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NSA

31 July 2003

NSA/0723-PPS/2920

See AC/301 STANAG distribution List

STANAG 2920 PPS (EDITION 2) – BALLISTIC TEST METHOD FOR PERSONAL ARMOUR MATERIALS AND COMBAT CLOTHING

References: a. AC/301-D/499, dated 18 June 2001
b. MAS/419-PCS/2920 dated 17 December 1996 (Edition 1)

1. The enclosed NATO Standardization Agreement which has been ratified by nations as reflected in the **NATO Standardization Document Database (NSDD)**, 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.

ACTION BY NATIONAL STAFFS

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

Jan H ERIKSEN
Rear Admiral, NONA
Director, NSA

Enclosure:
STANAG 2920 (Edition 2)

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STANAG 2920
(Edition 2)

NORTH ATLANTIC TREATY ORGANIZATION
(NATO)

NATO STANDARDIZATION AGENCY
(NSA)

STANDARDIZATION AGREEMENT
(STANAG)

SUBJECT: **BALLISTIC TEST METHOD FOR PERSONAL ARMOUR MATERIALS AND COMBAT CLOTHING**

Promulgated on 31 July 2003

Jan H ERIKSEN
Rear Admiral, NONA
Director, NSA

RECORD OF AMENDMENTS

No.	Reference/date of amendment	Date entered	Signature

EXPLANATORY NOTES

AGREEMENT

1. This NATO Standardization Agreement (STANAG) is promulgated by the Director, NSA 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. The NSDD gives the details of ratification, implementation, reservations and comments of this agreement. If no details are shown it signifies that the nation has not yet notified the tasking authority of its intentions.

FEEDBACK

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

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NAVY/ARMY/AIR

NATO STANDARDIZATION AGREEMENT
(STANAG)

BALLISTIC TEST METHOD FOR PERSONAL ARMOUR MATERIALS AND COMBAT CLOTHING

Annexes:

	A.	Fragment simulating projectiles
	B	Flechette simulators
	C	Target retention when no backing material is used
	D	Target retention system if backing material is used
	E	Helmet shell retention and witness system
	F	Methods of computation

Related Documents:

STANAG 2902 Criteria for a NATO Combat Helmet
STANAG 2911 Design Criteria for Fragmentation Protective Body Armour
STANAG 4296 Eye Protection for the Individual Soldier - Ballistic Protection
UK drawing DCTA /A3/6723 - Fragment Simulating Projectile

AIM

1. The aim of this agreement is to establish guidelines for the conduct of ballistic tests which are designed to measure the level of protection which is provided by personal armour materials and combat clothing against ballistic threats.

AGREEMENT

2. Participating nations agree to apply the principles contained herein in the testing of personal armour materials and combat clothing against ballistic threats.

GENERAL

3. The agreement is intended to cover testing with the ballistic threats of fragment simulating projectiles, bullets and flechettes. It is intended to aid comparison of the ballistic protective merit of armour materials and combat clothing. Specific categories which are referred to are materials intended for use in fragmentation, bullet or flechette-protective armour; helmet shells; face and eye protection and combat clothing, including NBC, personal load carriage equipment and footwear. The use of test methods which are described in this agreement does not preclude the use of alternative methods of evaluation.

PROJECTILES

4. The tests which are described in this STANAG may be carried out using bullets, flechettes, flechette or fragment simulators or any ballistic projectile which is potentially a threat to personnel.

4.1 **Fragment simulators**

If a fragment simulator is used and it is one of those which is described in Annex A then it may be referred to by its reference and mass, e.g. 2.8 g A_3 cylinder. If any variations to these projectiles are made (e.g. removing/retaining sharp edges) or if any other simulator is used, then those variations must be clearly identified and recorded in the final report.

4.2 **Bullets**

If the tests are carried out using bullets, the bullet used must be clearly identified in the final report.

4.3 **Flechettes**

If a flechette simulator or flechette type projectile is used and it is one of those which is described in Annex B then it may be referred to by its reference e.g. B_1 or B_2. If any variations to these projectiles are made or if any other flechette type projectile is used then they must be clearly identified and recorded in the final report.

TARGETS

5.1 **Target Retention**

The target retention method used must be clearly described in the final report and if backing material is used this must be clearly stated.

5.1.1 ***Materials intended for use in personal armour***

The method of target retention will depend on whether a backing material (i.e. a body simulant) is used. One suitable method of target retention when no backing material is used is shown in Annex C and one suitable method when a backing material is used is described in Annex D.

5.1.2 ***Helmet shells***

The helmet shell must be firmly clamped to a rigid support so that it remains in place and the support frame is not damaged during testing. A suitable system is illustrated in annex E.

5.1.3 ***Face and eye protection***

A suitable mounting system is to be used which will allow the target to be positioned and retained in the same way that it would be expected to be positioned and retained on the head.

5.1.4 ***Combat clothing***

A suitable mounting system is to be used which will allow the target to be positioned and retained in the same way that it would be expected to be positioned and retained on the body.

5.2 **Target Description**

The target should be described in sufficient detail so that others can obtain it or construct it in such a way that they are able to repeat the test using an identical target. The description must include sufficiently detailed information about the component material(s) and their dimensions. If more than one component material is used then the exact way in which they have been used together must be described. It is accepted that it may not always be possible to meet the full requirements of this clause because of security and/or commercial confidentiality considerations.

5.3 **Normal Impacts**

All impacts which are included in the computations are to be normal impacts. For the purpose of this STANAG, a normal impact is defined as the condition when, on impact, the intended strike face of the projectile forms an angle with the target surface of not more than either 5° for fragment simulating projectiles or 3° for bullets and flechettes. If impacts are **deliberately** intended to strike at angles greater than these, then such impacts may be considered as 'normal'. Angles of more than 5° or 3° respectively must however be recorded clearly in the final report.

5.4 **Location of Impact Points**

Impact points must be a sufficient distance from material edges, joins, holes (where relevant) and each other so that areas of damage, stress and/or distortion which have been caused during the test should not overlap. Even if visible damage, stress and/or distortion does not occur, impacts should be at least five projectile calibres from any material edges, joins, holes or the sites of previous impacts. Any impact which does not meet this requirement must not be included in the computations referred to in Section 9.

If backing material is used then impact sites should be such that the area of the backing material which is visibly affected by each impact must not overlap a visible area of damage which was caused by an earlier impact.

After the test is completed the target must be inspected to ensure that no impact has struck an area which was previously damaged. If it is not possible to verify that this damage has occurred then the reasons must be stated on the report form.

CALIBRATION

6.1 **Calibration of Measurement Devices**

Before the test procedure begins all measuring devices should be calibrated to an accuracy which allows them to meet the tolerances which are described in Section 8 of this document.

6.2 **Calibration of Exterior Ballistics**

Measurement of velocity loss due to air drag should be made before tests are carried out.

6.3 **Calibration of Backing Material**

The backing material, when used, and the process of producing it shall be described precisely, in order that other test centres may be able to use an identical material. A calibration method should be used which confirms that the material is homogeneous. The calibration should be carried out in the same ambient conditions that are used for the ballistic testing. The accuracy of the measuring equipment shall be correct within 2%.

If the calibration method damages the backing material then the damaged area(s) must be avoided during the ballistic testing.

CONDITIONING

7.1 **Pre-Conditioning of the Target**

Target materials should be pre-conditioned at a temperature of 20°C +/- 2°C and a Relative Humidity of 65% +/- 5% for a minimum of 24 hours. If any variations to these conditions are made then the conditions used must be recorded in the final report.

7.2 **Conditioning of Backing Material**

Backing material, when used, should be pre-conditioned for a suitable time and in suitable conditions that will cause it to meet the homogeneity requirement of section 6.3. If there is a likelihood that the characteristics of the material might change significantly during the ballistic testing then it should be subjected to further conditioning until it returns to the state that was measured during the calibration procedure.

7.3 **Test Area Ambient Conditions**

The ballistic testing should be carried out at an ambient temperature of 20°C +/- 5°C and at an ambient Relative Humidity of 65% +/- 10%, or within a maximum time of thirty minutes after the completion of pre-conditioning. If any variations to these conditions are made then the conditions used must be recorded in the final report.

