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H.P. WHITE LABORATORY, INC.
TEST PROCEDURES

SHARP INSTRUMENT PENETRATION
OF BODY ARMOR

H.P. White Laboratory, Inc.
3114 Scarboro Road
Street, Maryland 21154
(410) 838-6550

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SECTION 1.0 INTRODUCTION

1.1 Background

1.1.1 Increasing levels of social and institutional disorder have highlighted the need for law enforcement personnel to be equipped with passive personal protection from ballistic threats. To meet these requirements, the criminal justice community--in conjunction with law enforcement personnel--have developed a variety of commercially-available body armors which offer varying levels of compromise between ballistic protection and wearability.

1.1.2 In order to standardize the ballistic protection afforded by this body armor, the National Institute of Justice established a testing and evaluation procedure entitled, BALLISTIC RESISTANCE OF POLICE BODY ARMOR, NIJ-STD-0101.03. Several state and local law enforcement agencies have used this procedure as a basis for their individual requirements, which they perceive to be sufficiently different to justify modification of NIJ-STD-0101.03. While the scope of these testing procedures is limited to the BALLISTIC protection afforded by body armor, the average correctional and law enforcement officer erroneously perceives knife and ice pick assaults as lesser threats and, therefore, within the spectrum of the protection of the armor. However, neither NIJ-STD-0101.03 nor any other body armor testing procedure known to H.P. White Laboratory, Inc. addresses the sharp instrument threat commonly encountered by law enforcement and correctional officers.

1.2 Objective

1.2.1 The objective of this standard is to supplement existing ballistic testing procedures and to establish a consistent and reliable means of evaluating the resistance to sharp instrument penetration of body armor.

1.3 Scope of Testing

1.3.1 The scope of these procedures is limited to evaluating the sharp instrument penetration resistance of body armor whose ballistic resistance need not have been previously established by alternate testing procedures.

1.3.2 These procedures are intended to reflect the effect of hand-delivered impacts of sharp, pointed instruments whose point or tip is not offset more than 3/4 inch from the center-line of the clenched fist(s) delivering the impact.

1.3.3 Specifically exempted from these procedures are axes, picks, hatchets, claw hammers, mauls, adzes and any other similar devices whose line of action is generally offset from its grip.

1.4 Disclaimer

- 1.4.1 Compliance with the testing procedures presented herein will not relieve the manufacturer, distributor, or user of all specific and implied liabilities to which they would otherwise be exposed, nor does compliance with these procedures imply any transferral of any portion of the manufacturer's or distributor's product liability exposure to H.P. White Laboratory, Inc., whether or not testing--conducted to demonstrate this compliance--is conducted by H.P. White Laboratory, Inc.

- 1.4.2 The procedures contained herein are offered to the manufacturer (and others with a direct or indirect interest in personal safety) as a means of evaluating the design and performance of puncture resistant body armor. Nothing contained herein is to be construed as a guarantee, warranty, or endorsement by H.P. White Laboratory, Inc.--or its personnel--of the design or performance of any puncture resistant body armor.

SECTION 2.0 PROCEDURES

2.1 General

- 2.1.1 The basis of these procedures is the creation of a consistent and repeatable sharp instrument impact which is representative of:
- a) a typical sharp instrument which may be used to defeat the protection of ballistic body armor, and
 - b) the maximum energy with which such an instrument could be hand-delivered by a healthy, athletic male with no physical infirmities.
- 2.1.2 The essential characteristics of the implement selected for these tests are its relatively high length to diameter ratio, its pointed configuration, and its hardness. The implement selected was an ice pick shaft whose material is defined as S.A.E. Specification Number 1060, whose length is 7 inches, whose diameter is 0.163 inches, whose point taper is 15:1, and whose hardness is units, Rockwell Superficial Scale 30N.
- 2.1.3 The maximum kinetic energy with which such an implement could be hand-delivered was determined experimentally using several suitable participants who repeatedly delivered blows with a two-handed, overhead chopping motion onto a horizontal surface 40 inches above the surface on which they were standing. This kinetic energy value was then increased 15 per cent.
- 2.1.4 This resultant value is to be replicated using a 40 pound weight dropped from a stationary position located 47.15 inches above the test panel impact surface, such that the resultant theoretical kinetic energy is 1886 inch-pounds, the resultant theoretical translational momentum is 19.8 pound-seconds, and the resultant theoretical striking velocity is 15.91 feet per second. These values are theoretical, inasmuch as the calculations assume the potential energy to be wholly-transformed into kinetic energy, disregarding that portion of the potential energy actually transformed into friction, heat, sound, et cetera.

