NORTH ATLANTIC TREATY ORGANIZATION
ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD

MILITARY AGENCY FOR STANDARDIZATION (MAS)
BUREAU MILITAIRE DE STANDARDISATION (BMS)
1110 BRUSSELS

Tel : 707.43.02

5 November 1998 MAS/417-LAND/4190

STANAG 4190 LAND (EDITION 2) - TEST PROCEDURES FOR MEASURING BEHIND-ARMOUR EFFECTS OF ANTI-ARMOUR AMMUNITION

Reference:
a. AC/225-D/1393, AC/225(Panel III)D/370 dated 28 June 1996 (Edition 2)(1st Draft)
b. MAS/303-LAND/4190 dated 28 November 1989 (Edition 1)

1. The enclosed NATO Standardization Agreement which has been ratified by nations as reflected in page iii is promulgated herewith.

2. The references listed above are to be destroyed in accordance with local document destruction procedures.

3. AAP-4 should be amended to reflect the latest status of the STANAG (and AP if applicable).

ACTION BY NATIONAL STAFFS

4. National staffs are requested to examine page iii of the STANAG and, if they have not already done so, advise the Defence Support Division, IS, through their national delegation as appropriate of their intention regarding its ratification and implementation.

A. GRØNHEIM
Major General, NOAF
Chairman MAS

Enclosure:
STANAG 4190 (Edition 2)

STANAG No. 4190
(Edition 2)

NORTH ATLANTIC TREATY ORGANIZATION
(NATO)

MILITARY AGENCY FOR STANDARDIZATION
(MAS)

STANDARDIZATION AGREEMENT
(STANAG)

SUBJECT: **TEST PROCEDURES FOR MEASURING BEHIND-ARMOUR EFFECTS OF ANTI-ARMOUR AMMUNITION**

Promulgated on 5 November 1998

A. GRØNHEIM
Major General, NOAF
Chairman, MAS

RECORD OF AMENDMENTS

No.	Reference/date of amendment	Date entered	Signature

EXPLANATORY NOTES

AGREEMENT

1. This NATO Standardization Agreement (STANAG) is promulgated by the Chairman MAS under the authority vested in him by the NATO Military Committee.

2. No departure may be made from the agreement without consultation with the tasking authority. Nations may propose changes at any time to the tasking authority where they will be processed in the same manner as the original agreement.

3. Ratifying nations have agreed that national orders, manuals and instructions implementing this STANAG will include a reference to the STANAG number for purposes of identification.

DEFINITIONS

4. Ratification is "In NATO Standardization, the fulfilment by which a member nation formally accepts, with or without reservation, the content of a Standardization Agreement" (AAP-6).

5. Implementation is "In NATO Standardization, the fulfilment by a member nation of its obligations as specified in a Standardization Agreement" (AAP-6).

6. Reservation is "In NATO Standardization, the stated qualification by a member nation that describes the part of a Standardization Agreement that it will not implement or will implement only with limitations" (AAP-6).

RATIFICATION, IMPLEMENTATION AND RESERVATIONS

7. Page iii gives the details of ratification and implementation of this agreement. If no details are shown it signifies that the nation has not yet notified the tasking authority of its intentions. Page iv (and subsequent) gives details of reservations and proprietary rights that have been stated.

FEEDBACK

8. Any comments concerning this publication should be directed to NATO/MAS - Bvd Leopold III - 1110 Brussels - BE

STANAG 4190
(Edition 2)

NAVY/ARMY/AIR

NATO STANDARDISATION AGREEMENT
(STANAG)

TEST PROCEDURES FOR MEASURING BEHIND-ARMOUR EFFECTS OF ANTI-ARMOUR AMMUNITION

Annexes:

A. Residual Penetration Measurements
B. Measurement of Distribution of Fragments
C. Other Behind-Armour Effects

Related Documents:

STANAG 4089 Armour Plate Configuration for Anti-Armour Ammunition Tests

STANAG 4164 Test Procedures for Armour Perforation Tests of Anti-Armour Ammunition

AIM

1. The aim of this agreement is to establish standard techniques for measuring the effect of anti-armour ammunition subsequent to a perforation of an armour target.

AGREEMENT

2. Participating nations agree to use the test procedures defined in this STANAG for measuring behind-armour effects of anti-armour ammunition.