MEASUREMENTS

8.1 **Projectile Spin**

When fragment simulators or flechettes are used and spin stabilised to achieve a particular strike orientation, the projectile rate of spin on impact or the twist in the barrel should be recorded. The optimum rate of spin is zero.

When bullets are used and **ranges are simulated** then the spin rate expected from firing tables must be used. If the rate of spin is such that the requirements of section

5.3 would not be achieved then both the spin rate and impact angle must be recorded clearly in the final report.

8.2 Velocity

Measurements of velocity are to be recorded within an accuracy of +/- 0.2%, e.g. a true velocity of 1000m/s should be recorded within an accuracy of +/- 2m/s. The figures which are included in the computation must have also been corrected to allow for velocity loss due to air drag between the timing point and the target.

8.3 Impact Angles

The angle of impact may be measured by any suitable means that does not in itself cause projectile instability and which is accurate within 1°.

8.4 Measurement of perforation and non-perforation without backing material.

8.4.1 *Witness system*

The witness system is to consist of a nominal 0.5 mm thick aluminium alloy sheet (AlCuMg alloy in accordance with ISO/R209 with tensile strength 440 N/mm^2 minimum) or a detector which registers projectiles with sufficient momentum to pass completely through such a sheet. Perforation of the sheet or recording by the detector will be considered as perforation of the target material. Impacts which are not identified as perforations using this definition are to be recorded as non-perforations.

8.4.2 *Materials intended for use in fragmentation and bullet-protective armours*

The witness system is to be placed at a distance of at least 15 cm behind the target and must extend over a sufficient area such that all projectiles with sufficient momentum can be detected.

8.4.3 *Materials intended for use in flechette-protective armours*

The witness system is to be placed in contact with the rear surface of the target. With some items of equipment (e.g. helmets) a clearance distance exists when positioned on the body. In these cases the witness plate must be placed at that clearance distance from the target.

8.4.4 *Helmet Shells*

The witness system is to be rigidly mounted inside the helmet shell at a distance of 5 cm behind the impact area and must extend over a sufficient area such that all projectiles with sufficient momentum can be detected. One suitable method for mounting and positioning such a witness system is described in Annex E figure 2.

8.4.5 ***Face and Eye Protection***

The witness system and the distance behind the target is to be decided by the tester and must be described in the final report. A definition of perforation and non perforation must be clearly stated.

8.4.6 ***Combat Clothing***

As in section 8.4.2 or 8.4.3 as appropriate.

8.5 **Measurement of perforation and non-perforation with backing material**

8.5.1 ***Witness System***

The backing material is to be in contact with the rear face of the target and must extend over a sufficient area behind the target to ensure that all perforations are detected. The identification of impacts as perforation or non-perforation shall be made after separating the target from the backing material and inspecting the impact point.

8.5.2 ***Materials intended for use in fragmentation and bullet-protective armours***

A firing shall be considered as a perforation when any projectile, i.e. not neccessarily the initial projectile, has passed completely through the target and is captured by or has passed through the backing material. Impacts which are not identified as perforations using this definition are to be recorded as non-perforations.

In the final report, the state of damage to the projectile, where appropriate and if possible, shall be specified. In a case where fragments of target have separated from the target and penetrated the backing material, this shall be specified in the final report by describing the state of damage to the target and the characteristics of the target fragments.

8.5.3 ***Materials intended for use in flechette-protective armours***

A firing shall be considered as a perforation when all or any part of any projectile, i.e. not necessarily the initial projectile, has passed through the target and registers an effect on the backing material. Impacts which are not identified as perforations using this definition are to be recorded as non-perforations. In the final report, the state of damage to the projectile, where appropriate and if possible, shall be specified. In a case where the flechette protrudes from the rear surface of the target the length protruding must also be recorded in the final report.

8.5.4 ***Combat Clothing***

As in section 8.5.2 or 8.5.3 as appropriate.

8.6 **Measurements of Backing Material Deformation**

The measurements to be carried out on the material are intended to characterise the deformation following the impact. It may therefore be necessary to record the area, the volume and the depth of the depression, and any other relevant information.

The measurements shall depend on the type of backing material used. The accuracy of the equipment used shall be □ 1%. The method of measuring and the equipment which is used shall be accurately described in the final report in order to allow complete reproduction of the measurement by other test centres.

8.7 **Temperature and Humidity Measurements**

The temperature and relative humidity values of the test area, the target and the backing material should be measured during the firing every 5 minutes with any equipment with an accuracy of ± 1°C for temperature and ± 3% for relative humidity.

COMPUTATION

9. The methods for calculating the values V_{50}, V_0, V_{LNP} and V_{LP} are given in Annex F.

9.1 **Definition of V_{50}.**

The V_{50} is the velocity at which, using the named projectile and target material, the estimated probability of perforation is 0.5.

9.2 **Definition of V_0**

The V_0 is the lowest velocity at which, using the named projectile and target material, it is estimated that perforation will occur. It is based on the principle that the loss in kinetic energy during perforation of the original projectile is measurable by comparing the strike energy and the exit energy. It is also assumed that this loss is constant within the limits of experimental error. The velocity component of that constant value is the V_0.

9.3 **Definitions of V_{LNP} and V_{LP}**

V_{LP} is the lowest recorded velocity at which perforation occurs.

V_{LNP} is the highest recorded velocity below that of the lowest complete perforation.

FINAL REPORT

10. The final report should be dated and should have a test number which is unique for the laboratory where the test is carried out. It must record sufficient information to demonstrate that the requirements of this STANAG have been met, and should clearly indicate which of the test measures in Section 9 has been computed. All test shots fired must be included with the velocity and the result recorded.

IMPLEMENTATION OF THE AGREEMENT

11. This STANAG is implemented when a nation uses the test methods which are described to assess the effectiveness of personal armour materials and combat clothing against ballistic threats.

ANNEX A to
STANAG 2920
(Edition 2)

FRAGMENT SIMULATING PROJECTILES

Appendix: 1. Category A2

Where descriptions do not exist:
all burrs are to be removed and all surfaces to be as smooth as possible;
projectiles are to have a hardness value of HRC 30±2 ;

A.1. FSP As described in UK drawing DCTA/A3/6723

A.2. FSP As described in Appendix 1 to Annex A.

A.3. Steel Cylinder - of diameter A and length B
Length B is approximate and must be adjusted to obtain indicated mass.

MASS (g)	A (mm)	B (mm)
4.15 ± 0.03	8.74 ± 0.03	8.82
2.83 ± 0.03	7.49 ± 0.04	8.19
1.10 ± 0.03	5.39 ± 0.06	6.17
0.49 ± 0.03	4.06 ± 0.14	4.78
0.33 ± 0.03	3.60 ± 0.19	4.07
0.24 ± 0.03	3.25 ± 0.22	3.64
0.16 ± 0.03	2.64 ± 0.27	3.77

A.4. Steel Sphere - of diameter A

MASS (g)	A (mm)
4.11 ± 0.03	10.0 ± 0.03
2.99 ± 0.03	9.0 ± 0.03
1.13 ± 0.03	6.5 ± 0.06
0.51 ± 0.03	5.0 ± 0.10
0.37 ± 0.03	4.5 ± 0.12
0.26 ± 0.03	4.0 ± 0.15
0.18 ± 0.03	3.5 ± 0.19

A.5. Steel Cube - of length A

MASS (g)	A (mm)
4.15 ± 0.03	8.09 ± 0.02
2.83 ± 0.03	7.12 ± 0.03
1.10 ± 0.03	5.20 ± 0.04
0.49 ± 0.03	3.96 ± 0.09
0.33 ± 0.03	3.46 ± 0.12
0.24 ± 0.03	3.12 ± 0.13
0.16 ± 0.03	2.74 ± 0.15

A.6. Steel Parallelepiped - of length A
Length A is approximate and must be adjusted to obtain indicated mass.

