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MIL-DTL-32262 (MR)
31 July 2007

DETAIL SPECIFICATION

ARMOR PLATE, ALUMINUM ALLOY, UNWELDABLE APPLIQUE 6061

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 unweldable 6061 wrought aluminum alloy armor plate in nominal thicknesses from 0.250 to 3.000 inch, inclusive (see 6.2). The weldability of 6061 wrought aluminum alloy armor has not been determined. Therefore, these alloys should be used as an appliqué armor.

1.2 Classification. The wrought aluminum armor should be of the following classes as specified (see 6.2).

1.2.1 Class 1. Wrought aluminum armor that conforms to the Aluminum Association designation for the 6061 aluminum alloy.

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.

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| Comments, suggestions, or questions on this document should be addressed to: Director, U.S. Army Research Laboratory, Weapons and Materials Research Directorate, Materials Application Branch, Specifications and Standards Office, 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/ . |
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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 (see 6.2), the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-662 - V₅₀ Ballistic Test for Armor

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

2.3 Non-Government publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated (see 6.2), the issue in effect on the date of invitation for bids or request for proposal should apply.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

| | | |
|------------|---|---|
| ASTM B209 | - | Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (DoD adopted) |
| ASTM B557 | - | Standard Test Methods for Tension Testing Wrought and Cast Aluminum and Magnesium-Alloy Products (DoD adopted) |
| ASTM E34 | - | Standard Test Methods for Chemical Analysis of Aluminum and Aluminum-Base Alloys (DoD adopted) |
| ASTM E227 | - | Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique (DOCUMENT WITHDRAWN BY ASTM IN 2002) |
| ASTM E607 | - | Standard Test Method for Atomic Emission Spectrometric Analysis of Aluminum Alloys by the Point-to-Plane Technique, Nitrogen Atmosphere (DoD adopted) |
| ASTM E716 | - | Standard Practices for Sampling Aluminum and Aluminum Alloys for Spectrochemical Analysis |
| ASTM E1251 | - | Test Method for Analysis of Aluminum and Aluminum Alloys by Atomic Emission Spectrometry (DoD adopted) |

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

2.4 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.

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3. REQUIREMENTS

3.1 First article. When specified in the contract or purchase order (see 6.2), first article testing shall be required and all test samples required by this specification shall be made available to the contracting officer or his authorized representative for approval in accordance with 4.3. First article testing shall be completed before production material is submitted for acceptance testing. The approval of the first article samples authorizes commencement of production but does not relieve the supplier of the responsibility to comply with all the applicable provisions of this specification. The first article samples and acceptance test plates shall be manufactured by the process proposed for use on production items.

3.2 Chemical composition. The chemical composition of the plates shall be within the limits shown in Table I. The limits specified in Table I were taken from ASTM B209. A certification of conformance of the chemical composition of the alloy shall be furnished with the ballistic test plates.

3.3 Mechanical properties. Unless otherwise specified in the contract or order (see 6.2 and 6.3), the mechanical properties of the test specimen taken in the longitudinal direction shall meet the minimum mechanical properties listed in Table II. If mechanical property requirements differ from those contained in Table II, or if any other properties are required, the ballistic requirements shall be negotiated between the procuring activity and the supplier.

3.4 Ballistic limit. The protection ballistic limit, BL(P), shall be as specified in Appendix A. No ballistic limit shall be specified for plate thickness of 0.250 to 0.499 inch, inclusive. When a complete penetration can not be obtained for any class of armor material, the following rule shall be in effect until a new ballistic acceptance round can be developed and utilized. When the ballistic velocities of four (4) partial penetrations are above the minimum ballistic requirement for the specific thickness, the material shall be certified as acceptable with a V_{50} (which obviously can not be explicitly determined) above the minimum requirement.

3.5 Thermal processing. Any thermal processing exceeding 200°F (93°C) excluding fabrication by welding shall necessitate recertification for conformance to 3.3 and 3.4.

3.6 Dimensions. Dimensions and tolerances shall be as specified in the contract or order (see 6.2).

3.6.1 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 as specified in Table III.

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TABLE I. Chemical composition, percent. ^{1/}

| ELEMENTS | 6061 ALLOY ^{2/} |
|---------------------------------|---------------------------------|
| Silicon | 0.40 – 0.80 |
| Iron | 0.70 |
| Copper | 0.15 – 0.40 |
| Manganese | 0.15 |
| Magnesium | 0.8 – 1.2 |
| Chromium | 0.04 – 0.35 |
| Zinc | 0.25 |
| Titanium | 0.15 |
| Other, max. Each | 0.05 |
| Other, max. Total ^{3/} | 0.15 |
| Aluminum | Remainder |

^{1/} Except for “Aluminum” and “others”, analysis normally is made for elements for which specific limits are shown.

^{2/} Where single units are shown, these indicate the maximum amounts permitted.

^{3/} The sum of those “others” metallic elements 0.010 percent or more each, expressed to the second decimal before determining the sum.

3.7 Marking for identification. Unless otherwise specified in the contract or purchase order (see 6.2) each plate shall be marked on one plate edge with the manufacturer's name or trademark, the basic number of this specification, the plate thickness in inches, the alloy designation and the lot number or code relating to the lot number (see 4.2). The height of the characters shall be 3/8 of an inch or greater. Impression stamping shall not be used unless permitted by the procuring activity (see 6.2). Each plate shall be marked in lengthwise rows of characters recurring at intervals not greater than 3 feet, the rows being spaced not more than 6 inches apart and alternately staggered. The characters shall be not less than 3/8 inch in height and shall be applied using a suitable marking fluid whose residue shall contain not more than traces of halogen-bearing compounds and shall be capable of being removed in hot alkaline cleaning solution without rubbing. The markings shall have no deleterious effect on the plate material or its performance and shall be sufficiently stable to withstand normal handling.

3.7.1 Ballistic test plates. In addition to the markings in 3.7, 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 on the edge in letters 3/8 inch high or greater. Ballistic retest plates shall be marked "R1" and "R2" respectively (see A.5.2).

