

INCH-POUND

MIL-DTL-46100E (MR)
w/AMENDMENT 1
24 October 2008

SUPERSEDING
MIL-DTL-46100E (MR)
9 July 2006

DETAIL SPECIFICATION

ARMOR PLATE, STEEL, WROUGHT, HIGH-HARDNESS

This specification is approved for use by the 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 quenched and tempered high-hardness wrought steel armor plate for lightweight armor applications for ordered thicknesses from 0.118 inches (3 mm) up to an ordered thickness of 2.000 inches (50.8 mm), inclusive (see 6.1, 6.2, and 6.3).

1.2 Classification. Wrought armor should be of the following classes as specified in the contract or purchase order (see 6.2). If no class is specified then Class 1 should be supplied.

1.2.1 Class 1. Wrought armor plate which is liquid (e.g., water or oil) quenched and tempered.

1.2.2 Class 2. Wrought armor plate which is air quenched and tempered/autotempered.

Comments, suggestions, or questions on this document should be addressed to: Director, U.S. Army Research Laboratory, Weapons and Materials Research Directorate, Materials Applications Branch, Attn: AMSRD-ARL-WM-MC, Aberdeen Proving Ground, MD 21005-5069 or emailed to rsquilla@arl.army.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at <http://assist.daps.dla.mil/>.

AMSC N/A

FSC 9515

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2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-129 - Military Marking for Shipment and Storage

(Copies of these documents are available online at <http://assist.daps.dla.mil/quicksearch/> or <http://assist.daps.dla.mil/> or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

USADTC TOP 2-2-710	-	Ballistic Tests of Armor Materials
ITOP 2-2-713	-	Ballistic Testing of Armor

(Application for copies is available online at <http://www.dtic.mil/> or from the Defense Technical Information Center, 8725 John J. Kingman Road, Suite 0944, Fort Belvoir, VA 22060-6218.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

AMERICAN SOCIETY OF NONDESTRUCTIVE TESTING

ANSI/ASNT CP-189-2006	-	ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel
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(Copies of ANSI/ASNT publications are available from [http:// www.asnt.org/shop/](http://www.asnt.org/shop/) or from the American Society for Nondestructive Testing, P.O. Box 28518, 1711 Arlingate Lane, Columbus, OH 43228-0518)

ASTM INTERNATIONAL

ASTM A6/A6M	-	Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes and Sheet Piling
ASTM A370	-	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM A578/ A578M-	-	Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications
ASTM A751	-	Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
ASTM E10	-	Standard Test Method for Brinell Hardness of Metallic Materials
ASTM E23	-	Standard Test Methods for Notched Bar Impact Testing of Metallic Materials
ASTM E110	-	Standard Test Method for Indentation Hardness of Metallic Materials by Portable Hardness Testers
ASTM E290	-	Standard Test Methods for Bend Testing of Material for Ductility (DoD adopted)

(Copies of these documents are available from www.astm.org or ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein (except for related specification sheets), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 First article. When specified in the contract or purchase order (see 6.2, 6.4, and 6.9), 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 4.4. The contractor shall comply with this requirement at the time of his first order or contract and at any time that the supplier has not furnished the same class of high hard armor in the applicable thickness range (within the same nominal thickness ranges of Table V) under this specification within a period of 37 months. The approval of the first article samples authorizes the commencement of shipment but does not relieve the supplier of responsibility for compliance with all applicable provisions of this specification, namely conformance or

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production acceptance. The first article samples and test plates shall be manufactured by the process proposed for use on production armor. The manufacturer's declared chemical analysis shall be submitted to the contracting agency (or purchasing activity) and to the ballistic test agency. The ballistic test agency shall record the first article ballistic test plates submitted, showing the dates tested. Requests from the procuring activity to the ballistic test agency as to prior conformance with first article tests shall be accompanied by copies of the first article test firing records. Any deviation(s) noticed by the ballistic agency shall be brought to the attention of the contracting activity and to the manufacturer. After first article testing has been accepted by the contracting activity, the composition and processing shall be considered fixed. If either of these change, outside the limitations allowed, then a new first article test shall be required.

3.1.1 First time producer. First time producers wishing to qualify to this specification shall follow the instructions of 6.7.

3.2 Production acceptance.

3.2.1 Chemical composition. A declared chemistry shall be submitted to the contracting agency or its authorized representative and to the ballistic test agency for each lot of material. The chemical composition of the declared chemistry shall conform to the requirements of Table I, column A, unless otherwise specified in the contract or purchase order (see 6.2). The chemical composition shall be determined by a product analysis (values shall be listed as weight percent) in accordance with 4.6.1.1 and 4.8.1. The first article samples and the production test plates shall utilize the same declared chemistry within the allowable ranges proposed for use in production. A statement showing the heat analysis of each melt and one product analysis of each lot and complete details of the heat treatment of each lot shall be furnished for the files of the purchaser at no cost. All elements of the chemical composition specified in Table I shall be shown in the statement. This statement shall be attached to the completed High Hard Armor Test Data Form (see Figure 1).

3.2.2 Carbon equivalence. Carbon equivalence (CE) shall be calculated for each heat per ASTM A6/A6M, i.e.,

$$CE = C + [Mn/6] + [(Cr + Mo + V)/5] + [(Ni + Cu)/15]$$

where the elements are expressed in wt%.

3.2.2.1 Class 1. Class 1 steels shall have a CE of less than 0.80 wt%.

3.2.2.2 Class 2. Class 2 steels shall have no CE limit unless otherwise specified in the contract or purchase order (see 6.2).

3.2.3 Heat treatment. All plates in each lot, including samples, shall receive the same heat treatment except for such variations in tempering temperature as shall be necessary to produce the prescribed hardness. Unless otherwise specified in the contract or purchase order (see 6.2), local or general heating shall not be performed after the final heat treating operation. This does not include preheating for welding or flame cutting, as long as the

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tempering temperature is not exceeded (see 6.6 and 6.11). Tempering temperature shall be reported on Figure 1.

