

INCH-POUND
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MIL-DTL-32341 (MR)

31 March 2010

## DETAIL SPECIFICATION

## ARMOR PLATE, ALUMINUM ALLOY, 2xxx, UNWELDABLE APPLIQUE

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 2xxx wrought aluminum alloy armor plate for non fusion welded applications in nominal thicknesses from 0.500 to 4.000 inch, inclusive (see 6.2). The fusion weldability of 2xxx wrought aluminum alloy armor has not been determined over this thickness range. Therefore, these alloys should only be used as appliqué armor.

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

1.2.1 Class I. Wrought aluminum armor that conforms to the Aluminum Association designation for the 2139 aluminum alloy in a T8 temper. The applicable gauge range for Class I is 0.500-4.000 inches.

1.2.2 Class II. Wrought aluminum armor that conforms to the Aluminum Association designation for the 2195 aluminum alloy in a T64 temper. The applicable gauge range for Class II is 0.500-2.250 inches.

Comments, suggestions, or questions on this document should be addressed to: Director, U.S. Army Research Laboratory, Weapons and Materials Research Directorate, Materials and Manufacturing Technology Branch, Specifications and Standards Office, Attn: RDRL-WMM-D, Aberdeen Proving Ground, MD 21005-5069 or emailed to <a href="mailto:rsquilla@arl.army.mil">rsquilla@arl.army.mil</a> . Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at <a href="https://assist.daps.dla.mil/">https://assist.daps.dla.mil/</a> .
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AMSC N/A

FSC 9535

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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 - V<sub>50</sub> Ballistic Test for Armor

(Copies of these documents are available online at <https://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.

## SAE INTERNATIONAL

AMS 2750 - Pyrometry  
AMS 2772 - Heat Treatment of Aluminum Alloy Raw Materials

(Application for copies should be addressed to SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001.)

## AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

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)

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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	-	Standard 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](http://www.astm.org) or ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959.)

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

### 3. REQUIREMENTS

3.1 First article. When specified in the contract or purchase order (see 6.2), 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 Aluminum Association (AA) registered composition limits for Aluminum Alloys. 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), 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. When a complete penetration can not be obtained for any class of armor

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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.

TABLE I. Chemical composition, weight percent. <sup>1/</sup>

ELEMENTS	SYMBOL	Class I 2139 ALLOY <sup>2/</sup>	Class II 2195 ALLOY <sup>2/</sup>
Silicon	Si	0.10	0.12
Iron	Fe	0.15	0.15
Copper	Cu	4.5 - 5.5	3.7 - 4.3
Manganese	Mn	0.20 - 0.60	0.25
Magnesium	Mg	0.20 - 0.80	0.25 - 0.8
Chromium	Cr	0.005	N/A
Zinc	Zn	0.25	0.25
Titanium	Ti	0.15	0.10
Vanadium	V	0.05	N/A
Zirconium	Zr	N/A	0.08 - 0.16
Lithium	Li	N/A	0.8 - 1.2
Silver	Ag	0.15 - 0.60	0.25 - 0.6
Other, max. Each	---	0.05	0.05
Other, max. Total <sup>3/</sup>	---	0.15	0.15
Aluminum	Al	Remainder	Remainder

<sup>1/</sup> Except for “Aluminum” and “others”, analysis normally is made for elements for which specific limits are shown.

<sup>2/</sup> Where single units are shown, these indicate the maximum amounts permitted.

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

TABLE II. Minimum mechanical properties. <sup>1/</sup>

Thickness, inches	Tensile Strength, ksi		Yield Strength, 0.2% Offset, ksi		Elongation percent	
	Class I	Class II	Class I	Class II	Class I	Class II
0.500 to 3.000, incl.	67	71 <sup>2/</sup>	64	63 <sup>2/</sup>	9	9 <sup>2/</sup>
3.001 to 4.000, incl.	67	N/A	64	N/A	9	N/A

<sup>1/</sup> The gage length shall be 1.400 inch for plates having a nominal thickness of 0.500 inch.

<sup>2/</sup> For alloy 2195 (Class II) the applicable gauge range is 0.500-2.250 inches.

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3.5 Thermal processing. Heat treatment shall conform to the requirements of SAE AMS 2750 and SAE AMS 2772 and shall be such as to enable the material to meet the requirements of these specifications.

3.6 Dimensions. Dimensions 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.

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 CAGE code, 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).