MASS (g)	SECTION (mm^2) ± 0.05 x ± 0.05	A (mm)
2.85 ± 0.06	5.8 x 5.8	11.6
1.10 ± 0.03	4.0 x 4.0	8.9
0.20 ± 0.03	2.0 x 2.0	6.7

APPENDIX 1 TO ANNEX A - CATEGORY A2

1. **Material composition.** The fragment-simulating projectile shall be manufactured from material as noted below:

Caliber .22 – Type 1 } Caliber .30 } Caliber .50 } 20MM }	Cold rolled, annealed steel conforming to compositions 4337H or 4340H.
Caliber .22 – Type 2	Same as above or other steels capable of hardness uniformity within hardness values indicated in Table 1.

2. **Weight & Hardness.** The fragment-simulating projectile shall be fully quenched and tempered to a Rockwell hardness value as shown in Table 1.

TABLE 1

Projectile Type	Rockwell hardness C	Weight*	
Caliber .22 – Type 1	30 ± 1	1.1 ± 0.03	(17.0 ± 0.5)
Caliber .22 – Type 2	27 ± 3	1.1 ± 0.03	(17.0 ± 0.5)
Caliber .30	30 ± 1	2.84 ± 0.03	(44.0 ± 0.5)
Caliber .50	30 ± 1	13.39 ± 0.13	(207.0 ± 2.0)
20MM	30 ± 1	52.73 ± 0.26	(830.0 ± 4.0)

*grams (grains)

3. **Dimensions**. Dimensions and tolerances shall be as shown in figures A1, A1a, A2, A3 and A4.

4. **Finish.** The fragment-simulating projectiles shall have a surface finish as shown in figures A1, A1a, A2, A3, and A4.

ANNEX A to
STANAG 2920
(Edition 2)

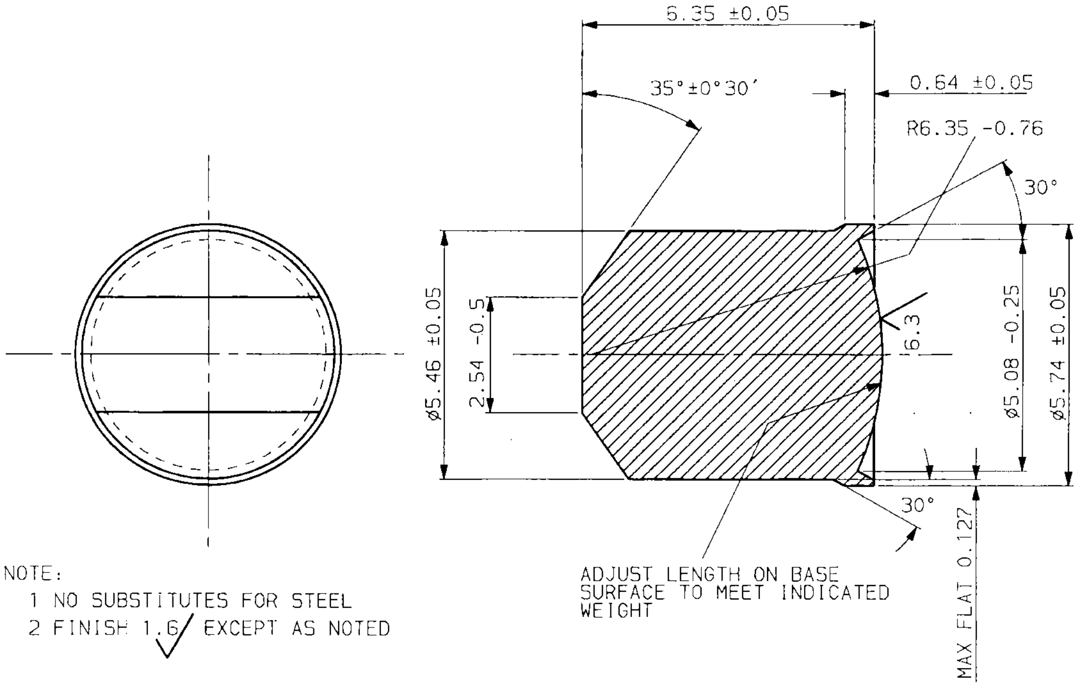

Figure A1 – Fragment Simulator Caliber .22, Type 1 (armor plate)

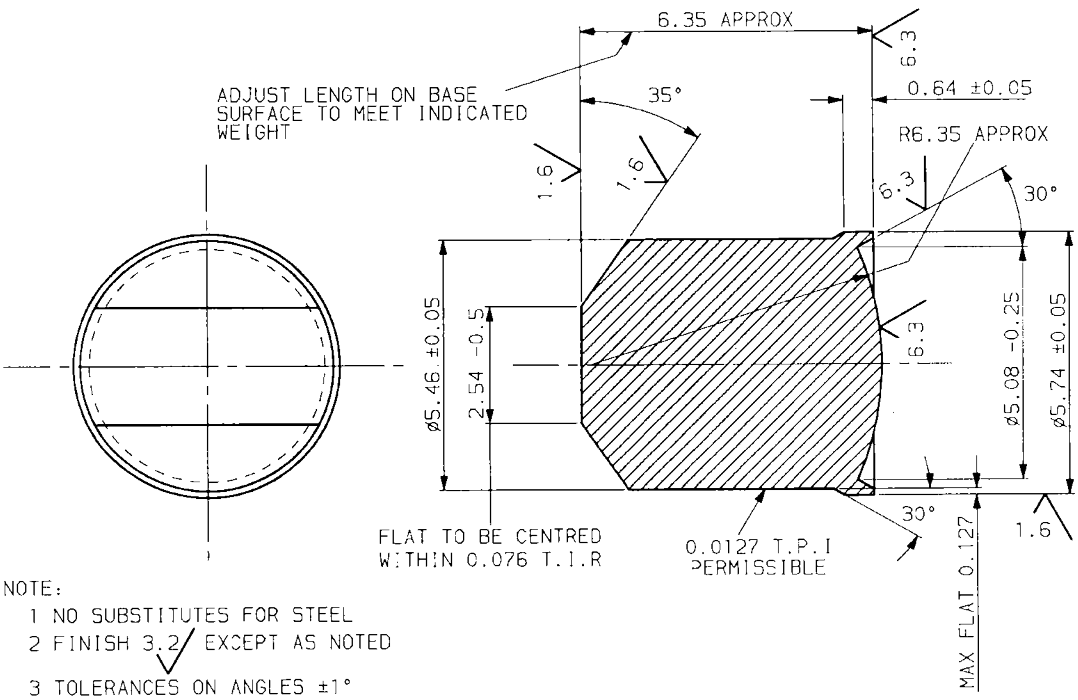

Figure A1a – Fragment Simulator Caliber .22, Type 2 (Body Armor)

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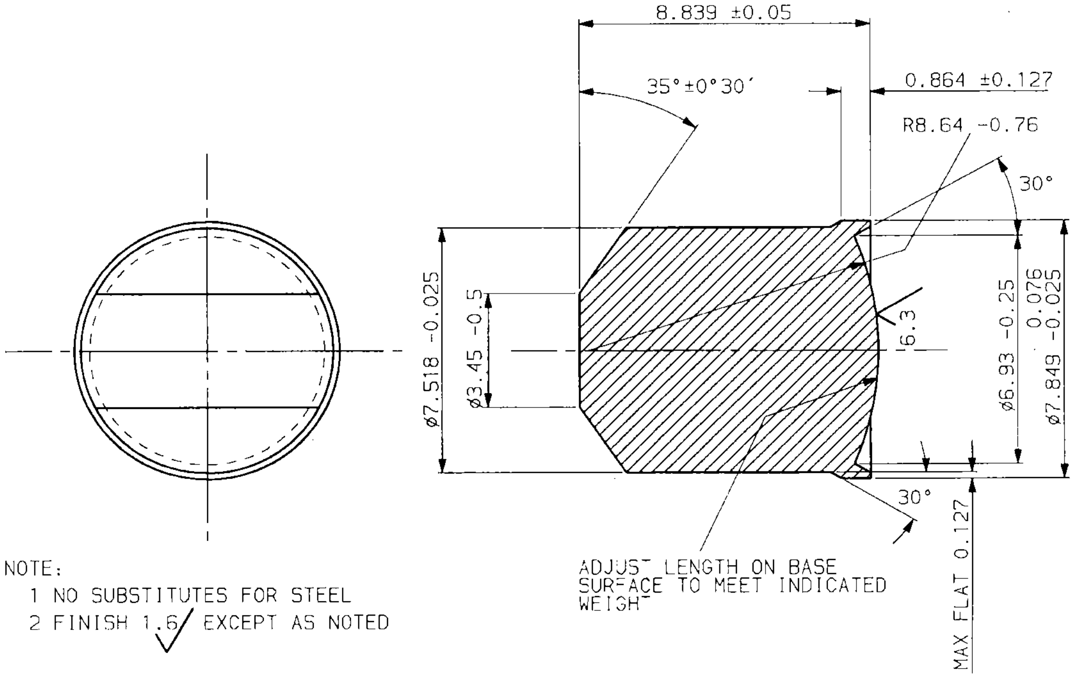

