FBI Body Armor Test Protocol

Version 2.0
12/02/2008
(Replaces v1.0, 09/5/2006)

Defensive Systems Unit
FBI Academy

Revisions:

v1.0 – v2.0

Velocity window of control round is increased by 25 fps. Old window was 1375 – 1425. New window is 1375 – 1450.

Weight of control projectile listed (124 grains).

Number of velocity shots for estimation of contact shot velocity is reduced from 10 to 5.

Exposure time window increased. Old window was 14 – 18 hours. New window is 14 – 24 hours.

Contact information for procurement of control projectile updated. New contact is Colista Stamper, 208-799-3288, colista.stamper@atk.com

Addition of Vyse Gelatine as a retail seller of Foam Eater.

Addition of technical drawing of control projectile.

FBI BODY ARMOR
TEST PROTOCOL

Administrative

The FBI Ballistic Research Facility, part of the Defensive Systems Unit of the Training Division, has created a body armor test protocol to ensure, that the vests issued to our personnel perform at the highest level possible. No test is perfect. No test can tell, with certainty, what will happen. Some key facts of this test protocol should be kept in mind.

1. The test is not meant to replace the NIJ Standardized testing. A prerequisite to FBI testing is that the subject vest have NIJ certification.

2. The test is designed to place additional, more stringent, demands on body armor.

3. The test is intended to simulate threats/conditions that FBI personnel are likely to face.

4. The test may be updated as needed, to reflect additional threats faced by FBI personnel.

5. Peer review input was requested to ensure that the FBI test protocol is relevant and repeatable. While all suggestions were reviewed, no promise was made that any suggestion would be implemented.

6. Peer review input, in many instances, was incorporated in the protocol.

Forward

The FBI test protocol is designed to test under conditions likely to be faced by our personnel. The test protocol replicates extreme cold, extreme heat and the submersion of a vest into water. The FBI test is also designed to assist the Law Enforcement and Military Community by providing an additional test standard that is scientifically repeatable. It is hoped that this will enable manufacturers of Body Armor to engineer through their own testing, products to better protect law enforcement officers and service members.

The FBI test protocol utilizes a "Control Projectile" which represents what we believe is the worst case handgun round our personnel are likely to face. It is understood that other projectiles, with higher threat levels, may come along in the future. They will be considered if/when they arise. The original (previous to v1.0) FBI protocol utilized a cartridge which was custom loaded and unobtainable by body armor manufacturers. As such, it was difficult for the body armor manufacturers to engineer products capable of passing the test. The result was that most vests experienced penetrations during FBI testing.

The test cannot account for every threat to be faced by our personnel. The main purpose of this test is to provide additional standards, based on the needs of the FBI.

The following individuals/companies were provided a copy of the v1.0 protocol in draft form, and asked to provide their recommendations for changes, if any. Special thanks are offered to those who responded with comments/suggestions:

Government Agencies/individuals:

Catherine Crawford – UK Defence Clothing Research and Project Support
Dr. Bo Janzon – Swedish FOI
Dr. Eluned Lewis – UK Defence Clothing Research and Project Support
Drug Enforcement Administration, Firearms Training Unit
Greg Georgevitch – USASOC
National Institute of Justice
National Institute of Standards and Technologies
Kirk Rice, Weapons and Protective Systems
Michael Riley, Testing, Inspection, and Evaluation
James Wong
NLECTC-National, Lance Miller, Deputy Director, Manager, Testing Services
United States Department of State, Diplomatic Security Service
United States Marshal's Service

Independent researchers:

Kenneth Alexander
Dr. Martin Fackler
H.P. White Laboratories
Kevin McClung
Dr. Gary Roberts

Manufacturers of Body Armor

Armor Holdings
Diamondback Tactical dba Custom Armor Technologies
First Choice Armor
Point Blank
Protech Tactical Armor
RBR Tactical Armor
U.S. Armor

Scientific Method

The first step in this protocol was the designation of a "Control Projectile". Only the projectile, velocity and rate of twist are specified. No mention of the cartridge and/or barrel length is made as neither is significant provided the linear velocity and rate of twist are correct.