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TABLE II. Minimum mechanical properties. ^{1/2/}

| Thickness, inches | Tensile Strength, Ksi | Yield Strength, 0.2% Offset, Ksi | Elongation percent |
|-----------------------|-----------------------|-------------------------------------|--------------------|
| 0.250 to 0.499, incl. | 38.0 | 35.0 | 10 |
| 0.500 to 2.000, incl. | 38.0 | 37.0 | 10 |
| 2.001 to 3.000, incl. | 38.0 | 35.0 | 10 |

^{1/} See 6.3.^{2/} The gage length shall be 1.400 inch for plates having a nominal thickness of 0.500 inch.TABLE III. Thickness tolerances.

| Ordered Thickness (Inches) | | SPECIFIED WIDTH (Inches) | | | | | | | | |
|-------------------------------|-------|--------------------------------------|-------|-------|-------|-------|--------|--------|--------|--------|
| | | OVER | 0.00 | 39.37 | 59.06 | 78.74 | 98.43 | 118.11 | 137.80 | 157.48 |
| | | THRU | 39.37 | 59.06 | 78.74 | 98.43 | 118.11 | 137.80 | 157.48 | 177.17 |
| OVER | THRU | TOLERANCES - INCHES (PLUS and MINUS) | | | | | | | | |
| 0.250 | 0.315 | | 0.012 | 0.014 | 0.015 | 0.018 | 0.022 | 0.027 | 0.035 | 0.043 |
| 0.315 | 0.394 | | 0.015 | 0.017 | 0.020 | 0.023 | 0.027 | 0.033 | 0.041 | 0.051 |
| 0.394 | 0.630 | | 0.023 | 0.023 | 0.027 | 0.032 | 0.035 | 0.043 | 0.053 | 0.065 |
| 0.630 | 0.984 | | 0.031 | 0.031 | 0.037 | 0.043 | 0.047 | 0.058 | 0.070 | 0.085 |
| 0.984 | 1.575 | | 0.039 | 0.039 | 0.047 | 0.055 | 0.065 | 0.075 | 0.090 | 0.105 |
| 1.575 | 2.362 | | 0.055 | 0.055 | 0.060 | 0.070 | 0.085 | 0.100 | 0.115 | --- |
| 2.362 | 3.000 | | 0.075 | 0.075 | 0.085 | 0.100 | 0.105 | 0.125 | --- | --- |
| | | | | | | | | | | |

3.8 Ballistic test plate information. For each lot of aluminum alloy armor a properly completed Aluminum Armor Test Data Form (See Figure 1) shall be submitted with each ballistic test plate that represents that particular processing lot.

3.9 Workmanship. Plate produced under this specification shall be uniform in quality and clean, smooth and sufficiently free from buckles, blisters, hard spots, damaged ends, laminations and other defects which may affect its use.

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| REQUEST FOR BALLISTIC TEST OF ALUMINUM ARMOR | | | | | | | | | | |
|---|------------|---------------|--------------------------|-----------------------------------|------------------------------------|-------------------------|---------------|-------------------|------------------|-----|
| FIRING RECORD: | | | | | DATE: | | | | | |
| Plate MANUFACTURER / PRODUCER: | | | | | PRIME CONTRACTOR: | | | | | |
| Name: | | | | | Name: | | | | | |
| Address: | | | | | Address: | | | | | |
| POC: | | | | | POC: | | | | | |
| Phone No: | | | | | Phone No: | | | | | |
| Fax No: | | | | | Fax No: | | | | | |
| SPECIFICATION: MIL-DTL-32262 (MR) | | | | | REVISION: | | | AMENDMENT: | | |
| CONTRACT NO: | | | | | TECOM PROJECT NO: | | | | | |
| DCAS REGION: | | | | | BALLISTIC TEST CONTRACT NO: | | | | | |
| TEST ITEM IDENTIFICATION: | | | | | | | | | | |
| Lot No. | | | Plate No. | | | Ordered Thickness | | | Alloy and Temper | |
| PURPOSE: <input type="checkbox"/> Acceptance <input type="checkbox"/> First Article <input type="checkbox"/> Development | | | | | | | | | | |
| SAMPLE: <input type="checkbox"/> Primary <input type="checkbox"/> Retest (Firing Record No. of Failed Sample _____) | | | | | | | | | | |
| CHEMICAL ANALYSIS: | | | | | | | | | | |
| Si | Fe | Cu | Mn | Mg | Ch | Zn | Ti | Zr | | Al |
| | | | | | | | | | | Rem |
| MECHANICAL PROPERTIES: | | | | | | | | | | |
| UTS (ksi): | | | | 0.2% YS (ksi): | | | | Elongation (%): | | |
| BALLISTIC TEST RESULTS: | | | | | | | | | | |
| Test | Projectile | Obl. (deg) | Actual Thickness (in) | Required V ₅₀ (fps) | Actual V ₅₀ (fps) | Pass/ Fail | Notes | | | |
| | | | | | | | | | | |
| LOTS REPRESENTED BY: | | | | Reduced Testing | | | Audit Testing | | | |
| Lot [met] [failed to meet] the ballistic requirements of specification MIL-DTL-32262 (MR). | | | | | | | | | | |
| Government Representative | | | | Date | | Supplier Representative | | | Date | |

Figure 1. Aluminum Armor Test Data Form

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4. VERIFICATION

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

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

4.2 Lot. A lot shall consist of all plate of the same alloy and ordered thickness which has been processed together by the same mill practice. Unless otherwise specified in the contract or purchase order (see 6.2), the weight of the finished plate in the lot shall not exceed 50,000 pounds and shall be submitted for inspection as a unit.

4.3 First article inspection. 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 4.4.

4.4 Conformance inspection. Conformance inspection or production acceptance inspection shall include the examination of 4.6 and the tests of 4.7.

4.5 Sampling.

4.5.1 First article inspection.

4.5.1.1 Chemical composition. One (1) sample for chemical analysis shall be removed from each plate selected for ballistic testing and shall meet the requirements of 3.2 when tested as specified in 4.7.1.

4.5.1.2 Mechanical properties. One tension test specimen shall be removed from each plate that has been selected for ballistic testing and shall meet the requirements when tested as specified in 4.7.2.

4.5.1.3 Ballistic tests. Two plates, 12 inches by 36 inches of each thickness to be supplied on the contract, shall be submitted for ballistic testing in accordance with Appendix A. The orientation of these plates with respect to the rolling direction shall be at the option of the producer.

4.5.2 Conformance inspection.

4.5.2.1 Chemical composition. The sample shall meet the chemical composition requirements of 3.2 when tested as specified in 4.7.1.

4.5.2.1.1 Ingot analysis. At least one sample shall be taken from the molten metal representing the ingots poured as a unit from the same source molten metal. Complete ingot analysis records shall be available to the Government at the producer's facility.

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4.5.2.1.2 Product analysis. When sampling has not been made in accordance with 4.5.2.1.1, one sample shall be randomly taken for each 4,000 pounds or less in a lot. Complete product analysis records shall be available to the Government at the contractor's facility.

4.5.2.2 Mechanical properties. Samples for tension tests shall be selected from each lot in accordance with Table IV. Each sample shall be randomly selected from a different plate in the lot, and only one tension test specimen shall be made from each sample. The sample shall meet the requirements when tested as specified in 4.7.2.

