete penetration is considered a partial penetration.

Figure 9. Illustrations of Partial and Complete Penetrations



#### 4.6 Fair Hit Requirements.

a. A test shot is considered a fair hit if it impacts the test sample: at an angle of incidence (target obliquity) no greater than [redacted] from a line normal to the front surface (facing the line of fire) of the clay backing block; a projectile yaw of [redacted], no closer to the edge of the ballistic panel than the required shot-to-edge distance, and no closer to a prior hit than the required minimum shot-to-shot distance. In addition, for the V0 test series the measured velocity must be within [redacted] of the required



velocity for the specified threat round being fired (or as otherwise specified in the governing requirements documentation).

b. For rounds impacting the test sample that fall outside of the required velocity, it will still be considered a fair hit if either of the following conditions apply (unless otherwise specified by the applicable system requirements documentation):

(1) The required velocity was less than the required minimum velocity range for the threat round fired and resulted in a complete penetration or exceeded BFD requirements.

(2) The required velocity was greater than the maximum required velocity for the threat round but did not produce a complete penetration or exceed the BFD requirements.

#### 4.6.1 Shot-To-Edge Distance.

The minimum shot-to-edge distance shall be in accordance with the governing system requirements documentation. In order to ensure proper edge shot spacing, a rubber edge strip witness will be used. The edge of the rubber edge strip provides an impact signature if struck by the projectile. The rubber edge strip, shown in Figure 10, will be adhered to the edge of the strike face of the armor plate and offset from the fair hit boundary by [redacted] of the test threat. In the event that the edge strip will not adhere to the hard armor plate the test will continue and the deficiency will be noted in the notes section of the data collection sheet.

#### 4.6.2 Shot-To-Shot Distance.

The minimum shot-to-shot distance shall be in accordance with the governing system requirements documentation.

Figure 10. Hard Armor Plate with Rubber Edge Strip



#### 4.7 Firing Sequence.

Consideration should be given to ordering shots to address specific test issues as efficiently as possible. Locations that should be considered are edge hits, center/crown shots, and shots into areas where x-ray data may indicate potential weak points.

#### 4.8 V50 Ballistic Limit: [Deleted].

#### 4.9 V0 Ballistic Performance Test.

The objective of the V0 ballistic performance test is to fire projectiles at a constant velocity (as specified in the system requirement documents) to demonstrate that the armor samples provide specified protection against required threats (i.e., all impacts result in partial penetrations and the specified maximum back face deformation (BFD) is not exceeded). Multi-hit performance is also demonstrated during this test phase by firing multiple hits on individual armor test plates (the number of impacts to be conducted on a single armor sample shall be based on the system requirement documents).

##### 4.9.1 Required Test Conditions.

The number of V0 test shots to be conducted for each threat projectile, protective insert size, and temperature/environmental condition shall be based on the system requirement documents. Consideration should be given to design a test matrix that will allow a comparison of 1st shots (on a plate) versus 2nd shots, and edge shots versus shots in the center area of a plate. Described below is a method commonly used when a minimum number of shots are conducted to assess V0 performance. A more rigorous test approach should be tailored as required if the system requirement documents specify required V0 performance metric and/or if additional target resources are available to increase confidence in V0 performance.

##### 4.9.2 V0 Limited Shot Method.

###### 4.9.2.1 Obliquity and Number of Shots.

Two shots are fired at the specified V0 velocity at worst case obliquity for each environmental condition to be tested. A third shot is fired at [redacted.]

#### 4.9.2.2 Performance Assessment.

The test results are evaluated to determine if the test sample meets the V0 ballistic performance requirements. Typically, V0 ballistic performance requirements are considered met if no complete penetrations (perforations) occur during this test phase and the maximum depth of BFD meets the criteria in the governing system requirements documentation.

#### 4.9.3 Back Face Deformation (BFD).

##### 4.9.3.1 Back Face Deformation Limit.

The BFD caused by ballistic impacts on the test samples has the potential to inflict blunt force trauma to the wearer, which can contribute to injury, incapacitation, or death. Current guidance contained in governing system requirement documentation establishes a BFD limit to protect Soldiers wearing the body armor from excessive blunt force trauma due to BFD. For evaluation purposes the rounding of BFD measurements will be in accordance with the governing system requirement documents.

##### 4.9.3.2 Metrological Definition of BFD.

a. Ideal Measurand Definition: The maximum distance length BFD (approved by ATC on December 9, 2009) 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. The reference direction is defined to be perpendicular to the surface of the rigid (metal) frame containing the clay backing material, with that surface defined as at least-squares plane fit through the front surface (i.e., facing the line of fire) of the clay backing block. The surface of the clay backing material, at a given location, is defined to be the arithmetic average height over a centered [redacted] square oriented perpendicular to the reference direction. The BFD surface is the clay surface obtained a short time after the impacted body armor is removed and with the clay backing block in the vertical (as shot) orientation and position.

b. ATC Daily Practice: [Redacted].

##### 4.9.3.3 Measurement of BFD.

a. Due to the irregularities in the shape of the post impact BFD surface in the clay backing material, it can be difficult to accurately identify, by observation, the point of deepest indentation. In addition, it is not the most accurate method to directly measure the maximum distance length BFD by mechanical means because the reference point for the maximum distance length BFD located on the original, undisturbed curved surface of the backing material is destroyed during the ballistic event.

b. Given (a), the use of commercially available laser scanning instrumentation that can accurately scan and measure the entire surface profile of the undisturbed backing material and the BFD impression is required. [Remainder redacted]. (U.S. Army Aberdeen Test Center, 2008, pp. 16–27)

## **E. TEST OVERVIEW CONTEXT**

In reviewing the procedures for IBA ballistic insert live-fire tests, it does not take long to realize that it is a complicated and methodical process. The process previously outlined is only part of a much larger process of testing body armor systems. This overview provides important context when analyzing the events that led to changes in the way the Department of the Army tests body armor. In the simplest of terms, the proper testing of body armor requires more than just shooting it with a projectile, and ensuring that the projectile did not penetrate the armor system.

Although beyond the scope of this research, it is worth mentioning the requirements aspect of testing. The purpose of testing is to determine whether a particular materiel solution meets validated military requirements. Requirements are determined by the user community (capability developers), and outlined in what the TOP refers to as the “governing system requirements documents.” The system must meet all the requirements (often in the form of subtests) to pass the overall test. A good example relating to body armor is that a system may meet the ballistic requirement (stop the bullet), but not meet the weight requirements. The ability to stop a bullet is great, but it is not useful to the military if the body armor is so heavy that the wearer loses critical mobility. This important aspect of the defense acquisition process is often overlooked by those leveling criticism at the process.

### **III. RELEVANT CHRONOLOGY AND DATA**

#### **A. INTRODUCTION**

A chronological examination of the key events outlined in this chapter shows how the testing of body armor came to the attention of the public, became an issue for the Army and Congress, and how the Army subsequently addressed it. Additional data provides a foundation for analysis to answer primary and subsidiary research questions.

#### **B. ARMY EVALUATION OF DRAGON SKIN, MAY 2006**

The Project Manager, Soldier Equipment (PM SEQ), PEO Soldier conducted a test of the Pinnacle Armor SOV 3000, also known as Dragon Skin, body armor system from May 16–19, 2006. The test was based on FAT protocols and held at H. P. White Laboratory, Incorporated in Street, Maryland. H. P. White is a world-renowned and National Institutes of Justice (NIJ)-certified ballistics laboratory. The test was conducted at the request of the House Armed Services Committee, and Senator Kay Bailey Hutchinson, a Republican from the state of Texas (House Armed Services Committee, 2007, p. 13).

#### **C. FINDINGS FROM GAO-07-662R, REVIEW OF BODY ARMOR**

The concerns that prompted this GAO audit are covered in the background of this joint applied project. The auditors examined requirements in terms of ballistic protection required for theater, and whether deploying Soldiers, Marines, and DOD civilians were issued the proper body armor. They also examined how the Army and Marine Corps tested body armor. Finally, they examined whether the Army and Marine Corps shared information regarding research, development, and the testing of body armor.

The report summary states:

- are currently meeting theater ballistic requirements and the required amount needed for personnel in theater, including the amounts needed for the surge of troops into Iraq;
- have controls in place during manufacturing and after fielding to assure that body armor meets requirements; and

- share information regarding ballistic requirements and testing, and the development of future body armor systems, although they are not required to do so. (Solis, 2007, p. 4)

The second bullet refers specifically to testing. The auditors found that:

- The Army and Marine Corps have controls in place during manufacturing and after fielding to assure that body armor meets requirements. The Army and the Marine Corps conduct quality and ballistic testing prior to fielding. Lots are rejected if the standards are not met. (Solis, 2007, p. 16)

It was noted that the Army ESAPI lot failure rate for 2006–2007 was only 3.32 percent. The report also cited efforts by the Army and Marine Corps to monitor armor performance in the field (Solis, 2007). Finally, the report states that the, “DOD has a standard methodology for ballistic testing of the hard body armor plates, but not for the soft body armor vest. Currently, DOD’s Director, Operational Test and Evaluation (DOT&E) office is developing a standard methodology for ballistic testing of the soft body armor to eliminate discrepancies in testing methodologies” (Solis, 2007, p. 5). Prior to 2008, the test methodology was included in the purchase description (PD), a document developed and maintained by the materiel developer.

#### **D. THE DATELINE NBC REPORT**

*Dateline NBC* commissioned a “side-by-side” test of IBA and Dragon Skin body armor conducted on May 3, 2007 at Beschussamt Mellrichstadt, a ballistics laboratory in Germany. The 9:52-report detailing the results of the test aired on May 20, 2007. The report was given by NBC reporter Lisa Myers and included expert commentary from the Honorable Philip E. Coyle III, former DOT&E and General (Retired) Wayne A. Downing, former Commander, United States Special Operations Command and Deputy National Security Advisor under the Bush Administration.

The report suggested that Dragon Skin body armor was superior to the IBA that the Army characterized as the finest body armor in the world. The overall test consisted of three subtests. The first two tests were “side-by-side” comparisons of IBA and Dragon Skin. Test 1 used armor piercing ammunition, and Test 2 used armor piercing incendiary ammunition. The third test was only conducted on the Dragon Skin armor and used an

armor-piercing round characterized as composite in nature. All subtests were conducted in ambient firing conditions.

The results of Test 1 were IBA stopped the first three rounds, and was completely penetrated on the fourth round. The first two BFDs were acceptable, and the third was high. Dragon Skin stopped a total of six rounds, and all BFDs were within the acceptable range. The results of Test 2 were IBA stopped four rounds, all with BFDs in the acceptable range. The fifth round was stopped, but had a high BFD. The sixth round was a complete penetration. Dragon Skin stopped all six rounds, and all BFDs were within the acceptable range. The results of Test 3 were Dragon Skin stopped all three rounds of the composite armor piercing ammunition, and all BFDs were within the acceptable range (NBC News, 2007).

#### **E. THE ARMY RELEASES RESULTS OF THE DRAGON SKIN TEST**

The results of the this test were released by the Army on May 21, 2007 in response to the *Dateline NBC* report that included a “side-by-side” test of Dragon Skin and IBA.