GENERAL

3. This agreement is divided into 3 annexes:

Annex A describes how residual penetration measurements are made;

Annex B deals with measuring fragment distributions;

Annex C comments on the measurement of other behind-armour effects.

4. Detailed study has shown that all the various techniques in use for measurement of behind-armour fragment distribution have both advantages and disadvantages. However, the metallic witness plate technique offers the considerable advantage of minimising the labour required for measurements, while yielding sufficiently detailed data for computer-based vulnerability and lethality assessments when supplemented with suitable data analysis based on an interpolation scheme. It is recommended that this technique, described in Annex B, be used, unless there are compelling reasons to select one of the others.

IMPLEMENTATION OF THE AGREEMENT

5. This STANAG is implemented when a nation has issued the necessary instructions to the establishments concerned putting the procedures detailed in this agreement into effect.

ANNEX A to
STANAG 4190
(Edition 2)

RESIDUAL PENETRATION MEASUREMENTS

This annex outlines the procedure for recording the penetration capability of the main residual kinetic energy penetrator pieces or the residual shaped charge jet.

1. Arrangement of Witness Plates.

The witness plates will be placed behind and parallel to the back surface of the target. The air space between the target and witness plates will be one of the following:

a. For shaped charge tests, 50 mm measured along the line of sight (Figure 1).

b. For tests of kinetic energy penetrators at obliquities less than or equal to 60 degrees, 100 mm measured perpendicular to the rear face of the armour (Figures 2a, 2b).

c. For tests of kinetic energy penetrators at obliquities greater than 60 degrees, 200 mm measured along the line of sight (Figure 2c).

d. If use of the configuration described in Sub-Paragraph c above would cause ricochet of the residual penetrator from the witness plates, the witness plates may be placed perpendicular to the line of sight (Figure 2d).

In all cases, report the actual distance between the exit hole in the armour and the entrance hole in the first witness plate.

2. Witness Plate Material and Geometry.

The witness plates will be rolled homogeneous armour, purchased under one of the four specifications given in STANAG 4089 but with the Brinell hardness falling between 275 and 325. Thicknesses of individual plates in the stack will be 25 mm or more for target obliquities less than 60 degrees, and 20 mm or more for target obliquities of 60 degrees or greater. The thickness of the total stack of witness plates should be large enough to contain the total residual path of the penetrator with no noticeable bulge on the rear of the last plate. Care should be taken to see that the witness plates are in close contact with each other.

3. Hole Depth Measurement.

In general, the major fragment of the residual penetrator will perforate a number of witness plates and then be stopped. The total residual penetration is the sum of the plate thicknesses penetrated plus the hole depth in the last plate penetrated. The hole depth in this plate should be measured perpendicular to the front surface of the plate. For an example, see Figure 3a. The measurement is the same for oblique and non-oblique targets. For oblique targets, however, the measurement is then converted to line-of-sight penetration.

Some situations may make measurement of hole depth difficult. For instance, the hole may be a very shallow trough and the front surface deformed, as shown in Figure 3b. Care should be taken to use the undeformed portion of the front surface of the witness plate as a reference. In the example shown in Figure 3c, it may be impossible to use a depth micrometer or similar measuring device due to the slant of the crater. In this case, it is advisable to section the plate to get an accurate measurement. When the residual penetrator becomes lodged in the hole (Figure 3d), it must either be removed (drilled out) or the plate sectioned. Another possible technique to use in this instance is to radiograph the residual penetrator in the plate. Measurements can then be made from the radiograph. However, this technique is only applicable when there is a large difference in the densities of the penetrator and the target.

If the last plate penetrated bulges, then the height of the bulge must be subtracted from the measured depth of the hole (Figure 3e).

4. Measurement of Hole Geometry.

Wherever practicable, measurements should be made of the geometry of the holes in the witness plates. The important features are volume and diameter of the hole as functions of depth in the plate. Diameters may be measured by any of a variety of techniques, eg, using vernier callipers or star gauges or by sectioning the plate, but they must be taken sufficiently below the surface to avoid edge effects. In the case of a hole with an elliptical cross section, diameters should be measured in the directions of the major and minor axes. Volumes of holes can be measured by filling them with a medium such as sand or a liquid, again taking the measurements corresponding to the undisturbed surfaces of the plates. The techniques adopted will be selected to suit the shape and character of the holes, which will in turn depend upon the type of munition and the configuration of the armour.