TABLE I. Chemical composition and precision (product analysis). ^{4/}

ELEMENT	COLUMN A MAXIMUM LIMIT for FIRST ARTICLE & PRODUCTION CHEMISTRY (WEIGHT PERCENT)	COLUMN B ^{5/} ALLOWABLE RANGE for FUTURE PRODUCTION LOTS (WEIGHT PERCENT)
Carbon	0.32	^{3/}
Manganese	NONE REQUIRED, HOWEVER IF: ≤ 1.00 > 1.00	± 0.15 ± 0.20
Phosphorus	0.020 ^{1/}	^{3/}
Sulfur	0.010 ^{1/}	^{3/}
Silicon	NONE REQUIRED, HOWEVER IF: ≤ 0.60 > 0.60 to ≤ 1.00 > 1.00	± 0.10 ± 0.15 ± 0.20
Nickel	NONE REQUIRED ^{2/}	± 0.25
Chromium	NONE REQUIRED, HOWEVER IF: ≤ 1.25 ^{2/} > 1.25	± 0.15 ± 0.25
Molybdenum	NONE REQUIRED, HOWEVER IF: ≤ 0.20 ^{2/} > 0.20	± 0.035 ± 0.075
Vanadium	NONE REQUIRED ^{2/}	± 0.075
Boron	0.003	^{3/}
Copper	0.25 ^{2/}	^{3/}
Titanium	0.10 ^{2/}	^{3/}
Zirconium	0.10 ^{2/}	^{3/}
Aluminum	0.10 ^{2/}	^{3/}
Lead	0.01 ^{2/}	^{3/}
Tin	0.02 ^{2/}	^{3/}
Antimony	0.02 ^{2/}	^{3/}
Arsenic	0.02 ^{2/}	^{3/}

^{1/} Phosphorus and sulfur should be controlled to the lowest attainable levels, but in no case shall the combined phosphorus and sulfur contents exceed 0.025 wt%.

^{2/} When the amount of an element is less than 0.02 wt% the analysis may be reported as [< 0.02 wt%].

^{3/} Product analysis values may not exceed those listed as the maximum limit.

^{4/} Elements not listed in table, but intentionally added, shall be reported.

^{5/} Values are actual tolerance limits NOT percent tolerances. The analysis from the First Article sample is the “Declared Chemistry” which is used to calculate the range.

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REQUEST FOR BALLISTIC TEST OF HIGH HARD ARMOR (MIL-DTL-46100)										
FIRING RECORD:			DATE:		REVISION: E		AMENDMENT:1			
Plate MANUFACTURER / PRODUCER:				PRIME CONTRACTOR:						
Name:				Name:						
Address:				Address:						
POC:				POC:						
Phone No:				Phone No:						
Fax No:				Fax No:						
CONTRACT NO:				ATC PROJECT NO:						
DCAS REGION:				BALLISTIC TEST CONTRACT NO:						
TEST ITEM IDENTIFICATION: Lot No. _____ Plate No. _____					CLASSIFICATION (CLASS): _____					
Carbon Equivalence (CE): _____			Ordered Thickness: _____			Tempering Temp (Class 1 only): _____				
Bend Test:	Plate Thickness	1) _____	2) _____	Pass / Fail		Alloy and Temper: _____				
	Inside Radius	1) _____	2) _____	Pass / Fail		Heat Treatment: _____				
PURPOSE: ___ Acceptance ___ First Article ___ Development					SAMPLE: ___ Primary ___ Retest (See below)					
Additional Requirements Specified in Contract: YES / NO					(Firing Record No. of Failed Sample _____)					
Comments:										
CHEMISTRY ANALYSIS		C	Mn	P	S	Si	Ni	Cr	Mo	V
FIRST ARTICLE RESULTS:										
PRODUCTION RESULTS:										
ACCEPTANCE (Pass / Fail)										
B:	Cu:	Ti:	Zr:	Al:	Pb:	Sn:	Sb:	As:		
MECHANICAL PROPERTIES: CHARPY IMPACT @ -40 Degr. F. Specimen Size: _____										
HARDNESS: _____		LT Direction:1: _____ 2: _____ 3: _____			TL Direction:1: _____ 2: _____ 3: _____					
BALLISTIC TEST RESULTS: SEPARATELY HEAT TREATED TEST PLATE : YES ___ NO ___										
<u>Test</u>	<u>Projectile</u>	<u>Obl.</u> (deg)	<u>Actual</u> <u>Thickness (in)</u>	<u>Required</u> <u>V50 (fps)</u>	<u>Actual</u> <u>V50 (fps)</u>	<u>Pass/</u> <u>Fail</u>	<u>Notes</u>			
LOTS REPRESENTED BY:			Reduced Testing			Audit Testing				
Lot [met] [failed to meet] the ballistic requirements of specification MIL-DTL-46100.										
Government Representative			Date		Supplier Representative			Date		

FIGURE 1. High Hard Armor Test Data Form.

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3.2.4 Condition. Unless otherwise specified in the contract or purchase order (see 6.2), plates shall be in the as-heat treated condition; surfaces shall not be pickled.

3.2.5 Mechanical properties.

3.2.5.1 Hardness. The surface hardness of each plate, including first article samples, shall be within the range of HBW 477 - HBW 534. The diameters of Brinell hardness impressions on any individual plate shall not vary by more than 0.15 mm (see 4.8.2).

3.2.5.2 Impact resistance. The minimum average Charpy V-notch impact resistance requirement of the armor plate shall be as shown in Table II. The Charpy V-notch 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 shall 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 resistance requirements at -40°F ± 2°F.

SPECIMEN ORIENTATION	IMPACT RESISTANCE FOR STANDARD DEPTH SPECIMENS (ft. lbs.)			
	Standard width	3/4 width	1/2 width	1/4 width
Transverse (T-L)	12.0	9.0	6.0	3.0
Longitudinal (L-T)	14.0	10.5	7.0	3.5

3.2.6 Bend test. All bend test samples from that lot shall be capable of being bent to the requirements specified in Table III without cracking as determined by visual inspection for thicknesses of 0.500 and under. When specified in the contract or purchase order (see 6.2), the bend test shall be performed on material thicker than 0.500 inch. Dimensions for thickness over 0.500 inches are listed in Table III for information purposes only. Two bend test samples shall be tested in the transverse direction per ASTM E290, transverse bend test, at room temperature through an included angle of 90° (unrestrained) to the inside radii shown below. After bending, samples shall be free of cracks as determined by visual inspection unless otherwise specified in the contract or order (see 6.2).

TABLE III. Bend test requirements.

PLATE THICKNESS (T)	INSIDE RADIUS
0.118 to 0.3125	4T
Over 0.3125 to 0.500	6T
Over 0.500 to 0.750	8T
Over 0.750 to 1.000	10T
Over 1.000 to 2.000	12T

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3.2.7 Ballistic requirements. Ballistic requirements shall be in accordance with the Appendix A of this specification.

3.2.7.1 Ballistic test plate information. For each lot of high hard armor plate a properly completed High Hard Armor Test Data Form (see Figure 1) shall be submitted with each ballistic test plate that represents that particular processing lot. If another form, such as a Material Test Report or a Test Certificate, that contains the same information as in Figure 1, is available, it can be used in combination with Figure 1, unless otherwise specified in the contract or purchase order (see 6.2). This additional form shall be attached to Figure 1 and submitted with each ballistic test plate.