TABLE IV. Number of tension tests.

| Lot size, pounds | Minimum number of samples ^{1/} |
|-------------------------|--|
| To 8,000, incl. | 2 |
| 8,001 to 12,000, incl. | 3 |
| 12,001 to 20,000, incl. | 4 |
| 20,001 up | 5 |

^{1/} If a lot consists of only one plate, one sample shall be required.

4.5.2.3 Ballistic testing. One plate, 12 inches by 36 inches, shall be randomly selected from each lot for ballistic testing. The orientation of the plate with respect to the rolling direction shall be at the option of the producer (see 6.2). The sample shall meet the requirements when tested as specified in 4.7.3.

4.6 Examination.

4.6.1 Visual. Each plate shall be examined for compliance with the identification marking (see 3.7) and workmanship (see 3.9) requirements.

4.6.2 Dimensions. Plates within a lot shall be measured to determine compliance with requirements of paragraph 3.6 in accordance with the sampling procedures approved by the procuring activity (see 6.2).

4.7 Test specimens.

4.7.1 Chemical composition. Samples for chemical analysis shall be prepared and tested in accordance with one or more ASTM methods of E34, E716, E227, E607, and E1251. In case of dispute, analysis by method E34 shall be the basis for acceptance or rejection.

4.7.2 Mechanical properties. Tension test specimens shall be prepared and tested in accordance with ASTM B557. Specimens shall be taken in the longitudinal direction. For material less than 0.500 inch in thickness, a standard rectangular tension test specimen shall be used. For plate in nominal thickness 0.500 to 1.500 inches, inclusive, tension test specimens shall be taken with the axis midway between the two plate

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surfaces. For plate in nominal thickness greater than 1.500 inches, the axis of the tension test specimen shall be three-fourths of the distance from one surface to the other.

4.7.3 Ballistic testing. The ordered thickness specified in the contract shall be used to determine the test projectile in accordance with Table V. Ballistic testing shall be in accordance with Appendix A. Test plate thickness, as measured by the ballistic testing agency, shall be used in conjunction with Table V and Appendix A to determine the required V_{50} protection ballistic limit for that plate. Thickness shall be determined as the average of at least four thickness measurements read on a deep throat micrometer or by means of an ultrasonic device to the nearest 0.001 of an inch and rounded off to the nearest 0.005 of an inch. Measurements shall be made on the intended impact area. In those cases where the BL(P) is within ± 10 fps of the minimum required value for the measured average thickness (to the nearest 0.005-inch), an interpolation of the appropriate ballistic limit table shall be performed. The average plate thickness, computed to the nearest 0.001-inch, shall be used to determine the minimum required BL(P) for that plate.

4.7.3.1 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: CSTE-DTC-AT-SL-V, Building 358, 400 Colleran Road, APG, MD 21005-5059 for ballistic testing for first article or lot acceptance.

TABLE V. Acceptance ballistic test plates.

| Ordered Thickness, Inches | Projectile | Angle of Obliquity in Degrees |
|-----------------------------|----------------|-------------------------------|
| 0.500 – 0.749 | Cal. .30 AP | 30 |
| 0.750 – 1.000 | Cal. .50 FSP | 0 |
| 1.001 – 1.700 ^{1/} | 20mm FSP | 0 |
| 1.001 – 1.700 ^{1/} | Cal. .30 AP M2 | 0 |
| 1.701 – 2.000 | Cal. .30 AP M2 | 0 |
| 2.001 – 3.000 | Cal. .50 AP M2 | 0 |

^{1/} Two (2) types of projectiles for the same thickness range.

4.7.3.2 Incomplete penetrations. When a complete penetration can not be obtained, the following rule shall be in effect until a new ballistic acceptance round can be developed and utilized. When the ballistic velocities of four (4) partial penetrations are above the minimum ballistic requirement for the specific thickness, the material shall be certified as acceptable with a V_{50} (which obviously can not be explicitly determined) above the minimum requirement.

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4.8 Rejection and retest. Unless otherwise specified in the contract or order (see 6.2) and except as specified in 4.7.2 and 4.7.3, rejection and retest shall be conducted in accordance with 4.8.1, 4.8.1.1, and 4.8.2.

4.8.1 Rejection of first article plates. When one or more first article test specimens fail to meet the requirements of 4.3, the product lot and process, represented by the test plates or specimens shall be subject to rejection except as otherwise provided in a sampling plan approved by the procuring activity and in requirements of 4.8.1.1.

4.8.1.1 Retest of first article samples. Resubmission and retest 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. If one of the retest specimens fails the lot shall be permanently rejected with no further testing permitted.

4.8.2 Ballistic. Rejection and retest of ballistic test plates shall be in accordance with A.5.2.

4.9 Reduced testing. At the discretion of the procuring activity (see 6.2), 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 providing the manufacturer agrees to maintain the same manufacturing procedures. Testing for a given plate thickness shall return to standard (non-reduced testing) conditions of one plate per lot, whenever a ballistic test plate fails to meet ballistic requirements.

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 components are 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 commands. 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 armor specified herein is intended for use on combat vehicles to protect the occupants against small arms fire, fragments, and shrapnel. Application for the 6061 alloy is the M1114 Up-Armored HMMWV vehicle. Program Executive Offices

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(PEO) for the Ground Combat Systems and the Future Combat Vehicle, Brigade Combat Team will also use 6061 alloys for their applications.

6.2 Ordering data. Procurement documents should specify the following:

- (a) Title, number and date of this specification.
- (b) Specify choice of alloy, and ordered thickness (see 1.1)
- (c) Specify classification (see 1.2).
- (d) If issues of documents are different (see 2.2.1 and A.2.1.1).
- (e) If a different issue is to be used (see 2.3)
- (f) When first article is required (see 3.1).
- (g) Special mechanical properties and ballistic requirements, if required (see 3.3).
- (h) Dimension and tolerance requirements if other than in 3.6 and 3.6.1.
- (i) If markings are different and when impression stamping is permissible (see 3.7).
- (j) If the weight of finished plate can exceed 50,000 pounds (see 4.2).
- (k) The orientation of the ballistic plate is different (see 4.5.2.3).
- (l) Dimensional sampling procedure approved by the procuring activity (see 4.6.2).
- (m) If approval was requested and received for a different ballistic testing facility (see 4.7.3.1)
- (n) Rejection and retest requirement, if other than in 4.8.
- (o) If reduced testing is allowed (see 4.9).
- (p) Packaging requirements (see 5.1).

6.3 Mechanical properties to ballistic requirements. The minimum mechanical properties specified (see 3.3) may not assure aluminum armor plate meeting the specified ballistic requirements (see 3.4). The following mechanical properties listed in Table VI for the various alloys and tempers are suggested values that can be specified in the contract or order, if a temper is to be specified.