A briefing released by PM SEQ (see Appendix A) provided the following background information:

- Since the inception of the IBA program in 1999, Pinnacle Armor has never responded to a full and open competition.
- Test was conducted using enhanced small arms protective inserts (ESAPI) and enhanced side ballistic inserts (ESBI) first article test protocols.
- Prior to fielding, all ESAPI designs must pass a robust FAT protocol under a variety of environmental conditions including high (+160° F) and low (-60° F) temperature, diesel fuel, oil, saltwater immersion, and a 14-hour temperature cycle from -25° F to +120° F.
- Pinnacle SOV 3000 level IV Dragon Skin suffered catastrophic failure of the ceramic disc containment grid adhesive at -60° F, 120° F and 160° F.

- SOV 3000 design is sensitive to extreme temperatures and failed to maintain ballistic integrity at temperatures below summer ambient in OIF.
- This failure mode caused discs to delaminate and accumulate in the lower portion of the armor panel, thus resulting in exposing the spine, vital organs, and critical blood vessels to lesser ballistic threats.
- Pinnacle SOV 3000 level IV Dragon Skin vests suffered 13 first or second shot complete penetrations, failing 4 of 8 initial subtests with ESAPI threat baseline 7.62x63mm APM2 Armor Piercing (AP) ammunition. (Project Manager Soldier Equipment, 2007, pp. 2–3)

Brigadier General Mark Brown held a press conference at the Pentagon that coincided with the release of the PM SEQ briefing. Brown summarized the results of the test for the press in attendance by stating: “The Pinnacle armor was subjected to the same tests Interceptor body armor goes through, first being X-rayed and analyzed and then undergoing a series of live-fire tests,” (Wood, 2007).

Brig. Gen. Brown also noted that the Dragon Skin vests are significantly heavier and thicker than the Interceptor vests. Dragon Skin vests in size extra large are 47.5 pounds and 1.7 to 1.9 inches thick; the Interceptor vests in size large, which offer an equivalent coverage area to the extra large Dragon Skin vests, weigh 28 pounds and are 1.3 inches thick. (Wood, 2007).

“Bottom line is it does not meet Army standards,” the general said of the Pinnacle body armor (Wood, 2007).

#### **F. H.A.S.C. HEARING NO. 110-58, JUNE 6, 2007**

The House Armed Services Committee called a hearing (110-58) to address questions raised by *NBC* in the *Dateline NBC* report, as well as what were viewed as contradictory presentations by the Army both before and after the show aired.

The hearing occurred on June 6, 2007. The key participants were:

- Ike Skelton, Representative from Missouri, Chairman
- Duncan Hunter, Representative from California, Ranking Member, Committee on Armed Services



- Honorable Philip Coyle, former DOT&E, Office of the Secretary of Defense (Witness)
- Murray Neal, Founder and CEO, Pinnacle Armor, Incorporated (Witness)
- Lieutenant General (LTG) N. Ross Thompson, Military Deputy to the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (Witness)

The transcripts of the proceedings including full statements and exhibits are over 200 pages in length. The statements of the key participants provide the best data for analyzing the proceedings.

The following is the opening statement by the Honorable Ike Skelton, Committee Chairman, at the House Armed Services Committee (HASC) hearing on DOD Body Armor Programs, held on June 6, 2007:

The jurisdiction of our committee is such that we cover a wide range of issues with the significance of other issues relative to the importance of providing the best protection possible for our men and women serving.

Our committee has been in the forefront providing necessary, nonpartisan oversight on the full spectrum of protection matters. Since 2001, our committee has authorized over \$5 billion to help the services procure body armor and expand that industrial base.

Effective body armor is the baseline component to force protection. It is critical promoting survivability of military personnel serving in combat environments.

Recent media reports have suggested that we may not be providing the best body armor available. NBC News commissioned an independent round of limited ballistic tests that compared current body armor to another system called Dragon Skin that was produced by Pinnacle Armor. NBC indicates the results from these tests favor Dragon Skin over the current military Interceptor Body Armor (IBA).

NBC tests contradict the information provided to this committee by military and Department of Defense (DOD) officials in numerous briefings and hearings. Most recently, the Army indicated to this committee in a closed briefing on May the 24th that they conducted first article live-fire ballistic tests on the Dragon Skin system in May of 2006. These tests also included environmental constraints such as subjecting the vests to extreme temperatures and fluids to ensure the vests would hold up to conditions that the troops might find in the field. The Army tests

engaged in showed Dragon Skin failed to meet the military body armor specifications.

We are here today to gain a better understanding of our facts and to reassure our constituents that our goal remains that we are ensuring their sons and daughters are being provided the best body armor available. (House Armed Services Committee, 2007, pp. 1–2)

The following quote is the portion of Duncan Hunter’s statement pertaining directly to Dragon Skin, IBA, and force protection (the opening portion of his statement has been omitted for brevity and relevance):

I heard about the Dragon Skin either from a soldier or a marine who had heard about it from a family member or from a Web site; I can't remember exactly which one. But I called our staff here and said, “Bring these guys in; let's see what they've got.”

Your guys, Mr. Neal, came in and met with the Armed Services folks; and our guys called up the Army and said, We wanted you to test this, to which the Army responded, We have already got a test laid on. And I have got a letter here, but apparently they also responded to Mrs.--to Senator Hutchison, who had made a request to have Dragon Skin tested.

The Army said, We are going to test it; and the Army did test it.

Now, I have looked at the tests today, the tests that they did, and they said they did these tests with you folks present at the test. Showed a lot of penetrations. I saw after that--the back-and-forth where you felt that you had unfair tests. You shot at the edges, and other things were done that you think allowed these penetrations to take place, but there are fairly substantial penetrations in that armor.

Now I understand that you then went to a German tester and you got a test done that indicated that Dragon Skin does great. A couple of things: I think that there is always a massive bureaucracy in the Department of Defense. We all know that, and we in Congress who helped to create that bureaucracy with our rules and regulations--many of which attend the competitive arena and accommodate the competitive arena, which you wouldn't have otherwise.

But we also have the ability to move very quickly, and often there is a response, a bureaucratic response. It builds up. That does impede getting equipment to the battlefield quickly.

I don't know which category this falls in, but I do know this: The Army reported back to us, after we told them we wanted them to test this, that they did test this and they told us the results and they showed penetrations.

I know there are lots of folks, families paying \$5K apiece for this body armor. I can tell you there are five members of this committee who have their kids at one time or another wearing body armor in theater, either Iraq or Afghanistan. And that includes this Member of Congress. In fact, as we sit here today, my son is wearing, on his third tour, the body armor that is issued to him by the U.S. Marine Corps, the same stuff that everybody else is using.

So what I would like you to address today is whether or not you folks have come to closure with the Army on doing a test.

The Army informed us that it took five months to get a set of Dragon Skin or enough sets from you guys to get the test done, but that ultimately it was done with you folks attending the test. And I want to know what your take is, if you stood there and watched them shoot this stuff and the bullets went through it, if you think the test was faulty. If it wasn't faulty, why didn't you speak up, or let us know that you thought you had a faulty test? And did you talk to the Army about it? And then we are going to ask the Army if there is an opportunity to take this stuff out and shoot it and see if it works.

And, Mr. Coyle, as a guy who has worked on lots of things like the B-2 bomber and lots of other very complex systems, it seems to me that this shouldn't require rocket science to tell if a bullet goes through a certain substance. We ought to be able to figure this out.

So I hope that we finish this hearing off by coming to some kind of an agreed-upon third-party test, Mr. Chairman that will help to resolve this issue. And I think we need to move egos and personalities and cross-currents aside.

And, Mr. Neal, I saw some pretty strong statements by you after I asked our guys to have you come in and show us what you had. They wrote a report that said that they saw what the Army had seen on this test. You had a couple of strong statements about them to the effect that they were part of a--part of the problem.

And I can just assure you that the guys that we have got working, the men and women that we have working on force protection, have had lots of occasions when they brought in the Army and the Marine Corps, and this committee has brought in the Army and the Marine Corps, and we have

put enormous pressure on them when they have not provided what we thought was needed to be provided in terms of force protection.

If you want to go to sleep, get some late night C-SPAN, you can run some of the old tests or some of the old C-SPAN of hearings that this committee has done on force protection with respect to Humvees, up-armor, and jammers and the like.

So we are interested in making sure we get the right protection for our troops. But the big question here is, how could the Army's test--which shows complete penetration, and I have looked at it--be so different from this test that you folks took with this independent agency in Germany? I would like to see those tests reconciled.

So, Mr. Chairman, thank you for holding this hearing today. I think it is absolutely timely, and I look forward to seeing how these, how the Army tests and the Dragon Skin tests stack up. And if you've got the--if you've got the real McCoy, Mr. Neal, we want to get it out there fast. (House Armed Services Committee, 2007, pp. 3-5)

The following is the statement by Mr. Murray Neal, CEO of Pinnacle Armor:

Mr. Chairman, honorable members of the committee. Thank you for the opportunity to come before you today to give you the facts and information needed to make sure that as long as we have American men and women in harm's way in Iraq, Afghanistan, or anywhere else, they will have the best possible body armor production available.

My name is Murray Neal, and I am the founder and chief executive officer of Pinnacle Armor, a company in Fresno, California. You have my written testimony addressing all of the concerns of testing, protocol issues, and my request for a fair and honest, unbiased hearing.

The bottom line for me, and I would say for the American people, is that Dragon Skin has been verified as the best body armor in the world by testing throughout the U.S., as well as in other allied nations and beyond. Therefore, all we ask is for a third-party independent testing of Dragon Skin at a facility that has Office of the Secretary of the Defense Department Testing and Evaluation oversight.

Please note that the only testing facility where the Dragon Skin has allegedly failed happens to be the only place where the current Interceptor has always passed, which is why we are seeking a neutral and independent party.

That testing facility where the Interceptor always passes is the H. P. White Laboratory, which is primarily the Army's go-to lab for the testing of

body armor. And I believe that any future tests at that laboratory of either type of body armor will yield the same results.

The Army tells you that it wants to test Dragon Skin along with the Interceptor, and we welcome such a test. But they insist on us using rigid-plate technology, and we insist on using the most technologically advanced, only flexible, rifle-defeating body armor in the world. If Dragon Skin performed as poorly as the Army claims, why is it doing everything in its power to obfuscate and avoid such an independent test, which would ostensibly validate its allegations against Dragon Skin and support Army claims that the Interceptor is the best body armor in the world, bar none?

There is a pattern of anti-Dragon Skin disinformation coming from the Armed Forces, and most of this can be traced to a single source.

If that isn't enough, you would be intrigued that despite the fact that the Army claims it uses H. P. White Laboratory as an independent facility, it is that source that runs the entire so-called "independent testing protocol," monitors and controls the test. General Mark Brown has told you that he told the media in the May 21st briefing that Mr. Karl Masters is, in Brown's words, the chief engineer and test director. That begs the question of how independent and unbiased the H. P. White test really was or could be in the future.

The issue of the lack of quality of the Interceptor vests was broadly discussed during a Federal investigation of a body armor defense contractor that was conducted by the FBI, the Defense Criminal Investigative agency and the United States attorney for the Eastern District of New York.

This Federal investigation also determined that fielded Interceptor Body Armor did not meet ballistic standards. And the investigator discovered that the armor had failed these standards and was recalled, yet it is still issued to our troops.

The Army allows the test director to have broad discretion above and beyond the written test protocols and procedures.

Lieutenant Colonel Gabriel Patricio of the Marine Corps, program manager responsible for body armor said, and I quote, "Failing or passing anything, that is a matter of some testing, procedures, and interpretations."

