

INCH-POUND

MIL-A-46192B(MR)
1 July 1991
SUPERSEDING
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MILITARY SPECIFICATION

ALUMINUM ALLOY ARMOR ROLLED PLATE (1/2 TO 4 INCHES THICK), WELDABLE (ALLOY 2519)

This specification is approved for use within 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 aluminum alloy 2519 armor rolled plate from 1/2 inch up to and including 4 inches in thickness.

1.2 Weldability. The material covered by this specification is weldable to itself and other weldable 2000 series alloys using a 2000 series filler and is weldable to 6000 series alloys using a 4000 series filler. It is not weldable to 5000 series or 7000 series alloys by conventional welding techniques.

1.3 Classification. Material furnished under this specification shall be rolled plate in a T87 temper

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified in the contract or purchase order, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

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 Laboratory Command, Materials Technology Laboratory, ATTN: SLCMT-MEE, Watertown, MA 02172-0001 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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SPECIFICATIONS

MILITARY

MIL-H-6088 - Heat Treatment of Aluminum Alloys

STANDARDS

MILITARY

MIL-STD-129 - Marking for Shipment and Storage
MIL-STD-367 - Armor Test Data Reporting

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.1.2 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 are those cited in the solicitation.

AAA-PFE-1 - Aluminum Alloy Armor - Plate, Forged, Extruded

(Application for copies should be addressed to the Administrator, Defense Technical Information Center, ATTN: DTIC-HDB, Cameron Station, Alexandria, VA 22304-6145.

2.2 Non-Government publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified in the contract or purchase order, the issues of the documents which are DoD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified in the contract or purchase order, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI - H35.2 - American National Standard Dimensional Tolerances for Aluminum Mill Products

(Applications for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018-3350.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B557 - Tension Testing Wrought and Cast Aluminum and Magnesium-Alloy Products
ASTM B666 - Identification Marking of Aluminum Products
ASTM D3951 - Practice for Commercial Packaging
ASTM E34 - Methods for Chemical Analysis of Aluminum and Aluminum Alloys
ASTM E101 - Method for Spectrographic Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique

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- ASTM E227 - Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique
- ASTM E380 - Metric Practice Guide
- ASTM E527 - Practice for Numbering Metals and Alloys (UNS)
- ASTM E607 - Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique, Nitrogen Atmosphere
- ASTM E716 - Practice for Sampling Aluminum and its Alloys for Spectro-
- ASTM E1251 - Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by Argon Atmosphere, Point to Plane, Unipolar Self-initiating Capacitor Discharge Chemical Analysis
- ASTM G47 - Determining Susceptibility to Stress-Corrosion Cracking of High Strength Aluminum Alloy Products

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103-1187.)

(Technical society and technical associations 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 document and the references cited herein, 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 and 6.6), a sample or samples of the specified item shall be made available to the contracting officer or his authorized representative for approval. The approval of the first article sample(s) authorizes 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. When specified in the contract or order a certified test report of the declared chemical analysis shall be prepared (see 6.2.2) and submitted to the contracting agency and to the ballistic test agency. The ballistic test agency will 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 must be accompanied by copies of the first article test firing record. Any deviation(s) noticed by the ballistic agency will be brought to the attention of the contracting agency and to the manufacturer.

3.1.1 First time producer. First time producers wishing to qualify for this specification should follow the instructions of 6.5.

3.1.2 Process changes. After an armor material has successfully complied with the requirements of this specification, any deliberate change in the mill processing by the manufacturer which could affect the material characteristics controlled by this specification, shall be drawn to the attention of the

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procuring activity and the contractor. Tests, as stated in this specification, may be required to determine if the material made with process changes meets the requirements of this specification (see 6.2.2).

3.2 Chemical composition. Chemical composition of material furnished under this specification shall be within the limits specified in table I (see 6.2.2).

3.3 Mechanical properties. Unless otherwise specified in the contract or order (see 6.2), the mechanical properties of rolled plate shall meet the requirements of table II, when tested as specified in 4.8.2.

3.3.1 If mechanical property requirements differ from the values shown in table II, or if any other properties are required, the ballistic requirements shall be as agreed upon between the procuring activity and the manufacturer.

3.4 Ballistic requirements. Each ballistic test plate shall be proof fired for resistance to penetration by determining a protection ballistic limit, BL(P) (see 6.2.2). The BL(P) shall be as specified in appendix A.

TABLE I. Chemical composition, percent (ladle analysis).

Element	Min.	Max.
Silicon	-	0.25 <u>1/</u>
Iron	-	0.30 <u>1/</u>
Copper	5.3	6.4
Manganese	0.10	0.50
Magnesium	0.05	0.40
Titanium	0.02	0.10
Zinc	-	0.10
Zirconium	0.10	0.25
Vanadium	0.05	0.15
Others, each	-	0.05
Others, total	-	0.15
Aluminum,	Remainder	

1/ The combined silicon and iron content shall not exceed 0.40 percent.

