

MIL-A-46186(MR)

11 June 1984**MILITARY SPECIFICATION****ARMOR PLATE, STEEL, WROUGHT, HIGH-STRENGTH, HIGH-QUALITY**

This specification is approved for use by the Army Materials and Mechanics Research Center, Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

**1. SCOPE**

1.1 Scope. This specification covers materials requirements for quenched and tempered high-strength wrought steel armor plate for lightweight armor applications (up to 1/2") (see 6.1 and 6.3).

**2. APPLICABLE DOCUMENTS****2.1 Government documents.**

2.1.1 Specifications and standards. Unless otherwise specified (see 6.2), the following specifications and standards of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DODISS) specified in the solicitation, form a part of this specification to the extent specified herein.

**STANDARDS****FEDERAL**

Fed. Test Method Std. No. 151 - Metals; Test Methods

**MILITARY**

MIL-STD-129 - Marking for Shipment and Storage

MIL-STD-163 - Steel Mill Products Preparation for Shipment and Storage

MIL-STD-1185 - Welding High Hardness Armor

(Copies of specifications, standards, handbooks, drawings, and publications required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

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Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Director, US Army Materials and Mechanics Research Center, ATTN: DRXMR-SMS, Watertown, MA 02172 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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2.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this specification to the extent specified herein.

TECOMTOP 2-2-710 - Ballistic Test of Armor Materials

(Application for copies should be addressed to: Director, Defense Technical Information Center, ATTN: DDR, Cameron Station, Alexandria, VA 22314.)

2.2 Other publications. The following document(s) form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the current DODISS and the supplement thereto, if applicable.

American Society for Testing and Materials (ASTM) Standards

- E8 - Tension Testing of Metallic Materials
- E18 - Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
- E23 - Notched Bar Impact Testing of Metallic Materials
- E109 - Dry Powder Magnetic Particle Inspection

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

3. REQUIREMENTS

3.1 First article. When specified in the contract or purchase order (see 6.2), a sample or samples of the specified item shall be made available to the contracting officer or his authorized representative for approval in accordance with 4.2.1.1. The approval of the first article samples authorized the commencement of shipment but does not relieve the supplier of responsibility for compliance with all applicable provisions of this specification. The first article samples and test plates shall be manufactured by the process proposed for use on production armor. If, within 37 months the manufacturer has produced plate in the range of Table VI, first article may be waived for that thickness range.

3.1.1 First time producer. First time producers wishing to qualify to this specification should follow the instructions of 6.6.

3.2 Acceptance requirements.

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3.2.1 General Material Requirements. Material shall be produced by open hearth, basic oxygen furnace, or electric furnace.

3.2.1.1 Condition. Plates shall be in the as heat treated condition; no shearing, cutting, or pickling shall be permitted after the final treatment.

3.2.1.2 Formulation.

3.2.1.2.1 Chemical composition. The chemical composition shall conform to table I. In addition, those additives or hardening agents intentionally added shall be declared and must meet with the approval of the procuring activity. Also, some method of sulfide shape control shall be used, and reported on form MIL-46186.

TABLE I. CHEMICAL COMPOSITION (LADLE ANALYSIS)

ELEMENT	RANGE PERCENT
Carbon	.29 to .33
Manganese	.85 to 1.0
Phosphorus	.015 Max
Sulfur	.015 Max
Silicon	.35 to .50
Nickel	.95 to 1.30
Chromium	.50 to .65
Molybdenum	.50 to .60
Aluminum	.02 Min/.08 Max
Residual Elements*	
Boron	.0010 max
Copper	.40 max

\* Elements not intentionally added.

A statement showing the heat analysis of each melt and complete details of the heat treatment of each lot shall be furnished through the contracting officer at no cost to the Government or the procuring activity for review and approval. All elements of chemical composition shall be shown in the statement. The chemical composition range established by the producer and the chemical analysis of the material submitted shall be reported on the check list for steel armor data Form MIL46186 (see figure 1 and 6.5).

3.2.2 Heat treatment. All plates in each lot, including samples, shall receive the same heat treatment. Local or general heating shall not be performed after the final heat treating operation (see 6.2). All plates shall be tempered at a temperature of at least 350°F for a total of 30 minutes minimum as a final heat treating operation.

3.2.3 Mechanical properties.

3.2.3.1 Tensile Properties. The average (or aim) ultimate tensile strength (UTS) shall be 275,000 psi. The following minimum ultimate tensile strength, minimum yield strength (offset = 0.2%), minimum ratio of UTS to yield strength (UTS/ys), minimum elongation and reduction of area shall be met by every

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lot. The UTS shall be at least 270,000 psi average per lot. The yield strength (offset = 0.2%) shall be at least 190,000 psi average per lot. The ratio of UTS/ys shall be at least 1.15. The elongation and reduction-in-area shall be at least 4.0% and 25% respectively. Individual test results shall be reported, as well as lot averages.

3.2.3.2 Hardness. Rockwell C hardness readings shall be taken on opposite corners (or opposite ends) of an individual plate (see 4.4.2.2 and 4.6.2.1.2). The minimum hardness shall be Rockwell C 51.