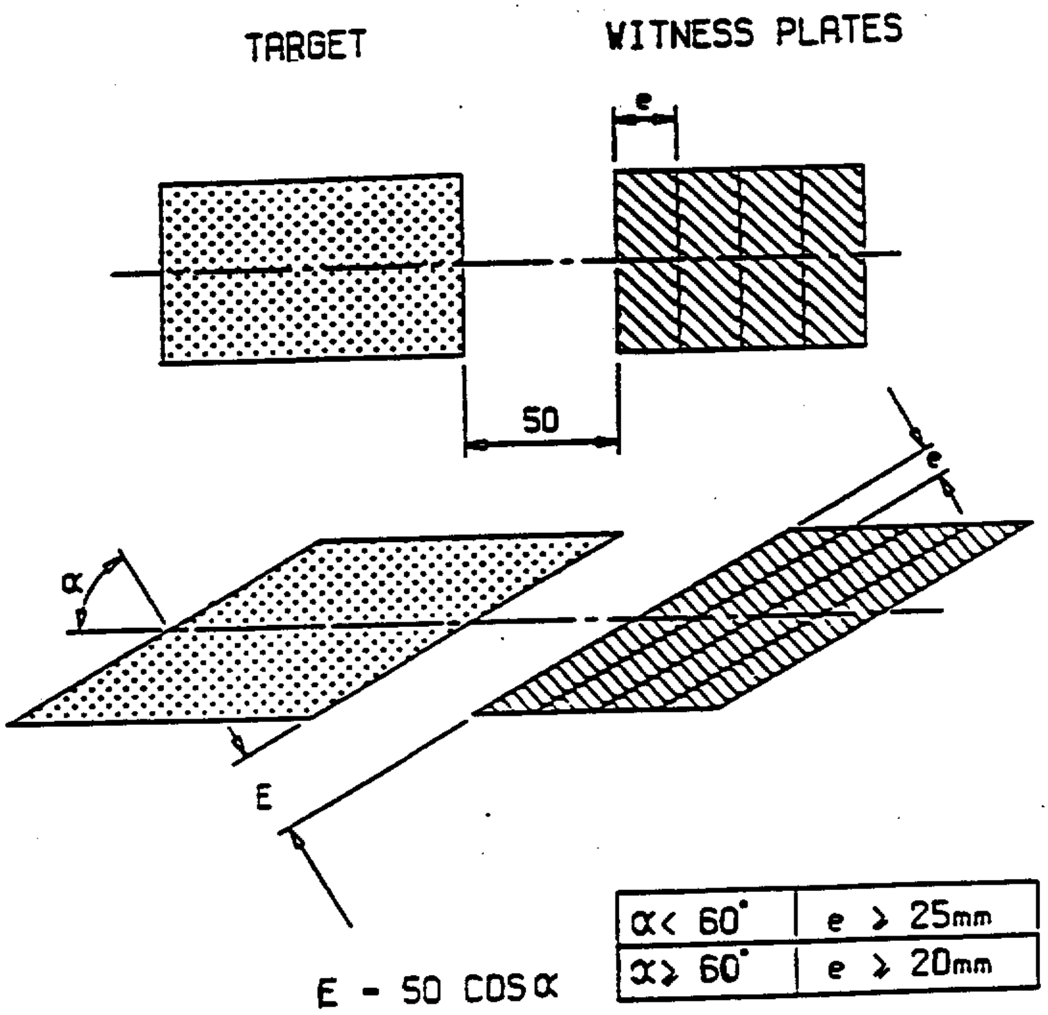


Figure 1 Shaped Charge

ANNEX A to
STANAG 4190
(Edition 2)