Figure A2 – Fragment Simulator Caliber .30

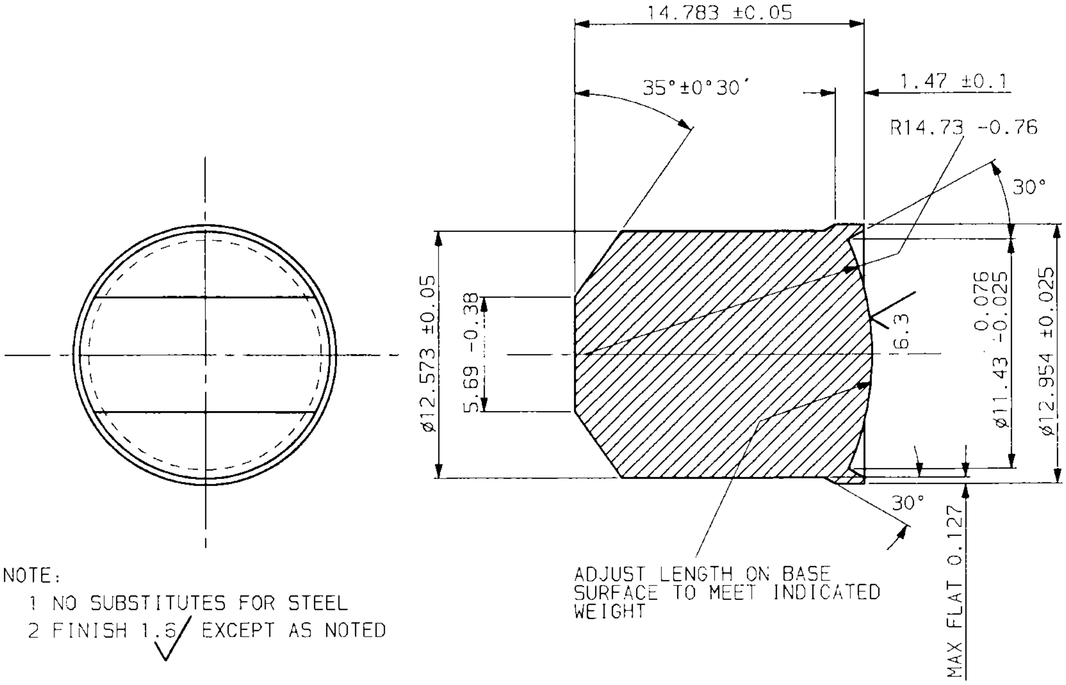

Figure A3 – Fragment Simulator Caliber .50

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(Edition 2)

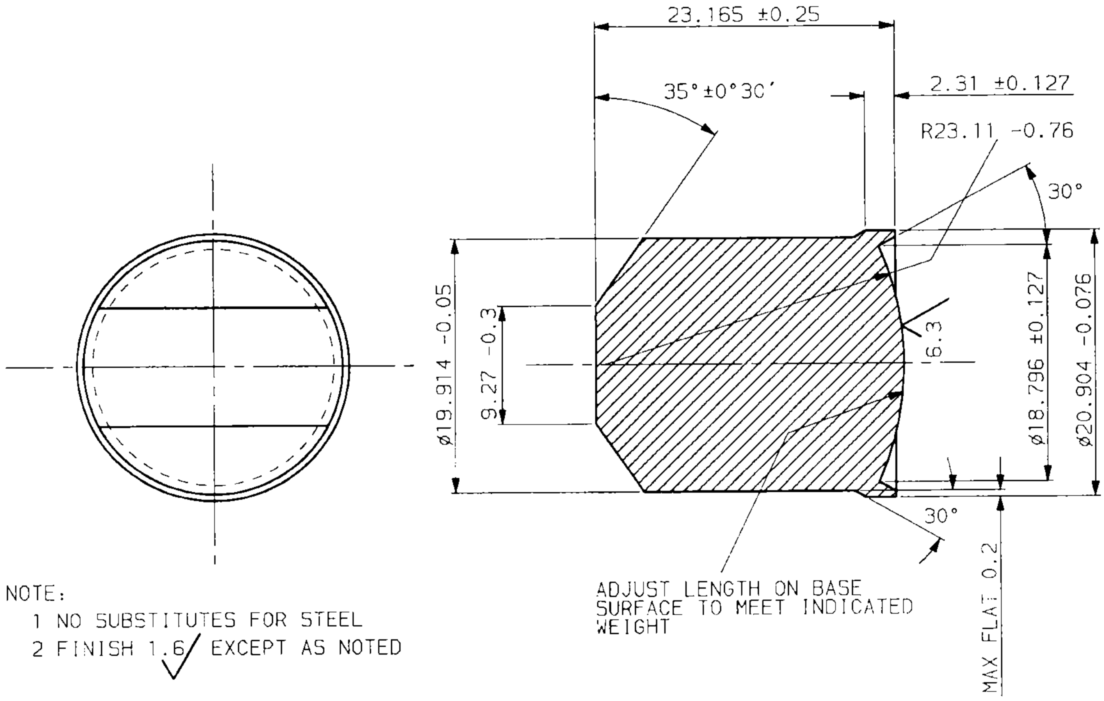
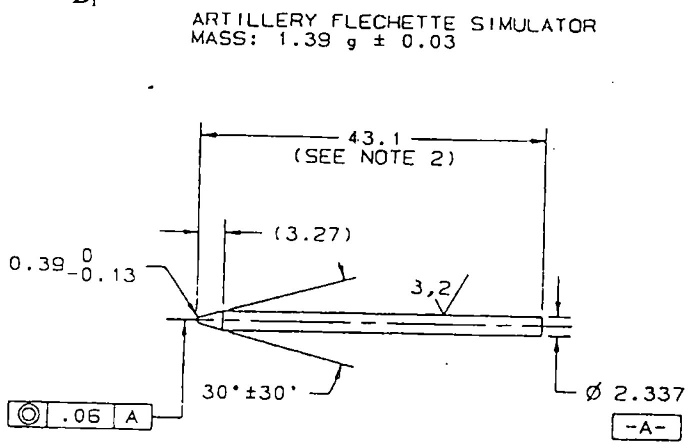


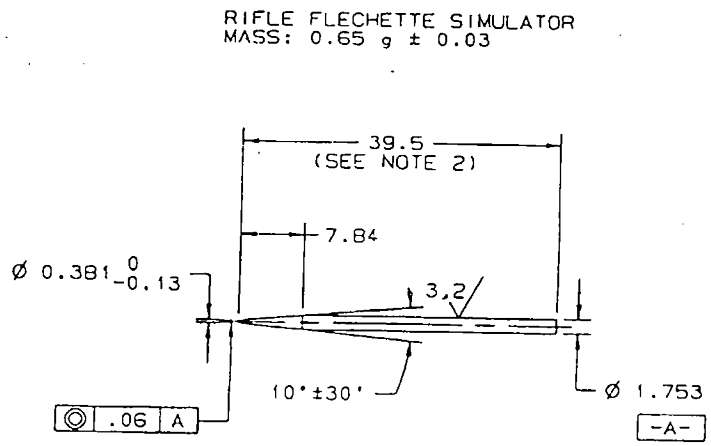
Figure A4 – Fragment Simulator Caliber 20mm