Over a 3-year period from 2002 to 2005, in cooperation with the Army Research Lab in Aberdeen, I worked on a development of a testing protocol for a flexible, rifle-defeating body armor that would provide a 95 percent level of confidence indicating multiple high-powered rifle rounds

across the board. This is at a success rate level that is 100 percent higher than the current issued Interceptor whose ballistic integrity degrades with each additional shot.

Natick was established to test and evaluate clothing and foodstuffs and additional, ancillary equipment for the military and now spends approximately—the vast majority of its time and budget on the ceramic-plate-based Interceptor Body Armor system.

The introduction of a flexible system like Dragon Skin would cost Natick a significant chunk of its research and development budget because the dated armor plate system would disappear. Could that threat to the Natick's budget be the reason for this opposition? I don't know.

Honorable members, when the smoke clears from a true, Independent, third-party testing of Dragon Skin, you will see that Dragon Skin has the capability to substantially save American lives. That is the bottom line.

Thank you for your time and your invitation to lay out some facts and the true story of Dragon Skin, and for giving me the opportunity to share with you my passion for protecting the lives of men and women in harm's way.

Mr. Chairman, I would like to submit my testimony and documents package to be provided and entered into the record. (House Armed Services Committee, 2007, pp. 5–7)

The following quote is Mr. Coyle's statement, and it is divided into two parts (The portion of the statement omitted covers the *NBC* test results previously covered in paragraph C of this chapter):

I have over 30 years of test and test-related experience involving U.S. defense systems and equipment; and knowing this, NBC invited me to observe side-by-side body armor tests that were conducted at the Beschussamt Mellrichstadt laboratory in Germany on May 3, 2007. My role was to observe those tests, to provide advice and commentary where I saw fit; and I neither requested nor received any compensation from NBC for my time spent traveling to the laboratory nor for observing the tests.

This committee needs to be open-minded about looking at the questions which the NBC body armor tests have raised. I say this because you know that body armor is of critical importance to U.S. military personnel in Iraq and Afghanistan. However, in the recent past, this committee has not shown itself to be open-minded on issues raised by NBC. I refer to NBC reporting on active protective systems. The House Armed Services Committee (HASC) held two hearings to denounce NBC for raising those

issues, and those hearings did not engage the specific facts which NBC raised. In the course of those two hearings, this committee received testimony from the U.S. Army which was misleading and sometimes just plain wrong.

On the positive side, after those two hearings, Senator John Warner requested an independent study of active protection systems. That study was completed 2 months ago by the Institute for Defense Analyses and showed that NBC was correct. The IDA study showed that the Trophy Active Protection System was the farthest along, as NBC had reported, and ranked the system which the Army system favored, the Raytheon ``Quick Kill" system, ninth in terms of technical readiness.

In short, the IDA report confirmed that NBC got it right. With respect to the questions that NBC has raised on body armor, I hope this committee will consider that NBC may have gotten it right again.

From the outset, it was apparent that NBC would not have the capacity to conduct full-scale body armor tests that would capture all of the variables of importance to the U.S. Army. For example, NBC did not conduct tests at high or low temperatures; all of the rounds fired in the NBC body armor tests were fired at ambient temperature. Nevertheless, it was important for NBC to be sure that their tests, although limited, were fair and conducted according to professional standards, which I can attest they were.

The results of the NBC tests, which are summarized on their Web site, were significant. The test showed that the Army Interceptor Body Armor meets U.S. Army requirements, something which I myself stated on camera. The NBC tests also showed that the ballistic protection from Dragon Skin body armor is better.

I would now like to talk about the actual results of those tests commissioned by NBC and conducted on May 3rd in Germany--actually, northern Bavaria.

At NBC's request, the Mellrichstadt laboratory performed comparative testing of the Army's body armor, Interceptor, which employs rigid plates inserted into large pockets in an outer vest, against Dragon Skin, a flexible body armor, which employs a series of overlapping disks, each a little larger in diameter than a silver dollar.

The Mellrichstadt laboratory is well familiar with the specifications governing body armor testing, regularly conducts body armor tests and has an outstanding reputation as the BMW of ballistic testing laboratories. Body armor tests are tested against a special kind of clay that simulates the resistance of the human body and provides a way to measure blunt force

trauma. After each shot, each vest is removed to see whether or not the bullet has penetrated, and if not, to measure the blunt force trauma to a person wearing the vest.

The U.S. Army generally considers a cavity deeper than 44 millimeters to be a failure even if the bullet does not penetrate because the shock can be so great that the wearer of the body armor could die anyway. The sternum is a particularly dangerous area for blunt force trauma, as chest bones can be broken and propelled into the heart, lungs and so forth. A ruptured spleen or other damaged organ can be very dangerous, if not fatal, also.

The measure of this blunt force trauma is called BFS, or Back Face The measure of this blunt force trauma is called BFS, or Back Face Signature. That is the depth of the indentation caused in the clay when a bullet strikes a body armor vest. The NBC test consisted of six groups of test firings involving a total of 31 rounds of ammunition of different types and lethalties.

Test number one was of Dragon Skin only. That is before the comparative testing began, a preliminary series of six shots were fired against Dragon Skin only using 7.62 caliber by 51mm long, M80 rounds. This is called a Level III threat, meaning capable of defending against high-powered rifle ammunition, and both Dragon Skin and Interceptor are National Institute of Justice certified at this level.

The Army requires that three rounds be defeated; the National Institute of Justice requires that six rounds be defeated. And in this first test series, six rounds were fired at Dragon Skin body armor, and it stopped all six rounds, allowing no penetration. The Back Face Signatures were well within the Army standard. So this test showed that Dragon Skin could defeat this threat and meet both the Army standard and the tougher National Institute of Justice standard.

From this point forward in this open testimony, I do not speak of the specific caliber or construction of each round fired in the NBC-sponsored test. Similarly, in their broadcast and on their Web site, NBC News did not describe the specific caliber or ammunition used in the comparative test because the Army believes that level of detail may assist the enemy.

NBC News did, however, share those details with the Army, and the Army itself reported some of those in an open press conference on May 21st. (House Armed Services Committee, 2007, pp. 7-9)

Given the NBC test results, the refusal of the Army to undertake side-by-side testing is puzzling. When NBC News Reporter Lisa Myers asked General Mark Brown whether the Army would do side-by-side testing,



General Brown said that the Army doesn't do side-by-side testing, but tests to a standard. Of course, they test to a standard, but NBC News tested both vests to the Army standard, and Dragon Skin performed better.

Side-by-side testing means testing both types of body armor under the same conditions according to the same scoring rules, in short, a level playing field.

In his recent press conference, General Brown said he had all of the money and all of the leadership support he needed to get body armor and to get improvements to body armor. He also said that the Army is never satisfied with the status quo and that the Army is always looking for the next best thing and that if there is something better out there, we are going to buy it after we have live-fire tested it. If this is true, doing fair, contemporary, side-by-side tests should not be a problem.

I am not saying that Interceptor does not provide good protection; nor is retired Army General Wayne Downing, who observed the tests with me. He noted on camera, as did I, that Interceptor performed well during the NBC tests. But Dragon Skin was better, notably against multiple rounds and in reducing blunt force trauma which can kill even if a bullet doesn't actually penetrate the vest.

From the body armor tests that I observed in Germany, Dragon Skin appears to have five advantages, advantages in which I would think the Army and this committee would be interested. Those advantages appear to be, first, Dragon Skin is flexible and conforms better to the contours of the human body which is also helpful for female soldiers. Dragon Skin covers more of the torso and does not leave gaps. Dragon Skin is better against multiple shots. Dragon Skin reduces blunt force trauma. The depth of the cavities caused in the test clay by shots fired at Dragon Skin were often half as deep as the cavities caused in the clay during Interceptor tests. And fifth, Dragon Skin performed perfectly, allowing no penetrations, and defeated six rounds of a particularly deadly ammunition threat which U.S. troops in Iraq and Afghanistan may face.

Mr. Chairman, in conclusion, the controversy over the most effective body armor for the U.S. Army has been brewing for a long time and was not started by NBC. NBC, ABC, CBS, the Discovery Channel, the History Channel and the National Geographic Channel that I know of have all either aired programs on this controversy or plan to do so.

This does not count the scores of prank media sources who have reported on the body armor controversy. Even YouTube has pictures of Dragon Skin body armor testing on the Internet and Wikipedia has posted a carefully documented description of the history of this controversy. Some

news organizations have shown successful ballistic tests of Dragon Skin body armor conducted on behalf of other agencies such as police departments.

In addition, officials with the FBI, the CIA, the U.S. Marshal Service, the GSA, the U.S. Navy, the U.S. Air Force, the Federal Protective Service, the Department of State, the Department of Energy, and the U.S. Coast Guard have all bought or placed orders for Dragon Skin. And so also have private security firms that provide security protection for high-ranking officials in Iraq or other dangerous places.

Mr. Chairman, the tests conducted by H. P. White for the Army in May 2006 and the NBC tests conducted this year can probably never be compared one for one. Too much time has passed since the tests a year ago, and the Army is overly invested in proving NBC wrong.

The best way to resolve this matter would be for the U.S. Army Test and Evaluation Command to conduct comparable side-by-side tests of both the Interceptor and Dragon Skin body armor.

Those tests should be overseen, in my view, by an independent third party such as the Director of Operational Tests and Evaluation. That is what the Senate Armed Services Committee has called for, and I hope the House Armed Services Committee will join the Senate to call for a fair, balanced, and refereed body armor testing program. Committee has called for, and I hope the House Armed Services Committee will join the Senate to call for a fair, balanced, and refereed body armor testing program. (House Armed Services Committee, 2007, pp. 10–12)

The relevant portion of Lieutenant General Thompson's statement:

The safety of our soldiers is paramount. In March of 2006, the Army issued a Safety of Use Message prohibiting the use of any commercially available body armor products to include Dragon Skin that are not Army approved and issued.

This Safety of Use Message was issued as a result of several previous tests that took place from May 2004 to February of 2006 on Dragon Skin. These tests indicated that Dragon Skin did not meet the Army requirements. So we are talking about five previous tests, not just the test in May of 2006 that was referred to in the panel one testimony today.

As a result of the Safety of Use Message Pinnacle Dragon Skin 2000 Body Armor purchased by an Army unit was turned into the PEO and as indicated during the previous panel's testimony, it contained a fraudulent National Institute of Justice certification statement that was fully 8 months

before the National Institute of Justice certified that version of the body armor.

Each vest contained the Pinnacle Armor's manufacture label with the compliance statement that was read by Chairman Skelton.

Army coordination with the National Institute of Justice revealed that this statement was not true. As of April 2006, the 2000 Dragon Skin armor had not been tested by NIJ and was not certified to defeat the Level III threat.

In my opinion, this is a serious fraudulent claim, and it is my hope that the investigative process results in the appropriate consequences.

In the interest of fairness and because of intense media interest in Dragon Skin, the Army chose to run a full test of Dragon Skin last spring. In May 2006, H. P. White Laboratory, an independent test facility, certified by the National Institute of Justice for ballistic testing, tested Pinnacle's 3000 Level IV Dragon Skin vest using the same test protocols that we use with the Interceptor Body Armor. Before the testing was halted, the Dragon Skin vest suffered 13 of 48 first- or second-round shot complete penetrations failing four of eight initial subtests.