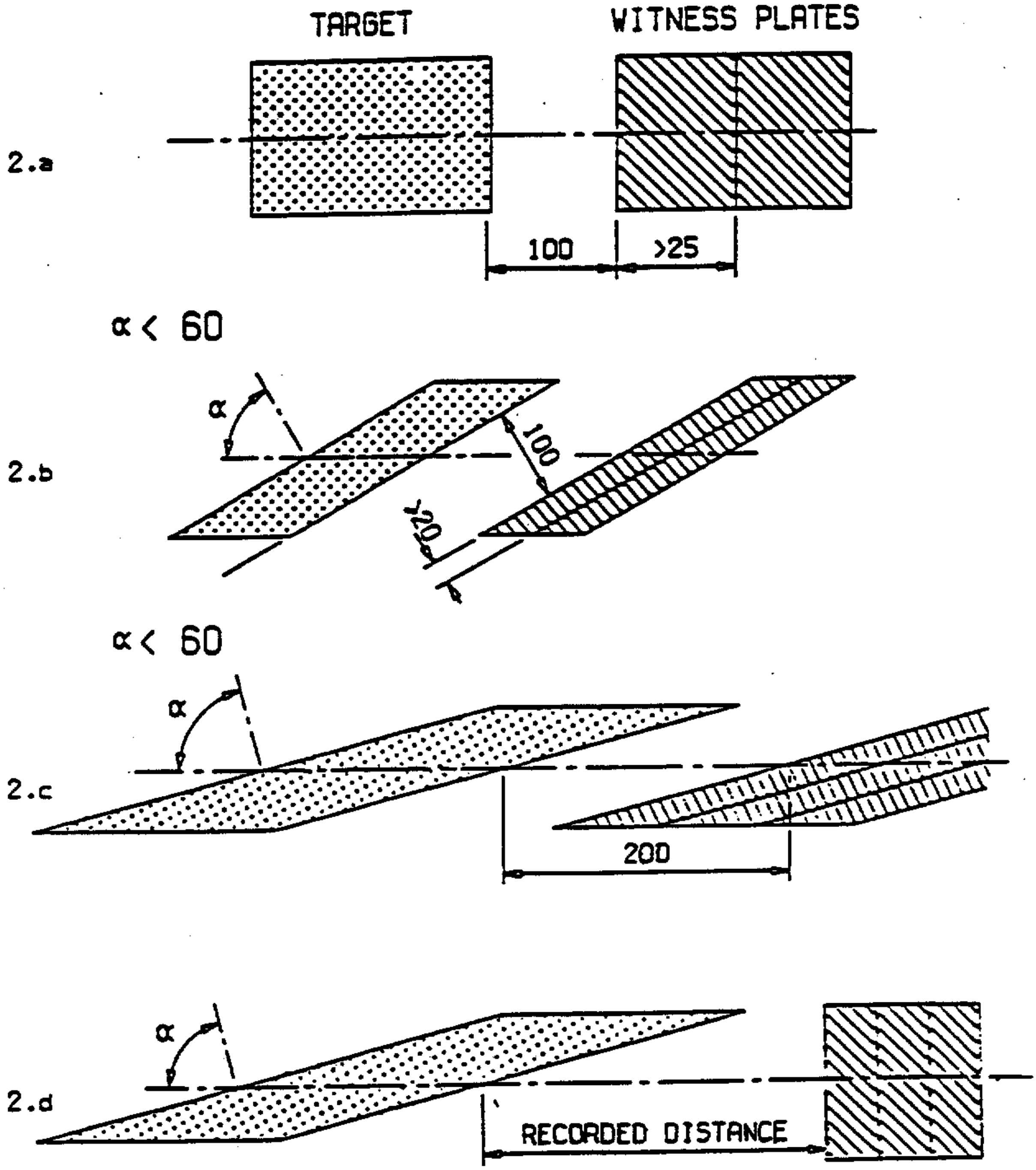


Figure 2 Kinetic Energy Projectile

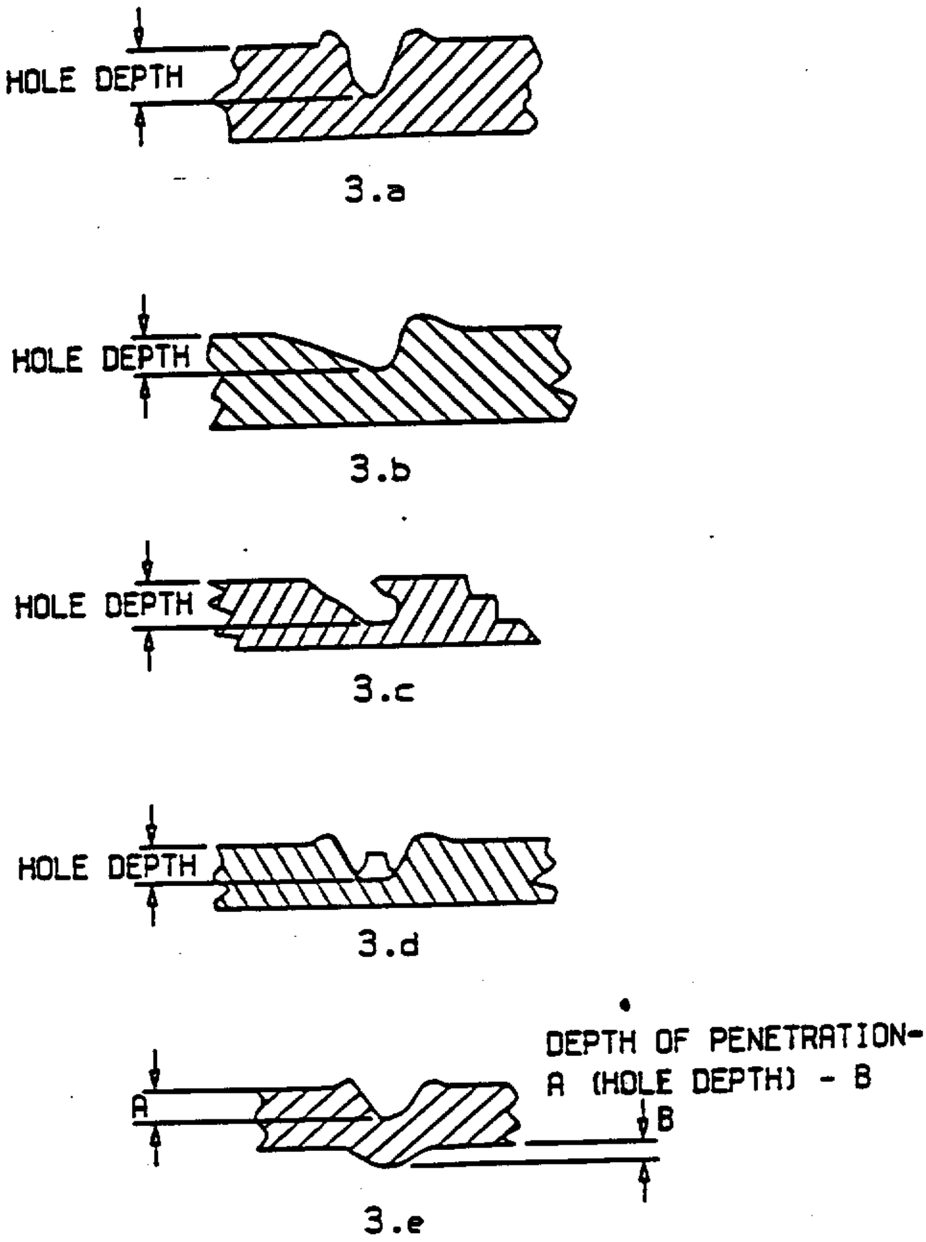


Figure 3 Measurements of Depth of Holes

MEASUREMENT OF DISTRIBUTION OF FRAGMENTS

1. Background.

The metallic witness plate technique has been devised to overcome some of the difficulties of fragment collection in low density media, including the substantial labour involved in fragment recovery. It sacrifices explicit measurement of fragment mass and penetration distance in the medium, in return for a more robust witness pack and data collection which is more amenable to semi-automated methods.

The witness pack comprises a series of thin parallel metal plates, spaced apart with expanded polystyrene. No attempt is made to recover any residual fragments after firing. Instead, measurements are made of the position and size of each hole in each of the plates.

All coordinates are measured relative to a datum such that the data readily yields the spatial distribution and number of fragments penetrating successively the first plate, the first plus the second plate, and so on.

The full spectrum of weapon and target combinations yields a very wide range of behind-armour characteristics. It has not proved possible to formulate a unique design of witness pack to encompass all these characteristics. Instead a range of configurations has evolved to meet particular needs. Nevertheless, there is considerable commonality in these designs, and the recommended design parameters are set out in Paragraph 3 below.

2. Trial Arrangement.

Witness packs will be mounted behind range targets as shown in Figure 4. For the zero degree incidence configuration, the use of two witness packs is possible to separate the fragments near the shotline. To this end, a cylindrical hole is cut in the first witness pack, the diameter of the hole being such that the fragments are expected to spread over most of the area of the second pack.