This projectile was chosen specifically because it is believed to represent the most prolific threat commonly faced by our personnel. Additional considerations were

availability to body armor manufacturers and range safety. The projectile chosen, available from Federal Cartridge Company, part #706236, is similar to a standard NATO specification 9mm projectile. The projectile weight is 124 grains.

A significant difference from the NATO specification is the addition of a brass closure disk to the base of the projectile. This closure disk has been added in an attempt to reduce airborne lead in a test range. It is the FBI's practice to hand-load test cartridges to achieve the most consistent velocity level. Non-lead primers will be obtained and tested with the hope that they can further reduce airborne lead in a test facility. Special thanks to Bob Kramer and Bernie Ness of the Federal Cartridge Company for their assistance in the development of this projectile.

The FBI intends to provide body armor manufacturers and independent test facilities with sufficient information so that they may replicate the FBI test. This approach, previously used with ammunition testing, has proven very effective and provided great benefit, not only to the FBI, but to Law Enforcement in general.

It is recognized that very few Law Enforcement agencies possess the capability of conducting their own ballistic testing. It is also recognized that a primary mission of the FBI is to provide training and assistance to Local and State Law Enforcement agencies. Publication of body armor test data would provide great benefit to these agencies.

The FBI has published the results of its ammunition testing since approximately 1989. Since 1997, the FBI has maintained the position of providing performance data as opposed to performance opinion. The FBI makes no recommendations or judgments of "Pass" or "Fail" to inquiring Law Enforcement agencies. The FBI intends to publish body armor test data in a similar fashion. The FBI will report the test event, the ammunition used, and the result "Penetrated" or "Not Penetrated". It will be up to each agency to determine if the body armor meets their requirements.

All performance data will be “LE/Government restricted”, requiring an official letterhead request. The request must be signed by a supervisor (Sgt., or higher) and contain an “official use, non dissemination” statement. Additionally, test data will generally be provided to the manufacturer of the vest.

It should be remembered that the data reported will be obtained using relatively small sample sizes, under controlled and specified conditions, which do not necessarily represent every possible combination of circumstances that may influence projectile rigidity and impact velocity variations, impact angles, multiple close impacts, human rigidity factors and penetration characteristics in body armor. No test protocol can provide a certainty of ballistic protection.

For purposes of this protocol, the following definitions will apply:

Penetration – The projectile, or any part thereof, completely passes through the ballistic panel and contacts or enters the gelatine.

Vest – A generic term for a ballistic protective garment.

Panel – Either the front or rear portion of a vest.

Carrier – The garment which holds the ballistic panels of the vest.

Contact Shot – a shot fired with the barrel of the test weapon in contact with the carrier of the vest.

TEST PROTOCOL

For statistical confidence, it is preferred that five tests be performed per the sample model of the vest being tested. One complete test requires four panels. Consequently, a test of any model vest would require twenty panels. See attached diagram showing impact areas of individual shots.

CONTROL PROJECTILE

The vest test will use a control projectile for most shots. This will consist of a 9mm 124 grain NATO specification projectile, with an enclosed base, impacting the vest between 1375 and 1450 feet per second (fps). This projectile will be fired from a barrel with a twist rate of 1 turn in 10" +/- 1/4".

This projectile can be purchased from the Federal Cartridge Company. It is identified as part number 706236.

Throughout this test protocol, the above will apply anywhere the words "control projectile" are shown.

In the event that control impact velocity is below specification, the shot will be repeated unless the projectile penetrated the vest.

In the event that control projectile impact velocity is above specification, the shot will be repeated only if the projectile penetrates the vest.

The control projectile, fired at the previously mentioned velocity from the previously mentioned rate of twist, will be used to formulate a base line. Other munitions carried by Special Agent personnel may be included. The velocity of all shots fired will be recorded, when possible. The chronograph (used to measure velocity) consists of three sensors which record the passing of the projectile. Based on the time differential of the triggering of each sensor, and the known distance between the sensors, velocity is measured.

The vest will be placed approximately 4' beyond the last sensor.

Cartridges with velocities less than 1150 fps, and those to be used for contact shots, will be recorded using an estimated velocity. This estimated velocity would be based on a 5 shot sample, recorded the day of the test.