3.5 Stress-corrosion resistance. When stress corrosion testing is specified in the contract or order (see 6.2), plate 0.75 inch and greater in thickness shall be resistant to stress corrosion cracking, with 3 out of 3 specimens showing no evidence of cracking when tested in accordance with 4.6.3.

3.6 Thermal processing. Heat treatment shall conform to the requirements of MIL-H-6088 and shall be such as to enable the material to meet the requirements of this specification.

3.7 Dimensions and tolerances.

3.7.1 Dimensions. Size of plate shall be as specified in the invitation for bids, contract or order (see 6.2).

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TABLE II. Mechanical properties of plate.

Direction	Thickness, inches	Tensile strength min ksi.	Yield strength 0.2% offset min ksi	Elongation in 2 inches min. percent
Long transverse	0.500-1.500	68.0	58.0	7
	1.501-2.000	68.0	58.0	7
	2.001-3.000	68.0	59.0	6
	3.001-4.000	68.0	59.0	5
Longitudinal	0.500-1.500	66.0	59.0	10
	1.501-2.000	66.0	59.0	9
	2.001-3.000	67.0	60.0	8
	3.001-4.000	68.0	61.0	7

3.7.2 Tolerances. Unless otherwise specified in the contract or order (see 6.2), the plates submitted for acceptance shall not vary from the specified dimensions by an amount greater than the tolerances shown in ANSI H35.2. Similarly, the thickness tolerance shall be as specified in table III.

TABLE III. Thickness tolerances.

Ordered thickness, inches	Tolerance, inch	
	Minus	Plus
0.500-0.875, incl.	0.030	<u>1/</u>
0.876-1.125, incl.	0.035	--
1.126-1.375, incl.	0.040	--
1.376-1.625, incl.	0.045	--
1.626-1.875, incl.	0.050	--
1.876-2.250, incl.	0.055	--
2.251-2.750, incl.	0.060	--
2.751-3.000, incl.	0.065	--
3.001-4.000, incl.	0.070	--

1/ The values for the plus column are derived from the full range tolerances specified in table 3.1 of ANSI 35.2. For example, the tolerance for a 2.0 inch thick by a 73 inches wide plate would be as follows:

Thickness tolerance (from ANSI H 35.2) [±] 0.060	
Full tolerance less minus tolerance	0.120 - 0.055 = 0.065
Derived plus tolerance	0.065
Tabulated minus tolerance	0.055

3.8 Identification marking. Unless otherwise specified (see 6.2) each plate shall be continuously line marked along the rolling direction in accordance with ASTM B666.

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3.8.1 Ballistic test plates. In addition to the marking in 3.8, each ballistic test plate shall be marked with the letters PRE for first article test plates and ACC for acceptance test plates. This marking shall be impression

stamped or stenciled on the plate rolled surface not less than 1/2 inch high and within one inch of the plate edge.

3.9 Workmanship. Rolled plate shall be uniform in quality and shall be clean, smooth and commercially free from buckles, blisters, hard spots, damaged ends, laminations and other defects which may affect its use in fabrication. Surface cracks, edge cracks or edge laminations shall be cause for rejection.

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 (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase 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 this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. Ballistic tests shall be performed by U.S. Army Combat Systems Test Activity (see 6.5).

4.2 Classification of inspection. Inspection shall be classified as follows:

- (a) First article inspection (see 4.3).
- (b) Quality conformance inspection (see 4.4).

4.3 First article inspection. First article inspection shall consist of the following:

- (a) Chemical analysis (see 3.2 and 4.8.1).
- (b) Mechanical properties (see 3.3 and 4.8.2).
- (c) Ballistic tests (see 3.4, 4.8.4 and Appendix A).
- (d) Stress corrosion tests (see 3.5, 4.6.2.3 and 4.8.3)
- (e) Dimensions and tolerances (see 3.7 and 4.9.1).
- (f) Identification marking (see 3.8 and 4.9.2).
- (g) Workmanship (see 3.9 and 4.9.2).

4.4 Quality conformance inspection. Lot acceptance inspection shall consist of the following:

- (a) Chemical analysis (see 3.2 and 4.8.1).
- (b) Mechanical properties (see 3.3 and 4.8.2).
- (c) Ballistic tests (see 3.4, 4.8.4 and Appendix A).
- (d) Dimensions and tolerances (see 3.7 and 4.9.1).
- (e) Identification marking (see 3.8 and 4.9.2).
- (f) Workmanship (see 3.9 and 4.9.2).
- (g) Preparation for shipment (see section 5 and 4.9.3).

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4.5 Lot. For rolled plate a lot shall consist of plate of the same ordered thickness and temper submitted for inspection as a unit, provided that the weight of the finished plate in the lot does not exceed 50,000 pounds.