The bottom line is that the Dragon Skin vest did not stop the bullets.

And we can get into this in the questions and answers later, but Congressman Snyder and others asked a key question on who provided that body armor for the test that was conducted by NBC in Germany, and we have indicated from talking to NBC that PPI provided that body armor but that body armor that was provided for the NBC test was not from one of the six certified and tested producers of the body armor that is used by the military.

Before I conclude my remarks, I would like to highlight an issue of grave concern to me and that is the role of a responsible press, and in that term, I include the print media and the broadcasting industry. The press is an important guarantor of our freedom, and with that right, comes the responsibility to get the facts right and the stories straight.

The Army did not go public with our test results from last year because we are dealing with the very media-savvy enemy. The airing of the NBC news story prompted the Army to release information to assure service members and their families that the Army is providing the best body armor available. In this case, credible and factual evidence provided by the Army was cast aside for a sensational story that just was not true. It created needless worry among our men and women in uniform and their families and provided an adaptable enemy with additional information about how we equip our soldiers for the important missions they perform. It is a most

unfortunate situation, and in my view, brings NBC's credibility into serious question. (House Armed Services Committee, 2007, pp. 54–55)

**G. DEPARTMENT OF DEFENSE INSPECTOR GENERAL REPORT NO. D-2009-047, DOD TESTING REQUIREMENTS FOR BODY ARMOR, JANUARY 29, 2009**

Although the specific subject matter of this report is not a part of this research effort, the report contains comments by the Secretary of the Army and DOT&E that indicate the Army's intent to, at a minimum, conduct all future first article tests for body armor through ATEC. The report was issued on January 29, 2009; 11 days prior to the issuance of the Pops Memorandum entitled, Testing of Personal Protective Equipment (PPE) (see Appendix B).

The relevant Secretary of the Army comments are as follows:

- The Secretary also stated that he associated himself with the January 16, 2009, memorandum provided by the Principal Deputy Assistant Secretary of the Army (Acquisition, Logistics, and Technology), which endorsed comments from PEO Soldier. He further stated that as the Principal Deputy's memorandum explains, the Army, with DOT&E oversight, initiated comprehensive action to fix its testing system beginning in June 2007.
- The Secretary of the Army concluded that there is no higher priority for the Army than the safety of soldiers. He stated that anything that threatens the safety or erodes the confidence of soldiers, or the American people in the Army's commitment to their safety, is a matter of utmost importance to Army leadership. (United States Department of Defense Inspector General, 2009, p. 14)

Relevant DOT&E comments are as follows:

- Additionally, he stated that DOT&E ensured that the correctly sized plates were tested during preliminary design model testing in 2008 and that PEO Soldier intends to conduct all future first article tests at the Army Test and Evaluation Command to prevent recurrence of these issues. (United States Department of Defense Inspector General, 2009, p. 19)
- The DOT&E also supports PEO Soldier's intent to correct deficiencies in the first article testing process. The DOT&E also

supports PEO Soldier's intent to sponsor testing at Government facilities with independent Government oversight when possible and, when not possible, to use independent Government personnel to oversee testing. He stated that conducting first article testing at a Government facility, under Government oversight, and with adequate test processes significantly reduces the risk that the issues discussed in finding A will recur. (United States Department of Defense Inspector General, 2009, p. 23)

**H. MEMORANDUM FOR PROGRAM EXECUTIVE OFFICE SOLDIER, SUBJECT: TESTING OF PERSONAL PROTECTIVE EQUIPMENT (PPE) (POPPS MEMORANDUM), FEBRUARY 9, 2009**

This memorandum (see Appendix B) was issued on February 9, 2009. The first paragraph is particularly relevant to this research:

Recent internal and external reviews indicate that the testing process for personal protection equipment needs to be improved. The Army Test and Evaluation Command (ATEC) have both the expertise and the mission to test Body Armor. I direct that ATEC conduct all Body Armor first article and lot acceptance testing. Program Executive Officer (PEO) Soldier will ensure all solicitations articulate this policy. (Department of the Army, 2009)

**I. GAO-10-119, INDEPENDENT EXPERT ASSESSMENT OF BODY ARMOR TEST RESULTS AND PROCEDURES NEEDED BEFORE FIELDING, OCTOBER 2009**

The GAO-10-119 report on the first two body armor tests conducted after the decision was made to test body armor at ATEC, specifically the ATC, Aberdeen Proving Ground, MD.

The first test that GAO auditors observed was referred to as the preliminary design model (PDM) test. The test was conducted from February to June 2008. The purpose of the test was to determine whether the systems submitted met ballistic performance specifications to be awarded a production contract (Solis, 2009, p. 2).

This was a test of body armor systems submitted in response to a May 2007 solicitation that included the previous suppliers of IBA to the Army along with a flexible Small Arms Protective Vest-Enhanced (FSAPV-E) design. The flexible armor design was the Pinnacle Armor, Inc. Dragon Skin vest (Solis, 2009). It should be noted that this test

included Small Arms Protective Insert-X level (XSAPI) and Pinnacle Armor's version of that protective solution, Flexible Small Arms Protective Insert-X level (FSAPV-X). This level of protection is not discussed.

The Army awarded four indefinite delivery/indefinite quantity (IDIQ) contracts worth over \$8 billion for the production of ESAPI and XSAPI plates. Of particular note is the fact that neither of the Pinnacle Armor, Inc. Dragon Skin designs passed this test (Solis, 2009, p. 2).

The auditors observed test procedures, spoke with Army officials, and compared observations with established test protocols (Solis, 2009). The test procedures were outlined in the purchase descriptions from the solicitation.

The GAO found that:

During Preliminary Design Model testing the Army took significant steps to run a controlled test and maintain consistency throughout the process, but the Army did not always follow established testing protocols and, as a result, did not achieve its intended test objective of determining as a basis for awarding contracts which designs met performance requirements. In the most consequential of the Army's deviations from testing protocols, the Army testers incorrectly measured the amount of back-face deformation in the clay backing at the point of aim rather than at the deepest point of depression. Army testers recognized the error after completing about a third of the test and then changed the test plan to call for measuring at the point of aim and likewise issued a modification to the contract solicitation. At least two of the eight designs that passed Preliminary Design Model testing and were awarded contracts would have failed if measurements had been made to the deepest point of depression. The deviations from the testing protocols were the result of Aberdeen Test Center's incorrectly interpreting testing protocols. In all these cases of deviations from the testing protocols, the Aberdeen Test Center's implemented procedures were not reviewed or approved by the Army and Department of Defense officials responsible for approving the testing protocols. After concerns were raised regarding the Preliminary Design Model testing, the decision was made not to field any of the plate designs awarded contracts until after First Article Testing was conducted. Note: This is from the first page of the GAO Highlights for GAO-10-119, and no page number is provided. (Solis, 2009)

The second test was a FAT conducted as a follow-up to the PDM test due to the issues previously mentioned. The GAO observed this test in the same manner and noted the following:

During First Article Testing, the Army addressed some of the problems identified during Preliminary Design Model testing, but GAO observed instances in which Army testers did not follow the established protocols and did not maintain internal controls over the integrity and reliability of data, raising questions as to whether the Army met its First Article Test objective of determining whether each of the contracted designs met performance requirements. The following are examples of deviations from testing protocols and other issues that GAO observed:

- The clay backing placed behind the plates during ballistics testing was not always calibrated in accordance with testing protocols and was exposed to rain on one day, potentially impacting test results.
- Testers improperly rounded down back-face deformation measurements, which is not authorized in the established testing protocols and which resulted in two designs passing First Article Testing that otherwise would have failed. Army officials said rounding is a common practice; however, one private test facility that rounds told GAO that they round up, not down.
- Testers used a new instrument to measure back-face deformation without adequately certifying that the instrument could function correctly and in conformance with established testing protocols. The impact of this issue on test results is uncertain, but it could call into question the reliability and accuracy of the measurements.
- Testers deviated from the established testing protocols in one instance by improperly scoring a complete penetration. As a result, one design passed First Article Testing that would otherwise have failed.

With respect to internal control issues, the Army did not consistently maintain adequate internal controls to ensure the integrity and reliability of test data. In one example, during ballistic testing, data were lost, and testing had to be repeated because an official accidentally pressed the delete button and software controls were not in place to protect the integrity of test data. Army officials acknowledged that before GAO's review they were unaware of the specific internal control problems we identified.

As a result of the deviations from testing protocols that GAO observed, four of the five designs that passed First Article Testing and were certified

by the Army as ready for full production would have instead failed testing at some point during the process, either during Preliminary Design Model testing or the subsequent First Article Test. Thus, overall reliability and repeatability of the test results are uncertain. Although designs passed testing that would not have if the testing protocols were followed, independent ballistics experts have not assessed the impact of the deviations from the testing protocols to determine if the effect of the deviations is sufficient to call into question the ability of those designs to meet requirements. Vendors whose designs passed First Article Testing have begun production of plates. The Army has ordered 2,500 sets of plates (at two plates per set) from these vendors to be used for additional ballistics testing and 120,000 sets of plates to be put into inventory to address future requirements. However, to date, none of these designs have been fielded because, according to Army officials, there are adequate numbers of armor plates produced under prior contracts already in the inventory to meet current requirements. (Solis, 2009)



## IV. ANALYSIS

### A. INTRODUCTION

On April 26, 2007, the GAO released GAO-07-662R, *Review of Body Armor*.

As stated on the GAO website:

**Our Mission** is to support the Congress in meeting its constitutional responsibilities and to help improve the performance and ensure the accountability of the federal government for the benefit of the American people. We provide Congress with timely information that is objective, fact-based, nonpartisan, non-ideological, fair, and balanced.

**Our Work** is done at the request of congressional committees or subcommittees or is mandated by public laws or committee reports. We also undertake research under the authority of the Comptroller General. We support congressional oversight by:

- Auditing agency operations to determine whether federal funds are being spent efficiently and effectively;
- Investigating allegations of illegal and improper activities;
- Reporting on how well government programs and policies are meeting their objectives;
- Performing policy analyses and outlining options for congressional consideration; and
- Issuing legal decisions and opinions, such as bid protest rulings and reports on agency rules.

We advise Congress and the heads of executive agencies about ways to make government more efficient, effective, ethical, equitable and responsive.

Our work leads to laws and acts that improve government operations, saving the government and taxpayers billions of dollars. (U.S. Government Accountability Office, 2015)

GAO-07-662R was released less than a month prior to the *Dateline NBC* report, and just over a month before HASC hearing 110-58. The report found very little in terms of issues with body armor to include the testing processes. This analysis examines why

Congress, in spite of the findings of its own auditing organization, questioned the Army's handling of body armor procurement (including testing), how that led to the decision to test all body armor at ATEC, and the impacts of that decision.

## **B. THE DATELINE NBC REPORT**

*NBC* characterized this test as an “independent side-by-side test.” It is a perfect example of Chapter II, Section E, Test Overview Context. Testing body armor is more than just shooting it with a projectile, and ensuring that the projectile did not penetrate the armor system. From what *NBC* presented, it is not possible to know how the Dragon Skin armor was targeted for the test. Additionally, it is also not possible to validate that the armor represented as IBA was actually from the Army production line.