TABLE VI. MECHANICAL PROPERTIES FOR EACH CLASS OF ALLOY

| ALLOY | TEMPER | Min. YS (Ksi) | Min. UTS (Ksi) | Min. E (%) |
|-------|----------|---------------|----------------|------------------------------|
| 6061 | T4, T451 | 21.0 | 35.0 | 22 |
| 6061 | T6, T651 | 40.0 | 45.0 | ¹ / ₁₆ |
| 6061 | T8 | 40.0 | 45.0 | 8 |
| 6061 | T91 | 57.3 | 58.7 | 12 |
| 6061 | T913 | 66.0 | 66.7 | 10 |

¹/₁₆ Elongation (% in 2"): 17 @ 1/2" thick or 12 @ 1/16" thick

6.4 Metric units. When metric divisions 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:

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| 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) |
| pounds/sq. inch | 0.00689 | = | mega Pascal (MPa) |

6.5 Aluminum Alloy Temper Designations. Information obtained from the MatWeb site: www.matweb.com/reference/aluminum_temper.asp.

6.5.1 Basic Designations.

6.5.1.1 'F' As Fabricated. No special control has been performed to the heat treatment or strain hardening after the shaping process such as casting, hot working, or cold working.

6.5.1.2 'O' Annealed. This is the lowest strength, highest ductility temper.

6.5.1.3 'H' Strain Hardened (applied to wrought products only). Used for products that have been strengthened by strain hardening, with or without subsequent heat treatment. The designation is followed by two or more numbers as discussed below.

6.5.1.4 'W' Solution Heat Treated. This is seldom encountered because it is an unstable temper that applies only to alloys that spontaneously age at ambient temperature after heat treatment.

6.5.1.5 'T' Solution Heat Treated. Used for products that have been strengthened by heat treatment, with or without subsequent strain hardening. The designation is followed by one or more numbers as discussed below.

6.5.2 'T' Temper Codes. Additional digits may be used after the first T temper digit to indicate subsequent stress relieving by processes such as stretching, compressing, or a combination of the two.

6.5.2.1 T1. Cooled from an elevated temperature shaping process and naturally aged to a substantially stable condition.

6.5.2.2 T2. Cooled from an elevated temperature shaping process, cold worked, and naturally aged to a substantially stable condition.

6.5.2.3 T3. Solution heat treated, cold worked, and naturally aged to a substantially stable condition.

6.5.2.4 T4. Solution heat treated, and naturally aged to a substantially stable condition.

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6.5.2.5 T5. Cooled from an elevated temperature shaping process then artificially aged.

6.5.2.6 T6. Solution heat treated then artificially aged.

6.5.2.7 T7. Solution heat treated then and overaged/stabilized.

6.5.2.8 T8. Solution heat treated, cold worked, then artificially aged.

6.5.2.9 T9. Solution heat treated, artificially aged, then cold worked.

6.5.2.10 T10. Cooled from an elevated temperature shaping process, cold worked, then artificially aged.

6.5.3 H Temper Strain Hardening Codes. The second digit (required) after the first H temper digit indicates the level of strain hardening and is based on the minimum ultimate tensile strength obtained. The third digit (optional) is a variation of the two digit temper.

6.5.3.1 H1. Strain hardened only

6.5.3.2 H2. Strain hardened and partially annealed

6.5.3.3 H3. Strain hardened and stabilized

6.5.3.4 H4. Strain hardened and lacquered or painted. This assumes that thermal affects from the coating process affect the strain hardening; not encountered often.

6.6 Definitions. According to the Aluminum Association.

6.6.1 Temper. Temper is the state of an alloy based on its processing route, i.e. metallurgical processes performed on an alloy. Temper of an alloy determines its mechanical properties as well as some other properties.

6.6.2 Recovery. The process preceding re-crystallization in point of time, or at lower temperatures when a deformed (cold worked) metal is heated. It is characterized by changes in internal stresses and physical properties, but is not accompanied by marked changes in mechanical properties or detectable micro-structural changes.

6.6.3 Stabilizing. The cold worked tempers of certain aluminum alloys will gradually soften on standing at room temperature over a long period of time. Stabilizing is a recovery treatment given to these alloys in order to eliminate age softening effects and to achieve strength and hardness that do not show further change on standing at room temperature

6.6.4 Annealing. A process involving heating and cooling to induce softening. In wrought Aluminum, the term generally indicates a treatment above the re-crystallization temperature.

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6.6.5 Cold Working or Cold deformation. Working a metal at such a temperature and rate that strain hardening occurs. This means simply working below re-crystallization temperature.

6.6.6 Recrystallization. The process of nucleation and growth by which the deformed and stressed grains are replaced by a new system of essentially equi-axed and stress free grains.

6.6.7 Nucleation. The formation of aggregates of atoms which are stable enough to grow and form new grains upon heating after deformation.

6.6.8 Partial Annealing. A treatment below the re-crystallization temperature, used to bring fully strain hardened alloy back to a desired intermediate strength. The terms “Recovery” and “Stress relief” also used for this type of treatment in some cases.

6.7 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. Please note that alternate ballistic testing facilities are being considered but at the present time, the requirements needed for approving an alternate facility are not fully known.

6.8 Subject term (key word) listing.

| | |
|-------------------|-------------------|
| Aluminum alloys | 14.5-mm API |
| Armor | 20-mm FSP |
| Armor plate | 20-mm API-T M602 |
| Ballistic testing | Military vehicles |
| Caliber .30 AP M2 | Stress corrosion |
| Caliber .50 AP M2 | |
| Caliber .50 FSP | |
| M1114 HMMWV | |

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BALLISTIC TESTING OF ALUMINUM ALLOY 6061 ARMOR PLATE

A.1 SCOPE

A.1.1 Scope. This appendix covers the minimum ballistic limits for acceptable requirements of aluminum alloy armor plate, un-weldable, 6061 when tested in accordance with the provisions of this specification. When there is mutual agreement between contractor and procuring activity, this appendix becomes a mandatory part of this specification and the information contained herein is intended for compliance.

A.2 APPLICABLE DOCUMENTS

A.2.1 Government documents.

A.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 (see 6.2), the issues of these documents are those cited in the solicitation or contract.

STANDARDS

DEPARTMENT OF DEFENSE

MIL-STD-662 - V50 Ballistic Test for Armor

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

A.3 DEFINITIONS

A.3.1 Complete penetration, (CP). A complete penetration occurs when the impacting projectile, or any fragment thereof, or any fragment of the test specimen perforates the witness plate, resulting in a crack or hole which permits light passage when a 60-watt, 110-volt bulb is placed proximate to the witness plate.

A.3.2 Fair impact. An impact may be considered fair when an un-yawed fragment simulator or test projectile strikes an unsupported area of the target material at a specified obliquity at a distance of at least two projectile diameters from any previous impact or disturbed area resulting from an impact, or from any crack, or from any edge of the test specimen.