4.6 Sampling.

4.6.1 Sampling for first article testing.

4.6.1.1 For chemical composition. Samples for chemical analysis shall be removed from each plate selected for ballistic testing.

4.6.1.2 For mechanical properties tests: A tension test specimen for first article tests shall be removed from the same plate material that has been selected for the ballistic test. The location and type specimen shall be as specified in 4.7.2.

4.6.1.3 Stress corrosion tests. Stress corrosion test specimens shall be removed from the same plate selected for the ballistic test. The type of specimens shall be as specified in 4.8.3.

4.6.1.4 Ballistic tests: Two plates, 12 by 36 inches by the ordered thickness, shall be submitted for ballistic testing. The orientation of these plates with respect to the rolling direction shall be at the option of the manufacturer. The first article ballistic test may be waived at the discretion of the procuring activity if the manufacturer within 37 months has produced acceptable plate within plus and minus 0.250 inch of the ordered thickness, provided also that the test conditions are the same as for previously accepted plate.

4.6.2 Sampling for quality conformance testing.

4.6.2.1 Chemical composition:

(a) For ladle analysis. At least one sample shall have been taken from the molten metal representing one group of ingots poured as a unit from the same source of molten metal. Complete ingot analysis records shall be available to the Government at the ingot producer's facility.

(b) For check analysis. When sampling has not been made in accordance with 4.6.2.1(a), one sample shall be taken for each 4,000 pounds or less in each lot in accordance with methods specified in 4.8.1.

4.6.2.2 Mechanical properties tests: From each lot samples for tension tests shall be selected in accordance with table IV. Each sample shall be selected from a different plate in the lot. Should a lot consist of only one plate, only one tension test sample shall be taken. One tension test specimen shall be made from each sample.

4.6.2.3 Stress corrosion tests. One plate, approximately 12 inches by 12 inches by the ordered thickness shall be selected from the lot for stress corrosion tests. At the discretion of the procuring activity, reduced sampling may be instituted, i.e., not every lot need be sampled (see 4.10.2.4).

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TABLE IV. Number of tension test samples.

Lot size, pounds	Minimum number of samples
To 8,000, incl.	2
8,001-12,000, incl.	3
12,001-20,000, incl	4
Over 20,000, incl.	5

4.6.2.4 Ballistic testing: One plate approximately 12 inches by 36 inches by the ordered thickness shall be selected from the lot for ballistic testing. The orientation of this plate with respect to the rolling direction shall be at the option of the manufacturer.

4.7 Test specimen preparation.

4.7.1 Chemical analysis. Specimens for chemical analysis shall be prepared in accordance with the applicable method specified in 4.8.1.

4.7.2 Mechanical properties. Tension test specimens shall conform to the dimensions of the standard specimens (figure 8) of ASTM B557. They shall be taken in the long transverse direction. From plate in nominal thickness 0.50 to 1.50 inches inclusive, tension test specimens shall be taken with the axis midway between the two plate surfaces; from plate in nominal thicknesses greater than 1.50 inches, the axis of the tension test specimen shall be three-fourths of the distance from one surface to the other.

4.7.3 Stress corrosion. The stress corrosion specimens shall be stressed at 75% of the specified yield strength. The location of the specimens taken from the plate shall be specified in the drawing (see 6.2).

4.8 Test procedures.

4.8.1 Chemical composition. The determination of the chemical composition shall be made in accordance with one or more of the following test methods: ASTM E34, E227, E607, E1251.

4.8.2 Mechanical properties. The mechanical properties shall be determined in accordance with ASTM B557.

4.8.3 Resistance to stress corrosion. Stress corrosion testing shall be conducted in accordance with ASTM G47.

4.8.4 Ballistic tests: Plates shall be tested using projectiles chosen in accordance with the thickness ranges shown in table V. Plate thickness as determined by the ballistic test agency shall be used to determine the required ballistic limit for that plate. Individual thickness measurements are to be read from a deep throat micrometer or by means of an ultrasonic device to the nearest 0.001 inch and the average of these readings reported to the nearest 0.005 inch. Measurements shall be made on the intended impact area.

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4.9 Examination.

4.9.1 Dimensions. Each plate within the lot shall be measured to determine compliance with the requirements for dimensions and tolerances (see 3.7) or the lot shall be sampled in accordance with sampling procedures approved by the procuring activity.

4.9.2 Visual. Each plate shall be examined to determine compliance with the identification marking (see 3.8) and workmanship (see 3.9) requirements.

TABLE V. Acceptance ballistic test plates.