For all tests, the vest will be secured, using the strapping system and carrier of the vest, to validated nominal ten percent gelatine and re-secured whenever necessary. Following each shot, the impact will be marked and any penetration will be documented. The gelatine block weighs approximately 60 lbs. For dimensions, see attached photo of gelatine block and mold.

Body armor test samples will be a standard size and length to fit a male with a 44” - 46” chest, 15” – 17” front length, 17” – 19” back length.

FBI BALLISTIC VEST TEST WORKSHEET AND STANDARDS

Purchasing Agency: FBI _____ OTHER:_____

Manufacturer of Vest :_____

Model: _____

Serial Number(s) : _____ _____ _____

_____ _____ _____ _____

_____ _____ _____

Composition of Vest: _____

NIJ Certification Level: _____

Date of Test: _____

Testing Personnel: _____

A. Validation of Gelatine (Nominal 10% Ballistic Gelatine. BB velocity 590 fps +/- 15 fps. Penetration depth of 2.95" to 3.74").

Block #	Velocity of Validation Shot BB	Penetration in inches
1. ____	_____	_____
2. ____	_____	_____
3. ____	_____	_____
4. ____	_____	_____

SERVICE ROUNDS - CONTACT SHOT VELOCITY

Purpose

Handgun rounds currently carried by FBI personnel will be tested for "contact" shot penetration. This test will provide information on the ability of the vest to stop a projectile if the issued weapon is lost, pushed against the FBI person and fired (as in a physical struggle). Although these rounds are thought to be a lesser threat than the "control" round, it is prudent to test those munitions actually in use by our personnel. This section is intended to record velocity of projectiles which cannot be measured contemporaneously with vest test due to the contact

nature of these shots. Average velocity will be used to estimate impact velocity. Contact the FBI Defensive Systems Unit for a list of current service rounds.

Cartridge: _____

Lot:_____

Average velocity of 5 shots: _____
Standard Deviation: _____
Extreme Spread: _____

Notes: _____

Cartridge: _____

Lot:_____

Average velocity of 5 shots: _____
Standard Deviation: _____
Extreme Spread: _____

Notes: _____

Cartridge: _____

Lot:_____

Average velocity of 5 shots: _____
Standard Deviation: _____
Extreme Spread: _____

Notes: _____

9mm 127 grain SXT +P+, 8.85" barrel with 1:9.84" rate of twist. Note: This cartridge is included due to historical data showing its propensity to penetrate some fabrics commonly used in the production of soft body armor.

Lot: _____

Average velocity of 5 shots: _____
Standard Deviation: _____
Extreme Spread: _____

Notes: _____

A. <u>Dry Test - Control Projectile</u> **First Panel**

Three rounds of test ammunition will be fired into the upper left side of the vest (shooter's perspective) with the rounds impacting no closer than 1.25" and no further than 2" from any other shot, as measured on the outermost layer of the carrier. The panels will be smoothed and re-strapped between shots. Every effort will be made to position the panels consistently, with respect to the carrier, for each shot.

Round A-1 Velocity: _____ Penetration _____ No Penetration ____
Round A-2 Velocity: _____ Penetration _____ No Penetration _____
Round A-3 Velocity: _____ Penetration _____ No Penetration _____

Remarks: _____
_____
_____

B. <u>Multiple Rounds- Control Projectile</u> **First Panel**

Three rounds will be fired into the center of the vest within a three inch diameter circle, drawn on the vest carrier. There will be no smoothing of the ballistic material between shots. If any round impacts the carrier less than 1 inch from another round, as measured on the outermost layer of the carrier, and penetrates, the test will be repeated. Every effort will be made to secure the vest to the block of gelatine in the same manner as designed to be worn. It is realized that successive rounds may impact the vest panels closer than they impact the carrier, due to bunching of the vest.