2.2 Sampling

- 2.2.1 One complete armor assembly (front, back, and sides as appropriate) shall constitute a test sample. Each panel of a multi-panel armor is to be tested.

2.3 Set-Up

- 2.3.1 In preparation for these tests, the drop fixture of Figure 1 (or equivalent) will be fabricated. The fixture must maintain the centerline of the drop instrument assembly (Figure 3) within two degrees of the vertical.

2.3.2 A rectangular volume of non-hardening modelling clay measuring 24 inches x 24 inches x 4 inches within a topless five-sided container will be positioned with its 4 inch dimension in the vertical plane under the drop fixture. The clay will be free of air, its exposed upper surface smooth, even, and perpendicular to the centerline of the drop fixture.

2.4 Drop Test Verification

2.4.1 Prior to conducting tests of each sample of body armor, drop trials will be conducted to verify the suitability of the clay backing.

2.4.2 The clay verification drop weight (Figure 2) will be dropped three times from a height of 78.74 inches (2 meters) to impact the clay backing surface at locations sufficiently dispersed so as to prevent overlapping of the disturbed areas of the clay resulting from previous drop trials. The depth of the impression of each of the three trials shall not exceed 1.10 inches, nor be less than 0.90 inches. If this condition is not satisfied, the clay shall not be used for testing. Another clay backing satisfying this condition shall be used.

2.4.3 Once the clay backing has satisfied the above condition, testing should begin immediately. The clay should be removed from its temperature conditioning chamber for only as long as is required to complete the testing. If the clay plasticity is questionable, verification testing may be repeated, or another clay backing complying with the provisions of paragraph 2.4.2 may be substituted.

2.5 Drop Test Procedure

2.5.1 The test sample will be pressed onto the surface of the clay to a sufficient depth to assure intimate contact between the clay backing and all portions of the rear surface of the test panel. If a convex test sample is to be tested, clay will be built up behind the sample so as to occupy the volume defined by the inner, concave side. Intimate contact is to be made between the clay and the inner side of the test sample.

2.5.2 The clay and test panel will be positioned under the drop fixture in a manner which assures its rigidity in the vertical plane and that the anticipated point of impact is normal (± 2 degrees) to the line of translation of the drop instrument assembly. For rigid, convex armor, the line of translation shall be normal (± 2 degrees) to the tangent of the curve at the intended impact location.

2.5.3 Five fair drop trials will be conducted on each panel of armor tested. After each trial, the depth of the impression in the clay backing will be recorded to within 0.01 inches, and a determination of compliance or non-compliance (see Section 3.0) recorded.

2.5.4 The drop trial centers of impact shall be no closer than 2 inches to the edge of the test sample, nor closer than 2 inches to the center of impact of a prior trial.

2.6 Materials

2.6.1 The following materials and fixtures are required to complete these tests:

- a) Clay, Non-Hardening, Roma Plastilina No. 1 (no substitutes).
- b) Fixture, Test, Figure 1 (or equivalent).
- c) Fixture, Clay Verification, Figure 2 (or equivalent).
- d) Assembly, Instrument, Drop, Figure 3 (no substitutes).
- e) Pick, Ice, Figure 3 (no substitutes).
- f) Weight, Drop, Clay Verification, Figure 4 (no substitutes).

SECTION 3.0 DEFINITIONS AND REQUIREMENTS

3.1 General

- 3.1.1 The general definitions, requirements, and acceptance criteria of this procedure are based on NIJ-STD-0101.03, BALLISTIC RESISTANCE OF POLICE BODY ARMOR, dated April 1987, but are not necessarily endorsed by anyone other than H.P. White Laboratory, Inc.
- 3.1.2 The specific acceptance criteria of this procedure were derived from tests conducted by a 22 year old healthy male, active in a variety of body contact sports. While he was physically able to deliver impacts significantly in excess of nine other individuals tested, his performance should not necessarily be construed as the maximum which might be encountered in a much larger population. For that reason, the maximum performance amongst the 10 individuals tested was increased 15 per cent to establish the acceptable performance criterion presented herein.