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A.3.3 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.3.4 Partial penetration, (PP). Any impact which is not a complete penetration may be considered a partial penetration.

A.3.5 Witness plate. A thin sheet located behind and parallel to the ballistic test sample which is used to detect penetrating projectiles or spall.

A.4 REQUIREMENTS

A.4.1 Resistance to penetration. The minimum required V50 ballistic limit shall be in accordance with the values shown in tables A-I through A-V.

A.5 TESTS

A.5.1 Ballistic tests. Testing shall be in accordance with MIL-STD-662, V50 Ballistic Test for Armor, except that nothing in this procedure shall be construed to supersede or invalidate the requirements of this specification.

A.5.1.1 Temperature Conditioning. Prior to the test, the test item(s) shall be temperature conditioned at least eight hours. Thermostatic control shall be such that the average temperature of the item during the test shall be $72 \pm 15^{\circ}\text{F}$ ($22 \pm 8^{\circ}\text{C}$).

A.5.1.2 Protection ballistic limit, BL(P).

A.5.1.2.1 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) shall be reported.

A.5.1.2.2 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 shall 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 shall 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 shall continue until a 10-round ballistic limit has been attained

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using the smallest possible velocity spread. Ten-round ballistic limits shall be reported as agreed upon between the contractor and procuring activity.

A.5.1.2.3 Reduction of large velocity gap in borderline cases. If the ballistic limit, which has been determined, is within ± 10 fps from the minimum allowable ballistic limit and a gap exists which is greater than 25 fps, then another round, or rounds, shall be fired to reduce the gap to 25 fps or less. The ballistic limit shall then be recomputed using the above criteria. The recomputed BL(P) shall 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.5.2 Rejection and retest of ballistic plates.

A.5.2.1 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.5.2.2 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 shall be submitted for first article testing, and both tests shall pass; otherwise, the armor material shall be rejected.

A.5.2.3 Acceptance tests (rejection). Unless otherwise specified 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.5.2.4 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.5.3 Disposal of ballistic test plates.

A.5.3.1 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.5.3.2 Acceptance test plates. Acceptance test plates that comply with the requirements of this specification are considered 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 part of the lot they represent and remain the property of the producer. The now rejected lot also remains the property of the producer. The failed plates shall be returned, upon request, as in A.5.3.1.

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TABLE A-I. Minimum required ballistic limits - caliber .30 AP
M2 projectiles at 30° obliquity.

| Thickness, inches | Required BL(P), fps | Thickness, inches | Required BL(P), fps | Thickness, inches | Required BL(P), fps |
|----------------------|------------------------|----------------------|------------------------|----------------------|------------------------|
| 0.460 | 1290 | 0.570 | 1452 | 0.680 | 1599 |
| 0.465 | 1298 | 0.575 | 1459 | 0.685 | 1605 |
| 0.470 | 1305 | 0.580 | 1466 | 0.690 | 1612 |
| 0.475 | 1313 | 0.585 | 1473 | 0.695 | 1618 |
| 0.480 | 1321 | 0.590 | 1480 | 0.700 | 1624 |
| 0.485 | 1328 | 0.595 | 1487 | 0.705 | 1630 |
| 0.490 | 1336 | 0.600 | 1494 | 0.710 | 1637 |
| 0.495 | 1343 | 0.605 | 1500 | 0.715 | 1643 |
| 0.500 ^{1/} | 1351 | 0.610 | 1507 | 0.720 | 1649 |
| 0.505 | 1358 | 0.615 | 1514 | 0.725 | 1655 |
| 0.510 | 1366 | 0.620 | 1521 | 0.730 | 1661 |
| 0.515 | 1373 | 0.625 | 1527 | 0.735 | 1668 |
| 0.520 | 1381 | 0.630 | 1534 | 0.740 | 1674 |
| 0.525 | 1388 | 0.635 | 1541 | 0.745 | 1680 |
| 0.530 | 1395 | 0.640 | 1547 | 0.749 ^{2/} | 1685 |
| 0.535 | 1402 | 0.645 | 1554 | 0.750 | 1686 |
| 0.540 | 1410 | 0.650 | 1560 | 0.755 | 1692 |
| 0.545 | 1417 | 0.655 | 1567 | 0.760 | 1699 |
| 0.550 | 1424 | 0.660 | 1573 | 0.765 | 1705 |
| 0.555 | 1431 | 0.665 | 1580 | 0.770 | 1711 |
| 0.560 | 1438 | 0.670 | 1586 | 0.775 | 1717 |
| 0.565 | 1445 | 0.675 | 1593 | 0.780 | 1723 |

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

^{2/} Specification requirements end for this ordered thickness (See Table A-II).

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TABLE A-II. Minimum required ballistic limits - caliber .50 fragment
simulating projectiles at 0° obliquity.

| Thickness, inches | Required BL(P), fps | Thickness, inches | Required BL(P), fps | Thickness, inches | Required BL(P), fps |
|----------------------|------------------------|----------------------|------------------------|----------------------|------------------------|
| 0.720 | 1681 | 0.835 | 2046 | 0.950 | 2485 |
| 0.725 | 1696 | 0.840 | 2064 | 0.955 | 2506 |
| 0.730 | 1711 | 0.845 | 2081 | 0.960 | 2527 |
| 0.735 | 1725 | 0.850 | 2099 | 0.965 | 2549 |
| 0.740 | 1740 | 0.855 | 2117 | 0.970 | 2570 |
| 0.745 | 1755 | 0.860 | 2135 | 0.975 | 2592 |
| 0.750 ^{1/} | 1770 | 0.865 | 2153 | 0.980 | 2614 |
| 0.755 | 1785 | 0.870 | 2171 | 0.985 | 2636 |
| 0.760 | 1801 | 0.875 | 2190 | 0.990 | 2658 |
| 0.765 | 1816 | 0.880 | 2209 | 0.995 | 2680 |
| 0.770 | 1832 | 0.885 | 2227 | 1.000 ^{2/} | 2703 |
| 0.775 | 1848 | 0.890 | 2246 | 1.005 | 2726 |
| 0.780 | 1863 | 0.895 | 2265 | 1.010 | 2749 |
| 0.785 | 1879 | 0.900 | 2284 | 1.015 | 2772 |
| 0.790 | 1895 | 0.905 | 2304 | 1.020 | 2795 |
| 0.795 | 1912 | 0.910 | 2323 | 1.025 | 2819 |
| 0.800 | 1928 | 0.915 | 2343 | 1.030 | 2842 |
| 0.805 | 1945 | 0.920 | 2363 | 1.035 | 2866 |
| 0.810 | 1961 | 0.925 | 2383 | 1.040 | 2890 |
| 0.815 | 1978 | 0.930 | 2403 | 1.045 | 2914 |
| 0.820 | 1995 | 0.935 | 2423 | 1.050 | 2939 |
| 0.825 | 2012 | 0.940 | 2444 | 1.055 | 2963 |
| 0.830 | 2029 | 0.945 | 2464 | 1.060 | 2988 |

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

^{2/} Specification requirements end for this ordered thickness (See Table A-III and Table A-IV).