3.2.8 Dimensions and tolerances.

3.2.8.1 Dimensions. Plates shall comply with the dimensions specified in the applicable drawings or in the contract or purchase order (see 6.2). Unless otherwise specified in the contract or order (see 6.2), dimensional tolerances will be in accordance with ASTM A6/A6M.

3.2.8.2 Thickness. The thickness tolerance of each plate, after final treatment, shall be in accordance with Table IV for the thickness specified.

3.2.8.3 Flatness. Unless otherwise specified in the contract or order (see 6.2), the flatness tolerance of each plate shall be within the requirements specified in ASTM A6/A6M for hot rolled or thermally treated plates. Tighter tolerance requirements shall be specified in the contract or purchase order (see 6.2) and shall be as agreed upon between the contractor and the procuring activity.

3.2.8.4 Waviness. Unless otherwise specified in the contract or purchase order (see 6.2), the waviness tolerance of each plate shall be within the requirements of ASTM A6/A6M.

3.2.9 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. Marking shall be approximately six inches in from the edge of the plate. 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 shall be marked "R1" and "R2." If a second set of retest plates are submitted they shall be marked "RR1" and "RR2."

3.2.9.1 Stamping. Stamping of any kind is not allowed unless the finished rolled plates are stamped "hot" (>600° F for plates greater than 3/8 inch thick and >500° F for plates 3/8 inch thick and under.) with a stamp having a minimal surface distortion or residual stress. The plate shall be hot stamped prior to austenization.

3.2.10 Workmanship.

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TABLE IV. Thickness tolerances for ordered thickness ^{1/}, inches (over and under) ^{2/}.

Specified Thickness, inches	Tolerances over and under ordered thickness for widths given, inches						
	to 72 excl.	72 to 84 excl.	84 to 96 excl.	96 to 108 excl.	108 to 120 excl.	120 to 132 excl.	132 to 144 incl.
0.1180	0.016	0.016	0.019	0.019	0.023	---	---
0.1250	0.016	0.016	0.019	0.019	0.023	---	---
0.1875	0.016	0.016	0.019	0.019	0.023	---	---
0.2500	0.016	0.016	0.019	0.019	0.023	---	---
0.3125	0.016	0.019	0.019	0.019	0.023	0.026	---
0.3750	0.016	0.019	0.019	0.023	0.023	0.026	---
0.4375	0.016	0.019	0.019	0.023	0.026	0.026	0.031
0.5000	0.016	0.019	0.019	0.023	0.026	0.026	0.031
0.5625	0.019	0.019	0.019	0.023	0.026	0.031	0.031
0.6250	0.019	0.019	0.019	0.023	0.026	0.031	0.031
0.6875	0.019	0.019	0.019	0.023	0.026	0.031	0.031
0.7500	0.019	0.019	0.023	0.023	0.026	0.031	0.039
0.8125	0.023	0.023	0.023	0.026	0.031	0.031	0.039
0.8750	0.023	0.023	0.026	0.026	0.031	0.031	0.039
0.9375	0.023	0.023	0.026	0.026	0.031	0.036	0.043
1.0000	0.026	0.026	0.026	0.026	0.031	0.036	0.043
1.0625	0.026	0.026	0.026	0.031	0.031	0.036	0.043
1.1250	0.026	0.026	0.026	0.031	0.031	0.039	0.043
1.1875	0.031	0.031	0.031	0.031	0.036	0.043	0.048
1.2500	0.031	0.031	0.031	0.036	0.036	0.043	0.048
1.3125	0.031	0.031	0.031	0.036	0.036	0.043	0.053
1.3750	0.031	0.031	0.031	0.036	0.039	0.048	0.053
1.4375	0.036	0.036	0.036	0.036	0.043	0.048	0.058
1.5000	0.036	0.036	0.036	0.039	0.043	0.048	0.058
1.5625	0.036	0.036	0.036	0.039	0.043	0.058	0.058
1.6250	0.036	0.036	0.036	0.043	0.048	0.058	0.063
1.6875	0.039	0.039	0.039	0.043	0.048	0.058	0.063
1.7500	0.039	0.039	0.039	0.043	0.048	0.058	0.068
1.8125	0.043	0.043	0.043	0.048	0.053	0.058	0.068
1.8750	0.043	0.043	0.043	0.048	0.053	0.063	0.068
1.9375	0.043	0.043	0.043	0.048	0.053	0.063	0.076
2.0000	0.043	0.043	0.043	0.048	0.053	0.063	0.076

^{1/} For intermediate thickness, the tolerance of the closer specified gage shall apply. In case of mid-point, the tolerance for lower gage or interpolated value shall apply.

^{2/} When plates under 60 inches are rolled double width, the equivalent wider plate tolerance shall apply.

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3.2.10.1 Surface condition. The top and bottom surface of each plate shall be free from the following surface defects: slivers, laps, checks, seams, blisters, snakes, cold shuts, cracks, burning, mechanical seams, mechanical gouges and laminations (see 6.10). The surface of each plate shall be such that mill scale or oxidation product shall not interfere with determination of acceptability. Imperfections listed above, which are of such a nature as to affect the fabrication of the materials, shall be rejected.

3.2.10.1.1 Depth of imperfections. The depth of rolled-in scale, scale pitting or snakes shall not exceed 0.015 inch and shall not reduce the steel thickness below the allowable minimum. Isolated individual pits over 0.015 inch deep but not over 0.03 inch deep and not within 6 inches of each other and which do not violate the minimum allowable thickness, as specified in the applicable drawings and fabrication documents, are acceptable.

3.2.10.2 Internal soundness. One plate from every lot that has an ordered thickness greater than 0.500 inch shall be ultrasonically examined for internal soundness in accordance with 4.8.6. The acceptance level shall be C, unless otherwise specified in the contract or purchase order (see 6.2).

3.2.10.3 Edge preparation and quality.

3.2.10.3.1 Plate. Thermal cutting of production plate shall be permitted after final heat treatment provided the procedure, which may include grinding after thermal cutting, is such that no cracks develop on any thermally cut edge whether detected by nondestructive inspection, or as agreed upon in the contract. The heat affected zone of thermally cut plates (up to and including 0.500 inches in thickness) shall not exceed 1.2 times the plate's thickness from the cut edge. For plates over 0.500 inches thick, the heat affected zone shall not exceed 0.625 inches from the cut edge. Approval shall be obtained from the procuring activity and shall be as specified in the contract or purchase order (see 6.2) in order to have the heat affected zone exceed these limits. To reduce the potential for plate cracking, plates shall not be cut by cold shearing after final heat treatment, unless otherwise specified in the contract or purchase order (see 6.2). For plates that will be cut with a pattern of piece parts from within the edges of the plate, the condition of the discarded material shall not require inspection as long as cracks do not infringe into the pattern.