3.2.3.3 Impact resistance. The minimum Charpy V-notch impact energy of the plate as determined by the average of 2 or more specimens in accordance with ASTM E 23 shall be as shown in table II. The Charpy V-notch impact specimens shall be obtained in both the TL orientation (i.e., transverse to the major direction of rolling with the notch perpendicular to the plate surface so that the crack will propagate in the longitudinal direction) and the LT orientation (i.e., parallel to the major direction of rolling).

TABLE II. Minimum Charpy V-notch impact energy in ft.-lbs. at  $-400^{\circ}\text{F} \pm 20^{\circ}\text{F}$  for standard or sub-size specimens

Specimen orientation	Impact energy for standard depth specimens but with the following width (Average of 2 or more tests), ft. lbs.)			
	Standard width	3/4 width	1/2 width	1/4 width
Transverse (T-L)	10.0	7.5	5.0	2.5
Longitudinal (L-T)	12.0	9.0	6.0	3.0

3.2.4 Ballistic requirements. Ballistic requirements shall be in accordance with the appendix of this specification.

3.2.5 Dimensions and tolerances.

3.2.5.1 Dimensions. Plates shall comply with the dimensions specified in the applicable drawings or in the contract or order (see 6.2).

3.2.5.2 Thickness. The thickness tolerance of each plate, after final treatment, shall be in accordance with table III for the thickness specified.

3.2.5.3 Flatness. Unless otherwise specified in the contract or order, the flatness tolerance of each plate shall be within the requirements specified in table IV. Tighter tolerance requirements may be specified in the contract or order and shall be as agreed upon between the contractor and the procuring activity.

3.2.5.4 Waviness. Unless otherwise specified in the contract or order, the waviness tolerance of each plate shall be within the requirements of table V.

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\*TABLE III. Thickness tolerances for ordered thickness<sup>1/</sup>, inches (over and under)

Specified Thickness Inches	Up to 72"	Tolerance (inch) for width of plate					
		72" to 84" excl.	84" to 96" excl.	96" to 108" excl.	108" to 120" excl.	120" to 132" excl.	132" to 144" excl.
1/8	.016	.016	.019	.019	.023	----	----
3/16	.016	.016	.019	.019	.023	----	----
1/4	.016	.016	.019	.019	.023	----	----
5/16	.016	.019	.019	.019	.023	.026	----
3/8	.016	.019	.019	.023	.023	.026	----
7/16	.016	.019	.019	.023	.026	.026	.031
1/2	.016	.019	.019	.023	.026	.026	.031

<sup>1/</sup> For intermediate thickness, the tolerance of the closer specified gage shall apply.

TABLE IV. Permissible variations from flatness.

Specified Thickness, in.	Variations from a flat surface for specified widths, in.									
	Over 8 to 36 to 36 excl.	48 to 48 excl.	60 to 60 excl.	72 to 72 excl.	84 to 84 excl.	96 to 96 excl.	108 to 108 excl.	120 to 120 excl.	144 to 144 excl.	120 to 120 excl.
Up to 1/4, excl.	1/2	1/2	1/2	3/4	1	1	1	1	1	1
1/4 to 3/8, excl.	3/4	15/16	1-1/8	1-3/8	1-7/8	1-7/8	2	2-1/4	2-3/8	1
3/8 to 1/2, excl.	3/4	7/8	15/16	1-1/8	1-5/16	1-5/16	1-1/2	1-5/8	1-7/8	1-7/8
1/2 to 3/4, excl.	5/8	3/4	13/16	7/8	1-1/8	1-1/8	1-1/4	1-3/8	1-5/8	1-5/8

Note 1 - Flatness tolerances for length - The longer dimension specified is considered the length, and variations from a flat surface along the length should not exceed the tabular amount for the specified width in plates up to 12 ft. in length, or in any 12 ft. or longer plates.

Note 2 - Flatness tolerances for width - The flatness variations across the width should not exceed the tabular amount for the specified width.

Note 3 - When the longer dimension is under 36 in., the variation should not exceed 3/8 in. When the larger dimension is from 36 to 72 in., incl., the variation should not exceed 75% of the tabular amount for the specified width.

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TABLE V. Waviness tolerances for plates