Ordered or nominal design thickness specified on drawings, inches	Test angle	Projectile to be used
0.500-0.749	30°	Cal. .30 AP, M2
0.750-1.500	0°	Cal. .30 AP, M2
0.750-0.950	0°	Cal. .50 FS
0.951-1.500	0°	20 mm FS
(a) 1.501-3.000	0°	Cal. .50 AP, M2
(a) 3.001-4.000	0°	14.5 mm API, BS41

(a) Ballistic limit requirements to be developed.

4.9.3 Preparation for shipment. Prior to shipment, examination shall be made to determine compliance with section 5.

4.10 Rejection and retest.

4.10.1 First article. Failure of the first article test plates to meet the requirements of 4.3 indicates rejection of the product and process.

4.10.1.1 Retests. Resubmission of first article samples shall not be made until the manufacturer has made necessary corrections in the processing of the material to the satisfaction of the procuring activity. Samples submitted for retest shall be marked R1, R2 and R3, if applicable, in addition to the requirements of 3.8.

4.10.2 Acceptance.

4.10.2.1 Examination. A quality conformance lot shall be rejected for failure to meet the visual, dimensional and preparation for delivery requirements when examined in accordance with 4.9.

4.10.2.2 Tests. A quality conformance lot shall be rejected for failure to meet any of the requirements of any of the tests outlined in 4.4.

4.10.2.3 Retests.

4.10.2.3.1 Chemical composition and mechanical properties. Retests shall be conducted in accordance with the methods specified in 4.8.1 and 4.8.2.

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4.10.2.3.2 Stress corrosion (first article) testing only. If the manufacturer so desires, a retest shall be performed using three additional specimens. No cracking shall occur in 10 days. If the retest also fails, the manufacturer may elect to resubmit the lot after retreatment of the entire lot. After retreatment, the lot must conform to the requirements outlined in 3.5.

4.10.2.3.3 Ballistic. Rejection and retest of ballistic test plates shall be in accordance with A-50.2.

4.10.2.4 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 uniform product, meeting the testing requirements is being produced and provided the manufacturer agrees to maintain the same manufacturing procedures.

5. PACKAGING

5.1 Preservation.

5.1.1 Commercial. The commercial preservation of material shall be in accordance with the requirements of ASTM D3951.

5.2 Packing.

5.2.1 Commercial. The preserved material shall be packed in accordance with the requirements of ASTM D3951.

5.3 Marking of shipment. In addition to any special marking specified in the contract or order (see 6.2), marking for shipment shall be in accordance with MIL-STD-129.

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 material specified herein is for military vehicles.

6.1.1 Title. The title of the specification has been changed from "Aluminum Alloy Armor Rolled Plate (1/4 to 4 Inches Thick), Weldable (Alloy 2519)" to "Aluminum Alloy Armor Rolled Plate (1/2 to 4 Inches Thick), Weldable (Alloy 2519)"

6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents should specify the following:

- (a) Title, number and date of this specification.
- (b) If first article inspection is required (see 3.1).
- (c) If stress corrosion testing is required (see 3.5).
- (d) Drawings, dimensions and tolerances (see 3.7, table III and 4.8.3).
- (e) If different identification marking is required (see 3.8).
- (f) Destination of ballistic test samples (see 4.6.1.4).
- (g) Additional marking, if required (see 5.3).

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6.2.2 Consideration of data requirements. The following data requirements should be considered when this specification is applied on a contract. The applicable Data Item Descriptions (DID's) should be reviewed in conjunction with the specific acquisition to ensure that only essential data are requested/provided and that the DID's are tailored to reflect the requirements of the specific acquisition. To ensure correct contractual application of the data requirements, a Contract Data Requirements List (DD Form 1423) must be prepared to obtain the data, except where DOD FAR Supplement 27.475-1 exempts the requirement for a DD Form 1423.

<u>Reference Paragraph</u>	<u>DID Number</u>	<u>DID Title</u>	<u>Suggested Tailoring</u>
3.1	DI-FORG-80962	First Article Forging Report	--
3.2, 3.3	DI-MISC-80678	Certification Data Report	--
3.4	DI-MISC-80073	Armor Material Test Reports	Format II

(Copies of data item descriptions related to this specification, and identified in section 6 will be approved and listed as such in DOD 5010.12L, Vol. 11, AMSDL. Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the Standardization Documents Order Desk, Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094 or as directed by the contracting officer.)

6.3 Definitions.

6.3.1 Manufacturer. The manufacturer is defined as the company producing the aluminum alloy plate.

6.3.2 Contractor. The contractor is the company which has a direct contract from the Government to furnish an end item - usually a vehicle. Also known as the prime contractor.

6.3.3 Contracting officer. The term "contracting officer" means the person executing a contract on behalf of the Government and any other officer or civilian employee who is properly designated contracting officer; and the term includes, except as otherwise provided, the authorized representative of a contracting officer acting within the limits of his authority.

6.3.4 Procuring activity. The term "procuring activity" is that activity of the Government which actually initiates the request for procurement and maintains the records of the procurement.

