Ministry of Defence
Defence Standard 95-13

Issue 4 Publication Date 2 September 2011

Armour Plate for Proof of Projectile Purposes

Content

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Foreword

AMENDMENT RECORD

Amd No	Date	Text Affected	Signature and Date

Revision Note

This standard is raised to Issue 4 to update its content.

Historical Record

This standard supersedes the following:
STA 61 dated July 1967
Def Stan 95-13 / Issue 1 dated 17 November 1981
Def Stan 95-13 / Issue 2 dated 5 January 2001
Def Stan 95-13 / Issue 3 dated 19 May 2006

a. This standard specifies the material and performance requirements for Proof of Projectile Armour Plate (3 - 300 mm thick) for Ministry of Defence use.

b. This standard has been produced on behalf of the Standardization Advisory Group (SAG) by the Corrosion Prevention and Metallic Materials Standards Production Group (E3).

c. This standard has been agreed by the authorities concerned with its use and is intended to be used whenever relevant in all future designs, contracts, orders etc and whenever practicable by amendment to those already in existence. If any difficulty arises which prevents application of the Defence Standard, the Directorate of Standardization (DStan) shall be informed so that a remedy may be sought.

d. Any enquiries regarding this standard in relation to an invitation to tender or a contract in which it is incorporated are to be addressed to the responsible technical or supervising authority named in the invitation to tender or contract.

e. Compliance with this Defence Standard shall not in itself relieve any person from any legal obligations imposed upon them.

f. This standard has been devised solely for the use of the Ministry of Defence (MOD) and its contractors in the execution of contracts for the MOD. To the extent permitted by law, the MOD hereby excludes all liability whatsoever and howsoever arising (including, but without limitation, liability resulting from negligence) for any loss or damage however caused when the standard is used for any other purpose.

Introduction

This standard specifies the requirements for proof of projectile armour plate from 3mm to 300mm thick. Two types of plate are defined, Type 1 and Type 2, the purchase order shall state which type is required. The quality of production shall be assured by quality control, inspection and testing procedures defined in a Process Control Schedule (PCS).

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Armour Plate for Proof of Projectiles Purposes -

1 Scope

This Standard specifies the requirements for proof of projectile armour plate with a thickness of 3 mm to 300 mm and includes manufacture, inspection, dimensions, mechanical properties, ultrasonic examination and test requirements. Two types of plate are defined, Type 1 and Type 2, the purchase order shall state which type is required. The quality of production shall be assured by quality control, inspection and testing procedures defined in a process Control Schedule (PCS)

2 Warning

The Ministry of Defence (MOD), like its contractors, is subject to both United Kingdom and European laws regarding Health & Safety at Work, without exemption. All Defence Standards either directly or indirectly invoke the use of processes and procedures that could be injurious to health if adequate precautions are not taken. Defence Standards or their use in no way absolves users from complying with statutory and legal requirements relating to Health & Safety at Work.

3 Normative References

3.1 The publications shown below are referred to in the text of this standard. Publications are grouped and listed in alpha numeric order.

3.2 Reference in this standard to any related document means in any invitation to tender or contract the edition and all amendments current at the date of such tender or contract unless a specific edition is indicated.

3.3 In consideration of **3.2** above, users shall be fully aware of the issue and amendment status of all related documents, particularly when forming part of an invitation to tender or contract. Responsibility for the correct application of standards rests with users.

3.4 DStan can advise from where related documents can be obtained. Requests for such information can be made to the DStan Helpdesk. How to contact the helpdesk is shown on the outside rear cover of Def Stans.

Designation	**Title**
BS EN ISO 148-1	Metallic Materials. Charpy Pendulum Impact Test. Test Method.
BS EN ISO 6506 - 1	Metallic Materials. Brinell Hardness test. Test Method.
BS EN ISO 6892-1	Metallic Materials. Tensile Testing. Method of Test at Ambient Temperature.
BS EN 10160	Ultrasonic Testing of Steel Flat Product of Thickness Equal or Greater than 6mm (Reflection Method).
BS ISO 3058	Non-destructive testing. Aids to visual inspection. Selection of low-power magnifiers
BS ISO 9328	Steel Flat Products for Pressure Purposes. Technical Delivery Conditions. General Requirements

4 Definitions

4.1 For the purpose of this Defence Standard the following definitions apply:

4.2 Cast

This is the product of a melting or refining process involving one teeming operation used to produce a batch of ingots or slabs of known chemical composition.