Flatness tolerance from table IV	When number of waves in 12 ft is:						
	1	2	3	4	5	6	7
5/16	5/16	1/4	3/16	1/8	1/8	1/16	1/16
3/8	3/8	5/16	3/16	3/16	1/8	1/16	1/16
7/16	7/16	5/16	1/4	3/16	1/8	1/8	1/16
1/2	1/2	3/8	5/16	3/16	3/16	1/8	1/16
9/16	9/16	7/16	5/16	1/4	3/16	1/8	1/8
5/8	5/8	1/2	3/8	1/4	3/16	1/8	1/8
11/16	11/16	1/2	3/8	5/16	3/16	3/16	1/8
3/4	3/4	9/16	7/16	5/16	1/4	3/16	1/8
13/16	13/16	5/8	7/16	5/16	1/4	3/16	1/8
7/8	7/8	11/16	1/2	3/8	1/4	3/16	1/8
15/16	15/16	11/16	1/2	3/8	5/16	1/4	3/16
1	1	3/4	9/16	7/16	5/16	1/4	3/16
1-1/8	1-1/8	7/8	5/8	1/2	3/8	1/4	3/16
1-1/4	1-1/4	15/16	11/16	1/2	3/8	5/16	1/4
1-3/8	1-3/8	1-1/16	3/4	9/16	7/16	5/16	1/4
1-1/2	1-1/2	1-1/8	7/8	5/8	1/2	3/8	1/4
1-5/8	1-5/8	1-1/4	15/16	11/16	1/2	3/8	5/16
1-3/4	1-3/4	1-5/16	1	3/4	9/16	7/16	5/16
1-7/8	1-7/8	1-7/16	1-1/16	13/16	9/16	7/16	5/16
2	2	1-1/2	1-1/8	7/8	5/8	1/2	3/8
2-1/8	2-1/8	1-5/8	1-3/16	7/8	11/16	1/2	3/8
2-1/4	2-1/4	1-11/16	1-1/4	15/16	11/16	9/16	3/8
2-3/8	2-3/8	1-13/16	1-5/16	1	3/4	9/16	7/16
2-1/2	2-1/2	1-7/8	1-7/16	1-1/16	13/16	9/16	7/16
2-5/8	2-5/8	2	1-1/2	1-1/8	13/16	5/8	7/16
2-3/4	2-3/4	2-1/16	1-9/16	1-1/8	7/8	5/8	1/2

Note - Waviness denotes the deviation of the top or bottom surface from a horizontal line, when the plate is resting on a flat surface, as measured in an increment of less than 12 ft of length. The waviness tolerance is a function of the flatness tolerance as obtained from table IV.

Note - When the flatness tolerance is 1/2 inch or less for plate thicknesses 1/2 inch and under, the waviness tolerance shall not apply.

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**3.2.6 Surface and internal soundness.** Unless otherwise specified in the contract or order, all plates shall be free from laminations, cracks, seams, laps, and other imperfections which would adversely affect the strength, fabricability, or ballistic performance of the armor.

**3.2.7 Identification marking.** Identification marking shall be legibly painted and records shall be such as to ensure positive identification of all plates, including test samples and specimens, with the lot and corresponding heat from which they were produced. Traceability of plates from first to last in each lot shall be maintained. The markings shall be such that quick and positive identification of the UTS of each plate tested (see 4.4.2.2) can be made. It is recommended that the UTS be marked on every plate tested (see 4.4.2.2). The key to identification symbols shall be furnished to the inspector prior to submittal for inspection. First article and acceptance ballistic test plates shall also be marked with the manufacturer's name or trademark, the number of this specification, and the ordered plate thickness in inches. First article plates shall be marked "PRE", acceptance plates "ACC", and retest plates will be marked "R1" and "R2". If a second set of retest plates are submitted they shall be marked "RR1" and "RR2". The primary plate rolling direction shall be identified. The key to the identification of the UTS of the plates shall be supplied to the procuring activity for review and approval.

**3.2.8 Workmanship.** All plates shall be free from scale, pits, tears, folds, and other surface imperfections which are of such a nature as to affect the fabricability or serviceability of the material.

**3.2.9 Information Required.** A statement showing the ingot analysis of each melt and complete details of the heat treatment of each lot shall be furnished to the procuring activity. All elements of the chemical composition shall be shown in the statement, including special additives or hardening agents, whether shown in Table I or not. Hardness results for each plate and impact results for each lot shall be included in the statement.

#### **4. QUALITY ASSURANCE PROVISIONS**

**4.1 Responsibility for inspection.** Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

#### **4.2 Classification.**

**4.2.1 Classification of inspection.** The inspection requirements specified herein are classified as follows:

1. First article inspection (see 4.4.1).
2. Quality conformance inspection (see 4.4.2).

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4.2.1.1 First article inspection. When required, the first article samples submitted in accordance with 3.1, shall be examined for all the provisions of this specification applicable to end item examination.

4.2.1.1.1 First article tests. First article tests (see 6.2) shall consist of all the tests specified in 4.6.

4.2.1.1.2 Waiving of first article ballistic test. Unless otherwise specified (see 3.1 and 6.2), the first article ballistic test shall not be required provided (a) the manufacturer, within 37 months, has produced acceptable plates within the same nominal thickness ranges of Table VI and (b) his production conditions are the same as for previously accepted plates. A supplier who has previously met the first article requirements will furnish the procuring activity with the pertinent data relative to compliance with first article test.

4.2.1.2 Quality conformance (acceptance) inspection. The acceptance examination under 4.5 and the tests under 4.6 shall serve as a basis for the acceptance of individual production plates.

4.3 Lot. A lot shall consist of all plates of the same melt (heat) of steel, of the same thickness, having the same treatment, and heat treated at the same temperature in the same facility. For material heat treated in a continuous furnace, a lot shall consist of all plates of the same size or thickness which were heat treated exactly alike and which are represented by one melt of steel subject to inspection at the same time.

4.4 Sampling.

4.4.1 For first article.

4.4.1.1 Chemical analysis samples. One sample for chemical analysis shall be taken from each plate submitted for ballistic testing.