Round B-1 Velocity**:** _____ Penetration _____ No Penetration _____
Round B-2 Velocity**:** _____ Penetration _____ No Penetration _____
Round B-3 Velocity**:** _____ Penetration _____ No Penetration _____

Remarks**:** _____
_____

C. <u>Edge Test- Control Projectile</u> **First Panel**

**Rounds which impact outside the designated area will be repeated if penetration occurs less than 1.5" from edge or no penetration occurs more than 2.25" from edge.*

1. One round of test ammunition will be fired into the vest approximately 1 ½ - 2" below the neckline. Technician will insure the ballistic panel is firmly against the gelatine block at the top during the test.

Round C-1 Velocity: _____ Penetration _____ No Penetration _____

Remarks: _____
_____

2. One round of test ammunition will be fired into the vest approximately 1 ½ - 2" above the lower edge of the ballistic panel. Technician will insure the ballistic panel is firmly against the gelatine block at the bottom during the test.

Round C-2 Velocity: _____ Penetration _____ No Penetration _____

Remarks: _____
_____
_____

D. <u>Heat Test - Control Projectile</u> Second Panel

The panel will be placed into an environmental chamber and the temperature will be raised to 140 degrees Fahrenheit. The panel will be conditioned between 14-24 hours. Three rounds of test ammunition will be fired into the lower left quadrant (shooter's perspective) of the abdominal area impacting no closer than 1.25" and no further than 2" from any other shot, as measured on the outermost layer of the carrier. The panels will be smoothed and re-strapped between shots. Every effort will be made to position the panels consistently, with respect to the carrier, for each shot. This test will simulate a vest being secured in a vehicle during the extreme heat of summer months.

Controlled Exposure Time: _____

Round D-1 Velocity: _____ Penetration _____ No Penetration _____
Round D-2 Velocity: _____ Penetration _____ No Penetration _____
Round D-3 Velocity: _____ Penetration _____ No Penetration _____

Remarks: _____
_____
_____

E. <u>Cold Test - Control Projectile</u> Third Panel

The vest will be placed in an environmental chamber and the temperature reduced to minus 40 degrees Fahrenheit. The panel will be conditioned between 14-24 hours. Three rounds of test ammunition will be fired into the upper right quadrant (shooter's perspective) of the chest area impacting no closer than 1.25" and no further than 2" from any other shot, as measured on the outermost layer of the carrier. The panels will be smoothed and re-strapped between shots. Every effort will be made to

position the panels consistently, with respect to the carrier, for each shot. This test will simulate a vest being secured in a vehicle during the extreme cold of winter months.

Controlled Exposure Time: _____

Round E-1 Velocity: _____ Penetration _____ No Penetration _____
Round E-2 Velocity: _____ Penetration _____ No Penetration _____
Round E-3 Velocity: _____ Penetration _____ No Penetration _____

Remarks: _____
_____
_____

F. <u>Wet Test - Control Projectile</u> **Fourth Panel**

The vest will be submerged approximately 18"- 24" in room temperature tap water for 14-24 hours. Immediately upon removal from the water, the vest will be strapped to the block of gelatine. The test will commence as soon as possible. Three rounds of control ammunition will be fired into the center of the chest area, impacting no closer than 1.25" and no further than 2" from any other shot, as measured on the outermost layer of the carrier. The panels will be smoothed and re-strapped between shots. Every effort will be made to position the panels consistently, with respect to the carrier, for each shot. This will simulate a vest being exposed to heavy rain or having been immersed in a body of water.

Round F-1 Velocity: _____ Penetration _____ No Penetration _____
Round F-2 Velocity: _____ Penetration _____ No Penetration _____
Round F-3 Velocity: _____ Penetration _____ No Penetration _____

Remarks: _____
_____
_____

G. <u>Contact Shots</u> **Second, Third, or Fourth Panel**

The muzzle of the test weapon will be placed as close to the vest as possible, making contact but not dimpling the outer carrier. One round of ammunition will be fired, impacting no closer than 1.25" from any other shot, as measured on the outermost layer of the carrier. The panels will be smoothed and re-strapped between shots. Every effort will be made to position the panels consistently, with respect to the carrier, for each shot. This will simulate an encounter at point blank range. See attached template for approximate placement of shots.

SERVICE ROUND

All current-issue handgun caliber rounds will be tested against the vest. In the event that the round is used in both a handgun and a submachine gun, velocity testing will be conducted with each type of weapon. Thereafter, the weapon providing the higher velocity will be used for this test. In the event that only handguns are used with this round, the issue handgun with the longest barrel length will be used.