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TABLE A-III. Minimum required ballistic limits – 20 mm fragment
simulating projectiles at 0° obliquity.

| Thickness, inches | Required BL(P), fps | Thickness, inches | Required BL(P), fps | Thickness, inches | Required BL(P), fps |
|----------------------|------------------------|----------------------|------------------------|----------------------|------------------------|
| 0.980 | 1389 | 1.170 | 1700 | 1.360 | 2076 |
| 0.985 | 1397 | 1.175 | 1709 | 1.365 | 2087 |
| 0.990 | 1404 | 1.180 | 1718 | 1.370 | 2098 |
| 0.995 | 1412 | 1.185 | 1727 | 1.375 | 2109 |
| 1.001 ^{1/} | 1420 | 1.190 | 1736 | 1.380 | 2120 |
| 1.005 | 1427 | 1.195 | 1745 | 1.385 | 2131 |
| 1.010 | 1435 | 1.200 | 1755 | 1.390 | 2142 |
| 1.015 | 1443 | 1.205 | 1764 | 1.395 | 2153 |
| 1.020 | 1450 | 1.210 | 1773 | 1.400 | 2165 |
| 1.025 | 1458 | 1.215 | 1783 | 1.405 | 2176 |
| 1.030 | 1466 | 1.220 | 1792 | 1.410 | 2187 |
| 1.035 | 1474 | 1.225 | 1801 | 1.415 | 2199 |
| 1.040 | 1481 | 1.230 | 1811 | 1.420 | 2210 |
| 1.045 | 1489 | 1.235 | 1821 | 1.425 | 2222 |
| 1.050 | 1497 | 1.240 | 1830 | 1.430 | 2234 |
| 1.055 | 1505 | 1.245 | 1840 | 1.435 | 2245 |
| 1.060 | 1513 | 1.250 | 1849 | 1.440 | 2257 |
| 1.065 | 1521 | 1.255 | 1859 | 1.445 | 2269 |
| 1.070 | 1529 | 1.260 | 1869 | 1.450 | 2281 |
| 1.075 | 1537 | 1.265 | 1879 | 1.455 | 2293 |
| 1.080 | 1546 | 1.270 | 1889 | 1.460 | 2305 |
| 1.085 | 1554 | 1.275 | 1899 | 1.465 | 2317 |
| 1.090 | 1562 | 1.280 | 1909 | 1.470 | 2329 |
| 1.095 | 1570 | 1.285 | 1919 | 1.475 | 2341 |
| 1.100 | 1579 | 1.290 | 1929 | 1.480 | 2353 |
| 1.105 | 1587 | 1.295 | 1939 | 1.485 | 2366 |
| 1.110 | 1596 | 1.300 | 1949 | 1.490 | 2378 |
| 1.115 | 1604 | 1.305 | 1959 | 1.495 | 2390 |
| 1.120 | 1613 | 1.310 | 1970 | 1.500 | 2403 |
| 1.125 | 1621 | 1.315 | 1980 | 1.505 | 2415 |
| 1.130 | 1630 | 1.320 | 1991 | 1.510 | 2428 |
| 1.135 | 1638 | 1.325 | 2001 | 1.515 | 2441 |
| 1.140 | 1647 | 1.330 | 2012 | 1.520 | 2453 |
| 1.145 | 1656 | 1.335 | 2022 | 1.525 | 2466 |
| 1.150 | 1664 | 1.340 | 2033 | 1.530 | 2479 |
| 1.155 | 1673 | 1.345 | 2043 | 1.535 | 2492 |
| 1.160 | 1682 | 1.350 | 2054 | 1.540 | 2505 |
| 1.165 | 1691 | 1.355 | 2065 | 1.545 | 2518 |

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

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TABLE A-III. Minimum required ballistic limits – 20 mm fragment
simulating projectiles at 0° obliquity - (continued).

| Thickness, inches | Required BL(P), fps | Thickness, inches | Required BL(P), fps | Thickness, inches | Required BL(P), fps |
|----------------------|------------------------|----------------------|------------------------|----------------------|------------------------|
| 1.550 | 2531 | 1.610 | 2694 | 1.670 | 2867 |
| 1.555 | 2544 | 1.615 | 2708 | 1.675 | 2882 |
| 1.560 | 2558 | 1.620 | 2722 | 1.680 | 2897 |
| 1.565 | 2571 | 1.625 | 2737 | 1.685 | 2912 |
| 1.570 | 2585 | 1.630 | 2751 | 1.690 | 2928 |
| 1.575 | 2598 | 1.635 | 2765 | 1.695 | 2943 |
| 1.580 | 2612 | 1.640 | 2780 | 1.700 ^{2/} | 2958 |
| 1.585 | 2625 | 1.645 | 2794 | 1.705 | 2973 |
| 1.590 | 2639 | 1.650 | 2809 | 1.710 | 2989 |
| 1.595 | 2653 | 1.655 | 2823 | 1.715 | 3004 |
| 1.600 | 2666 | 1.660 | 2838 | 1.720 | 3019 |
| 1.605 | 2680 | 1.665 | 2853 | 1.725 | 3035 |

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

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TABLE A-IV. Minimum required ballistic limits - caliber .30 AP
M2 projectiles at 0° obliquity.