4.4.1.2 Impact samples. At least one impact test sample in the TL orientation and one impact test sample in the LT orientation shall be taken from each test plate submitted.

4.4.1.3 Ballistic samples. Two ballistic plates, of the same ordered thickness range shown in Table VI below shall be submitted for ballistic testing and shall represent any other thickness in the range. One sample shall be taken from the first plate heat treated and one from the last plate heat treated in the initial lot produced. When only one plate is heat treated, a sample shall be taken from each end of the plate. The ballistic test plates shall be 12 inches by 36 inches.

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Table VI. Thickness ranges and corresponding test projectiles for first article and acceptance testing (a).

Nominal thickness range (inches)	Test Projectile
0.125 to 0.300 incl.	Cal .30 AP, M2
0.301 to 0.590 incl.	Cal .50 AP, M2

(a) Minimum required ballistic limits are tabulated in Tables VII and VIII of the Appendix. The plates are tested at 30° obliquity.

4.4.1.4 Tensile specimens. One tensile specimen shall be taken from each of the plates submitted.

4.4.2 Sampling for quality conformance inspection.

4.4.2.1 For chemical analysis. At least one sample for chemical analysis shall be taken from each lot in accordance with method 111 or 112 of Fed. Test Method Std. No. 151.

4.4.2.2 Hardness and tensile tests. Unless otherwise specified, the first and last parent plates from the first and last applied ingots of each lot shall be tensile tested in triplicate in accordance with ASTM E 8 in the transverse direction on both ends of the parent plate after final heat treatment. A Rockwell C hardness test shall be taken adjacent to the location where the tension specimens were taken, as well as the other end of the individual plate (4.4.1.2.2). All other parent plates in a given lot will be hardness tested on diagonal corners. The hardness shall be according to ASTM E 18 and shall be the average of at least three readings at one location.

4.4.2.2.1 Plates. A plate shall consist of either individual plates (cut to final size for shipping) or shall be a parent plate. A parent plate has the same dimensions (except for length) and processing sequence as the individual plates (as sized for shipping); and a parent plate is one piece during final heat treatment. A parent plate is, by definition, not longer than 50 feet. For example, a 30-foot parent plate could be cut into three 10-foot individual plates.

4.4.2.3 For Charpy V-notch impact tests. A sample shall be taken from a plate representing each lot for Charpy V-Notch impact tests. The sample shall be the same thickness as the plate it represents and large enough to obtain at least four specimens from the sample in accordance with 4.6.3. The sample shall be taken from one of the same plates from which tensile specimens are taken.

4.4.2.4 For ballistic testing. One plate, of each thickness to be supplied on the contract, shall be randomly taken from each lot for ballistic testing. Unless otherwise specified, the plates shall be 12 inches by 36 inches.

4.4.2.5 For soundness. Unless otherwise specified, two samples shall be randomly taken from each lot for these tests; however, when an entire heat represents only one lot the samples shall be taken from the first and last usable portion of the heat.

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**4.5 Examination.**

4.5.1 Visual. All steel plate shall be subject to visual inspection for compliance with the requirements for identification marking (see 3.2.7) and for workmanship (see 3.2.8).

4.5.2 Dimensional. All steel plate shall be subject to inspection for compliance with dimensional and tolerance requirements (see 3.2.5).

4.5.3 Preparation for shipment. Examination shall be made to determine compliance with the requirements for preparation for shipment (see section 5).

**4.6 Tests.**

4.6.1 Chemical analysis. Chemical analysis shall be conducted in accordance with the procedures of method 111 or method 112 of Fed. Test Method Std. No. 151 (see 6.5). In case of dispute, the analysis by 111 shall be the basis for acceptance or rejection.

4.6.2 Tensile properties. Tension tests shall be conducted in accordance with ASTM E 8. Standard or subsize specimens (Fig. 6 of ASTM E 8-81) may be used or the specimen shown in Figures 2 and 3 of this specification. Machining shall be conducted in a manner not to alter the mechanical properties of the specimen by overheating. Tensile specimens shall be taken so that the gage section of the specimen must be at least 4 inches from any quenched edge, as well as outside the heat affected zone of any cut edge. The tensile specimens shall be oriented in the preliminary rolling direction of the plate.

4.6.2.1 Machined tensile bars. The machining of the tensile specimens shall be machined to the required length and width (see 4.5.2) and then carefully ground to proper thickness by removing equal amount of material from both sides. To prevent overheating, sufficient coolant (mixture of water and water soluble oil) must be used during all grinding operations. Precaution must be taken in the event the specimens bow after grinding one side. The second step shall be grinding the configuration of the notched area. Work shall proceed slowly with the use of sufficient coolant in order not to overheat the specimens.

4.6.2.1.2 Rockwell hardness tests. Rockwell-C hardness tests in accordance with ASTM E 18 will be used, where required, (see 3.2.3.2 and 4.4.2.2) but may not be substituted for tension tests.