Cartridge: _____

Panel Used: _____ Location: _____

Test Weapon: _____

Average Velocity as recorded above:_____

Penetration _____No Penetration _____

Cartridge: _____

Panel Used: _____ Location: _____

Test Weapon: _____

Average Velocity as recorded above:_____

Penetration _____No Penetration _____

Cartridge: _____

Panel Used: _____ Location: _____

Test Weapon: _____

Average Velocity as recorded above:_____

Penetration _____No Penetration _____

Cartridge: _____

Panel Used: _____ Location: _____

Test Weapon:_____

Average Velocity as recorded above:_____

Penetration _____No Penetration _____

Cartridge: _____

Panel Used:_____ Location: _____

Test Weapon: _____

Average Velocity as recorded above:_____

Penetration _____No Penetration _____

Remarks:_____

H. <u>9mm SXT Contact Shot</u> **Panel 3**

9mm SXT 127 grain +P+, 8.85" barrel with 1:9.84" rate of twist.

Location: _____

Average Velocity as recorded above: _____

Penetration _____No Penetration _____

Remarks: _____

Gelatine Preparation

Equipment:
A scale that measures to .01 lbs.
Kind & Knox or Vyse 250A gelatine
Foam Eater
Cinnamon oil
5 gallon buckets (three)
Pitchers (1-gallon), three for each block you intend to make
Cordless drill with stir (paint mixing) attachment
Water heater set to 150-155 degrees Fahrenheit
Refrigerator set to 39 degrees Fahrenheit
Corrugated cardboard squares approx 3" X 3", one per block
Sharpie marker
Aluminum mold(s)
Chronograph
BB Gun (nitrogen powered preferred)

Mix amounts – The gelatine utilized is referred to as "nominal" 10% ballistic gelatine. The most appropriate mix ratio is discovered by testing. The current (12/2008) ratio in use at the BRF is 11.25%. Calibration is achieved by mixing in .25% intervals and conducting penetration testing. Valid gelatine will result in a BB penetration of 2.95" to 3.74" provided that the BB is traveling 575-605 feet per second (fps).

Procedure, using above ratio (11.25%):

Note: Three (3) 5-gallon buckets are utilized. One is for measuring (weighing) the proper amount of water. One is for mixing the gelatine. The last is filled with hot water and used to rinse the mixing paddle after each mix.

1. Weigh out 2.25 lbs of gelatine into each gallon container.
2. Weigh out 17.75 lbs of hot tap water and then pour it into the mix bucket.
3. Add 1.5ml of Foam Eater to the water.
4. Add .5 ml of cinnamon oil (anti-fungal agent).
5. While stirring the hot water, slowly pour in the 2.25 lbs of gelatine.
6. Stir until all gelatine has dissolved.
7. Rinse mixing paddle in rinse bucket.
8. Pour gelatine mix into the aluminum mold.
9. Repeat steps 2-8 twice.
10. Allow the gelatine mix to sit out in the pan several hours.
11. Place the gelatine into the refrigerator then place the cardboard squares on the surface of the mix. The cardboard squares are approximately 3"x3". The date of the mix is recorded on the cardboard along with lines to enter the block # (i.e. 1-10), the BB velocity and the BB penetration. This "validation" information is entered into the datasheet during testing.

12. After a minimum of 24 hours, break the blocks of gelatine loose from the mold(s) by placing the mold(s) upside down and running hot water over them until the block drops free.
13. Verify the validity of each block by shooting a BB at 590 fps +/-15fps into each block and ensuring that the BB penetrates 2.95” to 3.74”.
14. Record validation information on the cardboard square.

Note: It is best practice to validate a gelatine block on the day of use. Blocks previously validated, but not used, should be re-validated on the actual test day.