| Thickness, inches | Required BL(P), fps | Thickness, inches | Required BL(P), fps | Thickness, inches | Required BL(P), fps |
|----------------------|------------------------|----------------------|------------------------|----------------------|------------------------|
| 0.980 | 1792 | 1.170 | 2016 | 1.360 | 2218 |
| 0.985 | 1798 | 1.175 | 2022 | 1.365 | 2223 |
| 0.990 | 1804 | 1.180 | 2027 | 1.370 | 2229 |
| 0.995 | 1810 | 1.185 | 2033 | 1.375 | 2234 |
| 1.001 ^{1/} | 1817 | 1.190 | 2038 | 1.380 | 2239 |
| 1.005 | 1823 | 1.195 | 2044 | 1.385 | 2244 |
| 1.010 | 1829 | 1.200 | 2050 | 1.390 | 2249 |
| 1.015 | 1836 | 1.205 | 2055 | 1.395 | 2254 |
| 1.020 | 1842 | 1.210 | 2060 | 1.400 | 2259 |
| 1.025 | 1848 | 1.215 | 2066 | 1.405 | 2264 |
| 1.030 | 1854 | 1.220 | 2071 | 1.410 | 2269 |
| 1.035 | 1860 | 1.225 | 2077 | 1.415 | 2273 |
| 1.040 | 1866 | 1.230 | 2082 | 1.420 | 2278 |
| 1.045 | 1872 | 1.235 | 2088 | 1.425 | 2283 |
| 1.050 | 1878 | 1.240 | 2093 | 1.430 | 2288 |
| 1.055 | 1884 | 1.245 | 2098 | 1.435 | 2293 |
| 1.060 | 1890 | 1.250 | 2104 | 1.440 | 2298 |
| 1.065 | 1896 | 1.255 | 2109 | 1.445 | 2303 |
| 1.070 | 1902 | 1.260 | 2114 | 1.450 | 2308 |
| 1.075 | 1907 | 1.265 | 2120 | 1.455 | 2313 |
| 1.080 | 1913 | 1.270 | 2125 | 1.460 | 2318 |
| 1.085 | 1919 | 1.275 | 2130 | 1.465 | 2322 |
| 1.090 | 1925 | 1.280 | 2136 | 1.470 | 2327 |
| 1.095 | 1931 | 1.285 | 2141 | 1.475 | 2332 |
| 1.100 | 1937 | 1.290 | 2146 | 1.480 | 2337 |
| 1.105 | 1942 | 1.295 | 2151 | 1.485 | 2342 |
| 1.110 | 1948 | 1.300 | 2157 | 1.490 | 2347 |
| 1.115 | 1954 | 1.305 | 2162 | 1.495 | 2352 |
| 1.120 | 1960 | 1.310 | 2167 | 1.500 | 2356 |
| 1.125 | 1965 | 1.315 | 2172 | 1.505 | 2361 |
| 1.130 | 1971 | 1.320 | 2177 | 1.510 | 2366 |
| 1.135 | 1977 | 1.325 | 2183 | 1.515 | 2371 |
| 1.140 | 1983 | 1.330 | 2188 | 1.520 | 2376 |
| 1.145 | 1988 | 1.335 | 2193 | 1.525 | 2380 |
| 1.150 | 1994 | 1.340 | 2198 | 1.530 | 2385 |
| 1.155 | 2000 | 1.345 | 2203 | 1.535 | 2390 |
| 1.160 | 2005 | 1.350 | 2208 | 1.540 | 2394 |
| 1.165 | 2011 | 1.355 | 2213 | 1.545 | 2399 |

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

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TABLE A-IV. Minimum required ballistic limits - caliber .30 AP
M2 projectiles at 0° obliquity (continued).

| Thickness, inches | Required BL(P), fps | Thickness, inches | Required BL(P), fps | Thickness, inches | Required BL(P), fps |
|----------------------|------------------------|----------------------|------------------------|----------------------|------------------------|
| 1.550 | 2404 | 1.720 | 2559 | 1.890 | 2705 |
| 1.555 | 2409 | 1.725 | 2563 | 1.895 | 2709 |
| 1.560 | 2413 | 1.730 | 2568 | 1.900 | 2713 |
| 1.565 | 2418 | 1.735 | 2572 | 1.905 | 2717 |
| 1.570 | 2423 | 1.740 | 2576 | 1.910 | 2722 |
| 1.575 | 2427 | 1.745 | 2581 | 1.915 | 2726 |
| 1.580 | 2432 | 1.750 | 2585 | 1.920 | 2730 |
| 1.585 | 2437 | 1.755 | 2590 | 1.925 | 2734 |
| 1.590 | 2441 | 1.760 | 2594 | 1.930 | 2738 |
| 1.595 | 2446 | 1.765 | 2598 | 1.935 | 2742 |
| 1.600 | 2450 | 1.770 | 2603 | 1.940 | 2746 |
| 1.605 | 2455 | 1.775 | 2607 | 1.945 | 2751 |
| 1.610 | 2460 | 1.780 | 2611 | 1.950 | 2755 |
| 1.615 | 2464 | 1.785 | 2616 | 1.955 | 2759 |
| 1.620 | 2469 | 1.790 | 2620 | 1.960 | 2763 |
| 1.625 | 2473 | 1.795 | 2624 | 1.965 | 2767 |
| 1.630 | 2478 | 1.800 | 2629 | 1.970 | 2771 |
| 1.635 | 2482 | 1.805 | 2633 | 1.975 | 2775 |
| 1.640 | 2487 | 1.810 | 2637 | 1.980 | 2779 |
| 1.645 | 2492 | 1.815 | 2641 | 1.985 | 2783 |
| 1.650 | 2496 | 1.820 | 2646 | 1.990 | 2787 |
| 1.655 | 2501 | 1.825 | 2650 | 1.995 | 2791 |
| 1.660 | 2505 | 1.830 | 2654 | 2.000 ^{2/} | 2796 |
| 1.665 | 2510 | 1.835 | 2658 | 2.005 | 2800 |
| 1.670 | 2514 | 1.840 | 2663 | 2.010 | 2804 |
| 1.675 | 2519 | 1.845 | 2667 | 2.015 | 2808 |
| 1.680 | 2523 | 1.850 | 2671 | 2.020 | 2812 |
| 1.685 | 2528 | 1.855 | 2675 | 2.025 | 2816 |
| 1.690 | 2532 | 1.860 | 2680 | 2.030 | 2820 |
| 1.695 | 2537 | 1.865 | 2684 | 2.035 | 2824 |
| 1.700 | 2541 | 1.870 | 2688 | 2.040 | 2828 |
| 1.705 | 2545 | 1.875 | 2692 | 2.045 | 2832 |
| 1.710 | 2550 | 1.880 | 2697 | 2.050 | 2836 |
| 1.715 | 2554 | 1.885 | 2701 | 2.055 | 2840 |

^{2/} Specification requirements end for this ordered thickness (See Table A-V).