When conducting live-fire test and evaluation on any system, one of the objectives should be to determine if the system has weaknesses that will compromise its performance. The 2006 Army test of Dragon Skin at H. P. White Laboratories used an ESAPI FAT test protocol with shot patterns developed to ensure any potential weaknesses would be discovered. The test proved that that the system did not meet Army ballistic requirements. The test was extensively documented to include videotaping of all of the sub-tests. Brigadier General Mark Brown, Program Executive Officer Soldier, was interviewed as part of the segment. He cited the fact that the Army tests to a standard (versus “side-by-side”), and that Dragon Skin had failed 13 out of 48 shots when tested by the Army (Wood, 2007). It was a reference to the H. P. White test, although it was not identified specifically.

*NBC* also failed to acknowledge that the Level IV version (designed to defeat armor piercing ammunition) of Dragon Skin that is the ballistic equivalent of IBA failed to meet Army weight requirements. As detailed in the Weight/Coverage slide of the PM SEQ briefing on the 2006 test (see Appendix A), the Level IV Dragon Skin vest in size extra-large weighed approximately 48 pounds versus approximately 28 pounds for the IBA with torso and side inserts. It was also noted that the extra-large Dragon Skin vest was equivalent to a size large Interceptor vest.

In spite of personally witnessing the H. P. White test, Mr. Murray Neal, the Pinnacle Armor Chief Executive Officer, stated in the *NBC* report that he would put his system up against the Army's system "any day of the week" (*NBC News*, 2007). Mr. Neal's persistence and use of the system by other U.S. government agencies made the story appear even more credible. Additionally, certain elements in the Army had procured the concealable version of Dragon Skin for members of protective details assigned to general officers in United States Central Command (USCENTCOM). It was done outside of the normal procurement channels. *NBC* cited the use of this version of Dragon Skin by the protective detail of General Peter Chiarelli, then Commander of Multi-National Corps Iraq, in spite of an Army-wide Safety of Use message banning the use of any armor system other than IBA (*NBC News*, 2007).

The result of the *Dateline NBC* report and several follow-up reports was the call by several members of Congress for an independent investigation to determine which armor system was the best. Congress moved quickly, and set a hearing for June 6, 2007. Regardless of the credibility of the *NBC* test, the damage to the confidence of many Soldiers, Marines, and their families was done, and it was a key factor that would influence decision makers.

### **C. H.A.S.C. HEARING NO. 110-58**

The HASC held the hearing on DOD Body Armor Systems on June 6, 2007. The HASC members and Army representatives were very thorough in detailing exactly how limited and misleading the *NBC* test was in determining which system was the better body armor design, as well as rebutting claims of unfair treatment by Mr. Neal. Michael Turner, Ohio, stated, "Mr. Neil, I have got to tell you, I have been on this committee five years. Your presentation has to be one of the least professional I have ever seen in front of this committee" (*House Armed Services Committee*, 2007, p. 42).

Duncan Hunter did the best job of rebutting Mr. Coyle's statement before the committee, and exposing Mr. Neal's deceptive Dragon Skin "marketing" campaign despite over-simplifying the process of testing body armor in his opening statement by

saying, “it seems to me that this shouldn’t require rocket science to tell if a bullet goes through a certain substance” (House Armed Services Committee, 2007, p. 4).

The following are excerpts from Duncan Hunter’s questioning of Mr. Coyle and Mr. Neal that force both into admitting that what was aired on *Dateline NBC* was inaccurate and misleading, and that the Army’s original test at H. P. White proved that Dragon Skin was not ready to be fielded to Soldiers and Marines.

Coyle Questioning:

Mr. Hunter. Okay. Having said that, Mr. Coyle, you have a long reputation of very fastidious testing where you would come to this committee after something had been shot 15, 20, 30, 40, 50 times and you would say no, it is not ready for prime time. We had a failure.

Now here is what we had. Mr. Neal had a test with the U.S. Army for practical purposes in a lab with integrity, a recognized certified, et cetera, laboratory. They had a test with him standing there and did a penetration. They then went to you and NBC and you guys did a separate test.

Did he tell you about the first test where they had the penetration?

Mr. Coyle. I saw from, as I say materials that I saw in the press and other places, I saw that that had happened. So I knew that the history from the tests a year ago was different. I didn’t know what to expect----

The Chairman. Let me interrupt. Answer the question. Did he tell you?

Mr. Coyle. He didn’t, but he didn’t need to because I already knew it.

Mr. Hunter. You knew there had been a total frontal penetration in this.

Mr. Coyle. I knew that before the tests in Germany began.

Mr. Hunter. I thought you told me earlier on in this testimony, I asked you after you had done the 12 shots or the 18 shots that were done in Germany, if you knew about the shot that went all the way through that was done in the Army lab, would you have then said that this was superior to the Army product and you said no. At least, that is what I got back about half an hour ago.

Mr. Coyle. If the results in Germany had been like the results that are----

Mr. Hunter. That wasn’t my question. My question was if you had known about those results at a government lab like the ones you relied on for

years when you take data from one of those government labs and say, Armed Services Committee, this is what we just got. The missile failed. I would not recommend going ahead. You did not say I think that this is duplicitous or we should do another test with a non-governmental lab. You said they failed. Don't go ahead. Now you had a shoot there that would have been fatal to a soldier wearing that vest, right?

Mr. Coyle. Yes, sir.

Mr. Hunter. Okay. Now if you had known that and you presumed that it was done under good conditions, and in this case they are unique conditions because your client or clients or the gentleman who owns the company was allowed by the Army was allowed to stand there and watch the shot and boom, the shot went through, would you have then said without further testing that this appeared to be a superior product to the Army product?

Mr. Neal. If I hadn't seen the results from the tests in Germany, no, sir. The Army has, I think, a very important position here. The Army says that one penetration is too many. And I agree with that. I think they are just right when they emphasize that point of view.

Mr. Hunter. So here is my question. You took how many shots in Germany?

Mr. Coyle. All in all, of all of the different types, 31.

Mr. Hunter. But the ones that you had, your primary ones you talked to us about, that was 18: Three sets of 6; is that right?

Mr. Coyle. Yes.

Mr. Hunter. So you took three sets of six and you had no penetrations, right?

Mr. Coyle. Yes, sir.

Mr. Hunter. Mr. Neal, before that, had his product which he selected, took down to the Army lab and they shot it and no complaints from Mr. Neal and boom, it went through with a killing shot, right?

Mr. Coyle. Yes, sir.

Mr. Hunter. So for practical purposes there you have at least one killing shot, and then you did 18 that were defeated.

Now I have known you for a long time testifying before this committee. Would you think that you could make that conclusive statement that it was superior to the Army product without shooting it a lot more times? This is the operational and test guy who tells us that thoroughness is so important?

Mr. Coyle. All I said was based on the test that I saw in Germany, Pinnacle performed better.

Mr. Hunter. We are getting to my point, and Mr. Chairman, I hope you would suffer me here because this is an important point.

Based on your statement, because you have a—you have an outstanding reputation. You are charged not only with the tests that you stood and watched, you are also charged with the information that comes from an officially certified military lab, like the ones you relied on for 20 years in your profession.

Now having known that fact, and Mr. Neal does not dispute it, that was a killing shot through that vest, would you then say that this lab—that this vest was ready for prime time?

Mr. Coyle. No, sir, and I do not say that today. What I say is the tests in Germany, which were limited, and which I say in my testimony were limited, based on those, as far as they went, which wasn't far enough, the Dragon Skin did better.

Mr. Hunter. So you are saying today, and I hope somebody from NBC is in the audience, you are saying today that based on those 18 shots and the shot that you now know about that was a killing shot; you can't say it is ready for prime time; is that your testimony?

Mr. Coyle. Yes, sir. (House Armed Services Committee, 2007, pp. 47–48)

Hunter summarized Mr. Neal's deceptive practices with these comments:

Mr. Hunter. Okay. Mr. Neal, having said that then, don't you think it is your obligation to tell the mothers and dads of this country when they read these articles that imply that Dragon Skin is a supreme type of a protection system, that you, in fact, did the test, the test that you did, that you don't disagree with, when you were standing there you were personally there, a killing shot went through that. Don't you think they need to know that as a caveat before they go down and spend their \$5,000? And Mr. Coyle, your tester, now says it is not ready for prime time.

Now don't you think that you at least owe that—if you are going to have these statements circulating in the press that are going to upset parents and

make them think that there is a super system out there, and it may overall, in fact, I think some of the aspects of this system, the flexibility of the system, the possibility being able to use this where you can put more weight on it where you are using armored vehicles, etcetera, where you are not having to carry stuff in a squad formation, I think there is a lot of possibilities here.

But I think the idea that you circulate this implication without telling them that you stood there and watched a killing shot go through this, I think that is not full disclosure. I think you owed full disclosure to Mr. Coyle, and I hope Mr. Coyle says it is not ready for prime time. That is not the headline that goes out over Dragon Skin. The headline that goes out over Dragon Skin is that it is fantastic.

One last point here that I think needs to be made is this: I saw this thing, and I told my guys to have you come in, or whoever your team is and show us because I wanted to get good stuff out to the field. About a year before NBC showed it.

Your guys came in, they briefed up our team. We called the Army, told them to test it. They said we are testing it, and they subsequently tested it, and those are the results that we have been discussing in that handout. That they did test it. And it may be better than they have advertised. It may be worse than they have advertised, and I want to see a test. In fact, I am ready to go down with an M-14 and some 7.62 stuff to the Marine Corps lab and try to get some shots off in the next week or so.

But everywhere you go, you leave the implication that everybody is a devil. I have got great professional staff members who called your guys in at my request, not NBC's, long before they discovered this because we heard about it. A few days later, their names pop up on Web sites saying that staff members of the Armed Services Committee are the devil that somehow they are in a conspiracy to thwart you from trying to get good stuff to the troops.

Every place you go you get these apocalyptic letters describing anybody who has questions about this as a devil and when you are asked about this about these letters in the hearing, you say you know, I was just passing along the concerns of the families.

I think it might be interesting for the families to know, in fact I would like to hear from them, how many got the information from you when you stood there and had your test, your vest shot, and the bullet went all the way through it, and you didn't report that to anybody. You didn't think those families needed to be burdened with that knowledge, did you? (House Armed Services Committee, 2007, pp. 49-50)

Perhaps an even more damaging blow to Mr. Neal's credibility and to Dragon Skin's performance reputation came from the statement of the United States Air Force representative to the proceedings. Douglas D. Thomas was the Executive Director for the Air Force Office of Special Investigations (OSI). He testified that in January of 2006, the Dragon Skin vests that the Air Force Research Lab (AFRL) tested had failed. They subsequently sent vests to the Aberdeen Test Center in February 2006 where they again failed (House Armed Services Committee, 2007).

On May 11, 2006, OSI was notified by the National Law Enforcement and Corrections Technology Center (NLECTC) that the SOV 2000 vests they had purchased were not tested or certified to NIJ standards (House Armed Services Committee, 2007).

Thomas stated, "In May of 2006, OSI opened a joint criminal investigation with Defense Criminal Investigative Service (DCIS) against Pinnacle Armor for false NIJ certification on the vests and false representation of its capabilities. In June 2006, we tested the vests again with HP White, and failed" (House Armed Services Committee, 2007, p. 58).