4.6.3 Charpy V-notch impact tests. At least four Charpy V-notch impact test specimens shall be taken from the sample and shall be prepared and tested in accordance with ASTM E 23. Charpy V-notch impact test specimens shall be taken in both the TL orientation and in the LT orientation from locations midway between the top and bottom surfaces of the plate and at least 4 inches or 2T, whichever is less, from any quenched edge as well as outside the heat affected zone of any oxygen-cut edge. The largest attainable subsize Charpy V-notch impact specimens shown in figure 4 of ASTM E 23-82 shall be used. Specimen widths between those of the standard bar and the 1/4, 1/2 or 3/4 size width may be used. If widths between the recommended subsizes are used, the energy shall be proportioned or scaled so as to normalize the data to standard size bars. The normalized charpy energy must then be compared to the standard width value of table I.

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4.6.4 Ballistic tests. Ballistic testing of armor plate shall be conducted at a Government test facility specified in the contract or order. Testing shall be conducted in accordance with the requirements of the appendix of this specification.

4.6.5 Soundness. Ultrasonic tests shall be carried out as agreed upon between the procuring activity and the contractor to determine the requirements of 3.2.6 (See ASTM A578).

4.7 Reduced testing. At the discretion of the procuring activity, the amount of testing may be reduced provided the results on consecutive lots indicate that a satisfactory uniform product meeting the testing requirements is being produced. Reduced testing shall be in accordance with a system previously approved or established by the procuring activity involved.

4.8 Rejection and retest.

4.8.1 Rejection. Unless otherwise specified in the contract or order, failure of the first article samples to meet the requirements of this specification shall be cause for rejection of the process, failure of the acceptance samples to meet the requirements of this specification shall be cause for rejection of the lot.

4.8.2 Retest. Unless a specific retest procedure is specified in the contract or order, lots rejected for failure to meet the requirements of the specification may be resubmitted for test provided the producer has reworked the lots, as necessary, to correct the deficiencies or has removed the nonconforming material. First article retests shall not be permitted until the supplier has made the necessary corrections in the processing of the material to the satisfaction of the procuring activity.

5. PACKAGING

5.1 Preservation and packaging. Preservation and packaging shall be level A or C as specified (see 6.2).

5.1.1 Level A. Cleaning, drying, preservation, and packaging shall be in accordance with MIL-STD-163.

5.1.2 Level C. Cleaning, drying, preservation, and packaging shall be in accordance with manufacturer's commercial practice.

5.2 Packing. Packing shall be level A or level C as specified (see 6.2).

5.2.1 Level A. Packing shall be in accordance with MIL-STD-163.

5.2.2 Level C. Packing shall be in accordance with commercial practice adequate to ensure acceptance and safe delivery by the carrier for the mode of transportation employed.

5.3 Marking. In addition to any special marking specified in the contract or order, shipments shall be marked in accordance with the requirements of MIL-STD-129.

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## 6. NOTES

6.1 Intended use. The steel armor covered by this specification is intended for non-structural use in lightweight applications generally up to and including 1/2 inch in thickness, where resistance to ball and armor piercing types of ammunition and multiple hit capability are required.

6.2 Ordering data.

6.2.1 Procurement requirements. Procurement documents should specify the following:

- a. Title, number and date of this specification.
- b. If first article samples are to be made available (see 3.1).
- c. If additional heat treatment may be performed (see 3.2).
- d. If plates may be furnished in a condition other than in 3.2.1.1.
- e. Dimensions (see 3.2.5).
- f. Soundness acceptance criteria if other than in 3.2.6, 4.6.5.
- g. Name of inspection agency when inspection shall be performed by other than the contractor (see 4.1).
- h. If first article testing is required (see 4.2.1.1).
- i. If first article ballistic testing may be waived (see 4.2.1.1.2).
- j. Production sampling if other than in 4.4.2.5.
- k. Where ballistic testing is to be conducted (see 4.6.4).
- l. The reduced testing plan when applicable (see 4.7).
- m. If rejection and retest differ from 4.8.
- n. Preparation for delivery requirements (see section 5).

6.2.2 Contract data requirements. When this specification is used in a procurement which incorporates a DD Form 1423 and invokes the provisions of the Defense Acquisition Regulatory System (DARS), the data requirements identified below will be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved Contract Data Requirements List (DD Form 1423) incorporated into the contract. When the provisions of DARS are not invoked, the data specified below may be delivered by the contractor in accordance with the contract requirements. Deliverable data required by this specification is cited in the following paragraphs:

<u>Paragraph no.</u>	<u>Data requirement title</u>	<u>Applicable DID no.</u>
3.1	Report, First Article Test	UDI-T-23790
3.2.9	Certification Data Report	UDI-T-23264

(Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the Naval Publications and Forms Center or as directed by the contracting officer.)

6.3 Fabrication. The armor plate covered by this specification is subject to fabrication involving cutting, drilling, forming, and welding. It is intended that selection and control of chemical composition, cleanliness, and plate processing will be such that the armor will be suitable for fabrication under procedures and controls such as specified in MIL-STD-1185, Welding High Hardness Armor, however the mechanical properties in 3.2.3 take priority over weldability.

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6.4 Chemical analysis. Suggested ASTM instrumental methods that can be used are chemical analysis E415, E282, E484 and E322. ASTM A751 should be consulted for a complete list of methods.