3.2.10.3.2 Piece parts cut from plate. For sections of production plate that are cut to size for a specific order from the vehicle fabricator, the supplier shall practice such necessary process controls to prevent edge cracking. For all piece parts, the supplier shall institute such necessary process inspection such that any cut edges shall comply with the requirements of 3.2.10.3.2.1.1 and 3.2.10.3.2.1.2 , using magnetic particle inspection, or liquid penetrant inspection.

3.2.10.3.2.1 Acceptance criteria.

3.2.10.3.2.1.1 Single linear indications. In any four inches of length a single linear indication shall not exceed twice the plate thickness.

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3.2.10.3.2.1.2 Multiple linear indications. Multiple linear indications shall not exceed 1.5 times the plate thickness if two or more lie in the same plane. The total length of indications in one plane, in any four inch length, shall not exceed twice the plate thickness. No more than ten indications, whether in one plane or multiple planes, are permitted in any four inch length.

3.2.10.3.2.1.3 Removal of large indications. Rejectable indications shall be removed by the manufacturer or processor by grinding, provided the resulting cavity does not exceed 10 % of the ordered thickness. Weld repair is acceptable as long as it is done before the final heat treatment.

4. VERIFICATION

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

- a. First article inspection (see 4.4).
- b. Production acceptance inspection (see 4.5).

4.2 Testing responsibility and facilities. Unless otherwise specified in the contract or purchase order (see 6.2), the contractor is responsible for the performance of all the requirements as specified herein. Unless otherwise specified in the contract or purchase order (see 6.2), the contractor may use his own or any other facilities suitable for the performance of the requirements specified herein, except ballistic tests (see 4.2.1), unless disapproved by the Government. The Government reserves the right to perform or check any of the inspections set forth in this specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements and to determine the validity of the certifications.

4.2.1 Ballistic testing facility. Unless otherwise specified in the contract or purchase order (see 6.2), the ballistic test plates shall be forwarded to the Commander, USA ATC, ATTN: TEDT-AT-SLV, Building 358, 400 Colleran Road, APG, MD 21005-5059 or to an approved Government facility for ballistic testing (see 6.8) for first article or production acceptance. Alternate ballistic testing facilities shall be considered as indicated in 6.8.

4.3 Lot. A lot shall consist of all production and ballistic test plates of the same melt of steel, of the same ordered thickness, having the same treatment, and heat treated with the same thermal cycle in the same production furnace(s) in the same facility. When specified by the procuring activity (see 4.3.1 and 6.2), production and ballistic test plates shall be allowed to be heat treated separately. The test plate shall be heat treated in a production furnace.

4.3.1 Separately heat treated ballistic test plate. When the procuring activity allows a ballistic test plate to be heat treated separately from the production plates it represents (see 4.3), it shall be so stated in the data (see 6.6).

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4.4 First article inspection. When required (see 6.2) first article inspection, except as otherwise indicated in this specification, shall utilize the same requirements and test methods as the production acceptance inspection shown in 4.5.

4.5 Production acceptance inspection. Production acceptance inspection shall include the examination of 4.7 and the tests of 4.8.

4.6 Sampling.

4.6.1 For first article inspection.

4.6.1.1 Chemical analysis samples. One sample for chemical analysis shall be taken from each plate submitted.

4.6.1.2 Impact samples. At least three (3) impact test specimens in each direction (TL & LT) shall be taken from each test plate submitted for ballistic testing.

4.6.1.3 Ballistic samples. Two (2) ballistic test plates of the same ordered thickness for each nominal thickness range shown in Table V 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.

TABLE V. Thickness ranges and corresponding test projectiles for first article testing.

Nominal thickness range, in	Obliquity, degrees	Test Projectile	Table
0.118 to 0.300 incl.	30	Cal .30 AP, M2	A-I
0.301 to 0.590 incl.	30	Cal .50 AP, M2	A-II
0.591 to 0.765 incl.	30	14.5 mm API, B32	A-III
0.766 to 1.130 incl.	30	14.5 mm API, BS41	A-IV
1.131 to 2.000 incl.	0	20 mm API-T, M602	A-V

4.6.1.4 Bend test samples. Unless otherwise specified in the contract or purchase order (see 6.2), two (2) samples shall be taken from each submitted test plate and shall be tested in accordance with 4.8.4 and shall meet the requirements of 3.2.6.

4.6.2 Sampling for production acceptance inspection.

4.6.2.1 For chemical analysis. At least one (1) sample for chemical analysis shall be taken from each heat in accordance with the applicable method specified in ASTM A751 (see 6.5).

4.6.2.2 For hardness tests. The Brinell hardness of each plate, as heat treated, shall be measured in two places, one at each end of a diagonal on one surface of the plate. Image

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analysis systems may be used to read the indent and compute the hardness and if the heat treating process is continuous (not batch or oscillation), then the amount of testing may be reduced to one measurement per plate. For Class 2 materials, hardness tests shall be conducted in six places on each plate, one at each corner and roughly at both edges at the center of one surface of the plate. If consistent hardness readings are obtained with established process controls, hardness measurements may be reduced to 2 places on each diagonal corner.

4.6.2.3 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 six specimens from the sample in accordance with 4.8.3.

4.6.2.4 For ballistic acceptance testing. One (1) plate, of each thickness to be supplied on the contract, shall be randomly taken from each lot for ballistic testing. In the event that plates of the same heat rolled to the same nominal thickness but with overlapping thickness tolerance ranges can be represented by one ballistic test plate, then only one of the ordered thicknesses need be submitted for acceptance testing. The other ordered thickness, however, shall be included on the applicable reporting form with the words indicating that it is represented by the sample to be tested. However, if the two ordered thicknesses are such that each thickness requires testing with a different type projectile as shown in Table IV, then each of the ordered thicknesses shall be ballistically tested. Unless otherwise specified in the contract or purchase order (see 6.2), the plates shall be 12 inches by 36 inches. Test projectiles shall be as specified in Table V.

4.6.2.5 Bend test samples. Unless otherwise specified in the contract or purchase order (see 6.2), two (2) samples shall be randomly taken from each lot for these tests representing the entire lot of material; however, when an entire heat represents only one lot the samples shall be taken from the first and last usable portion of the heat. Testing shall be conducted in accordance with 4.8.4 and shall meet the requirements of 3.2.6.

4.7 Examination.

4.7.1 Visual. All steel plate shall be subject to visual inspection for compliance with the requirements for identification marking (see 3.2.9) and for workmanship (see 3.2.10).