FLECHETTE SIMULATORS

B_1

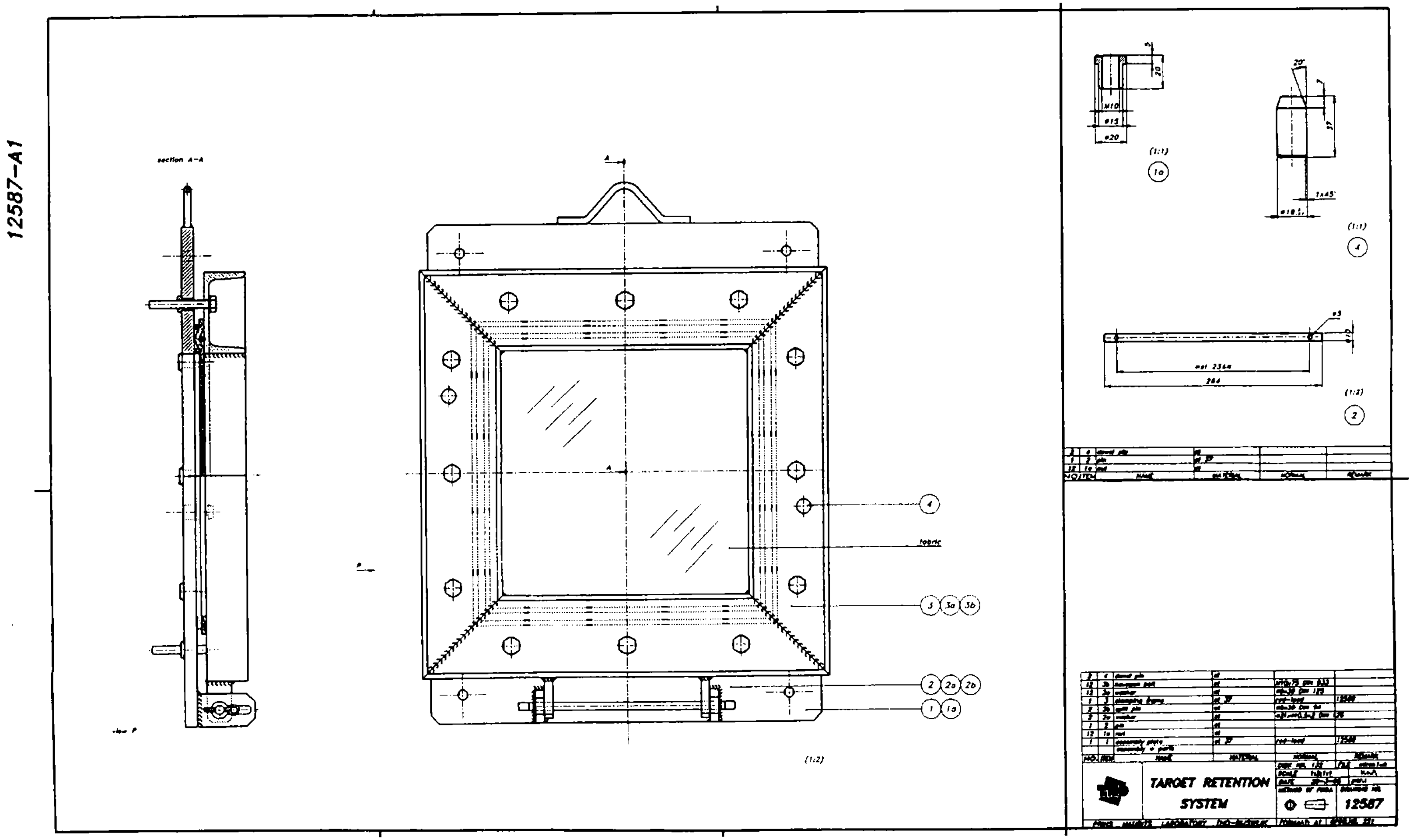


B_2

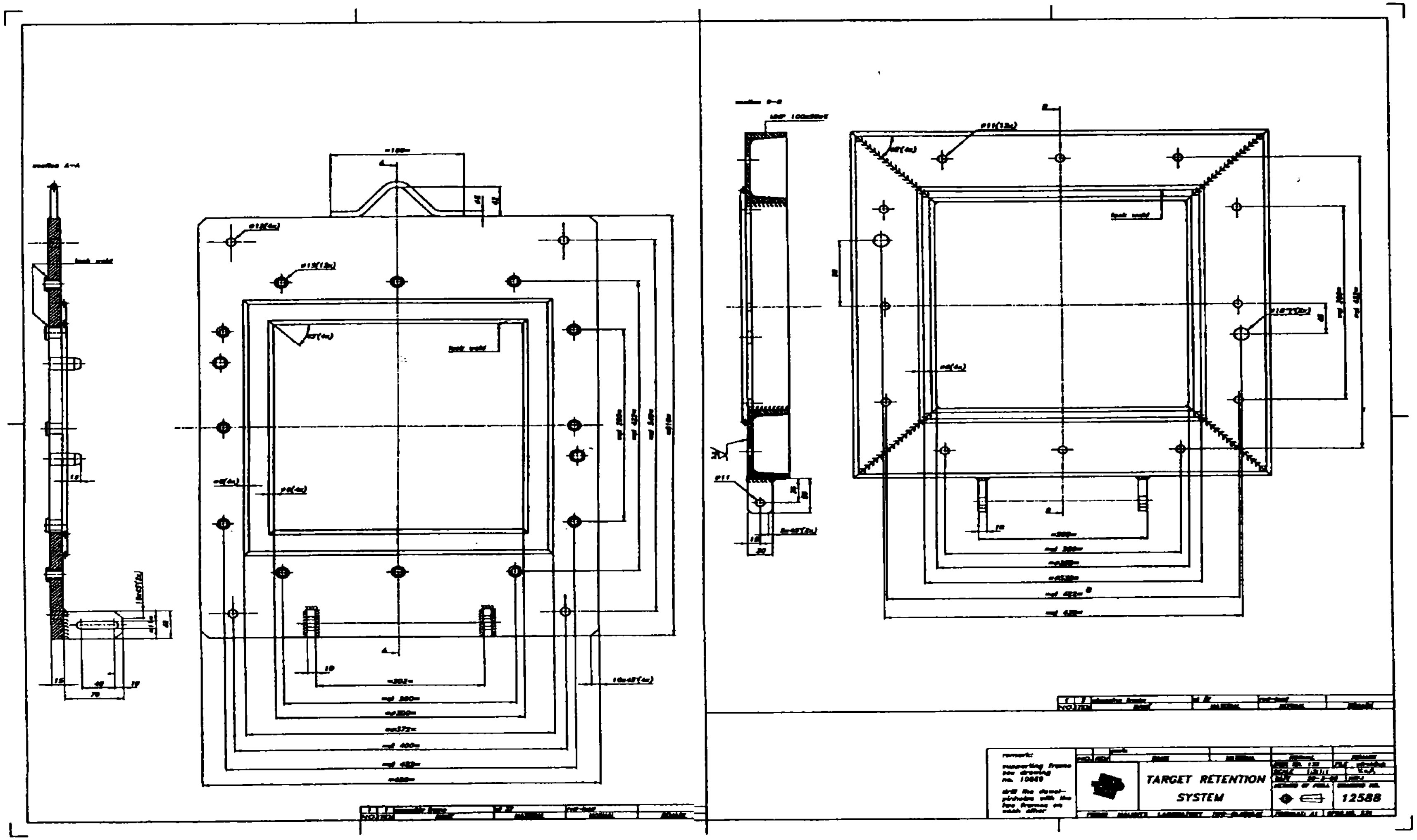


1- MATERIAL: STEEL 1090-1095 (DRILL ROD),38-46 Rc
2- MACHINE BACKFACE TO REACH REQUIRED MASS
3- DIMENSIONS IN mm

TARGET RETENTION WHEN NO BACKING MATERIAL IS USED



TARGET RETENTION WHEN NO BACKING MATERIAL IS USED (Cont'd)