3.2 Fair Drop Test

- 3.2.1 Each of the five required drop trials must comply with the following FAIR drop requirements--all others will be termed UNFAIR. Unfair trials shall be repeated pursuant to paragraph 3.4.6 until the required number of trials is obtained.
- a) The drop instrument assembly shall impact the test sample within 2 degrees of the vertical axis.
 - b) The vertical distance between the clay impact surface and the bottom of the clay verification drop weight (Figure 2) at the instant of its release shall be within 0.125 of an inch of that specified in Paragraph 2.4.2.
 - c) The vertical distance between the impact surface of the test panel and the point of the pick of the test drop weight (figure 3) at the instant of its release shall be 47.15 inches (\pm 0.125 of an inch).
 - d) The disturbed area of the clay backing or the test sample of each drop trial shall not extend to the periphery of the sample or clay backing, nor shall it overlap the disturbed area of any other drop trial.
 - e) The test drop weight (Figure 3) shall fully exit the drop tube prior to impacting the test panel, and its orientation shall be unrestrained after that impacting.

3.3 Clay Verification Test

- 3.3.1 The depth of the impression in the clay backing of each of the three fair clay verification trials shall be 1.0 inch plus or minus 0.1 inch. Any fair drop test which does not satisfy this requirement will disqualify the clay backing from use in testing, despite the number of other fair drop tests which meet this requirement.
- 3.3.2 The clay shall be temperature conditioned and retested until this requirement is satisfied, or another clay-filled container whose plasticity is determined to be in compliance may be substituted.
- 3.3.3 The depth of the impression in the clay will be measured from a horizontal reference line between the surface of two undisturbed areas of the clay vertically to the deepest point of the impression. Clay exuded at the periphery of the impression may be removed to facilitate this measurement.

3.4 Test Sample Acceptance Criteria

- 3.4.1 Any fair trial of the test drop instrument assembly (Figure 3) which does not penetrate the rear surface of the test sample AND which does not produce an impression in the clay backing in excess of 1.73 inches (44mm) will be termed as being in compliance with the requirements of this procedure.
- 3.4.2 Any drop trial of the test drop weight whose kinetic energy is LESS THAN 1886 inch-pounds, which penetrates the rear surface of the test sample AND/OR which produces an impression in the clay backing in excess of 1.73 inches (44mm), shall be deemed a fair trial and shall fail the test sample.
- 3.4.3 Any drop trial of the test drop weight whose kinetic energy is LESS THAN 1886 inch-pounds, which does not penetrate the rear surface of the test sample AND/OR which does not produce an impression in the clay backing in excess of 1.73 inches (44mm), shall be deemed an unfair trial and shall be repeated.
- 3.4.4 Any drop trial of the test drop weight whose kinetic energy is MORE THAN 1886 inch-pounds, which penetrates the rear surface of the test sample AND/OR which produces an impression in the clay backing in excess of 1.73 inches (44mm), shall be deemed an unfair trial and shall be repeated.
- 3.4.5 Any drop trial of the test drop weight whose kinetic energy is MORE THAN 1886 inch-pounds, which does not penetrate the rear surface of the test sample AND/OR which does not produce an impression in the clay backing in excess of 1.73 inches (44mm), shall be deemed a fair trial.

- 3.4.6 Should one or more of the initial five trials be unfair, additional trials shall be conducted as necessary--and without limit--except as noted in paragraphs 2.5.4 and 3.2.1d.
- 3.4.7 Any fair drop trial which penetrates the test sample or deforms the clay in excess of that stipulated in paragraph 3.4.2 shall fail the test sample, despite the number of other trails which may have produced results complying with this procedure.