6.4 Mechanical properties and ballistic requirements. The minimum mechanical properties specified (see 3.3) may not assure aluminum armor material meeting the specified ballistic requirements (see 3.4).

6.5 Potential suppliers. Potential suppliers who have not previously supplied armor plate to MIL-A-46192(MR) 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 TECOM ATTN: AMSTE-TA-O, Aberdeen Proving Ground, MD 21005-5005.

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6.6 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 for the contractor the number, size and delivery schedule of the ballistic test plates which are to be submitted for first article acceptance testing. A lead time of 60 days after the contract has been signed is to be allowed prior to shipment of the first ballistic test plate(s) to APG to ensure that all administrative functions for the establishment of a new TECOM project have been completed in preparation for the test. The contracting government agency is to initiate the new project through a letter to Commander, US Army TECOM, ATTN: AMSTE-TA-O, APG, MD 21005-5005 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.

6.7 Metric units. When metric dimensions are required, units for inch, foot, foot-pounds, feet per second, and pounds per square inch may be converted to the metric equivalent by multiplying them by the following conversion factors:

<u>To go from</u> <u>English</u>	<u>Multiply by</u>	<u>To get</u> <u>Metric SI Unit</u>
inch	0.0254	metre (m)
foot	0.3048	metre (m)
foot/lb	1.3558	joule (J)
feet/sec	0.3048	meters per second (m/s)
pounds/sq. inch	0.00689	mega pascal (MPa)

Note: Conversion factors can be obtained from ASTM E380.

6.8 Patent notice. The material specified by this specification may be covered by U.S. Patent # 4610733 (expiration date September 9, 2003.) The Government does not have a royalty free license for this patent.

6.9 Key words.

Armor plate
Aluminum alloy 2519

Custodian:
Army - MR

Preparing activity:
Army - MR

Review Activities:
Army - AT, AR, ME, TE
DLA - IS

Project 9535-A036

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APPENDIX A

BALLISTIC TESTING OF ALUMINUM ALLOY ARMOR PLATE

A-10 SCOPE. This appendix covers the minimum ballistic limits for acceptable requirements of aluminum alloy armor, plate, weldable, when tested in accordance with the provisions of this specification. This Appendix is a mandatory part of this specification.

A-20 APPLICABLE DOCUMENTS

A-20.1 The following document forms a part of this appendix (see A-50.1):

Proving Ground Acceptance Test Procedure No. AAA-PFE-1
25 June 1979, for Aluminum Alloy Armor-Plate, Forged,
Extruded.

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

A-30 DEFINITIONS

A-30.1 Fair impact. A fair impact results when an unyawed projectile strikes an unsupported area of the ballistic test plate sample at such a location that there is at least two calibers of undisturbed metal between this impact and any previous impact, hole, crack, edge of plate or spalled area.

A-30.2 Witness plate. A witness plate 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 behind and parallel to the test plates or other ballistic sample.

A-30.3 Protection complete penetration, CP(P). A protection complete penetration will have been obtained when the projectile or a fragment of the projectile or a fragment of the ballistic test plate is thrown beyond the rear face of the plate with sufficient energy to perforate an approximate 0.020 inch thick sheet of 2024-T3 aluminum alloy (or a 0.014 inch thick sheet of 5052 H36) placed parallel to and 6 inches behind the plate.

A-30.4 Partial penetration, PP(P). Any fair impact that is not a complete penetration shall be considered a partial penetration.

A-30.5 Gap. A gap is the difference in fps between the high partial penetration velocity and the low complete penetration velocity used to compute the ballistic limit when the high partial penetration velocity is lower than the low complete penetration velocity.

A-40 REQUIREMENTS

A-40.1 Resistance to penetration. The minimum required V_{50} ballistic limit shall be in accordance with the values shown in tables A-I through A-IV.

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A-50 TESTS

A-50.1 Ballistic tests. Testing shall be in accordance with Proving Ground Acceptance Test Procedure AAA-PFE-1, 25 June 1979, for Aluminum Alloy Armor-Plate, Forged, Extruded, except that nothing in this procedure shall be construed to supersede or invalidate the requirements of this specification.

A-50.1.1 Temperature conditioning. Prior to the test, the test item(s) will be temperature conditioned at least eight hours. Thermostatic control will be such that the average temperature of the item during the test shall be $72^{\circ} \pm 15^{\circ}\text{F}$ ($22^{\circ} \pm 8^{\circ}\text{C}$).

A-50.1.2 Protection ballistic limit, BL(P).

A-50.1.2.1 Normal circumstances. The BL(P) shall consist of an equal number of fair impact complete and partial penetration velocities attained by the up-and-down firing method. All BL(P)'s shall be computed using the highest partial penetration velocities and the lowest complete penetration velocities. Firing shall continue until either a 4-round BL(P) having a maximum velocity spread of 60 fps or a 6-round BL(P) having a maximum velocity spread of 90 fps has been attained, whichever comes first in the normal sequence of firing. If both occur simultaneously, the 6-round BL(P) will be reported.