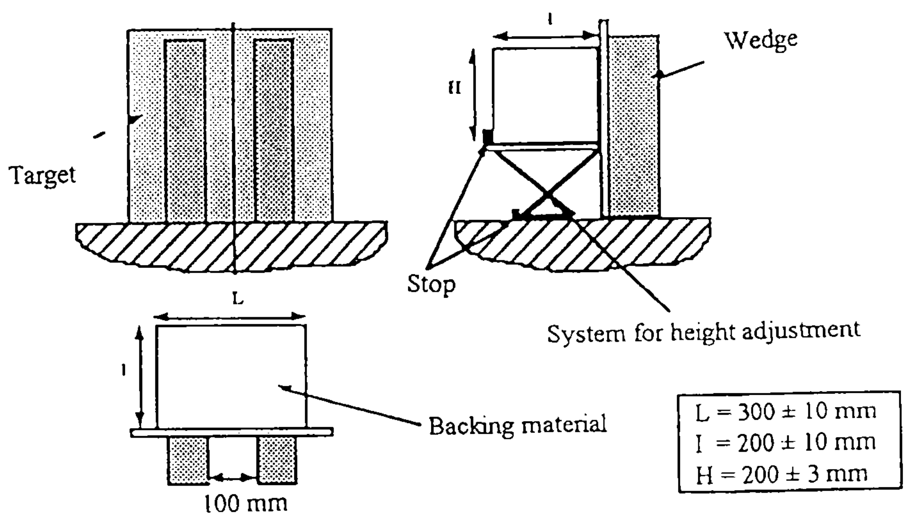
ANNEX D to
STANAG 2920
(Edition 2)

TARGET RETENTION SYSTEM IF BACKING MATERIAL IS USED

When backing material is used, close contact is to be ensured between the target and the backing material. This may be done (for example) by using retaining straps, as long as those straps do not introduce stresses in the target material.

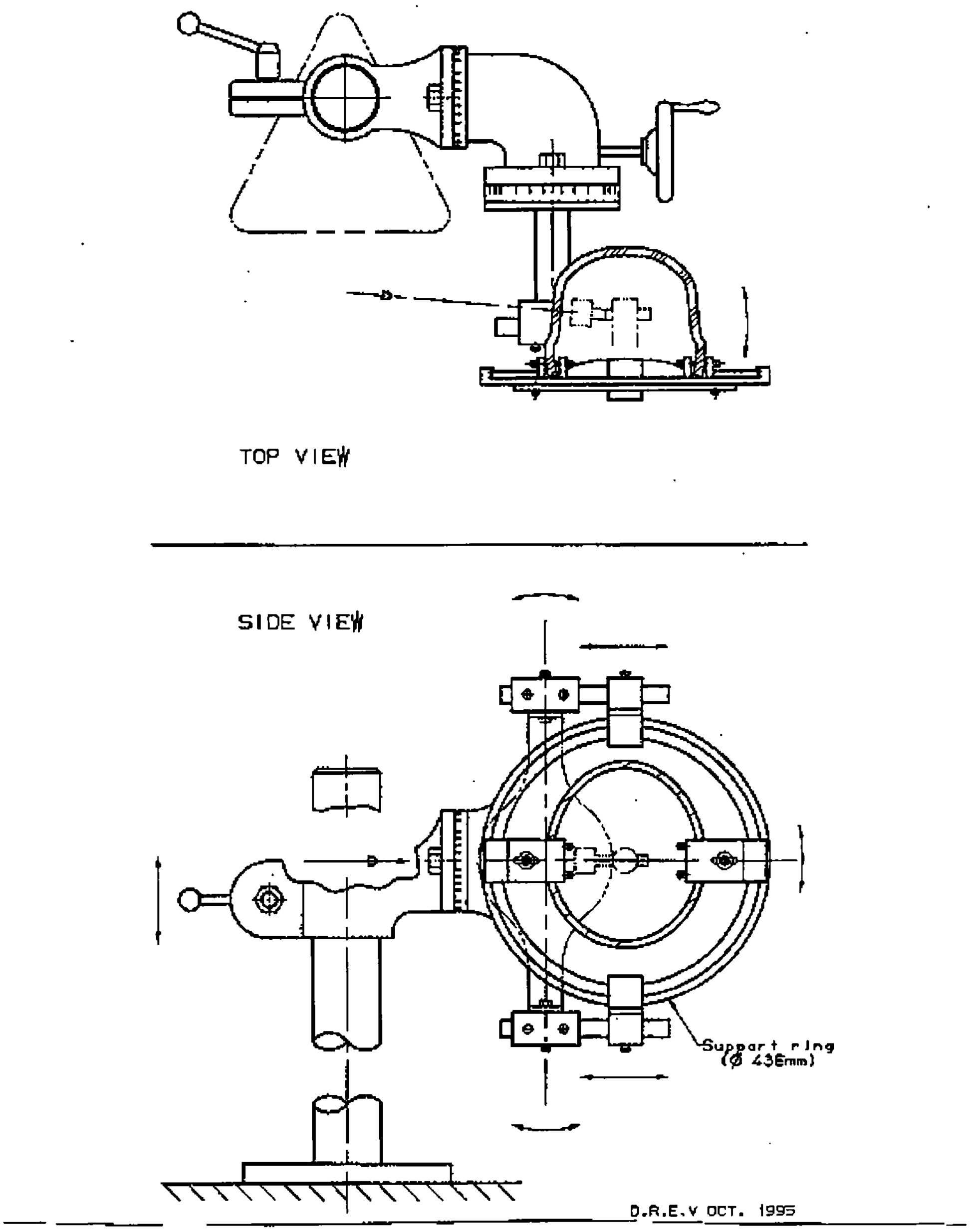
The target must be in close contact with the backing material. The use of two wedges enables the target to be held flat, without the need to use straps or a retaining frame against the backing material. The distance between the wedges shall be approximately 100 mm.

The point of impact, which shall comply with the conditions described in paragraph 5.3 and shall be at an equal distance from the two wedges.