6.5 Form MIL46186. Form MIL46186 may be reproduced and used for submittal of data required.

6.6 Potential suppliers. Potential suppliers who have not previously supplied armor plate to this specification and wish to have their material ballistically tested, may do so at their own expense. It is recommended that inquiries for such testing be directed to Commander, US Army Test and Evaluation Command, ATTN: DRSTE-TO-0, Aberdeen Proving Ground, MD 21005.

Custodian:  
Army - MR

Preparing activity:  
Army - MR

Project No. 9515-A041

(WP ID #3451A/DISC-0207A, FOR AMRC USE ONLY)

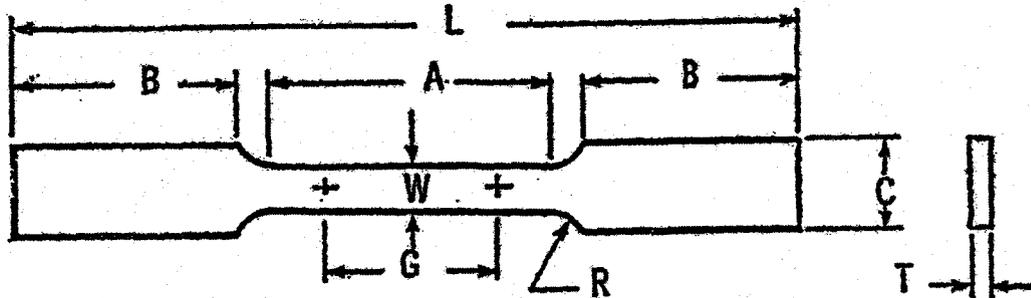
NOTE: This form may be reproduced for data submittal

<b>CHECK LIST FOR DATA ON STEEL PLATE ARMOR</b>						<b>DCAS REGION</b>					
INSTRUCTIONS: To be filled in by typewriter,						Contract No.					
PRIME CONTRACTOR						Contract No.					
MFG.						for Ballistic Test:					
Address						Firing Date:					
MFG. Record No. & Date						Firing Record No.					
Shipping Date:						MIL-A-46186 REV. ___ Amend. ___					
Shipped To:						Type of Furnace:					
PURPOSE: <input type="checkbox"/> Acceptance <input type="checkbox"/> Development <input type="checkbox"/> 1st Art.						Material for use on (Specific Vehicle)					
SAMPLE: <input type="checkbox"/> Primary <input type="checkbox"/> Retest											
Represents _____ Lbs.											
<b>CHEMICAL COMPOSITION RANGE ESTABLISHED BY FOUNDRY OR STEEL PRODUCER</b>											
C	Mn	P	+ S	Si	Ni	Cr	Mo	V	B	Zr	OTHER
/	/	/	/	/	/	/	/	/	/	/	
<b>CHEMICAL ANALYSIS OF MATERIAL SUBMITTED</b> * Sulfur Shape Control Method _____											
C	Mn	P	+ S	Si	Ni	Cr	Mo	V	B	Zr	OTHER
HOMOGENIZE			NORMALIZE			HARDEN			DRAW		COOLANT
Temp.	Time at Temp.	Temp.	Time at Temp.	Temp.	Time at Temp.	Temp.	Time at Temp.	Temp.	Time at Temp.		
LOT or HEAT No.	INGOT	SLAB	PLATE No.	ORD THICK	ORD SIZE	ORD WIDTH	ROLL WIDTH	REQ. HARD TYPE	ACT. HARD TYPE		
1											
2											
CRANFY IMPACT AT -40°F			Specimen Size			SIGNATURE OF SUPPLIER'S REPRESENTATIVE				DATE	
SIGNATURE OF GOVT. REPRESENTATIVE						DATE					
<b>BALLISTIC TEST REC.</b>											
TEST	PROJECTILE	OBL	THRS	REQ. VEL	ACT. VEL	PASSED/FAILED	REMARKS				
1											
2											
LOT _____ OK/FAILED TO MEET THE BALLISTIC REQUIREMENTS OF SPECIFICATION MIL-A-46186											
DATE				PROOF FACILITY SIGNATURES							
				CHIEF, ARMOR BRANCH				TEST DIRECTOR			

Figure 1. Form MIL46186 - Check List for Armor Data (Replaces TAC FORM 3983 for reporting data to MIL-A-46186)

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## TYPE A TENSILE



## LEGEND

L	Overall Length, min	7.0"
G	Gage Length	2.0"
W	Width (notes 1 and 2)	.50"
T	Thickness	$.125 < T < .135$ "
R	Radius of Filler, min	0.375"
A	Length of Reduced Section	3.0"
B	Length of Grip Section	2.0"
C	Width of Grip Section, Approx.	.75"

Note 1 - Width of reduced section to be parallel over full length (0.005").

