

INCH-POUND

MIL-DTL-46027K(MR)
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SUPERSEDING
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DETAIL SPECIFICATION

ARMOR PLATE, ALUMINUM ALLOY, WELDABLE 5083, 5456, & 5059

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 weldable 5083, 5456, and 5059 wrought aluminum alloy armor plate in nominal thicknesses from 0.250 to 3.000 inch, inclusive (see 6.2).

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 5083 aluminum alloy.

1.2.2 Class 2. Wrought aluminum armor that conforms to the Aluminum Association designation for the 5456 aluminum alloy.

1.2.3 Class 3. Wrought aluminum armor that conforms to the Aluminum Association designation for the 5059 aluminum alloy.

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. APPLICABLE DOCUMENTS

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

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified (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)

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ASTM G47 - Standard Test Method for Determining Susceptibility to Stress-Corrosion Cracking of 2XXX and 7XXX Aluminum Alloy Products (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.

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 purchase 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.

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

ELEMENTS	ALLOYS ^{2/}		
	5083 CLASS 1	5456 CLASS 2	5059 CLASS 3
Silicon	0.40	0.25	0.45
Iron	0.40	0.40	0.50
Copper	0.10	0.10	0.25
Manganese	0.40 - 1.0	0.50 - 1.0	0.6 - 1.2
Magnesium	4.0 - 4.9	4.7 - 5.5	5.0 - 6.0
Chromium	0.05 - 0.25	0.05 - 0.20	0.25
Zinc	0.25	0.25	0.40 - 0.9
Titanium	0.15	0.20	0.20
Other, max. Each	0.05	0.05	0.05
Other, max. Total ^{3/}	0.15	0.15	0.15
Aluminum	Remainder	Remainder	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.

3.5 Stress corrosion resistance. When stress corrosion testing is specified in the contract or purchase order (see 6.2) and unless otherwise specified in the contract or purchase order (see 6.2), plate 0.750 inch and over in thickness shall be resistant to stress corrosion cracking, with a minimum of 5 of the 9 specimens showing no evidence of cracking at the end of 96 hours.

3.6 Thermal processing. After final strain hardening performed during plate fabrication, any thermal processing exceeding 200°F (93°C) excluding fabrication by welding shall necessitate recertification for conformance to 3.3, 3.4 and 3.5.

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

Thickness, inches	Tensile Strength, Ksi			Yield Strength, 0.2% Offset, Ksi			Elongation percent		
	5083	5456	5059	5083	5456	5059	5083	5456	5059
0.250 to 0.499, incl.	45.0	45.0	53.0	35.0	35.0	39.0	8	8	8
0.500 to 2.000, incl.	45.0	45.0	52.0	37.0	37.0	39.0	8	8	7
2.001 to 3.000, incl.	44.0	44.0	47.0	35.0	35.0	39.0	9	9	8

^{1/} See 6.3.

^{2/} The gage length shall be 1.400 inch for plates having a nominal thickness of 0.500 inch.

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

3.7.1 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.

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
OVER	THRU	THRU	39.37	59.06	78.74	98.43	118.11	137.80	157.48	177.17
		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 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.

3.8.1 Ballistic test plates. In addition to the markings 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 on the horizontal edge face of the ballistic plate in letters 3/8 inch high or greater. Ballistic retest plates shall be marked "R1" and "R2" respectively (see A.5.2).

3.9 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.

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3.10 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.

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.

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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-46027					REVISION: K			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: ___ Acceptance ___ First Article ___ Development										
SAMPLE: ___ Primary ___ 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-46027K(MR).										
Government Representative				Date		Supplier Representative			Date	

Figure 1. Aluminum Armor Test Data Form

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4.5.1.4 Stress corrosion tests. The stress corrosion test specimens shall be removed from the same plate that has been selected for ballistic testing. The location and type of specimen shall be as specified in 4.7.4.

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.

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.

4.5.2.4 Stress corrosion tests. When required (see 6.2), one plate, 12 inches by 12 inches, shall be randomly selected from each lot for stress corrosion testing. The plate shall meet the requirements when tested as specified in 4.7.4.

4.6 Examination.

4.6.1 Visual. Each plate shall be examined for compliance with the identification marking (see 3.8) and workmanship (see 3.10) requirements.

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4.6.2 Dimensions. Plates within a lot shall be measured to determine compliance with requirements of paragraph 3.7 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 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.

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.

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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.

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.

4.7.4 Stress corrosion. The stress corrosion specimens shall be stressed at 30 ksi.

4.7.4.1 Capability requirements for resistance to stress corrosion. When stress corrosion testing is required (see 6.2), stress corrosion test specimens shall be prepared and tested in accordance with ASTM G47.

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.

4.8.3 Stress corrosion. Immediately upon notification of the failure of the specimens, the manufacturer may at his own expense submit thirteen additional specimens for testing. A minimum of seven specimens shall show no cracks at the end of 96 hours when tested as specified in 4.7.4.

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.