Should you require additional information, please contact the following BRF personnel:

Buford Boone	703-632-1753	bboone@fbiacademy.edu
Alan Marshall	703-632-1742	amarshall@fbiacademy.edu
Linda Allison	703-632-1802	lallison@fbiacademy.edu

Supply Information

Chronograph Equipment

Oehler Research Ballistic Instrumentation
P.O. Box 9135
Austin, TX 78766
512-327-6900

Ballistic Gelatine (250 Type A)

Kind & Knox
2445 Port Neal industrial Road
Sergeant Bluff, IA 51054
800-223-9244

Vyse Gelatine Company
5010 North Rose Street
Schiller Park, IL 60176
847-678-4780

Cinnamon Oil

Sigma Chemical Co. (Order number C-7267)
P.O. Box 14508
St. Louis, MO 63178
314-771-5750

Foam Eater

Vyse Gelatine Company
5010 North Rose Street
Schiller Park, IL 60176
847-678-4780

Scale

Doran 7050
A and A Scales LLC
78 North 12th St.
Prospect Park, NJ 07508
800-481-4114

Validation BB Gun

H-S Precision
1302 Turbine Drive
Rapid City, SD 57703
605-341-3006

Environmental Test Chamber

Tenny BTC-05-C
Thermal Products Solutions
P.O. Box 150
White Deer, PA 17887-0150
301-460-9530

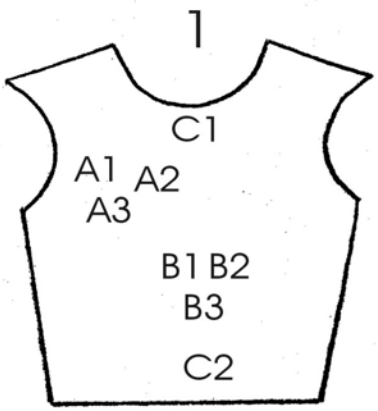
Gelatine Mold

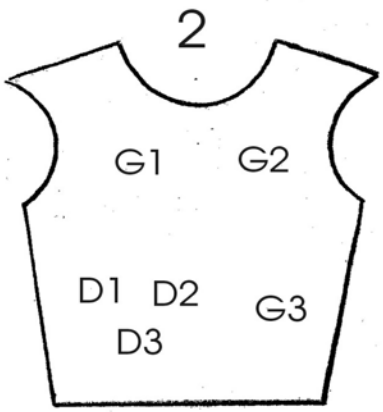
Manufactured In-house at FBI Academy. Should be able to have manufactured at local sheet metal shop. Drawings and photographs attached.

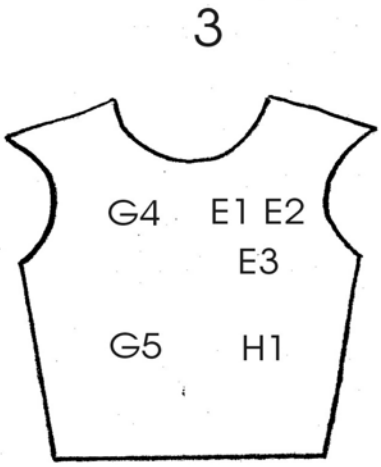
Control Projectile – part number 706236

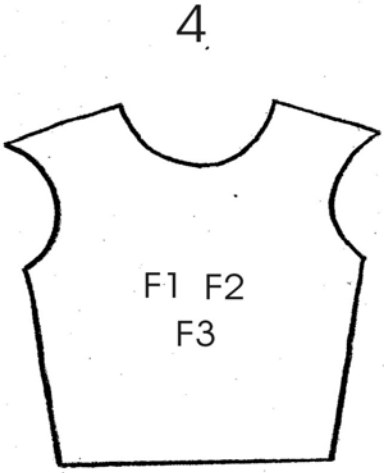
Federal Cartridge Company
Contact: Colista Stamper
208-799-3288
colista.stamper@atk.com

Vendor specificity in this Test Protocol is intended to neither endorse nor recommend a particular product or manufacturer. It is provided so that interested parties may replicate any and all test conditions as conducted by the FBI.