A-50.1.2.2 Large zone of mixed results. In the event that the zone of mixed results (difference between the high partial penetration velocity and the low complete penetration velocity, the PP[P] velocity being higher than the low CP[P] velocity) exceeds 90 fps, the firing data will be compared with the specification minimum ballistic requirements. If the lowest complete penetration velocity is equal to or above the minimum specified ballistic limit velocity for the plate thickness, the ballistic limit will be computed on the basis of 4- or 6-rounds using the smallest possible velocity spread. If the lowest complete penetration velocity is below the minimum allowable ballistic limit velocity, then testing will continue until a 10-round ballistic limit has been attained using the smallest practical velocity spread. Ten round ballistic limits will be reported as such on the armor data forms.

A-50.1.2.3 Reduction of large velocity gap in borderline cases. If the ballistic limit which has been attained is within ± 10 fps of the minimum allowable ballistic limit and a gap exists which is greater than 25 fps, then another round, or rounds, will be fired to reduce the gap to 25 fps or less. The ballistic limit will then be recomputed using the above criteria. The recomputed BL(P) will be reported as the BL(P) of the plate. In borderline cases, a reduction of the gap between the high partial penetration velocity and the low complete velocity should result in a better evaluation of the BL(P).

A-50.2 Rejection and retest of ballistic plates.

A-50.2.1 First article tests (rejection). Unless otherwise specified in the contract or order, failure of any of the first article test plates to meet the minimum ballistic requirements shown in the appendix of this specification indicates failure of the product and process.

A-50.2.2 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 as acknowledged by the procuring activity. Two

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retest plates shall be submitted for first article testing and both tests must pass; otherwise, the armor material shall be rejected.

A-50.2.3 Acceptance tests (rejection). Unless otherwise specified in the contract or order, failure of a test plate to meet the ballistic requirements indicates rejection of the lot; however, the final decision will depend on the outcome of retests, if submitted.

A-50.2.4 Acceptance tests (retests). If a test plate representing a lot fails to meet the ballistic requirement, the manufacturer, upon notification of the failure, may submit at his own expense two additional test plates from the same lot for ballistic retest. If either of these plates fail the ballistic test, the lot shall be rejected. The manufacturer may elect to resubmit the lot after retreatment of the entire lot by submitting two additional test plates. If either of these plates fail, the lot shall be permanently rejected.

A-50.3 Disposition of ballistic test plates.

A-50.3.1 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.

A-50.3.2 Acceptance test plates. Acceptance test plates that comply with the requirements of this specification are considered as part of the lot they represent, and ownership of the test plates 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 A-50.3.1.

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APPENDIX A

TABLE A-I. Minimum required ballistic limits -.30 caliber AP M2
projectile at 30 degrees obliquity - 2519 alloy
required BL based on 2% rejection curve.

<u>Thickness (inches)</u>	<u>Required BL(P) fps</u>	<u>Thickness (inches)</u>	<u>Required BL(P) fps</u>	<u>Thickness (inches)</u>	<u>Required BL(P) fps</u>
0.470	1382	0.595	1683	0.720	1939
0.475	1395	0.600	1694	0.725	1949
0.480	1409	0.605	1705	0.730	1958
0.485	1422	0.610	1716	0.735	1968
0.490	1434	0.615	1726	0.740	1977
0.495	1447	0.620	1737	0.745	1987
*0.500	1460	0.625	1748	**0.749	1994
0.505	1472	0.630	1758	0.750	1996
0.510	1485	0.635	1769	0.755	2005
0.515	1497	0.640	1779	0.760	2015
0.520	1509	0.645	1790	0.765	2024
0.525	1522	0.650	1800	0.770	2033
0.530	1534	0.655	1810	0.775	2042
0.535	1546	0.660	1821	0.780	2051
0.540	1557	0.665	1831	0.785	2060
0.545	1569	0.670	1841	0.790	2069
0.550	1581	0.675	1851	0.795	2078
0.555	1593	0.680	1861	0.800	2087
0.560	1604	0.685	1871	0.805	2096
0.565	1616	0.690	1881	0.810	2105
0.570	1627	0.695	1891	0.815	2114
0.575	1638	0.700	1900	0.820	2123
0.580	1650	0.705	1910	0.825	2132
0.585	1661	0.710	1920	0.830	2140
0.590	1672	0.715	1930		

* Specification requirements begin for ordered thickness .500 inch.

** Specification requirements end for ordered thickness .749 inch.

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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APPENDIX A

TABLE A-II. Minimum required ballistic limits -.30 caliber AP M2
projectile at 0 degrees obliquity - 2519 alloy
required BL based on 1% rejection curve.