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TEST FIXTURE

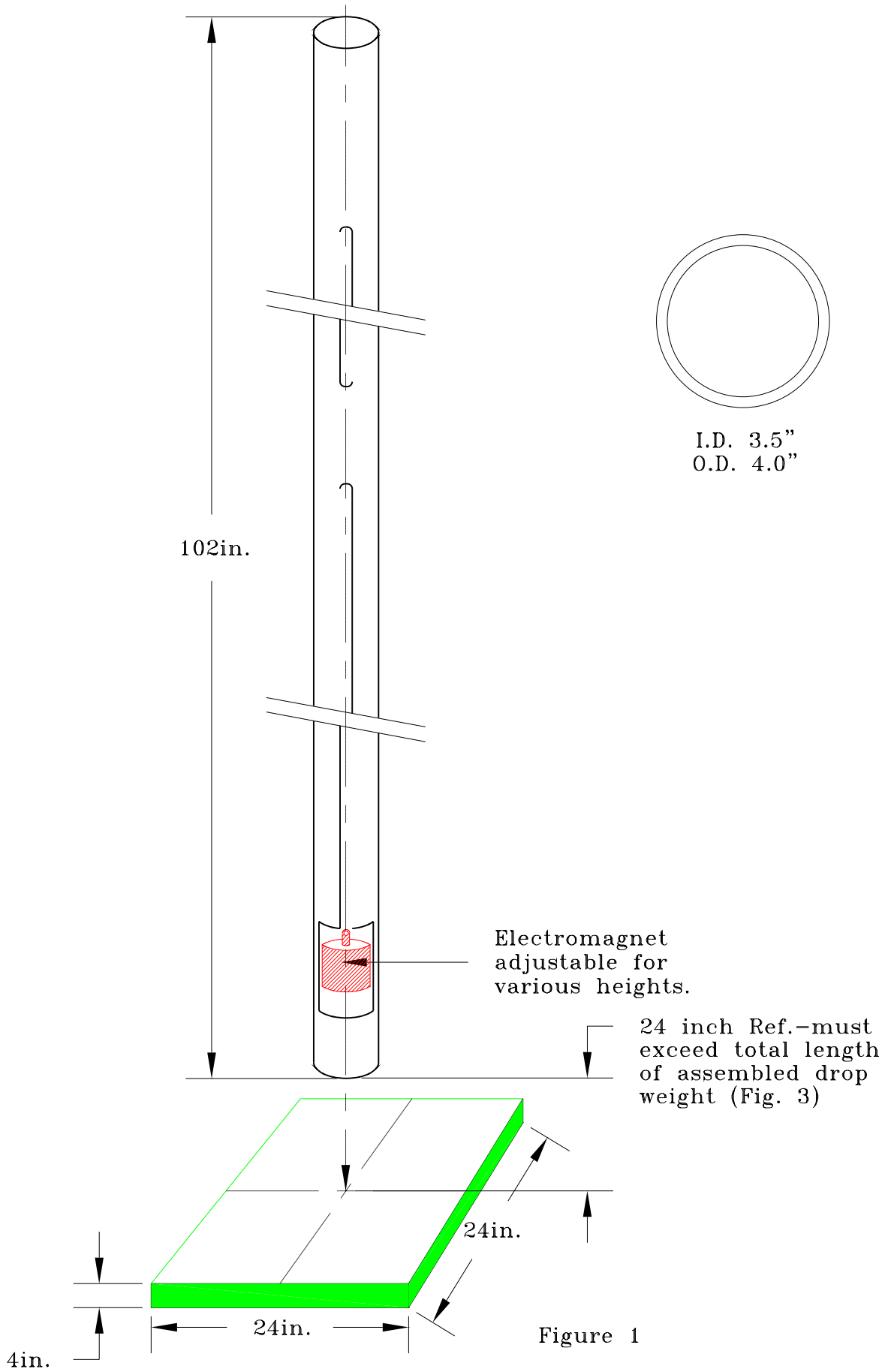


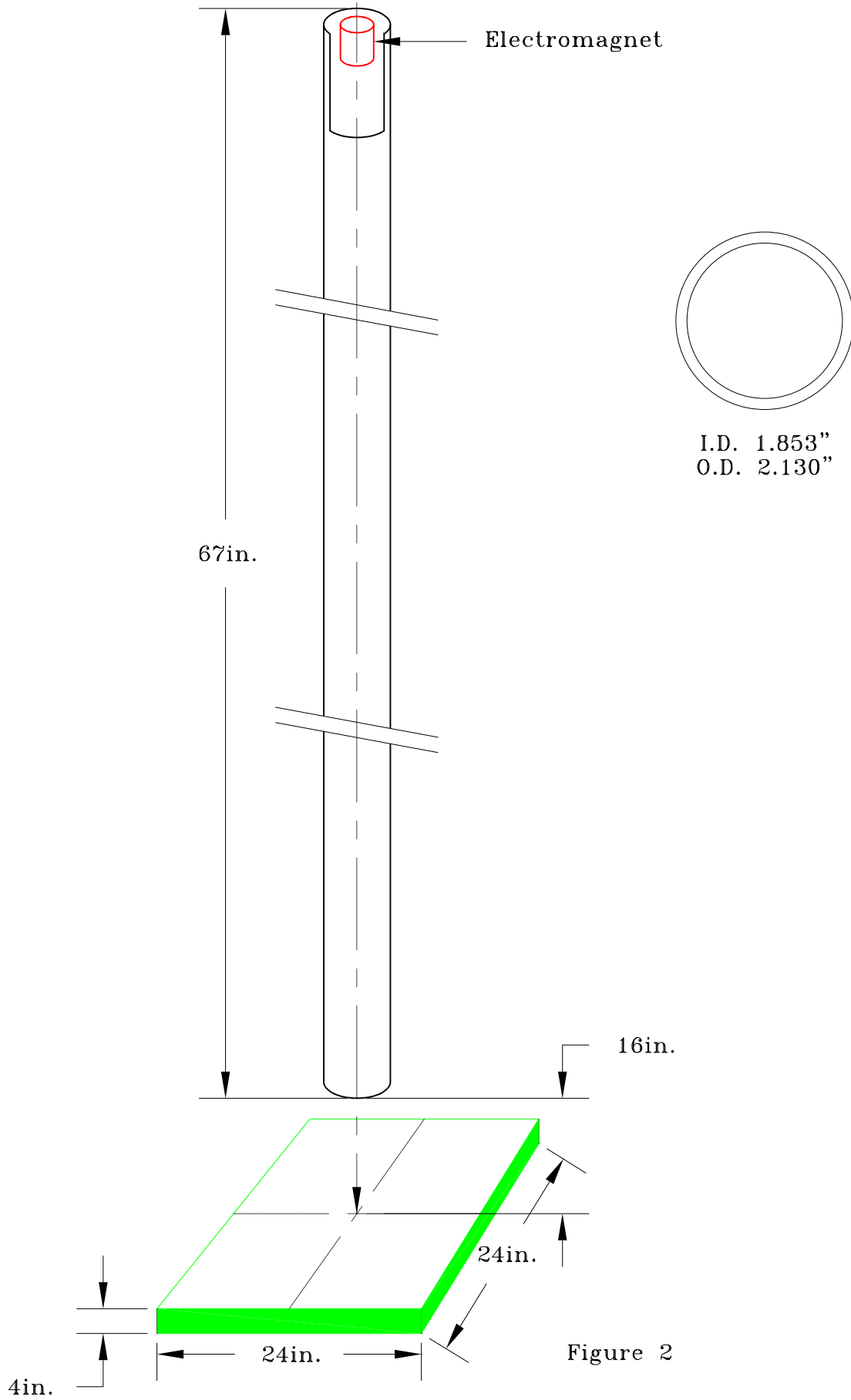
Figure 1



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CLAY VERIFICATION FIXTURE





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STANLEY MODEL 007 AWL

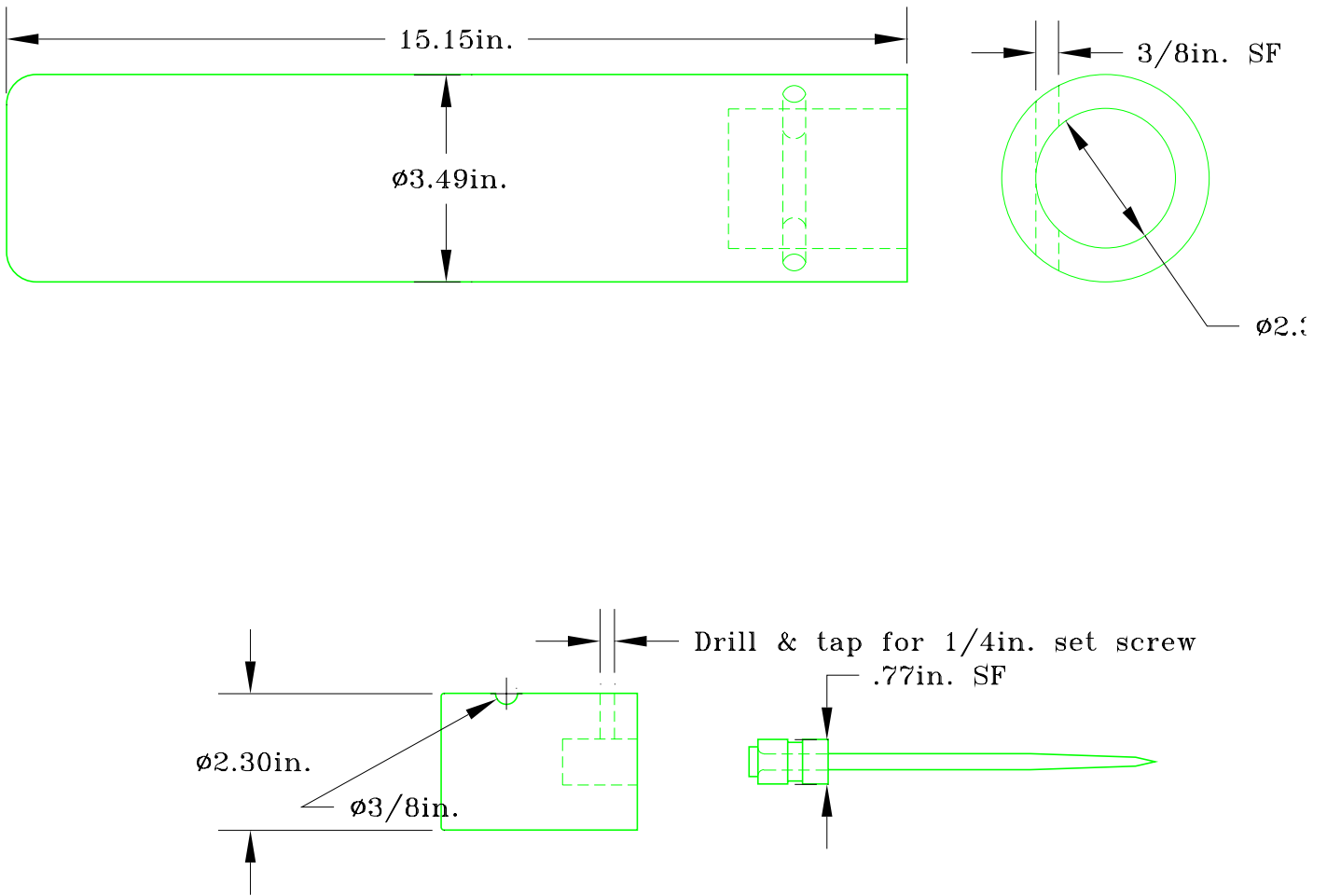


Figure 3



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CLAY VERIFICATION WEIGHT

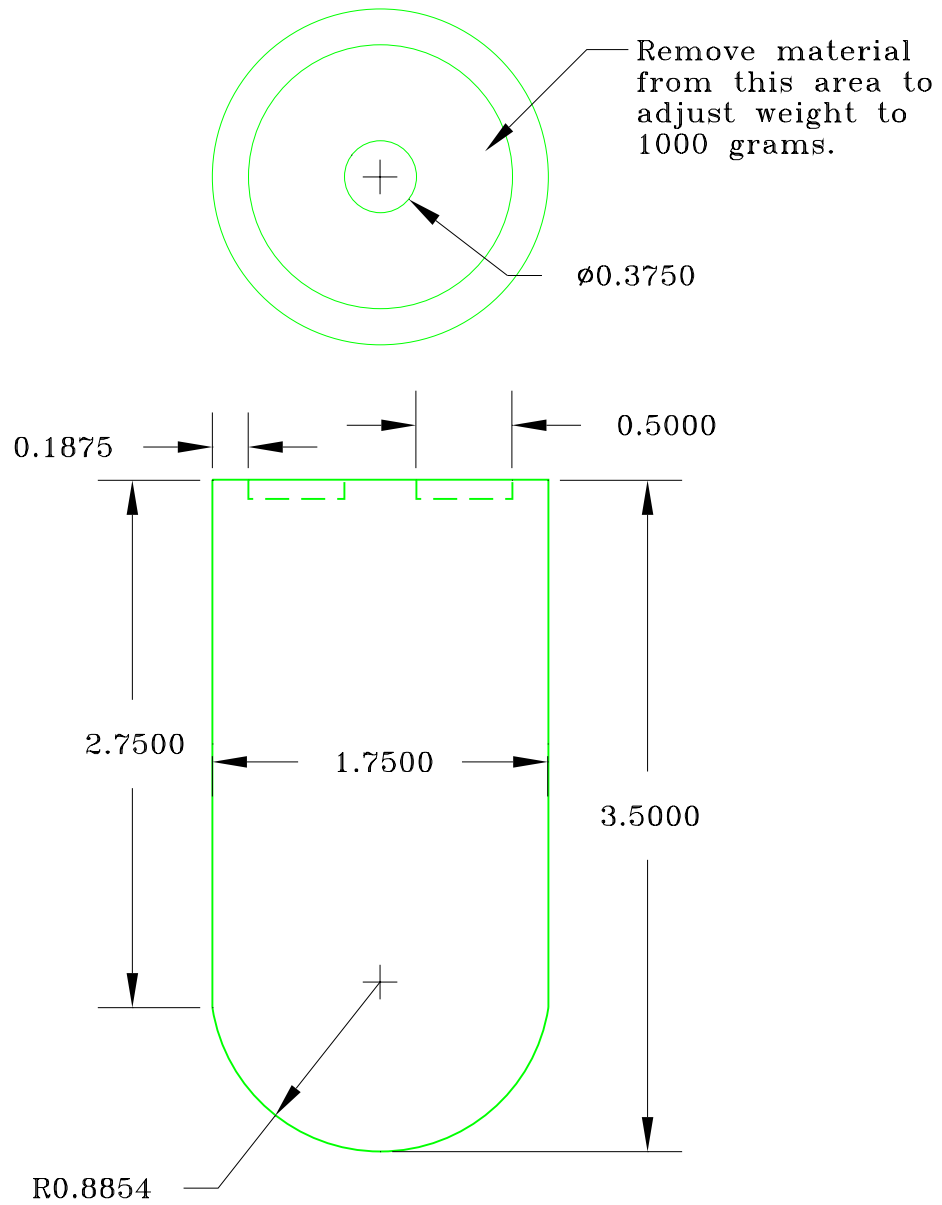


Figure 4



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DATA RECORD

Sharp Instrument Penetration
of Body Armor