1
C1
A1 A2
A3
B1 B2
B3
C2

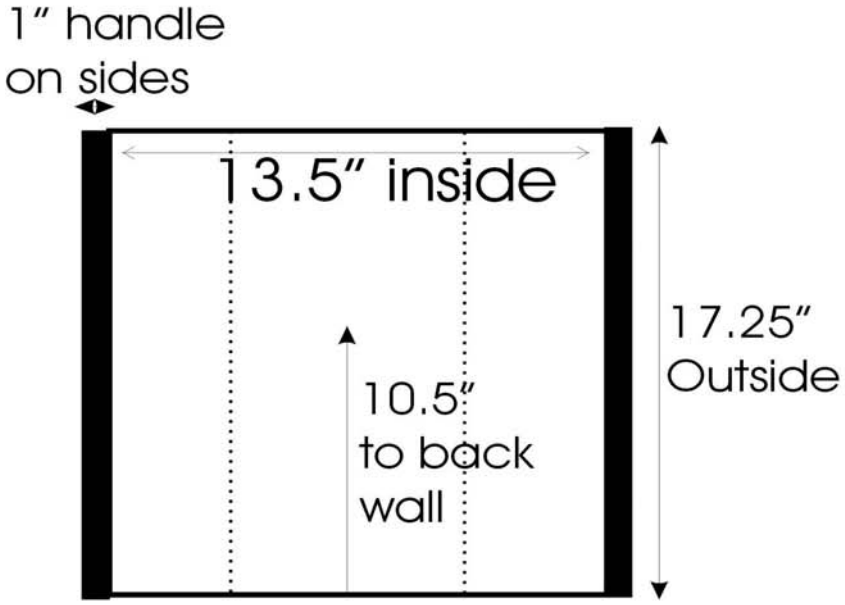

2
G1 G2
D1 D2
G3
D3

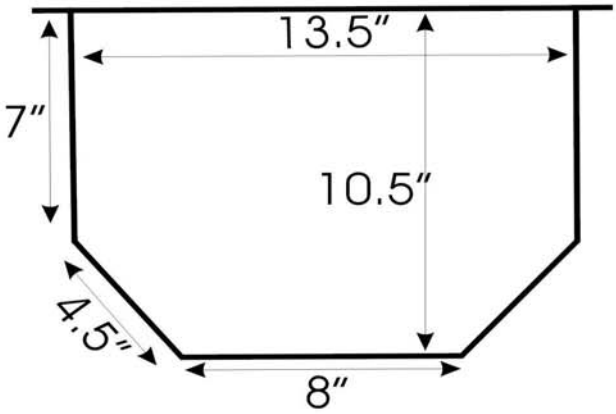

3
G4 E1 E2
E3
G5 H1

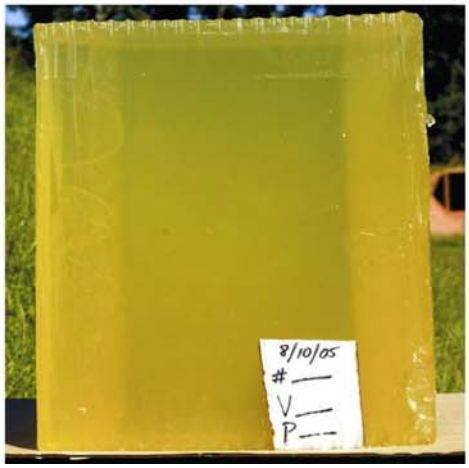

4
F1 F2
F3

FBI Body Armor Gelatine Mold

Mold is constructed of .120" thick aluminum
Creates a block that weighs 60 lbs.