<u>Thickness (inches)</u>	<u>Required BL(P) fps</u>	<u>Thickness (inches)</u>	<u>Required BL(P) fps</u>	<u>Thickness (inches)</u>	<u>Required BL(P) fps</u>
0.720	1770	0.920	2062	1.120	2317
0.725	1778	0.925	2068	1.125	2323
0.730	1786	0.930	2075	1.130	2329
0.735	1794	0.935	2082	1.135	2335
0.740	1802	0.940	2088	1.140	2341
0.745	1809	0.945	2095	1.145	2347
* 0.750	1817	0.950	2102	1.150	2353
0.755	1825	0.955	2108	1.155	2359
0.760	1832	0.960	2115	1.160	2365
0.765	1840	0.965	2122	1.165	2371
0.770	1847	0.970	2128	1.170	2377
0.775	1855	0.975	2135	1.175	2382
0.780	1862	0.980	2141	1.180	2388
0.785	1870	0.985	2148	1.185	2394
0.790	1877	0.990	2154	1.190	2400
0.795	1885	0.995	2161	1.195	2406
0.800	1892	1.000	2167	1.200	2412
0.805	1900	1.005	2174	1.205	2417
0.810	1907	1.010	2180	1.210	2423
0.815	1914	1.015	2187	1.215	2429
0.820	1921	1.020	2193	1.220	2435
0.825	1929	1.025	2199	1.225	2440
0.830	1936	1.030	2206	1.230	2446
0.835	1943	1.035	2212	1.235	2452
0.840	1950	1.040	2218	1.240	2458
0.845	1957	1.045	2225	1.245	2463
0.850	1964	1.050	2231	1.250	2469
0.855	1972	1.055	2237	1.255	2475
0.860	1979	1.060	2243	1.260	2480
0.865	1986	1.065	2250	1.265	2486
0.870	1993	1.070	2256	1.270	2492
0.875	2000	1.075	2262	1.275	2497
0.880	2007	1.080	2268	1.280	2503
0.885	2014	1.085	2274	1.285	2508
0.890	2021	1.090	2280	1.290	2514
0.895	2027	1.095	2287	1.295	2520
0.900	2034	1.100	2293	1.300	2525
0.905	2041	1.105	2299	1.305	2531
0.910	2048	1.110	2305	1.310	2536
0.915	2055	1.115	2311	1.315	2542

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APPENDIX A

TABLE A-II. Minimum required ballistic limits -.30 caliber AP M2
projectile at 0 degrees obliquity - 2519 alloy
required BL based on 1% rejection curve. (Continued)

<u>Thickness (inches)</u>	<u>Required BL(P) fps</u>	<u>Thickness (inches)</u>	<u>Required BL(P) fps</u>	<u>Thickness (inches)</u>	<u>Required BL(P) fps</u>
1.320	2547	1.425	2660	1.530	2769
1.325	2553	1.430	2665	1.535	2774
1.330	2558	1.435	2671	1.540	2779
1.335	2564	1.440	2676	1.545	2784
1.340	2569	1.445	2681	1.550	2789
1.345	2575	1.450	2686	1.555	2794
1.350	2580	1.455	2692	1.560	2799
1.355	2585	1.460	2697	1.565	2804
1.360	2591	1.465	2702	1.570	2809
1.365	2596	1.470	2707	1.575	2814
1.370	2602	1.475	2712	1.580	2819
1.375	2607	1.480	2718	1.585	2824
1.380	2612	1.485	2723	1.590	2829
1.385	2618	1.490	2728	1.595	2834
1.390	2623	1.495	2733	1.600	2839
1.395	2628	1.500	2738	1.605	2844
1.400	2634	1.505	2743	1.610	2849
1.405	2639	1.510	2748	1.615	2854
1.410	2644	1.515	2753	1.620	2858
1.415	2650	1.520	2759	1.625	2863
1.420	2655	1.525	2764		

* Specification requirements begin for ordered thickness .750 inch.

**Specification requirements end for ordered thickness 1.500 inch.

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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APPENDIX A

TABLE A-III. Minimum required ballistic limits .50 caliber
fragment simulating projectile at 0 degrees obliquity.