Date Received: _____
Via: _____
Returned: _____

HPWLI Job No.: _____
Customer: _____
Test Date: _____

Applicable Standard/Procedure: _____

Test Panel

Manufacturer: _____ Model No.: _____ Lot No.: _____

Serial No.: Front: _____ Weight (lbs): Front: _____
Back: _____ Back: _____

Tested Dry/Wet: _____ Ply Count: _____

Material Description: _____

Sharp Instrument: _____

Length (in): _____ Weight (lbs): _____ Diameter (in): _____

Drop No.	Instrument Hardness (a)	Drop System (b)					Results		
		Height (in)	Weight (lbs)	Kinetic Energy (in-lbs) (c)	Momentum (lb-sec) (c)	Striking Velocity (ft/sec) (c)	Penetration		Deformation (mm) (d)
							Yes	No	
Front									
1									
2									
3									
4									
5									
Back									
1									
2									
3									
4									
5									

- (a) As measured in units of Rockwell, scale C.
- (b) Combination of holding apparatus and sharp instrument.
- (c) Theoretical; friction, heat, sound, etc. not considered.
- (d) As measured on _____°F clay backing.

Test Personnel: _____

Figure 5

REVISIONS RECORD SHEET

Revision	Date	Type	Dia. (in)	Length (in)	L/D	Hardness Rc	Wgt. (lbs.)	Hgt. (in)	KE (in-lb)	Mom. (lb-s)	Vel. (ft/s)
0200.00	10/15/83	Awl	1/4	6-3/4	27:1	NA	18.5	102	1887	NA	NA
0200.01	02/03/87	Pick	0.163	7	27:1	42	18.5	102	1887	NA	NA
0400.00	07/22/88	Pick	0.163	7	27:1	42	20.5	92	1886	NA	NA
0400.01 (a)	07/00/90	Pick	0.163	7	27:1	42	20.5	92	1886	NA	NA
0400.02	09/00/90	Pick	0.163	7	NA(b)	42-44	40.0	47.15	1886	NA	NA
0400.03	11/23/94	Pick	0.163	7	NA(b)	55-58(c,d)	40.0	47.15	1886	19.8	15.9

(a) Minor clerical changes and rewording of HPW-TP-0400.00.

(b) No length to diameter ratio specified, but instead a 15:1 point taper ratio.

(c) Based on pick manufacturers' advice. All picks made to 55-58 Rc Hardness; none made to 42 Rc Hardness.

(d) Based on pick manufacturers' advice, alloy S.A.E. Specification Number 1060.