More generally, in any firing arrangement, a hole of suitable shape and dimension may be cut in the first and some subsequent plates, if appropriate, to limit excessive damage and plate distortion stemming from either fragments or residual kinetic penetrator pieces, which might hamper post-firing measurements.

The values recommended for dimension A in Figure 4 are based on experience, taking account of factors such as lateral pack dimensions and density of fragments. The distances should be appropriate for the majority of firings, but to suit special circumstances other values may be used.

3. Recommended Witness Pack.

In order to limit the variety of witness packs used in trials and to make the subsequent comparison of results easier, the following design constraints have been set:

a. All plates will be positioned 25 mm apart. The spaces between them will be filled with expanded polystyrene, with an average density of 15 kg/cubic metre.

b. Only aluminium (Grade 1200 Temper H14 or equivalent) and mild steel (Grade Fe 430A or equivalent) will be used for plates. The recommended mechanical properties for each of these materials are: aluminium, ultimate tensile strength 105 to 140 MPa, elongation 5% minimum; mild steel, ultimate tensile strength 430 to 580 MPa, yield strength (0.2% offset) 275 MPa minimum, elongation 17% minimum. Should it not be possible to provide material with these properties, the ultimate tensile strength, yield strength, and elongation should be measured and recorded. (Note: Mild steel Fe 430A is apparently becoming difficult to obtain. It is thought that BS1449 (1991) Grade 4, Rolled Condition CR, is a suitable, easily available, alternative, but the UK is to conduct trials to verify this.)

c. Where both materials are used, all aluminium plates will precede the first steel plate.

d. The areal density of successive plates in the pack will not decrease.

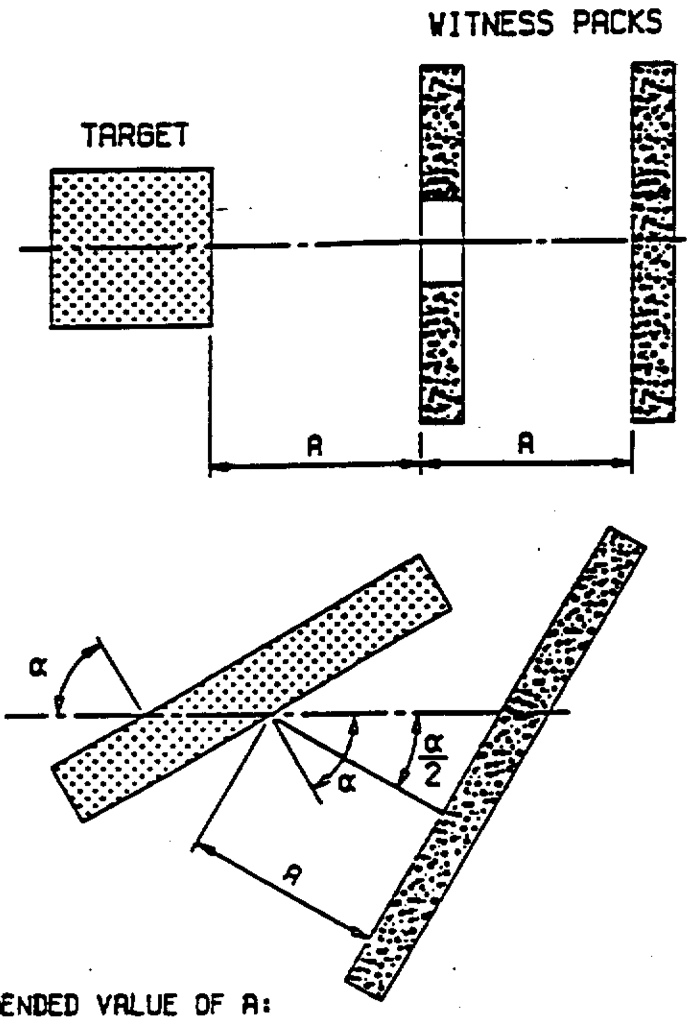
e. Aluminium plates, where used, will be between 1.0 and 3.2 mm thick. Steel plates, where used, will be between 0.8 and 12.7 mm thick.

f. No more than three different thicknesses of each plate material will be used in any witness pack.