4.7.2 Dimensional. All steel plate shall be subject to inspection for compliance with dimensional and tolerance requirements (see 3.2.8).

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

4.8 Tests.

4.8.1 Chemical analysis. Chemical analysis shall be conducted in accordance with the applicable method specified in ASTM A751 (see 6.5). The analysis shall comply with the declared composition established in accordance with the requirements of Table I (see 3.2.1).

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4.8.2 Hardness tests. Brinell hardness tests (HBW) shall be conducted in accordance with ASTM E10 or ASTM E110 (for portable testing), using a 10 mm carbide ball and a 3000 kilogram load. Surface scale and decarburization shall be removed from the areas where the tests are to be made. However, no more than 0.060 inches shall be removed from the test area.

4.8.2.1 Hardness tests for thin gage. For plates less than 0.187 inches (4.75 mm) in thickness, a Brinell hardness test shall be conducted in accordance with ASTM E10 or ASTM E110 (for portable testing), using either a 5 mm carbide ball and a 750 kilogram load or a 10 mm carbide ball and a 1500 kilogram load.

4.8.3 Charpy V-notch impact tests. At least three (3) Charpy V-notch impact test specimens per direction for a total of at least six (6) Charpy V-notch impact test specimens shall be taken from the sample and shall be prepared and tested in accordance with ASTM E23 and ASTM A370. 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 thermally-cut edge. The largest attainable subsize Charpy V-notch impact specimens shown in Figure 7 of ASTM E23 shall be used.

4.8.4 Bend test. The bend test shall be conducted in accordance with ASTM E290 using method referred to as the Guided-Bend Test, Figure 3.

4.8.5 Ballistic tests. Ballistic testing of armor plate shall be conducted at a Government approved test facility specified in 4.2.1, unless otherwise specified in the contract or purchase order (see 6.2). Testing shall be conducted in accordance with the requirements of Appendix A of this specification.

4.8.6 Ultrasonic examination.

4.8.6.1 Inspection equipment. The ultrasonic soundness inspection equipment shall conform to ASTM A578/A578M.

4.8.6.2 Procedure. Unless otherwise specified in the contract or purchase order (see 6.2), the ultrasonic examination shall be carried out in accordance with ASTM A578/A578M (see 3.2.10.2) with the following exceptions.

- (a) Scanning shall be continuous over 100% of the plate surface.
- (b) Scanning rate shall be at a speed where recordable discontinuities can be detected.
- (c) The testing frequency shall be a minimum of 2 megahertz (MHz).
- (d) Any area within a plate where a discontinuity produces a continuous total loss of back reflection accompanied by continuous indications on the same plane that cannot be encompassed within a circle whose diameter is 1 inch shall be cause for rejection of that plate. All discontinuities shall be evaluated using a frequency of 2 megahertz (MHz).

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4.8.6.3 Certification of inspection personnel. Unless otherwise specified in the contract or purchase order (see 6.2), personnel performing ultrasonic inspection shall comply with the qualification requirements of ANSI/ASNT CP-189-2006.

4.9 Reduced testing. At the discretion of the procuring activity, the amount of testing shall be reduced provided the results on consecutive lots indicate that a satisfactory uniform product meeting the testing requirements is being produced and shall be specified in the contract or purchase order (see 6.2). Reduced testing shall be in accordance with a system previously approved or established by the procuring activity involved.

4.10 Rejection and retest for non-ballistic requirements.

4.10.1 Rejection. Unless otherwise specified in the contract or order (see 6.2), 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 (see 4.10.2). For ballistic rejection procedures, see A.4.1.2.

4.10.2 Retest. Unless specific retest procedure is specified in the contract or order (see 6.2), two retest samples shall be submitted for each failed sample. Failure of either of the retest samples (plates) shall be cause for rejection of the 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. For ballistic retest procedures, see A.4.1.2.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system command. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The steel armor covered by this specification is intended for lightweight applications where resistance to ball and armor piercing types of ammunition and multiple hit capabilities are required.

6.1.1 Class 1. Class 1 high hardness armor is intended for use in welded structures and appliqué.

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6.1.2 Class 2. Class 2 high hardness armor is intended for use in welded structures and appliqué. However, its higher carbon equivalence (CE) may make it more difficult to weld than Class 1.

6.2 Acquisition requirements. Acquisition documents should specify the following:

- a. Title, number and date of this specification.
- b. Specify ordered thickness (see 1.1)
- c. Specify class of steel (see 1.2).
- d. If first article samples are required (see 3.1 and 4.4).
- e. If the declared chemistry composition can be different (see 3.2.1).
- f. Specify CE limit for Class 2 material, if required (see 3.2.2.2).
- g. If local or general heating can be performed after final heat treating (see 3.2.3).
- h. If plates may be furnished in a condition other than that specified (see 3.2.4).
- i. If a bend test is required for material greater than 0.500 inch in thickness (see 3.2.6).
- j. If another inspection for determining cracks is required (see 3.2.6 and 6.13).
- k. If a substitute form can not be used in place of Figure 1 (see 3.2.7.1).
- l. Specify dimensions (see 3.2.8.1).
- m. If dimensional tolerances can be other than in accordance with ASTM A6/A6M (see 3.2.8.1).
- n. If the flatness tolerance is different than those specified (see 3.2.8.3).
- o. If tighter flatness tolerance requirements are to be specified (see 3.2.8.3).
- p. If the waviness tolerance is different than those specified (see 3.2.8.4).
- q. Specify the acceptance level for internal soundness if other than Level C as defined in ASTM A578/A578M (see 3.2.10.2)
- r. If the limits specified for heat affected zone can to be exceeded (see 3.2.10.3.1).
- s. If plates can be cut by cold shearing after final heat treatment (see 3.2.10.3.1).
- t. If someone other than the contractor is responsible for the performance of all the requirements of the specification (see 4.2).
- u. If the contractor can't use his own facility or any other facility for testing (see 4.2).
- v. If the ballistic tests are to be conducted at another location (see 4.2.1 and 4.8.5).
- w. If production and ballistic test plates can be heat treated separately (see 4.3).
- x. If the number of bend test samples is different (see 4.6.1.4).
- y. If the size of the ballistic test plates can be different (see 4.6.2.4).
- z. If the bend test samples are selected other than randomly (see 4.6.2.5).
- aa. If the ultrasonic test procedures are different than that specified (see 4.8.6.2).
- ab. If a different certification for inspection personnel is required (see 4.8.6.3).
- ac. Specify reduced testing plan when applicable (see 4.9).
- ad. If rejection requirements differ (see 4.10.1).
- ae. If retest requirements differ (see 4.10.2).
- af. Preparation for delivery requirements (see section 5).