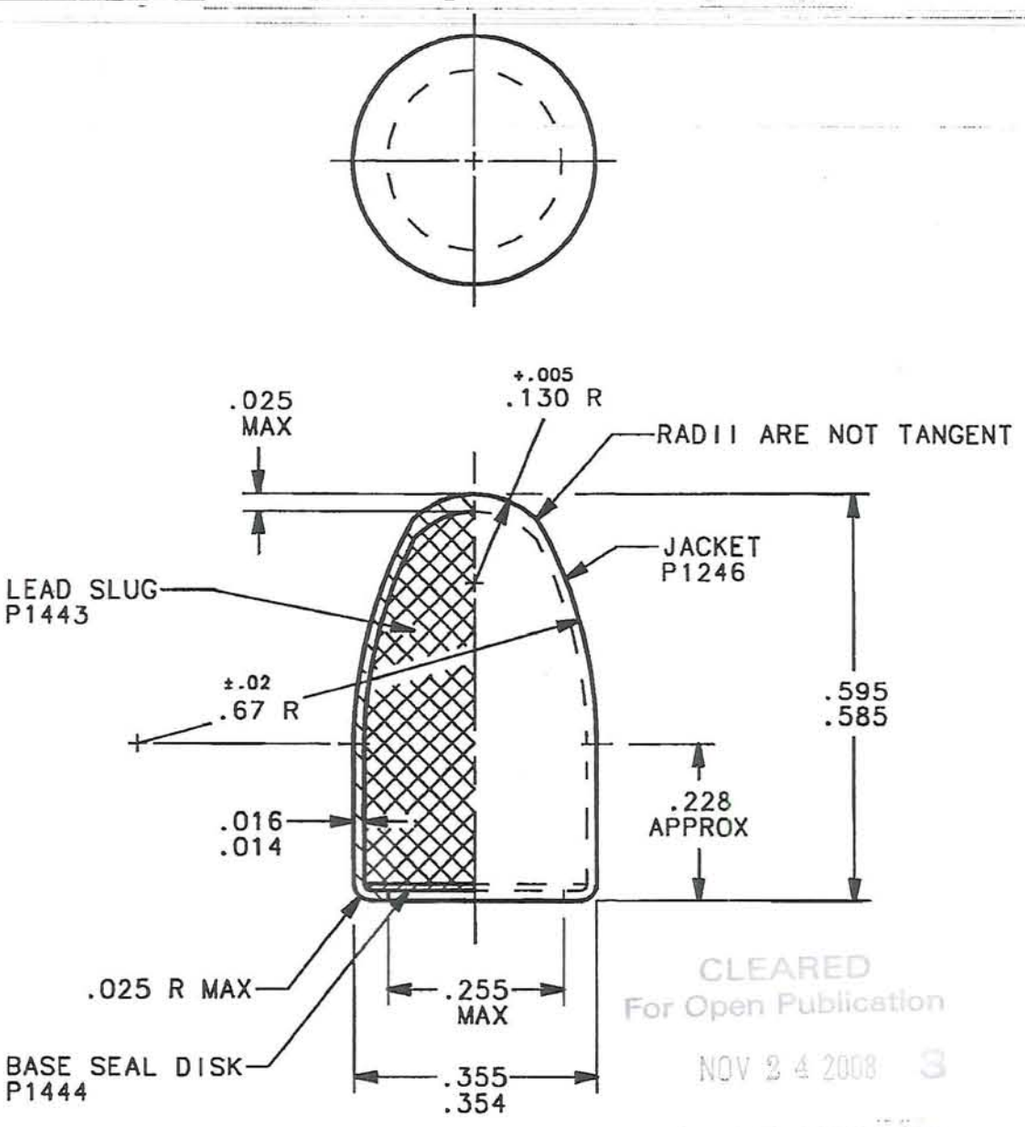






NOTES:

REVISIONS				
SYM	WAS	DATE	BY	APP'D.



LPR 1570
1X34518
REF 1973A15

BLOWUP

DO NOT SCALE DWG.

BREAK ALL SHARP CORNERS UNLESS OTHERWISE SPECIFIED.

TOLERANCE UNLESS NOTED:

ONE PLACE (.X)	±.020
TWO PLACE (.XX)	±.010
THREE PLACE (.XXX)	±.005
FOUR PLACE (.XXXX)	±.0005
FRACTIONAL (X/X)	± 1/32
ANGLES	±

SCALE 4 = 1	MATERIAL NOTED
FINISH	HEAT TREATMENT

CAD DRAWING

FEDERAL CARTRIDGE COMPANY
ANOKA, MINNESOTA

PART NAME: BULLET

FOR: 9MM LUGER, 124 GR TMJ (AE9N1)

DWN.BY RWP DATE 1-15-02 CHKD. PKF

APP'D. SUPERSEDES

NUMBER REQ'D.

NEXT ASSEMBLY

NUMBER: P1442

09-S-0306