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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. PEOs for the Ground Combat Systems and the Future Combat Vehicle, Brigade Combat Team will use the 5059 alloy 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) When stress corrosion testing is required and if the test conditions are different (see 3.5, 4.5.2.4, and 4.7.4.1).
- (i) Dimension and tolerance requirements if other than in 3.7 and 3.7.1.
- (j) If markings are different and when impression stamping is permissible (see 3.8).
- (k) If the weight of finished plate can exceed 50,000 pounds (see 4.2).
- (l) The orientation of the ballistic plate is different (see 4.5.2.3).
- (m) Dimensional sampling procedure approved by the procuring activity (see 4.6.2).
- (n) If approval was requested and received for a different ballistic testing facility (see 4.7.3.1)
- (o) Rejection and retest requirement, if other than in 4.8.
- (p) If reduced testing is allowed (see 4.9).
- (q) Packaging requirements (see 5.1).

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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. Minimum mechanical properties for each class of alloy.

5083	Tensile Strength, Ksi			Yield Strength, 0.2% Offset, Ksi			Elongation percent		
	H131	H136	H321 H116	H131	H136	H321 H116	H131	H136	H321 H116
Thickness, inches									
0.250 to 0.499, incl.	45.0	44.0	44.0	35.0	31.0	31.0	8	10	10
0.500 to 2.000, incl.	45.0	41.0	41.0	37.0	29.0	29.0	8	10	10
2.001 to 3.000, incl.	44.0	41.0	41.0	35.0	29.0	29.0	9	10	10

5083	Tensile Strength, Ksi			Yield Strength, 0.2% Offset, Ksi			Elongation percent		
	H112	H34 H343	H32 H323	H112	H34 H343	H32 H323	H112	H34 H343	H32 H323
Thickness, inches									
0.250 to 0.499, incl.	40.0	50.0	45.0	18.0	39.0	34.0	12	8	10
0.500 to 2.000, incl.	39.0	∟	∟	17.0	∟	∟	12	∟	∟
2.001 to 3.000, incl.	39.0	∟	∟	17.0	∟	∟	12	∟	∟

∟ Too thick for this temper.

5456	Tensile Strength, Ksi			Yield Strength, 0.2% Offset, Ksi			Elongation percent		
	H131	H321 H116	H24	H131	H321 H116	H24	H131	H321 H116	H24
Thickness, inches									
0.250 to 0.499, incl.	45.0	46.0	53.7	35.0	33.0	40.6	8	10	13
0.500 to 2.000, incl.	45.0	41.0	53.7	37.0	29.0	40.6	8	12	13
2.001 to 3.000, incl.	44.0	41.0	53.7	35.0	29.0	40.6	9	12	13

5456	Tensile Strength, Ksi			Yield Strength, 0.2% Offset, Ksi			Elongation percent		
	H111	H25	H112	H111	H25	H112	H111	H25	H112
Thickness, inches									
0.250 to 0.499, incl.	46.4	45.0	42.0	33.4	24.0	19.0	18	22	12
0.500 to 2.000, incl.	46.4	45.0	41.0	33.4	24.0	18.0	18	22	12
2.001 to 3.000, incl.	46.4	45.0	41.0	33.4	24.0	18.0	18	22	12

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5059	Tensile Strength, Ksi			Yield Strength, 0.2% Offset, Ksi			Elongation percent		
	H131	H136	H321 H116	H131	H136	H321 H116	H131	H136	H321 H116
0.250 to 0.499, incl.	57.0	53.0	44.0	44.0	43.0	31.0	8	10	10
0.500 to 2.000, incl.	57.0	52.0	41.0	43.0	42.0	29.0	7	10	10
2.001 to 3.000, incl.	50.0	50.0	41.0	42.0	42.0	29.0	8	10	10

5059	Tensile Strength, Ksi			Yield Strength, 0.2% Offset, Ksi			Elongation percent		
	H111	H112		H111	H112		H111	H112	
0.250 to 0.499, incl.	57.0	47.0		44.0	23.0		24	22	
0.500 to 2.000, incl.	57.0	∟		43.0	∟		17	∟	
2.001 to 3.000, incl.	50.0	∟		42.0	∟		17	∟	

∟ Too thick for this temper.

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:

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.

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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.

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

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6.5.3.3 H3. Strain hardened and stabilized

6.5.3.4 H4. Strain hardened and lacquered or painted. This assumes that thermal effects 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.

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

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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	

6.9 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

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APPENDIX A

BALLISTIC TESTING OF ALUMINUM ALLOY ARMOR PLATE
5083, 5456, and 5059

A.1 SCOPE

A.1.1 Scope. This appendix covers the minimum ballistic limits for acceptable requirements of aluminum alloy armor plate, weldable, 5083, 5456, and 5059 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, 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).

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 V₅₀ Ballistic Protection Limits (BL(P))
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 ^{1/2}	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

^{1/2} 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 ^{1/2}	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

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

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APPENDIX A

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-46027K(MR)

CONCLUDING MATERIAL

Custodians:
Army – MR

Preparing activity:
ARMY – MR
(Project 9535-2006-003)

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/>