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

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suitable for fabrication in accordance with TACOM code 12479550, TACOM Ground Combat Vehicle Welding Code-Steel. Copies of this document are available from U.S. Army Tank-Automotive and Armaments Command, Warren, MI 48397-6000. The long dimension of the plate is normally the rolling direction. If a forming operation is to be performed, the rolling direction should be tracked so that bending is preferably not performed longitudinal to the rolling direction.

6.4 Special first article ballistic test. Special first article ballistic tests are required when the manufacturer changes either the heat treatment or the declared chemistry of the armor.

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

6.6 Production plates. Material made to this specification has tendency to develop stress cracks if not tempered as soon as possible after austenitizing treatment. To avoid this situation, all plates should be left in the hot rolled or tempered condition while waiting for the ballistic test results.

6.7 Potential suppliers. Potential suppliers who have not previously supplied armor plate to MIL-DTL-46100 and wish to have their material ballistic tested, may do so at their own expense. It is recommended that inquiries for such testing be directed to Commander, USA ATC, ATTN: TEDT-AT-SLV, Building 358, 400 Colleran Road, APG, MD 21005-5059.

6.8 Alternate ballistic testing facility. Request for approval for an alternate ballistic testing facility should be forwarded by the procuring activity to the Director, U.S. Army Research Laboratory, Weapons and Materials Research Directorate, Specifications and Standards Office, Attn: AMSRD-ARL-WM-MC, Aberdeen Proving Ground, MD 21005-5069 and should be obtained prior to the contract award.

6.9 New contracts sponsored by government agencies. At the time that a new contract is initiated for the production of combat vehicles, the contractor's supplier is to estimate the number, size and delivery schedule of the ballistic test plates which are to be submitted for first article or acceptance testing (see 6.2). A lead time of 60 days after the contract has been signed is to be allowed prior to shipment of the first ballistic test(s) to APG to insure that all administrative functions for the establishment of a new ATC project have been completed in preparation for the test. The contracting government activity is to initiate the new project through a letter to Commander, USA ATC, ATTN: TEDT-AT-SLV, Building 358, 400 Colleran Road, APG, MD 21005-5059 requesting a cost estimate for the ballistic testing of the applicable number and sizes of plates. In the case of increases in scope of existing projects, similar correspondence is needed.

6.10 Definitions.

6.10.1 Slivers. An imperfection consisting of a very thin elongated piece of metal attached by only one end to the parent metal into whose surface it has been worked.

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6.10.2 Laps. A surface imperfection with the appearance of a seam, caused by hot metal, fins or sharp corners being folded over and thus being forged or rolled into the surface but without being welded.

6.10.3 Checks. Checks are numerous very fine cracks at the surface of a metal part. Checks may appear during processing or during service and are most often associated with thermal cycling or thermal treatment. Also called check marks, checking, heat checks.

6.10.4 Seams. Seams are an unwelded fold or lap that appears as a crack, usually resulting from a discontinuity on a metal surface.

6.10.5 Blisters. A raised area, often dome shaped, resulting from delamination under pressure of expanding gas trapped in metal in a near sub-surface zone. Very small blisters may be called pinhead blisters or pepper blisters.

6.10.6 Snakes. Any crooked surface imperfection in a metal plate, resembling a snake.

6.10.7 Cold shuts. A lap on the surface of a forging or billet that was closed without fusion during deformation.

6.10.8 Burning. Permanently damaged metal due to overheating enough to cause incipient melting or intergranular oxidation. Note: This condition is usually obscured by normal cleaning methods and would require deep pickling and/or metallography to note the continuous oxidation (chicken wire effect) of the enlarged grain boundaries. This defect is usually not limited to the surface and may be sub-surface or at interior locations when associated with heavy mechanical working. Metal with this condition will be scrapped.

6.10.9 Laminations. A type of discontinuity with separation or weakness generally aligned parallel to direction of the worked surface of the metal and may be the result of pipe blisters, seams, inclusions, or segregation elongated and made directional by working.

6.10.10 Linear indication. For nondestructive examination purposes, a linear indication is evidence of a discontinuity that requires interpretation to determine its significance.

6.10.11 Autotempering. When the martensite start temperature (M_s) lies well above room temperature, carbide precipitation (tempering) occurs upon quenching, after the transformation to martensite. Also called quench tempering.

6.11 Tempering. Any tempering should be performed as soon as possible after quenching. It is recommended that the delay after quenching be no greater than 24 hours.

6.12 Plates in the as-rolled condition. When the fabricator performs the final quench and temper of plates, it will be his responsibility that the mechanical and ballistic requirements of the plates, meet this specification.

6.13 Bend test inspection tests. If additional tests are required in the contract or purchase order, the following could be specified: "After bending, samples should be free of cracks as

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determined by either penetrate inspection per ASTM E1417 or magnetic particle inspection per ASTM E1444 (see 3.2.6).”

6.14 Metric units. When metric dimensions are required, units for inch, foot, foot-pounds and feet per second may be converted to the metric equivalent by multiplying them by the following conversion factors listed in Table VI.

TABLE VI. Conversion factors.

English	Multiply by	Equals	Metric SI unit
inch	0.0254	=	meter (m)
foot	0.3048	=	meter (m)
pound	0.4536	=	kilogram (kg)
foot-lb	1.3558	=	joule (j)
feet/sec	0.3048	=	meter per second (m/s)

Note: Conversion factors can be associated with ASTM E380 entitled “Metric Practice Guide.”

6.15 Subject term (key word) listing.

- Ballistic testing
- Batch tempering
- Continuous tempering
- Lightweight armor
- Heat treated plates

6.16 Changes from previous issue. The margins of this standard are marked with vertical lines to indicate modifications generated by this change. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations.

APPENDIX A

BALLISTIC TESTING OF ARMOR PLATE, STEEL, WROUGHT HIGH HARDNESS

A.1 SCOPE

A.1.1 This appendix covers the requirements for ballistic testing of high hardness steel armor plate.

A.2 DEFINITIONS

A.2.1 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.

A.2.2 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 (+ 0.5 inch) behind and parallel to the test plate or other ballistic sample.

A.2.3 Complete penetration, protection, CP(P). A protection complete penetration is a penetration in which the projectile or one or more fragments of the projectile or plate pass beyond the back of the test plate and perforates the witness plate.

A.2.4 Partial penetration, protection, PP(P). A partial penetration is any impact that is not a complete penetration.

A.2.5 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.