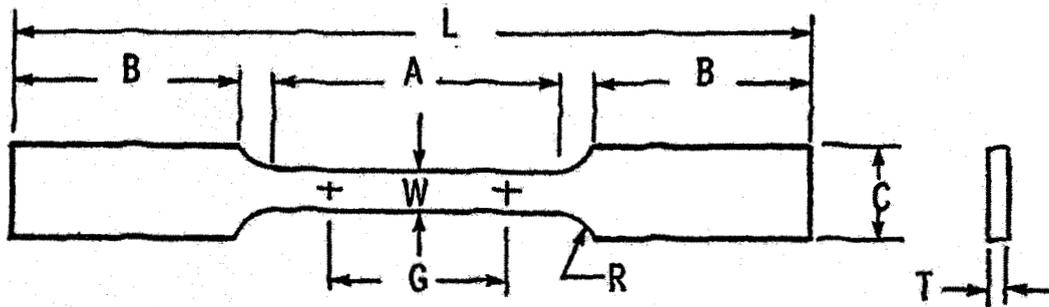
Note 2 - Ends of the reduced section shall not differ in width by more than 0.005"

Note 3 - Thickness of the reduced section shall not vary by more than 0.001".

Figure 2 RECTANGULAR TENSION TEST SPECIMEN

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## TYPE B TENSILE



## LEGEND

L	Overall Length, min	6.0"
G	Gage Length	2.0"
W	Width (notes 1 and 2)	.375"
T	Thickness	$.125" < T < .135"$
R	Radius of Fillet, min	0.375"
A	Length of Reduced Section	2.5
B	Length of Grip Section	1.5"
C	Width of Grip Section, approx.	.5"

Note 1 - Width of reduced section to be parallel over full length (0.005")

Note 2 - Ends of the reduced section shall not differ in width by more than 0.005"

Note 3 - Thickness of the reduced section shall not vary by more than 0.001".

Figure 3 RECTANGULAR TENSION TEST SPECIMEN

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## APPENDIX

BALLISTIC TESTING OF ARMOR PLATE, STEEL, WROUGHT,  
HIGH-STRENGTH, HIGH-QUALITY

## 10. SCOPE

10.1 This appendix covers the requirements for ballistic testing of high strength high quality steel armor plate.

## 20. DEFINITIONS

20.1 Fair impact. A fair impact is an impact resulting from the striking of the test plate by a projectile in normal flight (no yawing or tumbling) and separated from another impact or the edge of the plate, hole, crack, or spalled area by an undisturbed area of at least two test projectile diameters.

20.2 Witness sheet. A witness sheet is normally a 0.014 inch thick sheet of 5052 H36 aluminum alloy (or a 0.020 inch thick sheet of 2024-T3 aluminum alloy) placed 6 inches ( $\pm 1/2$  inch) behind and parallel to the test plate or other ballistic sample.

20.3 Complete penetration, protection, CP(P). A protection complete penetration is a penetration in which the projectile or one or more fragments of a projectile or plate pass beyond the back of the test plate and perforate the witness plate.

20.4 Partial penetration, protection, PP(P). A partial penetration is any impact that is not a complete penetration.

20.5 Gap. The difference in velocity between the high partial penetration velocity and the low complete penetration velocity used in computing the ballistic limit where the high partial penetration velocity is lower than the low complete penetration velocity.

20.6 V<sub>50</sub> protection ballistic limit, BL(P). The protection V<sub>50</sub> ballistic limit is defined as the average of 6 fair impact velocities comprising the three lowest velocities resulting in complete penetration and the three highest velocities resulting in partial penetration. A maximum spread of 150 feet per second shall be permitted between the lowest and highest velocities employed in determination of ballistic limits. In only those cases where the lowest complete penetration velocity is lower than the highest partial penetration velocity by more than 150 fps will the ballistic limit be based on 10 velocities (the 5 lowest velocities that resulted in complete penetration and the 5 highest velocities that resulted in partial penetrations). When the 10-round excessive spread, ballistic limit is used, the velocity spread will be reduced to the lowest practical level (as close to 150 fps as possible). When a 10-round ballistic limit is used, this will be noted in all reports. The normal up-and-down firing method will be used in the determination of all BL(P)'s, all velocities being corrected to striking

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velocity. In the event that the ballistic limit computed is less than 30 fps above the minimum required, if a gap (high partial penetration velocity below the low complete penetration velocity) of 30 fps or more exists, firing will continue as needed to reduce this gap to 25 fps or less. (This procedure will insure better evaluation of the steel when the ballistic limit is near the minimum required.)

20.7 Thickness, impact area. The thickness of ballistic test plates used for determining ballistic limits shall be that of the area subjected to the ballistic testing.

## 30. REQUIREMENTS

30.1 Resistance to penetration. The minimum ballistic limits shall be in accordance with the values shown in tables V, or VI as applicable.

30.2 Resistance to cracking. Ballistic test plates when visually examined after testing shall not develop any through-crack greater in length than five calibers of the projectile.

## 40. TESTS

40.1 Ballistic tests. V<sub>50</sub> ballistic tests shall be performed in accordance with USATECOMTOP 2-2-710, Ballistic Test of Armor Materials to determine compliance with the requirements of tables V and VI.

40.1.1 Plate thickness as measured by the ballistic test agency shall be used to determine the required ballistic limit for the plate. Individual thickness measurements are to be read from a micrometer to the nearest 0.001 inch and the average of these readings reported to the nearest 0.001 inch. At least one measurement shall be taken along each edge of the plate at a distance at least one inch from the edge, but preferably in the area which will be impacted. The required ballistic limit will be determined by interpolation, if necessary, in the tables in the appendix.