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TABLE A-V. Minimum required ballistic limits - caliber .50 AP
M2 projectiles at 0° obliquity.

| Thickness, inches | Required BL(P), fps | Thickness, inches | Required BL(P), fps | Thickness, inches | Required BL(P), fps |
|----------------------|------------------------|----------------------|------------------------|----------------------|------------------------|
| 1.950 | 2041 | 2.135 | 2164 | 2.320 | 2281 |
| 1.955 | 2045 | 2.140 | 2168 | 2.325 | 2284 |
| 1.960 | 2048 | 2.145 | 2171 | 2.330 | 2287 |
| 1.965 | 2051 | 2.150 | 2174 | 2.335 | 2290 |
| 1.970 | 2055 | 2.155 | 2177 | 2.340 | 2293 |
| 1.975 | 2058 | 2.160 | 2180 | 2.345 | 2296 |
| 1.980 | 2062 | 2.165 | 2184 | 2.350 | 2299 |
| 1.985 | 2065 | 2.170 | 2187 | 2.355 | 2303 |
| 1.990 | 2068 | 2.175 | 2190 | 2.360 | 2306 |
| 1.995 | 2072 | 2.180 | 2193 | 2.365 | 2309 |
| 2.001 ^{1/} | 2075 | 2.185 | 2196 | 2.370 | 2312 |
| 2.005 | 2079 | 2.190 | 2200 | 2.375 | 2315 |
| 2.010 | 2082 | 2.195 | 2203 | 2.380 | 2318 |
| 2.015 | 2085 | 2.200 | 2206 | 2.385 | 2321 |
| 2.020 | 2089 | 2.205 | 2209 | 2.390 | 2324 |
| 2.025 | 2092 | 2.210 | 2212 | 2.395 | 2327 |
| 2.030 | 2095 | 2.215 | 2216 | 2.400 | 2330 |
| 2.035 | 2099 | 2.220 | 2219 | 2.405 | 2333 |
| 2.040 | 2102 | 2.225 | 2222 | 2.410 | 2336 |
| 2.045 | 2105 | 2.230 | 2225 | 2.415 | 2339 |
| 2.050 | 2109 | 2.235 | 2228 | 2.420 | 2342 |
| 2.055 | 2112 | 2.240 | 2231 | 2.425 | 2345 |
| 2.060 | 2115 | 2.245 | 2234 | 2.430 | 2348 |
| 2.065 | 2119 | 2.250 | 2238 | 2.435 | 2351 |
| 2.070 | 2122 | 2.255 | 2241 | 2.440 | 2354 |
| 2.075 | 2125 | 2.260 | 2244 | 2.445 | 2357 |
| 2.080 | 2128 | 2.265 | 2247 | 2.450 | 2360 |
| 2.085 | 2132 | 2.270 | 2250 | 2.455 | 2363 |
| 2.090 | 2135 | 2.275 | 2253 | 2.460 | 2366 |
| 2.095 | 2138 | 2.280 | 2256 | 2.465 | 2369 |
| 2.100 | 2142 | 2.285 | 2259 | 2.470 | 2372 |
| 2.105 | 2145 | 2.290 | 2263 | 2.475 | 2375 |
| 2.110 | 2148 | 2.295 | 2266 | 2.480 | 2378 |
| 2.115 | 2151 | 2.300 | 2269 | 2.485 | 2380 |
| 2.120 | 2155 | 2.305 | 2272 | 2.490 | 2383 |
| 2.125 | 2158 | 2.310 | 2275 | 2.495 | 2386 |
| 2.130 | 2161 | 2.315 | 2278 | 2.500 | 2389 |

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

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TABLE A-V. Minimum required ballistic limits - caliber .50 AP
M2 projectiles at 0° obliquity (continued).

| Thickness, inches | Required BL(P), fps | Thickness, inches | Required BL(P), fps | Thickness, inches | Required BL(P), fps |
|----------------------|------------------------|----------------------|------------------------|----------------------|------------------------|
| 2.505 | 2392 | 2.695 | 2501 | 2.885 | 2606 |
| 2.510 | 2395 | 2.700 | 2504 | 2.890 | 2609 |
| 2.515 | 2398 | 2.705 | 2507 | 2.895 | 2612 |
| 2.520 | 2401 | 2.710 | 2510 | 2.900 | 2614 |
| 2.525 | 2404 | 2.715 | 2513 | 2.905 | 2617 |
| 2.530 | 2407 | 2.720 | 2516 | 2.910 | 2620 |
| 2.535 | 2410 | 2.725 | 2518 | 2.915 | 2622 |
| 2.540 | 2413 | 2.730 | 2521 | 2.920 | 2625 |
| 2.545 | 2416 | 2.735 | 2524 | 2.925 | 2628 |
| 2.550 | 2419 | 2.740 | 2527 | 2.930 | 2630 |
| 2.555 | 2421 | 2.745 | 2529 | 2.935 | 2633 |
| 2.560 | 2424 | 2.750 | 2532 | 2.940 | 2636 |
| 2.565 | 2427 | 2.755 | 2535 | 2.945 | 2639 |
| 2.570 | 2430 | 2.760 | 2538 | 2.950 | 2641 |
| 2.575 | 2433 | 2.765 | 2541 | 2.955 | 2644 |
| 2.580 | 2436 | 2.770 | 2543 | 2.960 | 2647 |
| 2.585 | 2439 | 2.775 | 2546 | 2.965 | 2649 |
| 2.590 | 2442 | 2.780 | 2549 | 2.970 | 2652 |
| 2.595 | 2445 | 2.785 | 2552 | 2.975 | 2654 |
| 2.600 | 2447 | 2.790 | 2554 | 2.980 | 2657 |
| 2.605 | 2450 | 2.795 | 2557 | 2.985 | 2660 |
| 2.610 | 2453 | 2.800 | 2560 | 2.990 | 2662 |
| 2.615 | 2456 | 2.805 | 2563 | 2.995 | 2665 |
| 2.620 | 2459 | 2.810 | 2565 | 3.000 ^{2/} | 2668 |
| 2.625 | 2462 | 2.815 | 2568 | 3.005 | 2670 |
| 2.630 | 2465 | 2.820 | 2571 | 3.010 | 2673 |
| 2.635 | 2468 | 2.825 | 2574 | 3.015 | 2676 |
| 2.640 | 2470 | 2.830 | 2576 | 3.020 | 2678 |
| 2.645 | 2473 | 2.835 | 2579 | 3.025 | 2681 |
| 2.650 | 2476 | 2.840 | 2582 | 3.030 | 2684 |
| 2.655 | 2479 | 2.845 | 2585 | 3.035 | 2686 |
| 2.660 | 2482 | 2.850 | 2587 | 3.040 | 2689 |
| 2.665 | 2485 | 2.855 | 2590 | 3.045 | 2691 |
| 2.670 | 2487 | 2.860 | 2593 | 3.050 | 2694 |
| 2.675 | 2490 | 2.865 | 2595 | 3.055 | 2697 |
| 2.680 | 2493 | 2.870 | 2598 | 3.060 | 2699 |
| 2.685 | 2496 | 2.875 | 2601 | 3.065 | 2702 |
| 2.690 | 2499 | 2.880 | 2604 | 3.070 | 2704 |

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

MIL-DTL-32262 (MR)

CONCLUDING MATERIAL

Custodians:
Army – MR

Preparing activity:
ARMY – MR
(Project 9535-2007-003)

Review activities:
Army – AR, AT, AV, TE
DLA – IS

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/>.