A.2.6 V₅₀ protection ballistic limit, BL(P). The protection V₅₀ 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 (fps) 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 shall 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 shall be reduced to the lowest practical level (as close to 150 fps as possible). When a 10-round ballistic limit is used, this shall be noted in all reports. The normal up-and-down firing method shall be used in the determination of all BL(P)'s, all velocities being corrected to striking velocity. In the event that the ballistic limit computed is less than 30 fps above the minimum required and if a gap (high partial penetration velocity below the low complete penetration velocity) of 30 fps or more exists, firing shall

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continue as needed to reduce this gap to 25 fps or less. (This procedure shall insure better evaluation of the steel when the ballistic limit is near the minimum required.)

A.2.7 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.

A.3 REQUIREMENTS

A.3.1 Resistance to penetration. The minimum ballistic limits shall be in accordance with the values shown in Tables A-I, A-II, A-III, A-IV or A-V, as applicable.

A.3.2 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.

A.4 TESTS

A.4.1 Ballistic tests. V₅₀ ballistic tests shall be performed in accordance with USADTC TOP 2-2-710, Ballistic Tests of Armor Materials or ITOP 2-2-713, Ballistic Testing of Armor to determine compliance with the requirements of Tables A-I through A-V.

A.4.1.1 Plate thickness. 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 of at least one inch from the edge, but preferably in the area which shall be impacted. The average of the measurements to the nearest 0.001 inch shall be used to determine the minimum ballistic limit requirements in the appropriate tables (Tables A-I through A-V). The required ballistic limit shall be determined by interpolation, if necessary, in the Tables in the Appendix.

A.4.1.2 Rejection and retest of ballistic plates.

A.4.1.2.1 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.

A.4.1.2.2 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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A.4.1.2.3 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 shall depend on the outcome of retests, if submitted.

A.4.1.2.4 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:

- (1) At manufacturer's expense submit two additional test plates from the same lot for ballistic retest, or
- (2) First reheat treat (quenching and tempering) the lot and then submit a test plate from the retreated lot, or
- (3) Scrap the lot and submit a plate representing a new lot for acceptance.

If the manufacturer chooses any one of these options and the ballistic retest plate (or plates) meets the requirements, then the lot represented is acceptable. If option (1) is chosen and one or both of the retest plates fail, the manufacturer may reheat treat the lot and submit a test plate from the retreated lot. If this plate fails, the lot is rejected. If option (3) is chosen and the test plate fails, any one of the three options may be chosen again. The manufacturer shall report the processing used on the failed plates.

A.4.1.3 Disposition of ballistic test plates.

A.4.1.3.1 First article test plates. Upon request of the applicant within 15 days after ballistic testing, first article plates shall be returned "as is" to the applicant, at his expense, unless the plates were destroyed in testing.

A.4.1.3.2 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 rejected lot does. The failed plates shall be returned, upon request, as in A.4.1.3.1.

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TABLE A-I. Minimum required ballistic limits - caliber .30 AP M2 projectile at 30 degrees obliquity.

Thickness inches	Required BL(P), ft/sec	Thickness inches	Required BL(P), ft/sec	Thickness inches	Required BL(P), ft/sec
0.100	616	0.180	1647	0.265	2329
0.105	694	0.185	1697	0.270	2359
0.110	770	0.190	1746	0.275	2389
0.115	845	0.195	1793	0.280	2418
0.118 ^{1/}	889	0.200	1839	0.285	2447
0.120	917	0.205	1884	0.290	2474
0.125	988	0.210	1927	0.295	2501
0.130	1057	0.215	1969	0.300 ^{2/}	2527
0.135	1123	0.220	2010	0.305	2553
0.140	1188	0.225	2050	0.310	2578
0.145	1251	0.230	2088	0.315	2603
0.150	1313	0.235	2126	0.320	2627
0.155	1373	0.240	2162	0.325	2650
0.160	1431	0.245	2197	0.330	2674
0.165	1487	0.250	2232	0.335	2697
0.170	1542	0.255	2265	0.340	2719
0.175	1595	0.260	2297		

^{1/} Specification requirements begin for this ordered thickness.

^{2/} Specification requirements end for this ordered thickness.

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

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TABLE A-II. Minimum required ballistic limits - caliber .50 AP M2 projectile at 30 degrees obliquity.

Thickness inches	Required BL(P), ft/sec	Thickness inches	Required BL(P), ft/sec	Thickness inches	Required BL(P), ft/sec
0.290	1783	0.400	2151	0.515	2481
0.295	1801	0.405	2166	0.520	2494
0.300	1820	0.410	2182	0.525	2508
0.301 ^{1/}	1823	0.415	2197	0.530	2521
0.305	1837	0.420	2212	0.535	2534
0.310	1855	0.425	2227	0.540	2547
0.315	1873	0.430	2242	0.545	2560
0.320	1890	0.435	2256	0.550	2573
0.325	1907	0.440	2271	0.555	2586
0.330	1925	0.445	2286	0.560	2599
0.335	1942	0.450	2300	0.565	2612
0.340	1958	0.455	2314	0.570	2625
0.345	1975	0.460	2329	0.575	2638
0.350	1992	0.465	2343	0.580	2650
0.355	2008	0.470	2357	0.585	2663
0.360	2025	0.475	2371	0.590 ^{2/}	2675
0.365	2041	0.480	2385	0.595	2688
0.370	2057	0.485	2399	0.600	2700
0.375	2073	0.490	2413	0.605	2713
0.380	2089	0.495	2427	0.610	2725
0.385	2104	0.500	2440	0.615	2737
0.390	2120	0.505	2454	0.620	2750
0.395	2136	0.510	2468	0.625	2762

^{1/} Specification requirements begin for this ordered thickness.

^{2/} Specification requirements end for this ordered thickness.

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

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TABLE A-III. Minimum required ballistic limits – 14.5 mm API B32 projectile at 30 degrees obliquity.

Thickness inches	Required BL(P), ft/sec	Thickness inches	Required BL(P), ft/sec	Thickness inches	Required BL(P), ft/sec
0.575	2320	0.645	2469	0.720	2621
0.580	2331	0.650	2480	0.725	2630
0.585	2342	0.655	2490	0.730	2640
0.590	2353	0.660	2500	0.735	2650
0.591 ^{1/}	2355	0.665	2511	0.740	2659
0.595	2364	0.670	2521	0.745	2669
0.600	2374	0.675	2531	0.750	2679
0.605	2385	0.680	2541	0.755	2688
0.610	2396	0.685	2551	0.760	2698
0.615	2407	0.690	2561	0.765 ^{2/}	2707
0.620	2417	0.695	2571	0.770	2717
0.625	2428	0.700	2581	0.775	2726
0.630	2438	0.705	2591	0.780	2736
0.635	2449	0.710	2601	0.785	2745
0.640	2459	0.715	2611	0.790	2754

^{1/} Specification requirements begin for this ordered thickness.