HELMET SHELL RETENTION AND WITNESS SYSTEM

FIGURE E1 SHELL POSITIONING



ANNEX E to
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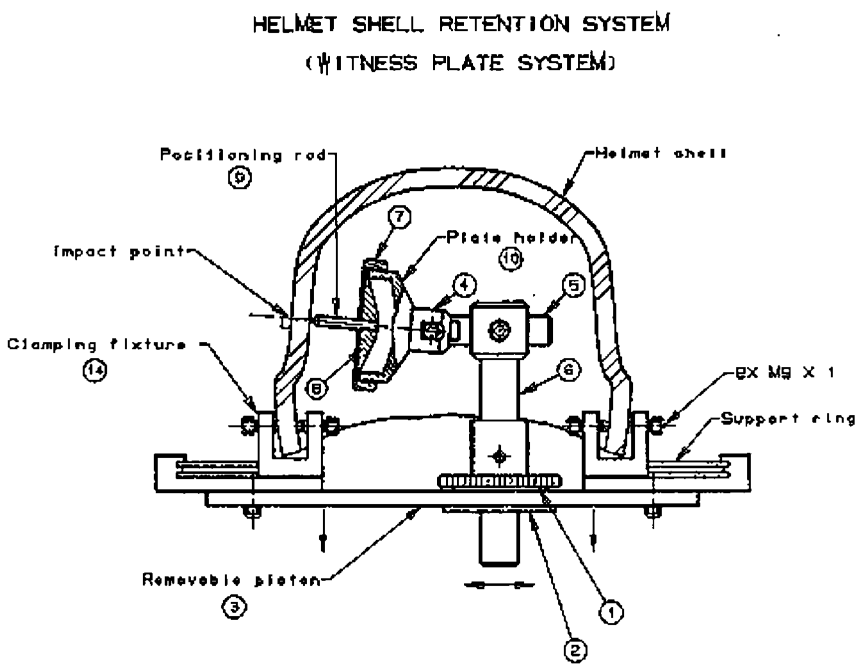
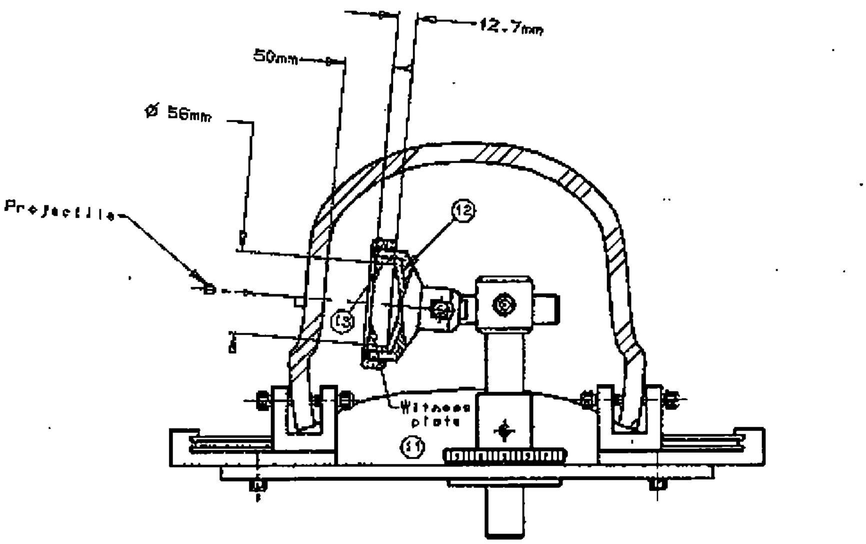
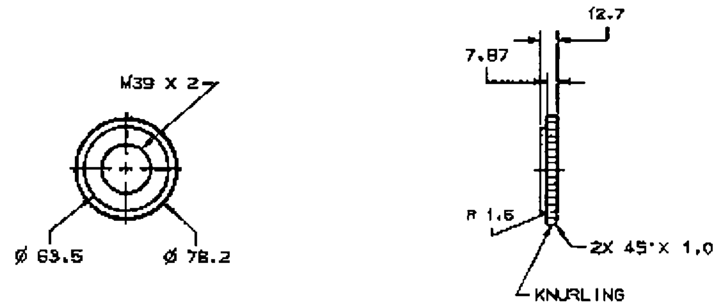
HELMET SHELL RETENTION AND WITNESS SYSTEM (Cont'd)

FIGURE E2 WITNESS PLATE SYSTEM



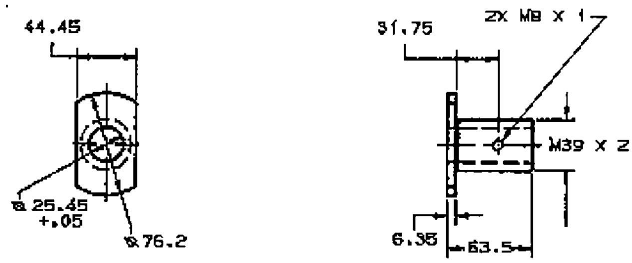


HELMET SHELL RETENTION AND WITNESS SYSTEM (Cont'd)



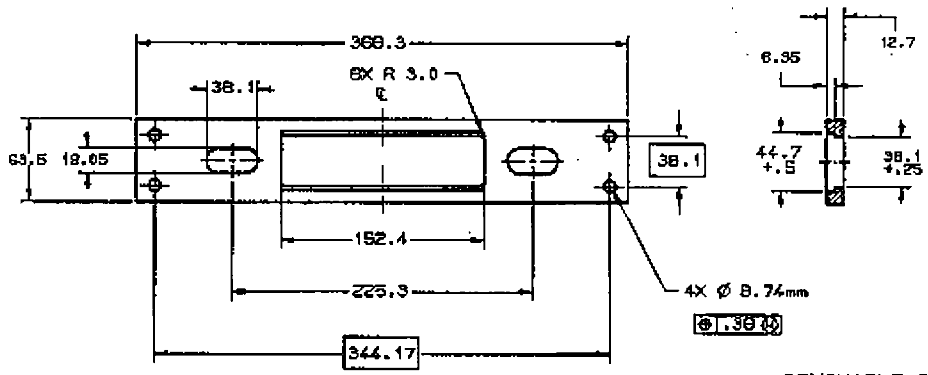
MATERIAL: ISO R209 AlMg1SiCu (6061-T6)
300 MPa Min. Strength

NUT
①



MATERIAL: ISO R209 AlMg1SiCu (6061-T6)
300 MPa Min. Strength

SLIDING BLOCK
②

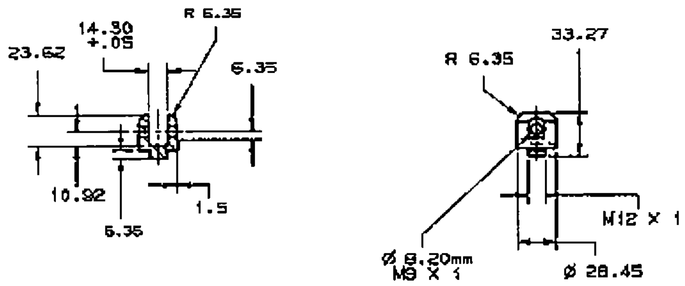


MATERIAL: ISO R209 AlMg1SiCu (6061-T6)
300 MPa Min. Strength

REMOVABLE PLATEN
D.R.E.V OCT. 1995 ③

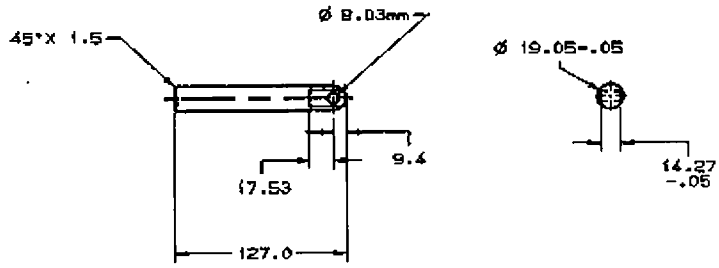
ANNEX E to
STANAG 2920
(Edition 2)

ANNEX E - HELMET SHELL RETENTION AND WITNESS SYSTEM cont.



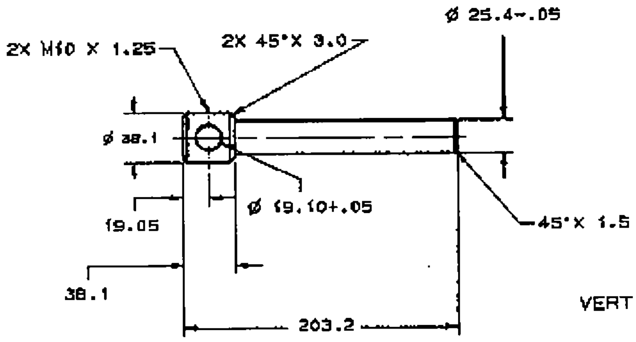
MATERIAL: BRASS

SWIVEL
(4)



MATERIAL: STEEL

HORIZONTAL SHAFT
(5)



MATERIAL: STEEL

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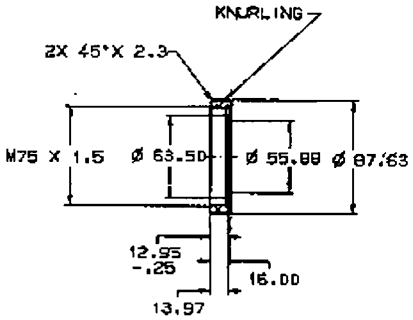
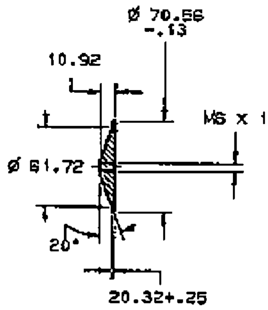
VERTICAL SHAFT
(6)

ANNEX E - HELMET SHELL RETENTION AND WITNESS SYSTEM cont.