Although Mr. Neal's claims and the *NBC* report were discredited during the course of the proceedings, Dragon Skin was given the opportunity to compete officially against ESAPI under the conditions that Mr. Neal sought, the test would be conducted at a facility considered to be unbiased, and overseen by a neutral third party. Two of the subsidiary research questions are answered in this portion of the testimony, specifically when Dr. Vic Snyder, Arkansas, was questioning LTG Thompson before and after a recess in the proceedings. Prior to the recess, Dr. Snyder stated,

General Thompson, I want to quibble with you a little bit. I don't think this is NBC's problem; I think it is our problem. We have got a lot of military families out there and people in the public that have questions about this. And for whatever reason it has been generated, we all need to do a better job of answering it. And the reality is, the NBC show, there are some questions to be asked about what NBC showed. (House Armed Services Committee, 2007, pp. 68-69)



The key piece of that statement, and the reality of the situation, was that doubts were raised not only in the minds of military families and the public, but, more importantly, in the minds of Soldiers and Marines themselves.

The portion of LTG Thompson's testimony that occurred after the recess, along with the Dr. Snyder's statement regarding whose problem it was, answers the first subsidiary research question:

- What were the reasons for the decision to conduct all IBA hard armor ballistic insert testing through ATEC versus National Institute of Justice (NIJ) certified laboratories?

On pages 70–71 of the hearing transcripts, Dr. Snyder asked LTG Thompson about a pending ESAPI request for proposal (RFP) released in May 2007. He asked whether all the current ESAPI manufacturers had to re-compete for this RFP, and if Pinnacle would be able to submit a proposal even though theirs was a flexible vs. monolithic design? LTG Thompson acknowledged that Pinnacle would be able to submit a proposal (House Armed Services Committee, 2007).

LTG Thompson went on to state (key pieces in bold):

Anybody that wants to continue to produce for us has got to respond to this RFP.

So I think the way ahead here very clearly is not an individual side-by-side between IBA and Pinnacle.

I heard what Mr. Neal said about responding to our RFPs. I checked with the program office here. He has not responded to our RFPs for body armor level IV. But we have the RFP on the street; 60 days from 25 May, which is the end of July, anybody that has got a product that can be put forward to be considered, to include Pinnacle—if Pinnacle puts forward their product to this RFP, we will test it along with every other competitor that comes forward out there.

And I think that is a fair and reasonable way ahead, because then they will get the time to respond to the RFP. But if they don't respond to the RFP, as an acquisition professional, I think it would be unfair to the other competitors to test them individually.

**So I think the way ahead here is, 60 days from now, whoever responds to that RFP—and I hope Pinnacle does respond—we will test to that**

**standard. We will test by the Army Test and Evaluation Command. We will pick an objective site; and I will tell you right now we won't pick H. P. White for this one.**

**In the audience today, and I talked to him yesterday, and I just talked to him a few minutes ago, is the current head of live fire testing for DOD, Mr. Rick Sayre, and we will have DOT&E, Director of Operational Test and Evaluation, the organization that Mr. Coyle used to head, oversee the ATEC testing of whoever responds to that RFP by the end of July.**

And I think that is a reasonable way ahead here for the committee, for the Army, and for Pinnacle, should they choose to respond to the RFP. (House Armed Services Committee, 2007, p. 71)

The “objective site” that LTG Thompson referred to turned out to be the ATEC’s ATC.

- The second subsidiary research question is: Who were important stakeholders in the decision making process, and what did they have at stake regarding this decision?

Obviously, Congress was a key stakeholder in the decision-making process, and facilitated the decision by holding this hearing. Congress is responsible for providing for the common defense and raising and supporting the Army. Clearly, the public’s confidence was at stake. The Congressmen cited in this research could all be considered important stakeholders.

Additional stakeholders were:

- LTG Thompson—as the highest-ranking uniformed Army Acquisition officer and the Principal Military Deputy to the Assistant Secretary of the Army for Acquisition, Logistics, and Technology, was responsible for all matters relating to the research, development, and fielding of equipment to the Army.
- Mr. Richard Sayre—as the Deputy Director for Live Fire Test and Evaluation (LFT&E), Office of DOT&E, his responsibilities included providing guidance on LFT&E matters; providing input regarding LFT&E to DOT&E annual reports to Congress; and approving test plans for LF oversight programs. His duties also included reporting to Congress on matters regarding survivability and the adequacy of LFT&E. (Office of the Director, Operational Test and Evaluation, 2015)

This decision, in effect, put body armor on the DOT&E Live Fire Test and Evaluation Oversight List. At that time, the Honorable Dr. Charles E. McQueary was the Director, DOT&E.

Although other stakeholders advised and provided input, the aforementioned can be directly documented as playing key roles in the decision-making process.

#### **D. THE DECISION TO TEST AT ABERDEEN TEST CENTER**

This portion of the analysis answers the primary research question:

- What are the impacts, positive and negative, of the decision to conduct IBA hard armor ballistic insert testing through the Army Test and Evaluation Command (ATEC)?

The research showed that with the exception of relieving the immediate pressure from the media and Congress, the impacts in the short term were negative.

In light of the heavy media coverage and concerns voiced by the families of Soldiers and Marines, it is understandable that Congress and the Army wanted to address the concerns quickly, and restore faith. However, the circumstances did not provide the decision makers time to do a thorough mission analysis and develop sound courses of action.

From a mission analysis perspective, the following areas immediately stand out:

- Constraints.
  - Time. The decision to test at ATEC was made in June 2007, and PDM testing commenced in February 2008. That timeframe gave the Army approximately seven months to resource, outfit, train, and rehearse this test mission. It is likely that LTG Thompson, Brigadier General Brown, and Mr. Sayre did not know exactly when the test would be executed; however, they did know they were working within the constraints of an active solicitation that would require a compressed time schedule.
  - Test Experience. The personnel with critical body armor test experience resided within PEO Soldier. ATC had not tested IBA for PEO Soldier since the 1990s.

The following quote was later articulated in GAO-10-119, and addresses both of these constraints:

Traditionally, Army body armor testing had been performed at an NIJ-certified facility. However, one manufacturer of flexible small arms protective vests, which had failed previous testing conducted for the PEO Soldier at an NIJ-certified facility made allegations that the PEO Soldier and the facility had wrongly failed its designs. As a result of these allegations, the Army decided instead to conduct testing for its current solicitation at the Army's Aberdeen Test Center, which had not performed testing of Interceptor Body Armor for PEO Soldier since the 1990s. Additionally, PEO Soldier decided not to provide any on-site testing oversight to avoid any appearance of bias against that manufacturer. (Solis, 2009, p. 2)

The IBA Ballistic Insert Test Overview indicates how big an undertaking it was under the aforementioned constraints. The overview is an extract from TOP 10-2-210 dated October 1, 2008. The TOP was not even published until four months after PDM testing had been completed, and 16 months after the decision had been made to test at ATC. Although test procedures were part of the purchase descriptions provided in the contract solicitation, they were not standard procedures for the testers at ATC. This lack of experience combined with PEO Soldier's experts not being available to assist, led to problems during the PDM test.

The problems in both PDM and the FAT have been previously covered, but an interesting aspect to these tests was not addressed in any of the official publications reviewed in the course of this research. The GAO stated, "The objective of PDM testing was to determine whether candidate designs submitted under the solicitation met required ballistics performance specifications and would be awarded a production contract" (Solis, 2009, p. 2). That statement is the definition of a FAT. In fact, this test was supposed to be a FAT. So why did it become known as a PDM test? The answer is obvious; the problems during this test required another test. That test was called a FAT and sufficient problems with it raised doubts as to whether the designs could meet requirements. Objective analysis of the facts leads to the conclusion that these two tests were failures.

The PDM test took place from February to June 2008. The FAT occurred between November and December 2008. The Poppo Memorandum was issued on February 9, 2009. The first paragraph of the memorandum (see Appendix B) states:

Recent internal and external reviews indicate that the testing process for personal protection equipment needs to be improved. The Army Test and Evaluation Command (ATEC) have both the expertise and the mission to test Body Armor. I direct that ATEC conduct all Body Armor first article and lot acceptance testing. Program Executive Officer (PEO) Soldier will ensure all solicitations articulate this policy. (Department of the Army, 2009)

Given the results of the first two tests, this quote was an interesting statement. The only logical conclusion is that the Army did not need any additional negative attention. This conclusion makes sense, given that DoDIG Report No. D-2009-047 had been released on January 29, 2009 and recommended the recall of 16,413 sets of ballistic inserts purchased under Army Contract 0040 (United States Department of Defense Inspector General, 2009, p. i).

The long-term impacts of the decision to test at ATC are positive. In accordance with the DOT&E recommendations from DoDIG Report No. D-2009-047, PEO Soldier permanently stationed a test oversight element comprised of a government lead with contractor support at the ATC body armor test ranges. This arrangement, although contentious at times, has proven to be very effective. ATC and the PEO Soldier test oversight element have collaborated extensively on quality control and quality assurance processes that have yielded continuous improvement.

The biggest challenge will be maintaining the expertise and institutional knowledge gained over more than half a decade, as the Army faces fiscal challenges. Continuous training and attention to detail are critical to continued success.

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## V. CONCLUSIONS AND RECOMMENDATIONS

### A. CONCLUSIONS

During the course of this research, it became apparent that some of the topics relating to this effort could easily be the topics of individual research projects, which presented a challenge in terms of scope. The research was not intended to delve into every issue, but to provide an overview of how decisions were made, the impacts from those changes, and larger issues for the current and future leadership to consider moving forward in an increasingly dangerous and unstable security environment.

The most important lesson to take away from this research is never to underestimate the impact that one unscrupulous vendor can have on the Army and industry. Again, this statement remains as true today as it did then, “For as long as American Soldiers will go in harm’s way, the Army should get in front of the certain bow wave of press reports finding fault with acquisition of these items” (Sahlin, 2010, p. 6).

Perspective matters. Some in the test community may disagree with the analysis and conclusions. That is understandable, as it was a difficult mission for testers, and their efforts should be recognized. However, no one has all the answers. This situation highlights the need for and importance of a truly collaborative test integrated product team. The PDM test might have been more successful had the PEO Soldier personnel experienced in body armor test been allowed to participate in the preparation and execution of the test.

Ultimately, the Army needs to ask what has really been accomplished by the changes made to body armor testing since June 6, 2007? The metric should be whether Soldiers are better protected now, as a result of the test changes, than they were before. It is an interesting question, given that no Soldier was killed due to a failure of body armor to protect against a threat it was certified to defeat prior to the changes being implemented (House Armed Services Committee, 2007, p. 57).

## **B. RECOMMENDATIONS**

As stated previously, many topics are worthy of additional research, but beyond the scope of this effort. However, one in particular should be considered for additional research.

The impact of changes to test on the body armor industrial base should be given serious consideration. A Hard Armor Industrial Capability Assessment was completed on behalf of PEO Soldier in January 2010. The results of this study are not cleared for release outside the government, but it is recommended that the results of that study be re-examined to determine if changes to test protocols (beyond the scope of this research) have negatively impacted the industrial base. It should include the potential risk incurred by vendors conducting research and development (R&D) testing at NIJ-certified labs versus ATC due to cost, and potential issues with DOD financial management policies regarding competition with commercial facilities in providing services to private parties and agencies outside the federal government.