^{2/} Specification requirements end for this ordered thickness.

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

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TABLE A-IV. Minimum required ballistic limits – 14.5 mm API BS41 projectile at 30 degrees obliquity.

Thickness inches	Required BL(P), ft/sec	Thickness inches	Required BL(P), ft/sec	Thickness inches	Required BL(P), ft/sec
0.740	2212	0.880	2564	1.025	2886
0.745	2225	0.885	2576	1.030	2896
0.750	2239	0.890	2588	1.035	2907
0.755	2252	0.895	2599	1.040	2917
0.760	2265	0.900	2611	1.045	2927
0.765	2278	0.905	2622	1.050	2938
0.766 ^{1/}	2281	0.910	2634	1.055	2948
0.770	2292	0.915	2645	1.060	2958
0.775	2305	0.920	2657	1.065	2968
0.780	2318	0.925	2668	1.070	2979
0.785	2331	0.930	2679	1.075	2988
0.790	2343	0.935	2690	1.080	2998
0.795	2356	0.940	2702	1.085	3008
0.800	2369	0.945	2713	1.090	3018
0.805	2382	0.950	2724	1.095	3027
0.810	2394	0.955	2735	1.100	3036
0.815	2407	0.960	2746	1.105	3046
0.820	2419	0.965	2757	1.110	3056
0.825	2431	0.970	2768	1.115	3065
0.830	2444	0.975	2779	1.120	3075
0.835	2456	0.980	2790	1.125	3084
0.840	2468	0.985	2800	1.130 ^{2/}	3094
0.845	2481	0.990	2811	1.135	3103
0.850	2493	0.995	2822	1.140	3112
0.855	2505	1.000	2832	1.145	3122
0.860	2517	1.005	2843	1.150	3131
0.865	2529	1.010	2854	1.155	3140
0.870	2540	1.015	2865	1.160	3149
0.875	2552	1.020	2875	1.165	3158

^{1/} Specification requirements begin for this ordered thickness.

^{2/} Specification requirements end for this ordered thickness.

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

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APPENDIX A

TABLE A-V. Minimum required ballistic limits – 20 mm API-T M602 projectile at 0 degrees obliquity.

Thickness inches	Required BL(P), ft/sec	Thickness inches	Required BL(P), ft/sec	Thickness inches	Required BL(P), ft/sec
1.070	1848	1.240	2127	1.415	2382
1.075	1857	1.245	2135	1.420	2389
1.080	1866	1.250	2143	1.425	2396
1.085	1874	1.255	2150	1.430	2402
1.090	1883	1.260	2158	1.435	2409
1.095	1892	1.265	2165	1.440	2416
1.100	1900	1.270	2173	1.445	2423
1.105	1909	1.275	2180	1.450	2430
1.110	1917	1.280	2188	1.455	2436
1.115	1926	1.285	2195	1.460	2443
1.120	1934	1.290	2203	1.465	2450
1.125	1943	1.295	2210	1.470	2457
1.130	1951	1.300	2218	1.475	2463
1.131 ^{1/2}	1953	1.305	2225	1.480	2470
1.135	1959	1.310	2232	1.485	2477
1.140	1968	1.315	2240	1.490	2483
1.145	1976	1.320	2247	1.495	2490
1.150	1984	1.325	2254	1.500	2496
1.155	1992	1.330	2262	1.505	2503
1.160	2001	1.335	2269	1.510	2510
1.165	2009	1.340	2276	1.515	2516
1.170	2017	1.345	2283	1.520	2523
1.175	2025	1.350	2290	1.525	2529
1.180	2033	1.355	2298	1.530	2536
1.185	2041	1.360	2305	1.535	2542
1.190	2049	1.365	2312	1.540	2549
1.195	2057	1.370	2319	1.545	2555
1.200	2065	1.375	2326	1.550	2561
1.205	2073	1.380	2333	1.555	2568
1.210	2081	1.385	2340	1.560	2574
1.215	2088	1.390	2347	1.565	2581
1.220	2096	1.395	2354	1.570	2587
1.225	2104	1.400	2361	1.575	2593
1.230	2112	1.405	2368	1.580	2600
1.235	2120	1.410	2375	1.585	2606

^{1/2} Specification requirements begin for this ordered thickness.

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

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APPENDIX A

TABLE A-V. Minimum required ballistic limits - 20 mm API-T M602 projectile at 0 degrees obliquity – Continued.

Thickness inches	Required BL(P), ft/sec	Thickness inches	Required BL(P), ft/sec	Thickness inches	Required BL(P), ft/sec
1.590	2612	1.760	2819	1.930	3012
1.595	2619	1.765	2825	1.935	3017
1.600	2625	1.770	2831	1.940	3023
1.605	2631	1.775	2836	1.945	3028
1.610	2637	1.780	2842	1.950	3033
1.615	2644	1.785	2848	1.955	3039
1.620	2650	1.790	2854	1.960	3044
1.625	2656	1.795	2860	1.965	3050
1.630	2662	1.800	2865	1.970	3055
1.635	2669	1.805	2871	1.975	3061
1.640	2675	1.810	2877	1.980	3066
1.645	2681	1.815	2883	1.985	3071
1.650	2687	1.820	2888	1.990	3077
1.655	2693	1.825	2894	1.995	3082
1.660	2699	1.830	2900	2.000 ^{2/}	3088
1.665	2705	1.835	2905	2.005	3093
1.670	2711	1.840	2911	2.010	3098
1.675	2718	1.845	2917	2.015	3104
1.680	2724	1.850	2922	2.020	3109
1.685	2730	1.855	2928	2.025	3114
1.690	2736	1.860	2934	2.030	3120
1.695	2742	1.865	2939	2.035	3125
1.700	2748	1.870	2945	2.040	3130
1.705	2754	1.875	2951	2.045	3135
1.710	2760	1.880	2956	2.050	3141
1.715	2766	1.885	2962	2.055	3146
1.720	2772	1.890	2967	2.060	3151
1.725	2778	1.895	2973	2.065	3156
1.730	2784	1.900	2978	2.070	3162
1.735	2789	1.905	2984	2.075	3167
1.740	2795	1.910	2990	2.080	3172
1.745	2801	1.915	2995	2.085	3177
1.750	2807	1.920	3001	2.090	3183
1.755	2813	1.925	3006		

^{2/} Specification requirements end for this ordered thickness.

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

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CONCLUDING MATERIAL

Custodian:
Army - MR

Preparing activity:
Army - MR

Review activities:
Army - AR, AT, TE
DLA - IS

Project 9515-2008-003

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at <http://assist.daps.dla.mil/>.