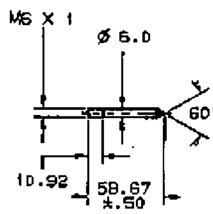
MATERIAL: ISO R209 AlMg1SiCu (6061-T6)
300 MPa Min. Strength

LOCKING RING
(7)



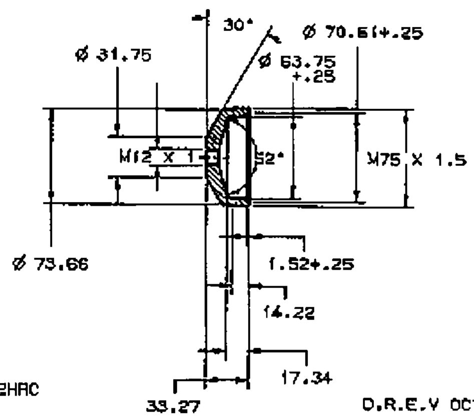
MATERIAL: STAINLESS STEEL

ROD HOLDER
(8)



POSITIONING ROD
(9)

MATERIAL: STAINLESS STEEL



MATERIAL: STEEL 38-42HRC

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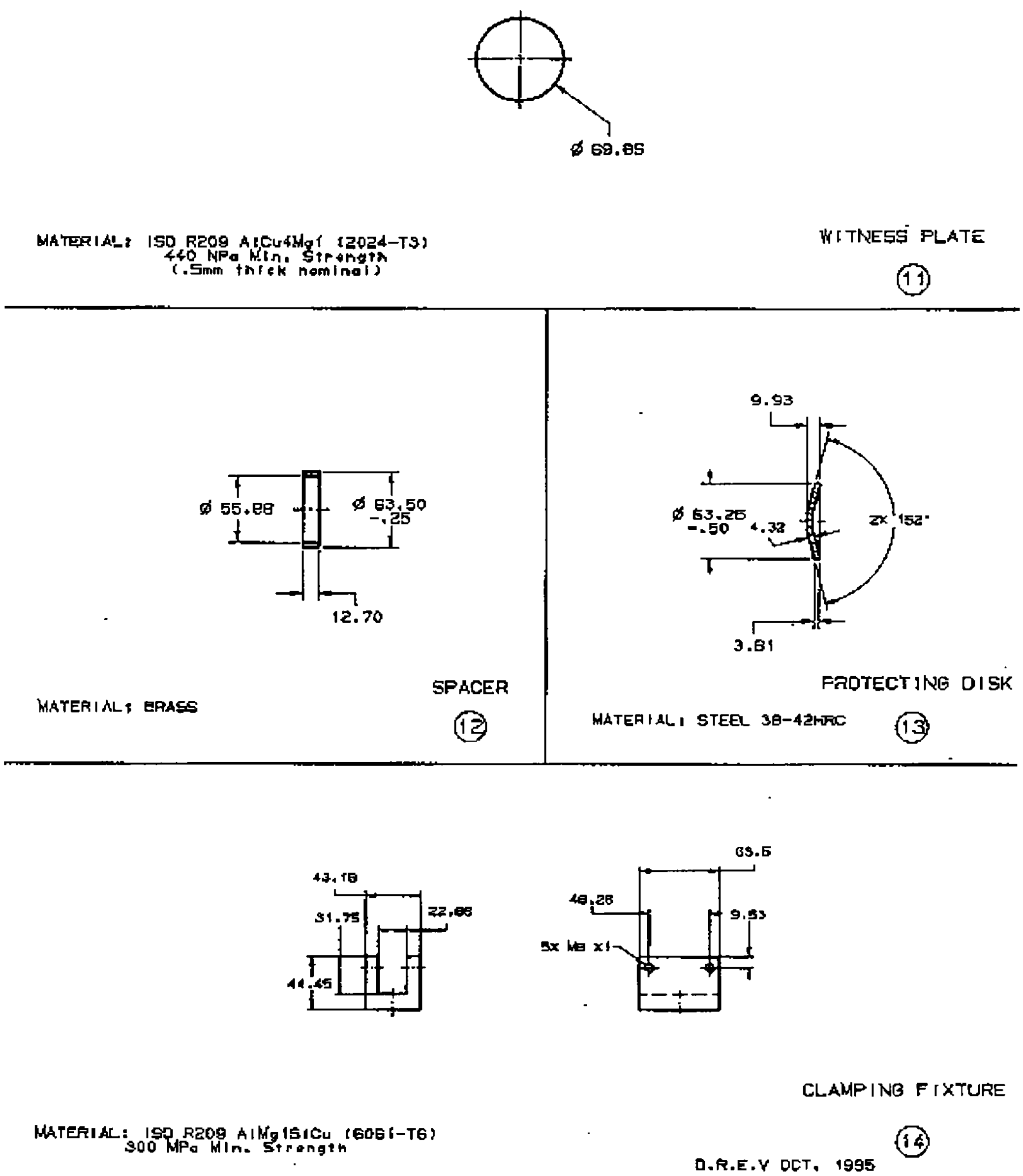
PLATE HOLDER
(10)

ANNEX E - HELMET SHELL RETENTION AND WITNESS SYSTEM cont.



METHODS OF COMPUTATION

If any one of the tests which are described below are repeated, it is unlikely that exactly the same figure will be reproduced. Whenever possible an indication of the extent of the variability for a particular projectile and target material should be given in the final report.

F.1 Measurement of V_{50}

An even number of shots, at least six, are used in the calculation.
Half of the shots must perforate the target material.
Half of the shots must not perforate the target material.
The highest recorded velocity of the group (half perforations and half non-perforations) must not be more than 40m/s higher than the lowest of the group.
The measurement is the arithmetic mean of the group of velocities.

Perforations and non-perforations are defined in sections 8.4. and 8.5.

F.2 Measurement of V_0

When the measured mass in front of and behind the target is expected to be the same then velocities can be compared directly. If both masses are not expected to be the same then direct measurement of the correct velocity and/or energy is likely to be difficult. Nevertheless, strike momentum and residual momentum can be compared using a slightly different calculation and V_0 can be derived from that. A ballistic pendulum which catches all residue is a suitable method of measuring behind target momentum.

The equation which is relevant for constant mass is

$$V_0 = [(V_s)^2 - (V_e)^2]^{1/2} \quad \ldots\ldots \quad 1$$

where V_s is strike velocity, V_e is exit velocity

The equation when variable mass is expected is

$$p_0 = K\,[(p_s)^2 - (p_e)^2]^{1/2} \quad \ldots\ldots \quad 2$$

where p_s is strike momentum and p_e is exit momentum

Using equation 1, a number of shots are fired and the two velocities are recorded for each shot and plotted on a graph (exit velocity against strike velocity). The velocities which are used should range from below the eventual calculated value of V_0 to a value which is at least 1.5 times the eventual calculated value of V_0. When there is a reasonably even distribution of impact velocities (judged by eye) over that range, then a value for estimated V_0 is calculated. The higher the impact velocities, the more accurate the estimated V_0.

Using equation 2, the same basic procedure is followed except that values of momentum are plotted on the graph. The best fit to equation 2 is calculated. The result is a value of K and a value of p_0. Dividing p_0 by the mass of the original projectile gives a value for V_0.

F.3 Measurement of V_{LNP} and V_{LP}

If perforation is achieved by the first shot, this is recorded as the provisional V_{LP}.
Following velocities are reduced until an impact does not result in perforation. The velocity of this impact is recorded as provisional V_{LNP}. Velocity is decreased further in order to ensure that there are no perforations at lower velocities.

If perforation is not achieved by the first shot, following velocities are increased until an impact does result in perforation. The velocity of this impact is recorded as provisional V_{LP}.

It is then necessary to carry out a continuous sequence of shots, none of which achieve perforation, but all of which are lower than the lowest perforation velocity by a narrow margin.

The lowest velocity that achieved perforation is recorded as the V_{LP}.
The highest velocity below V_{LP} is recorded as V_{LNP}.

The difference between V_{LP} and V_{LNP} must be less than 10 m/s and at least 14 acceptable velocity measurements should be used in the calculation.