40.1.2 Rejection and retest of ballistic plates.

40.1.2.1 First article tests (rejection). Unless noted otherwise in the contract or order, failure of either of the first article test plates to meet the minimum ballistic requirements as specified in the appendix to this specification indicates failure of the product and process.

40.1.2.2 First article (retests). Resubmission of ballistic retest plates shall not be made until the manufacturer has made the necessary corrections in the processing of the material to the satisfaction of the procuring activity. Two retest plates must be submitted for first article testing and both must pass.

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**40.1.2.3 Acceptance tests (rejection).** Unless otherwise noted in the contract or order, failure of a test plate to meet the ballistic requirements indicates failure of the lot, however, the final decision will depend on the outcome of retests, if submitted.

**40.1.2.4 Acceptance tests (retests).** If a test plate representing a lot fails to meet the ballistic requirements, the manufacturer has the following options: Immediately upon notification of the failure, he may:

(1) At his own expense submit two additional test plates from the same lot for ballistic retest, or

(2) He may first re-heat-treat (quenching and tempering) the lot and then submit a test plate from the re-treated lot, or

(3) He may scrap the lot and submit a plate representing a new lot for acceptance.

If he chooses any one of these options and the ballistic retest plate (or plates) meet the requirements, then the lot represented is acceptable. If he chooses option (1) and one or both of the retest plates fail, the manufacturer may re-heat-treat the lot and submit a test plate from the re-treated lot. If this plate fails, the lot is rejected. If he chooses option (3) and the test plate fails, he may again resort to any one of the three options. The manufacturer shall report the processing used on the failed plates.

**40.1.3 Disposition of ballistic test plates.**

**40.1.3.1 First article test plates.** Upon request of the applicant within 15 days after ballistic testing, first article plates will be returned "as is" to the applicant, at his expense, unless the plates were destroyed in testing.

**40.1.3.2 Acceptance test plates.** Acceptance test plates that comply with the requirements of this specification are considered as part of the lot of steel they represent and ownership of them passes to the Government with the acceptance of that lot. Acceptance test plates that fail to comply with the requirements of this specification are considered as part of the lot they represent and remain the property of the producer just as the rejectable lot does. The failed plates will be returned, upon request, as in 40.1.3.1.

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TABLE VII. Minimum required ballistic limits - Caliber .30  
AP M2 Projectiles at 30° Obliquity

Thickness, inch	Required BL(P), fps	Thickness, inch	Required BL(P), fps
0.102	595	0.220	2058
.105	665	.225	2100
.110	770	.230	2140
.115	863	.235	2180
.120	950	.240	2219
<u>1/</u> .125	1030	.245	2258
.130	1105	.250	2296
.135	1175	.255	2333
.140	1243	.260	2370
.145	1307	.265	2406
.150	1368	.270	2442
.155	1428	.275	2477
.160	1484	.280	2512
.165	1540	.285	2546
.170	1593	.290	2580
.175	1645	.295	2614
.180	1696	<u>2/</u> .300	2647
.185	1745	.305	2680
.190	1792	.310	2712
.195	1839	.315	2744
.200	1885	.320	2776
.205	1930	.325	2808
.210	1973	.330	2838
.215	2016	.335	2869
		.340	2900

1/ Specification requirements begin for this ordered thickness.

2/ Specification requirements end for this ordered thickness.

Note: Tabulated values on either side of the specification requirements are for interpolation of BL(P) requirements on undersize or oversize plates.

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TABLE VIII. Minimum required ballistic limits - Caliber .50  
AP M2 Projectiles at 30° Obliquity

Thickness, inch	Required BL(P), fps	Thickness, inch	Required BL(P), fps
0.275	1532	0.450	2272
.280	1557	.455	2290
.285	1582	.460	2307
.290	1607	.465	2325
.295	1632	.470	2342
.300	1656	.475	2360
<u>1/</u> .301	1661	.480	2377
.305	1680	.485	2394
.310	1703	.490	2411
.315	1726	.495	2428
.320	1749	.500	2445
.325	1772	.505	2462
.330	1794	.510	2478
.335	1817	.515	2495
.340	1839	.520	2511
.345	1860	.525	2528
.350	1882	.530	2544
.355	1903	.535	2560
.360	1924	.540	2576
.365	1945	.545	2592
.370	1966	.550	2608
.375	1986	.555	2623
.380	2006	.560	2639
.385	2026	.565	2654
.390	2046	.570	2670
.395	2066	.575	2685
.400	2085	.580	2701
.405	2105	.585	2716
.410	2124	<u>2/</u> .590	2731
.415	2143	.595	2746
.420	2162	.600	2761
.425	2180	.605	2776
.430	2199	.610	2791
.435	2217	.615	2806
.440	2236	.620	2820
.445	2254	.625	2835

1/ Specification requirements begin for this ordered thickness.

2/ Specification requirements end for this ordered thickness.

Note: Tabulated values on either side of the specification requirements are for interpolation of BL(P) requirements on undersize or oversize plates.