4.3 Contractor

A firm having a Ministry of Defence contract for the manufacture of equipment calling for the use of material to this Standard.

4.4 Design Authority

The approved firm, establishment or branch responsible for the detailed design of material to approved specifications and authorized to sign a certificate of design, or to certify sealed drawings.

4.5 Inspection Lot

This is all plate within one thickness range, as given in **Table 1**, that is of the same cast, having the same heat treatment and heat treated on the same facility. In cases where such plate consists of a variety of thicknesses, the thickest plate shall be sampled.

4.6 Mill Plate Unit

This is the plate product of a single slab.

4.7 Plate

This is a plate cut or profiled from a mill plate.

4.8 Process Control Schedule

The plan by which the supplier defines / specifies;

(a) the sequence of manufacturing operations and processes.

(b) the control parameters and their tolerances for each individual process within the total sequence.

4.9 Supplier

A firm manufacturing armour plate to this Standard.

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5 Certification

Suppliers shall provide a Certificate of Conformity with each plate supplied to this standard stating that all elements of the standard have been complied with and that manufacture has been in accordance with the agreed PCS.

6 Process Control Schedule (PCS)

6.1 A Process Control Schedule, suitable for achieving the requirements of this Standard, shall be prepared by the contractor(s) prior to the commencement of production.

6.2 Details of the manufacturing process, including chemical composition, steel-making, working of the cast product, heat treatment, tests, acceptance standards and all other processes and treatments shall be included in the PCS.

6.3 All stages of the complete schedule shall follow each other without delay, unless otherwise stated in the PCS.

6.4 Steel supplied to this Standard shall comply with all the relevant clauses as defined in the contract or order.

7 Steel Manufacture

7.1 The steel shall be either Type 1 or Type 2 as specified on the order or contract. Chemical composition shall be as defined in **Tables 2** and **3**.

7.2 Where ingot production is used, ingots shall be cast wide end up and, if allowed to cool, shall be given retarded cooling adequate to prevent the formation of harmful defects. Ingots that have defective surfaces on visual examination shall be rectified before further processing.

7.3 Where a continuous casting process is used a minimum reduction ratio of 3 to 1 shall be used when rolling plate from continuous cast slabs unless the supplier can clearly demonstrate that lower reduction ratios are sufficient to work the continuous cast structure and provide consistent mechanical properties throughout the plate thickness.

7.4 All ingots and con-cast slabs shall be metal stamped or metal tallied (inset) with the manufacturer's identification symbol, cast number and ingot/slab number or letter.

8 Manufacture and Inspection of Mill Plates

8.1 Ingots and slabs for rolling or forging into plates shall have satisfied the requirements of clause **7**.

8.2 Identification of plates by cast number and rolling direction shall be maintained through all stages of processing.

8.3 Plates shall be so cooled after hot working that the formation of harmful defects is prevented.

8.4 Adequate discards shall be taken in all cases to ensure freedom from piping and harmful segregation.

8.5 The permitted tolerances of each chemical analysis taken from the mechanical test position of each heat treated plate, when compared with the specified range of composition, shall be within the limits given in ISO 9328-4.

8.6 All plates shall be properly dressed to remove any surface defects.

8.7 All plates shall be given a full annealing or normalizing treatment prior to quenching and tempering. A complete heat-treatment record shall be kept for each plate. Pyrometers of proven accuracy shall be employed.

8.8 All accepted mill plates being transferred from one works to another shall be fully identified with the manufacturer's symbol, cast number, plate number and rolling direction.

9 Inspection of Plates in Final Size

9.1 Mill plates for cutting to final size shall have satisfied the requirements of clauses **7** and **8**.

9.2 Mill plates shall be cut and prepared in accordance with the requirements of the contract or order.

9.3 All plates cut to final size shall be visually inspected, to BS ISO 3058, on the edges and both faces after suitable preparation. Any with visible cracks, laminations, excessive scale, extensive or deep pitting or any other harmful defects shall be rejected, as also shall any plate with edges or holes in a ragged condition.