<u>Thickness</u> <u>(inches)</u>	<u>Required</u> <u>BL(P) fps</u>	<u>Thickness</u> <u>(inches)</u>	<u>Required</u> <u>BL(P) fps</u>	<u>Thickness</u> <u>(inches)</u>	<u>Required</u> <u>BL(P) fps</u>
0.720	1827	0.825	2274	0.930	2823
0.725	1847	0.830	2297	0.935	2852
0.730	1866	0.835	2321	0.940	2881
0.735	1886	0.840	2345	0.945	2911
0.740	1905	0.845	2370	** 0.950	2941
0.745	1925	0.850	2394	0.955	2971
* 0.750	1946	0.855	2419	0.960	3002
0.755	1966	0.860	2444	0.965	3033
0.760	1987	0.865	2469	0.970	3064
0.765	2007	0.870	2495	0.975	3095
0.770	2028	0.875	2521	0.980	3127
0.775	2050	0.880	2547	0.985	3159
0.780	2071	0.885	2573	0.990	3192
0.785	2093	0.890	2600	0.995	3225
0.790	2114	0.895	2627	1.000	3258
0.795	2136	0.900	2654	1.005	3291
0.800	2159	0.905	2681	1.010	3325
0.805	2181	0.910	2709	1.015	3359
0.810	2204	0.915	2737	1.020	3394
0.815	2227	0.920	2765	1.025	3428
0.820	2250	0.925	2794	1.030	3462

* Specification requirements begin for this ordered thickness .750 inch.

** Specification requirements end for ordered thickness .950 inch.

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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APPENDIX A

TABLE A-IV. Minimum required ballistic limits - 20 mm fragment
simulating projectile at 0 degrees obliquity - 2519 alloy
required BL based on 1% rejection curve.

Thickness (inches)	Required BL(P) fps	Thickness (inches)	Required BL(P) fps	Thickness (inches)	Required BL(P) fps
0.915	1269	1.110	1663	1.310	2184
0.920	1278	1.115	1675	1.315	2199
0.925	1287	1.120	1686	1.320	2214
0.930	1296	1.125	1698	1.325	2229
0.935	1305	1.130	1710	1.330	2244
0.940	1314	1.135	1721	1.335	2259
0.945	1324	1.140	1733	1.340	2274
0.950	1333	1.145	1745	1.345	2290
* 0.951	1335	1.150	1757	1.350	2305
0.955	1342	1.155	1769	1.355	2321
0.960	1352	1.160	1781	1.360	2336
0.965	1361	1.165	1793	1.365	2352
0.970	1371	1.170	1806	1.370	2368
0.975	1380	1.175	1818	1.375	2384
0.980	1390	1.180	1831	1.380	2400
0.985	1400	1.185	1843	1.385	2416
0.990	1409	1.190	1856	1.390	2433
0.995	1419	1.195	1868	1.395	2449
1.000	1429	1.200	1881	1.400	2465
1.005	1439	1.205	1894	1.405	2482
1.010	1449	1.210	1907	1.410	2499
1.015	1459	1.215	1920	1.415	2516
1.020	1469	1.220	1933	1.420	2532
1.025	1479	1.225	1946	1.425	2550
1.030	1490	1.230	1960	1.430	2567
1.035	1500	1.235	1973	1.435	2584
1.040	1510	1.240	1986	1.440	2601
1.045	1521	1.245	2000	1.445	2619
1.050	1531	1.250	2014	1.450	2636
1.055	1542	1.255	2027	1.455	2654
1.060	1553	1.260	2041	1.460	2672
1.065	1563	1.265	2055	1.465	2690
1.070	1574	1.270	2069	1.470	2708
1.075	1585	1.275	2083	1.475	2726
1.080	1596	1.280	2097	1.480	2744
1.085	1607	1.285	2111	1.485	2763
1.090	1618	1.290	2126	1.490	2781
1.095	1629	1.295	2140	1.495	2800
1.100	1641	1.300	2155	** 1.500	2819
1.105	1652	1.305	2169	1.505	2838

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APPENDIX A

TABLE A-IV. Minimum required ballistic limits - 20 mm fragment
simulating projectile at 0 degrees obliquity - 2519 alloy
required BL based on 1% rejection curve. - (Continued)

<u>Thickness (inches)</u>	<u>Required BL(P) fps</u>	<u>Thickness (inches)</u>	<u>Required BL(P) fps</u>	<u>Thickness (inches)</u>	<u>Required BL(P) fps</u>
1.510	2857	1.550	3013	1.590	3178
1.515	2876	1.555	3033	1.595	3199
1.520	2895	1.560	3053	1.600	3220
1.525	2914	1.565	3074	1.605	3242
1.530	2934	1.570	3094	1.610	3263
1.535	2953	1.575	3115	1.615	3285
1.540	2973	1.580	3136	1.620	3307
1.545	2993	1.585	3157	1.625	3329

* Specification requirements begin for ordered thickness 0.951 inch.

** Specification requirements end for ordered thickness 1.500 inches.

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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INSTRUCTIONS

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1. DOCUMENT NUMBER
MIL-A-46192B (MR)

2. DOCUMENT DATE (YYMMDD)
910701

ALUMINUM ALLOY ARMOR ROLLED PLATE (1/2 TO 4 INCHES THICK), WELDABLE (ALLOY 2519)

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*

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(2) AUTOVON
(if applicable)

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8. PREPARING ACTIVITY

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US ARMY RESEARCH LABORATORY

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