One of the subsidiary research questions that was not answered in the conduct of this research is:

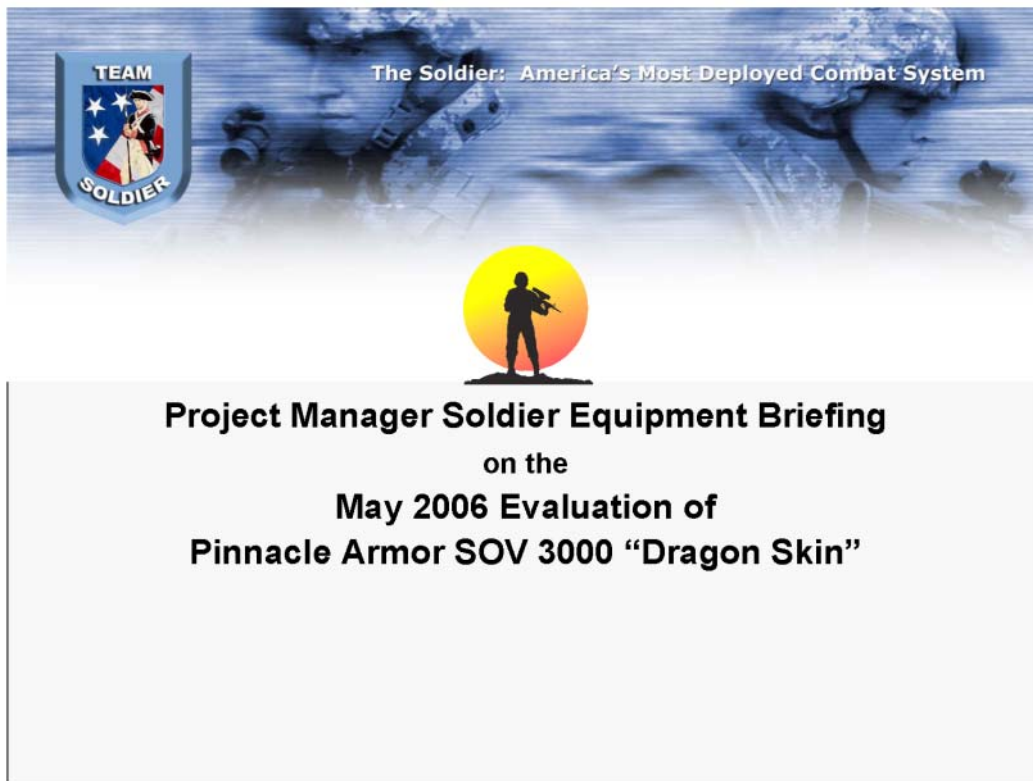
- What was the cost of FAT and LAT testing at the NIJ laboratories compared to the cost of testing at ATEC?

Cost estimates from both ATC and H. P. White were reviewed for both FATs and LATs. Due to a lack of detail in some of the estimates, it was difficult to ensure a fair comparison. The best source found during the research was a December 2009 information paper on Test Cost and Schedule Increase at ATC, prepared by PM Soldier Protective Equipment (PdM SPE) and approved by the PM Soldier Protective and Individual Equipment (PM SPIE). This information paper cited the cost of testing at ATC as double that of the NIJ-certified labs (Rickey, 2009). At the time of publication of this joint applied project, however, the relevance of this question for other than historical documentation appears doubtful.



## APPENDIX A.

The PM SEQ Briefing on May 2006 Evaluation of Dragon Skin came from the following link, [http://www.professionalsoldiers.com/files/dragon\\_skin\\_release\\_000121may07.pdf](http://www.professionalsoldiers.com/files/dragon_skin_release_000121may07.pdf). Reproduced by permission of Program Executive Office Solder, granted 1 Oct 2015.





## Executive Summary Background



- **Project Manager, Soldier Equipment (PM SEQ) conducted testing of Pinnacle Armor's SOV 3000™ Body Armor Vest (Dragon Skin) from 16 -19 May at H. P. White labs near APG. (HP White is the National Institute of Justice certified ballistics lab used to test Army Body Armor)**
- **Since the inception of the IBA program in 1999, Pinnacle Armor has never responded to a full and open competition.**
- **Test was conducted using Enhanced Small Arms Protective Inserts (ESAPI) and Enhanced Side Ballistic Inserts (ESBI) First Article Test protocols.**
- **Prior to fielding, ALL ESAPI designs must pass a robust FAT protocol under a variety of environmental conditions including high (+160° F) and low (-60° F) temperature, diesel fuel, oil, and saltwater immersion, and a 14 hour temperature cycle from -25° F to +120° F.**

2



## Executive Summary

### Background (continued)



- **Pinnacle SOV 3000 level IV Dragon Skin suffered catastrophic failure of the ceramic disc containment grid adhesive at -60° F, 120° F and 160° F.**
  - SOV 3000 design is sensitive to extreme temperatures and failed to maintain ballistic integrity at temperatures below summer ambient in OIF.
  - This failure mode caused discs to delaminate and accumulate in the lower portion of the armor panel, thus resulting in exposing the spine, vital organs, and critical blood vessels to lesser ballistic threats.
- **Pinnacle SOV 3000 level IV Dragon Skin vests suffered 13 first or second shot complete penetrations, failing 4 of 8 initial subtests with ESAPI threat baseline 7.62 x 63mm APM2 Armor Piercing (AP) ammunition.**

**Bottom Line up Front:**  
***Dragon skin does not meet required protection standards***

3



# Pinnacle Test Sequence



## Step 1: Configuration Analysis

- **Receipt of vests**
  - Establish initial accountability, storage, and security
- **Conduct Configuration Analysis:**
  - Label
  - Weight
  - Dimension
  - X-Ray
  - Photograph

## Step 2: Ballistic Testing

- **Prescribed series of live-fire tests**
- **Vests tested under varied conditions:**
  - Weather extremes
  - Conditioned with oil / fuel
- **After durability / drop test**
- **Record results**

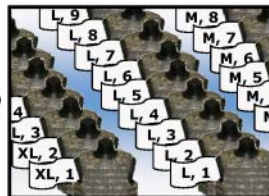
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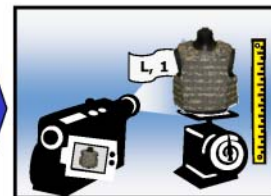
# Configuration Analysis



Receive delivery of 30 "Dragon Skin" vests.



Identify, tally and label vest:  
XL1 - XL10, L1 - L10, M1 - M10



Measure, weigh and photograph vests on scale.



Send vest to storage/appropriate conditioning area.



Analyze, correlate and print all list, measurements, photos and x-rays.



X-ray vests.



## Key Findings



- **Physical Characteristics**
  - Weight
  - Area of Coverage
  - Thickness
  - Ballistic Protection Coverage
- **Ballistic Performance**



## Weight / Coverage



### Interceptor Body Armor

Size: L



Weight: 28 lbs



Thickness:  $\leq$  1.3 in

Coverage: 720 in<sup>2</sup>

### Pinnacle SOV 3000

Size: XL\*



Weight: 47.5 lbs



Thickness: 1.7in - 1.9 in

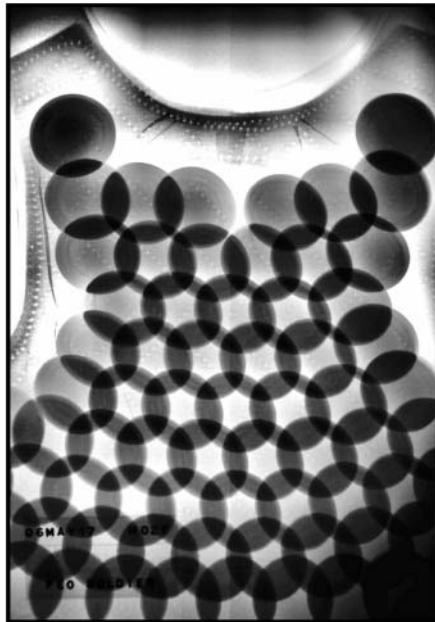
Coverage: 743 in<sup>2</sup>

\* Note, due to difference in sizing "Pinnacle SOV 3000" body armor extra large is equivalent to "Interceptor Body Armor" large in size and fit.

**For equivalent area of coverage, weight is 46% - 70% heavier.**



# Ballistic Protection



8





# Test Flow Chart



Day 1	Day 2	Day 3	
Ambient Temp XL APM2, V <sub>0</sub> 	Oil M APM2, V <sub>0</sub> 	Impact (Drop) L APM2, V <sub>0</sub> 	Ambient Temp XL M855, V <sub>0</sub> 
Weather M APM2, V <sub>0</sub> 	Diesel XL APM2, V <sub>0</sub> 	Low Temp M APM2, V <sub>0</sub> 	Ambient Temp L M80, V <sub>50</sub> 
Altitude XL APM2, V <sub>0</sub> 	Salt Water L APM2, V <sub>0</sub> 	High Temp XL APM2, V <sub>0</sub> 	Ambient Temp M LPS, V <sub>0</sub> 
XL L M APM2, V <sub>50</sub> 	L B32, V <sub>0</sub> 	Temp Cycle L APM2, V <sub>0</sub> 	XL L M 
	M BZ, V <sub>0</sub> 	XL L M M80, V <sub>50</sub> 	Kept As control 
		XL L M LPS, V <sub>50</sub> 	<b>30 Vests Total</b> <b>(27 Tested, 3 Control)</b>
		XL L M M855, V <sub>50</sub> 	

Test Omitted    
  Government Reference Only



# Ambient Temperature



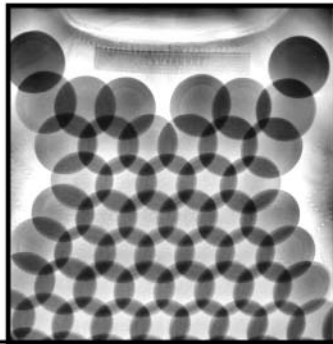
Ambient Temp



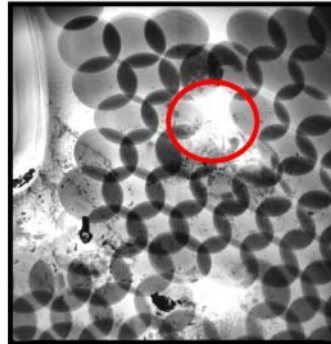
Extra Large



Vest/Panel	Result
XL-01-Front	<b>2d shot, complete penetration</b>
XL-01-Back	OK
XL-01-Left side	OK
XL-01-Right Side	OK



XL-01 FRONT Before Testing



XL-01 FRONT After Testing

10



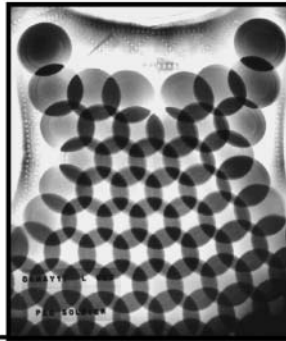
# Salt Water Exposure



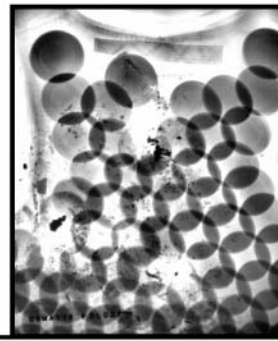
Large



Vest/Panel	Result
L-02-Front	OK
L-02-Back	OK
L-02-Left side	OK
L-02-Right Side	OK