9.3.1 If the dressing of the plate has resulted in areas outside the ordered thickness tolerance, such plates may be submitted for concession accompanied by a sketch showing the area and the depth of the depression.

9.4 Each plate shall be Brinell tested in conformity with BS EN ISO 6506-1 at each corner and at the middle, the former tests being made at least 50 mm from any edge. At the positions where the tests are to be made the surfaces must be ground to a depth of not less than 0.75 mm to clean away any decarburisation. The hardness values shall be within the range(s) specified in **Annex B**.

9.5 All plates 70 mm thick and over, shall be ultrasonically flaw detected in accordance with clause **10**.

9.6 All plates shall be measured and shall conform to the specified tolerances in respect of thickness, see **Table 1**, and flatness.

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Table 1: Thickness Tolerances

Nominal thickness - mm	Tolerances - mm	
	-	+
3 to less than 7	0	0.75
8 to less than 20	0	1.00
21 to less than 35	1.00	1.00
36 to less than 49	1.50	1.50
50 to less than 100	2.00	2.00
101 to less than 150	3.00	2.00
Over 150 mm	4.00	2.00

9.7 Flatness

The flatness of the plate shall be such that when laid on a surface plate the space between the plate and the table must not exceed 4.5 mm for plates of 3 to 14 mm thickness and 6 mm for all the thicker plates, over a length of not less than 2 metres.

9.8 All accepted plates shall be stamped or indelibly marked with the manufacturer's symbol, the cast number, the plate number, the rolling direction and any other markings required by the contract or order.

10 Ultrasonic Examination

10.1 This requirement only applies to rolled steel armour plate of thickness greater than 70mm.

10.2 Testing shall be carried out to the requirements of BS EN 10160, except as modified as below.

10.3 Converge of Plate

10.3.1 Testing shall be from one side of the plate.

10.3.2 The plate shall be examined by scanning along parallel lines, spaced 50 mm apart, transverse to the major rolling direction.

10.4 Acceptance Criteria

The plate shall comply with the requirements of BS EN 10160 Class S_2 from Table 4.

10.5 Recording of Results

10.5.1 The results of the ultrasonic examination shall be recorded on a square grid as per **Annex C** or suitable alternative. The examined face of the plate shall be identified by metal stamping with the letters A, B, C, D at the corners taken in order in a clockwise direction, the letter A being stamped on the corner at which the examination commenced. The sides AB and DC will be parallel to the rolling direction, and the sides AD and BC transverse to the rolling direction.

10.5.2 The following conditions shall be recorded and plotted on a plan view of the examined plate face, drawn on a squared grid, see **Annex C** for an example.

(a) all laminations greater than 5 sq cm.

(b) all individual and cluster discontinuities as described in the acceptance criteria.

(c) any area of plate greater than 25 sq cm over which the amplitude of the back wall echo is reduced by more than 50%, with or without any associated flaw indication.

11 Mechanical Properties

11.1 Test samples shall be cut from two diagonally opposite corners of each fully heat treated mill plate and samples for tensile testing, charpy impact and hardness testing shall be removed from the test sample in an orientation that is transverse to the direction of rolling.

11.2 When the thickness of the plate permits, the test pieces shall be cut from a position mid-way between the centre plane and the surface of the plate.

11.3 The test samples shall be hardness tested to the requirements of BS EN ISO 6506-1 and shall satisfy the requirements of **Annex B.**

11.4 Three tensile samples shall be prepared and tested in accordance with BS EN 6892-1and the tensile strength values must not vary by more than three quarters of the difference between the maximum and minimum values specified for the appropriate plate thickness in **Annex A**. In each case, the requirements of **Annex B** shall be satisfied.

11.5 Three Charpy test pieces shall be prepared and tested in accordance with BS EN ISO 148-1 and shall satisfy the requirements of **Annex B.** The Charpy notch shall be perpendicular to the plate surfaces i.e. shall run in the short transverse direction.

11.6 The results of testing and inspection shall be recorded on the pro-forma at **Annex C** or suitable alternative and copies sent to the purchaser and consignee.