For illustrative purposes an example of a practical construction that meets the above constraints is shown at Figure 5.

4. Measurements.

Hole positions (in the witness plates) must be measured with respect to the point of emergence of the penetrator from the rear surface of the armour. In practice, the centroid of each perforation and its associated area will be recorded in a local frame of reference for each plate. The relation of each plate's local frame of reference to the source of fragments will also be measured and recorded. The source of fragments will be interpreted to be the centre of the exit hole in the rear surface of the target.



RECOMMENDED VALUE OF A:

500mm FOR SHAPED CHARGES AND KINETIC ENERGY PROJECTILES UP TO 40mm CALIBRE

700 ~~1000~~mm FOR KINETIC ENERGY PROJECTILES OF 40mm CALIBRE OR GREATER

Figure 4 Witness Pack Mounting Geometry
For Shaped Charge Threat

ANNEX B to
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(Edition 2)

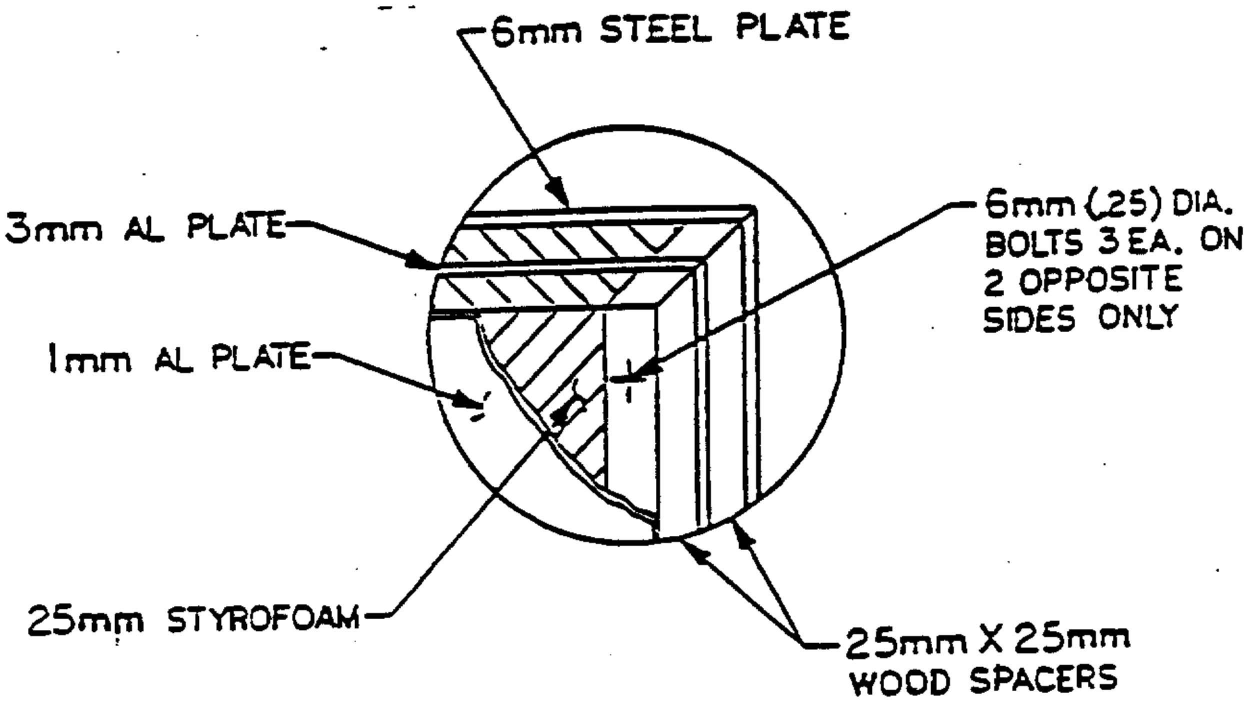

Figure 5 Example of Witness Pack to Illustrate Construction Details

OTHER BEHIND-ARMOUR EFFECTS

Other behind-armour effects include over-pressure, airborne particulates, toxic gases, ballistic shock, and heat. They may or may not be significant. Some NATO countries have conducted trials to measure these effects, but it is inappropriate to recommend standardized procedures at present. Any nation wishing to embark upon such experiments is advised to consult other nations for information on such aspects as monitoring equipment and instrumentation that have already been proven in trials.