L-02 FRONT Before Testing



L-02 FRONT After Testing

11



# Motor Oil Exposure



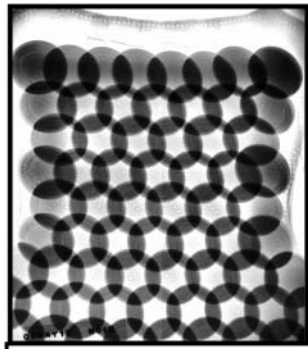
Oil



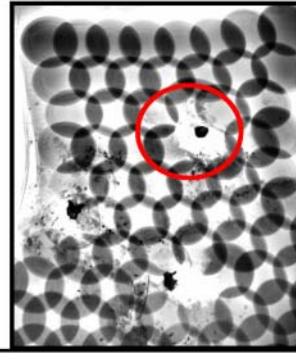
Medium



Vest/Panel	Result
M-01-Front	2d shot, complete penetration
M-01-Back	2d shot, complete penetration
M-01-Left Side	OK
M-01-01-Right Side	OK



M-01 BACK Before Testing



M-01 BACK After Testing

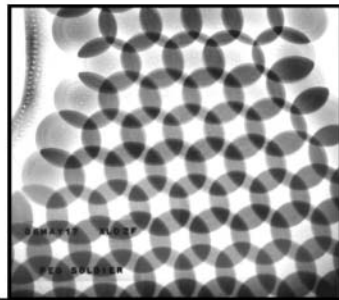
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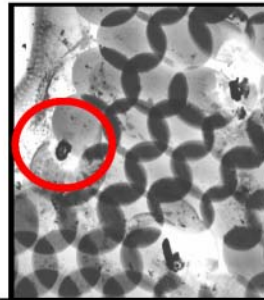
# Diesel Fuel Exposure



Vest/Panel	Result
XL-02-Front	1st shot, complete penetration
XL-02-Back	2nd shot, complete penetration
XL-02-Left Side	OK
XL-02-Right Side	1st shot, complete penetration



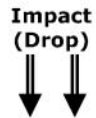
XL-02 FRONT Before Testing



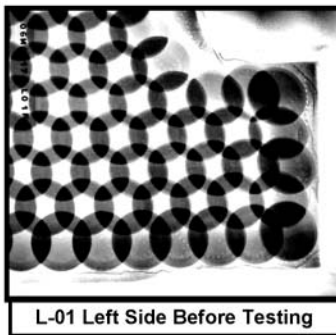
XL-02 FRONT After Testing



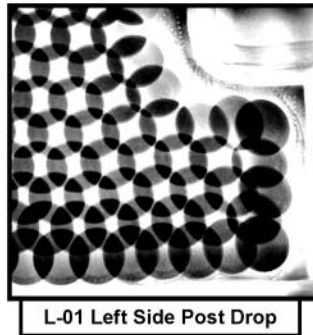
# Impact/Drop



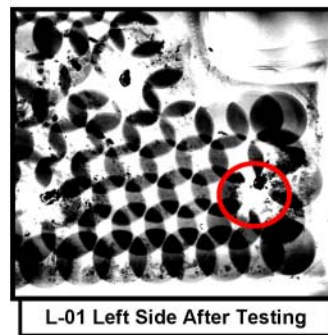
Vest/Panel	Result
L-01-Front	OK
L-01-Back	OK
L-01-Left Side	1st shot, complete penetration
L-01-Right Side	OK



L-01 Left Side Before Testing



L-01 Left Side Post Drop



L-01 Left Side After Testing



## Low Temperature (-60° F)



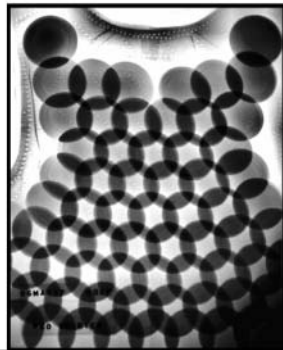
Low Temp



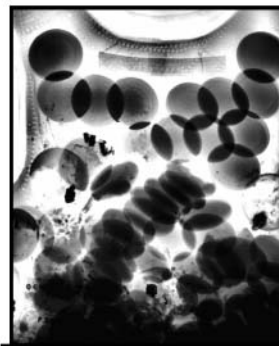
Medium



Vest/Panel	Result
M-02-Front	OK
M-02-Back	OK
M-02-Left Side	OK
M-02-Right Side	OK



M-02 FRONT Before Testing



M-02 FRONT After Testing

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# High Temp (160° F)



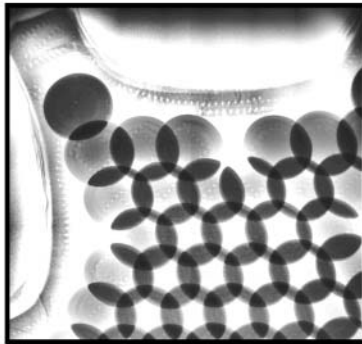
High Temp



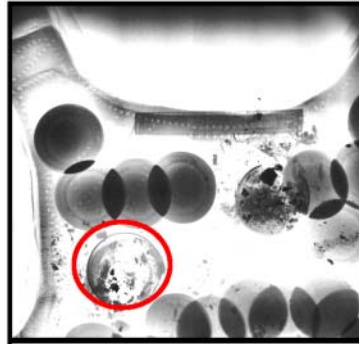
Extra Large



Vest/Panel	Result
XL-03-Front	1st shot, complete penetration
XL-03-Back	1st shot, complete penetration
XL-03-Left Side	1st shot, complete penetration
XL-03-Right Side	1st shot, complete penetration



XL-03 FRONT Before Testing



XL-03 FRONT After Testing

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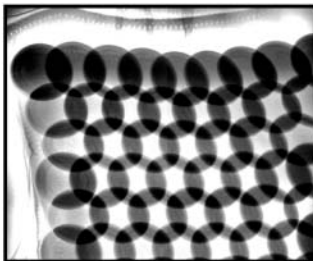




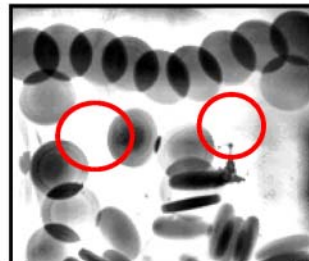
# Temperature Cycle (-25° F to 120° F)



Vest/Panel	Result
L-03-Front	OK
L-03-Back	1st & 2nd shot, complete penetration
L-03-Left Side	OK
L-03-Right Side	OK



L-03 BACK Before Testing



L-03 BACK After Testing

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## Conclusion



- Test results
  - Total number of vests tested: 8
  - Total number of vests failed: 4
  - Total number of penetrations: 13 of 48

***Conclusion: Dragon Skin does not meet required protection standards for Soldier use.***

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## APPENDIX B.

Dean G. Popp's memo retrieved from the author's own professional work archives  
(Department of the Army, 2009).



DEPARTMENT OF THE ARMY  
WASHINGTON DC 20310-0103

SAAL-PA

FEB 9 2009

MEMORANDUM FOR PROGRAM EXECUTIVE OFFICE, SOLDIER,  
5901 PUTNAM ROAD, BUILDING 328,  
FORT BELVOIR, VA 22060

SUBJECT: Testing of Personal Protection Equipment (PPE)

Recent internal and external reviews indicate that the testing process for personal protection equipment needs to be improved. The Army Test and Evaluation Command (ATEC) have both the expertise and the mission to test Body Armor. I direct that ATEC conduct all Body Armor first article and lot acceptance testing. Program Executive Officer (PEO) Soldier will ensure all solicitations articulate this policy.

In order to guarantee the quality of PPE, I intend to establish a clear, objective testing process that will not have an adverse impact on our ability to respond quickly to demands from the field. If PEO Soldier's requirement exceeds the capacity of ATEC to conduct testing, ATEC will contract the work to independent certified testing facilities, to include the National Institute of Justice (NIJ). PEO Soldier will coordinate with the Army Test and Evaluation Office and ATEC to develop the appropriate test documentation and execution of all testing. ATEC will manage any necessary contracting action and exercise oversight of the testing conducted at NIJ testing facilities.

Objective and independent testing of PPE is an important part of our commitment to support the Soldier. This policy will be incorporated into the next Army Regulation 70-1 and 73-1 updates. My point of contact is Mr. John Cason, he can be reached at (703) 604-7004, DSN 664-7004, or e-mail: john.cason@hqda.army.mil.

A handwritten signature in black ink that reads "Dean G. Popp".

Dean G. Popp  
Acting Assistant Secretary of the Army  
(Acquisition, Logistics and Technology)

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## LIST OF REFERENCES

- Department of the Army. (2009). *Memorandum for Program Executive Office, Soldier, 5901 Putnam Road, Building 328, Fort Belvoir, VA 22060*. Washington, DC: Author.
- House Armed Services Committee, 1. C. (2007, June 6). *H.A.S.C. No. 110-58, Department of Defense Body Armor Programs*. Washington, DC: U.S. Government Printing Office.
- Moss, M. (2006, January 7). Pentagon study links fatalities to body armor. Retrieved from <http://www.nytimes.com/2006/01/07/politics/07armor.html?pagewanted=all&r=0>
- NBC News. (2007, May 20). NBC news investigates: NBC puts body armors to the test. Retrieved from [http://www.nbcnews.com/id/18771904/ns/nbc\\_nightly\\_news\\_with\\_brian\\_williams-nbc\\_news\\_investigates/t/nbc-puts-body-armors-test/#.VeMpziCwOM8](http://www.nbcnews.com/id/18771904/ns/nbc_nightly_news_with_brian_williams-nbc_news_investigates/t/nbc-puts-body-armors-test/#.VeMpziCwOM8)
- Office of the Director, Operational Test and Evaluation. (2015, August 25). The Office of the Director, Operational Test and Evaluation/about/responsibilities. Retrieved from <http://www.dote.osd.mil/about/responsibilities.html>
- Project Manager Soldier Equipment. (2007). *Project Manager Soldier equipment briefing on the May 2006 evaluation of Pinnacle armor SOV 3000 "Dragon Skin."* Fort Belvoir, VA: Program Executive Office Soldier.
- Rickey, J. (2009). *Test cost and schedule information paper*. Fort Belvoir, VA: Author.
- Sahlin, T. (2010, March 15). *Program Executive Office Soldier FY2009 Historical Report "Supporting a dynamic Army."* Fort Belvoir, VA: Program Executive Office Soldier.
- Solis, W. M. (2007). *Review of body armor*. (GAO-07-662R). Washington, DC: United States Government Accountability Office.
- Solis, W. M. (2009). *Warfighter support: Independent expert assessment of Army body armor test results and procedures needed before fielding*. (GAO-10-119). Washington, DC: United States Government Accountability Office.
- Tyson, A. S. (2006, January 7). Body-armor gaps are shown to endanger troops. Retrieved from <http://www.washingtonpost.com/wp-dyn/content/article/2006/01/07/AR2006010700005.html>

U.S. Army Aberdeen Test Center. (2008). *Test Operations Procedure (TOP) 10-2-210 ballistic testing of hard body armor using clay backing*. Aberdeen Proving Ground, MD: Test Business Management Division, U.S. Army Developmental Test Command.

U.S. Government Accountability Office. (2015, August 25). About GAO. Retrieved from <http://www.gao.gov/about/>

United States Department of Defense Inspector General. (2009). *DOD testing requirements for body armor*. Arlington, VA: Author.

Wood, S. S. (2007, May 22). Army defends body armor quality. Retrieved from <http://www.army.mil/mobile/article/?p=3292>

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