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ANNEX A
CHEMICAL COMPOSITION

A.1 Specification Requirement

The Chemical Analysis shall be in accordance with accordance with either **Table 2** or **Table 3**.

Table 2: Chemical Composition for Type 1 Material

Element	Weight %
Carbon	0.26 to 0.31
Silicon	0.10 to 0.35
Manganese	0.50 to 0.80
Sulphur	0.010 max
Phosphorus	0.015 max
Nickel	0.50 to 1.00
Chromium	1.30 to 1.70
Molybdenum	0.30 to 0.50

Table 3: Chemical Composition for Type 3 Material

Element	Weight %
Carbon	0.28 to 0.33
Silicon	0.10 to 0.35
Manganese	0.40 to 0.70
Sulphur	0.010 max
Phosphorus	0.015 max
Nickel	0.60 max
Chromium	3.10 to 3.50
Molybdenum	0.40 to 0.60

Annex B
Mechanical Properties

B.1 Specification Requirement

The Mechanical properties shall be in accordance with either **Table 4** or **Table 5**.

Table 4: Mechanical Properties for Type 1 Material

Nominal Thickness mm	Hardness (BHN) Min	UTS (MPa) Min	Elong (%) MIN	Charpy V Notch (J) at -40°C Min
3-7	321-363	-	-	-
8-14	321-363	1080-1190	12	-
15-35	302-341	1005-1130	16	24.5
36-49	293-331	975-1100	16	27.0
50-100	277-321	925-1050	16	31.0
101-139	262-302	880-990	16	35.5
Note 1: The 0.2% Proof Stress shall be determined and recorded for information				
Note 2: 3 Charpy tests shall be carried out and the average of these tests shall not fall below the specified minimum value. Only one of these 3 results may fall below the specified minimum but must not do so by more than 4 Joules.				

Table 5: Mechanical Properties for Type 2 Material

Nominal Thickness mm	Hardness (BHN) Min	UTS (MPa) Min	Elong (%) Min	Charpy V Notch (J) at -40°C Min
71-100	277-321	925-1050	16	31.0
101-139	262-302	880-990	16	35.5
140-179	248-285	835-940	17	38.0
180-219	229-269	770-880	17	46.0
220-250	217-255	725-835	18	50.0
251-300	207-248	710-820	20	54.0
Note 1: The 0.2% Proof Stress shall be determined and recorded for information				
Note 2: 3 Charpy tests shall be carried out and the average of these tests shall not fall below the specified minimum value. Only one of these 3 results may fall below the specified minimum but must not do so by more than 4 Joules.				

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Annex C
Preferred Format for the Reporting of Results

ARMOUR PLATE FOR PROOF OF PROJECTILES

CONTRACTOR: SPECIFICATION:

CONTRACT No: DATE OF INSPECTION:

INTERNAL ORDER No: TEST No: REFERENCE No:

CAST No: INGOT No: IDENTITY NO:

CHEMICAL ANALYSIS

C	Si	Mn	S	P	Ni	Cr	Mo	Others

MECHANICAL TEST RESULTS

UTS (Mpa) MIN	Elong (%) MIN	V NOTCH CHARPY AT -40^{O}C (J) MIN	BRINELL HARDNESS TEST AT EACH CORNER (A to d) AND PLATE CENTRE (E)				
			A	B	C	D	E

DIMENSIONAL REPORT

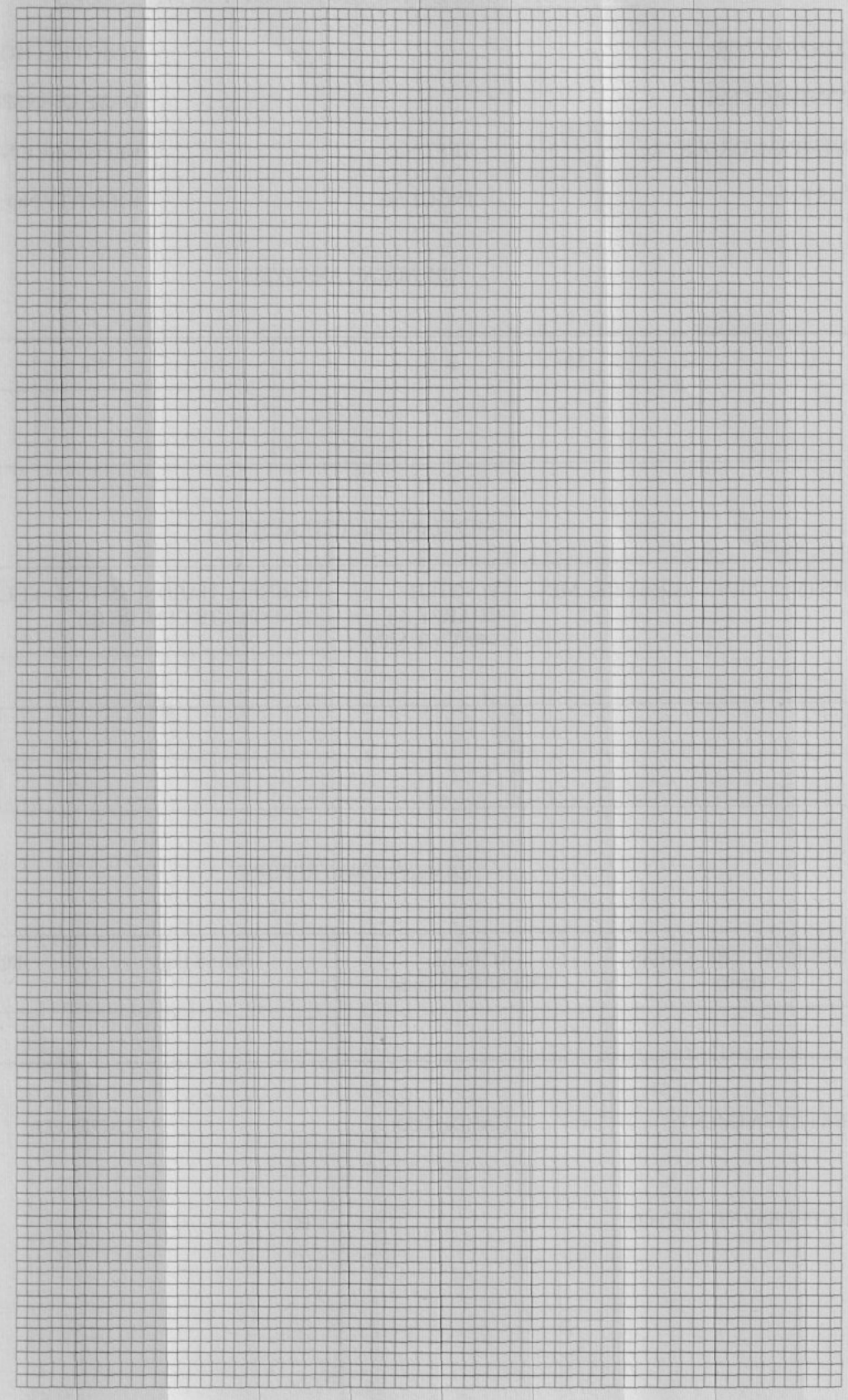
NOMINAL THICKNESS (mm)	ACTUAL THICKNESS (mm)	MASS (kg)	DIMENSIONS (mm)

HEAT TREATMENT: HARDENED: TEMPERED:

PLATE DESPATCHED ON: TO:

ANNEX C

Chart Of Results Of Ultrasonic Examination



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Contract Requirements

When Defence Standards are incorporated into contracts users are responsible for their correct application and for complying with contractual and statutory requirements. Compliance with a Defence Standard does not in itself confer immunity from legal obligations.

Revision of Defence Standards

Defence Standards are revised as necessary by up issue or amendment. It is important that users of Defence Standards should ascertain that they are in possession of the latest issue or amendment. Information on all Defence Standards can be found on the DStan web site www.dstan.mod.uk updated weekly and supplemented regularly by Standards in Defence News (SID News). Any person who, when making use of a Defence Standard encounters an inaccuracy or ambiguity is requested to notify the Directorate of Standardization (DStan) without delay in order that the matter may be investigated and appropriate action taken. Sponsors and authors shall refer to Def Stan 00-00 part 2 before proceeding with any standards work.