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)								
0.500	1.000		0.031	0.031	0.037	.043	0.051	0.060	0.070	0.085
1.000	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	---	---
3.000	4.000		0.090	0.090	0.105	0.110	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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<b>REQUEST FOR BALLISTIC TEST OF ALUMINUM ALLOY 2xxx ARMOR</b>											
<b>FIRING RECORD:</b>						<b>DATE:</b>					
<b>Plate MANUFACTURER / PRODUCER:</b>						<b>PRIME CONTRACTOR:</b>					
Name:						Name:					
Address:						Address:					
POC:						POC:					
Phone No:						Phone No:					
Fax No:						Fax No:					
<b>SPECIFICATION:</b> MIL-DTL- 32341 (MR)						<b>REVISION:</b>			<b>AMENDMENT:</b>		
<b>CONTRACT NO:</b>						<b>ATC PROJECT NO:</b>					
<b>DCAS REGION:</b>						<b>BALLISTIC TEST CONTRACT NO:</b>					
<b>TEST ITEM IDENTIFICATION:</b>											
Lot No.			Plate No.			Ordered			Alloy and Temper		
Class:						Thickness					
<b>PURPOSE:</b> Acceptance      First Article      Development											
<b>SAMPLE:</b> Primary      Retest (Firing Record No. of Failed Sample      )											
<b>CHEMICAL ANALYSIS:</b>				<b>OTHERS:</b>						Al :	
Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	V	Zr	Li	Ag
<b>MECHANICAL PROPERTIES:</b>											
UTS (ksi):				0.2% YS (ksi):				Elongation (%):			
<b>BALLISTIC TEST RESULTS:</b>											
Test	Projectile	Obl.	Actual	Required	Actual	Pass/	Notes				
		(deg)	Thickness (in)	V <sub>50</sub> (fps)	V <sub>50</sub> (fps)	Fail					
<b>LOTS REPRESENTED BY:</b>				Reduced Testing				Audit Testing			
Lot [ met ] [failed to meet ] the ballistic requirements of specification MIL-DTL- 32341 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.

<b>Lot size, pounds</b>	<b>Minimum number of samples <sup>1/</sup></b>
To 8,000, incl.	2
8,001 to 12,000, incl.	3
12,001 to 20,000, incl.	4
20,001 up	5

<sup>1/</sup> 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, E607, E716, 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  $\pm 10$  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	TABLE	CLASS I (2139)	CLASS II (2195)
0.500 - 0.749	Cal. .30 AP M2	30	A-I	TBD <sup>1/</sup>	LISTED
0.750 - 0.950	Cal. .50 FSP	0	A-II	LISTED – SAME $V_{50}$	
0.951 - 1.500	20-mm FSP	0	A-III	LISTED - SAME $V_{50}$	
0.750 - 1.500	Cal. .30 AP M2	0	A-IV	LISTED - SAME $V_{50}$	
1.501 - 2.500	Cal. .50 AP M2	0	A-V	LISTED	LISTED <sup>2/</sup>
2.501 - 3.500	14.5-mm BS41	0	A-VI	LISTED	N/A
3.501 – 4.000	20-mm M602	0	A-VII	TBD	N/A

<sup>1/</sup> To be determined.

<sup>2/</sup> Class II (alloy 2195) the applicable gauge for ordered thickness ends at 2.250 inches.

**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 and tactical vehicles to protect the occupants against small arms fire, fragments, and shrapnel.

6.2 Ordering data. Procurement documents should specify the following:

- (a) Title, number and date of this specification.

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- (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 Patent notice. It is noted that an U.S. patent number: 7,229,508 was filed on May 26, 2004 and published on June 12, 2007 for an aluminum alloy 2139.

6.4 Definitions. According to the Aluminum Association.

6.4.1 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.

6.4.2 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.

6.4.3 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

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

6.4.5 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.

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6.4.6 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.

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

6.4.8 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.

6.5 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: RDRL-WMM-C, 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.

6.6 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/second	0.3048	=	meter per second (m/s)
pounds/sq. inch	0.00689	=	Mega Pascal (MPa)

6.7 Subject term (key word) listing.

Ballistic testing  
 Caliber .30 AP M2  
 Caliber .50 AP M2  
 Caliber .50 FSP  
 M1114 HMMWV  
 Military vehicles  
 Stress corrosion

20-mm FSP  
 20-mm API-T M602  
 14.5-mm API

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## APPENDIX A

BALLISTIC TESTING OF ARMOR PLATE, ALUMINUM ALLOY, 2xxx,  
UNWELDABLE APPLIQUE

## A.1 SCOPE

A.1.1 Scope. This appendix covers the minimum ballistic limits for acceptable requirements of aluminum alloy armor plate, un-weldable, 2xxx 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 <https://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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## APPENDIX A

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  $\pm 10$  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 expense two additional test plates from the same lot for ballistic retest. If either of these plates fails 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 fails, 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	
	Class I	Class II		Class I	Class II		Class I	Class II
0.475	TBD	1496	0.580	TBD	1723	0.685	TBD	1924
0.480	TBD	1508	0.585	TBD	1733	0.690	TBD	1933
0.485	TBD	1519	0.590	TBD	1743	0.695	TBD	1942
0.490	TBD	1531	0.595	TBD	1753	0.700	TBD	1951
0.495	TBD	1542	0.600	TBD	1763	0.705	TBD	1960
0.500 <sup>1/</sup>	TBD	1553	0.605	TBD	1773	0.710	TBD	1969
0.505	TBD	1564	0.610	TBD	1783	0.715	TBD	1977
0.510	TBD	1575	0.615	TBD	1792	0.720	TBD	1986
0.515	TBD	1586	0.620	TBD	1802	0.725	TBD	1995
0.520	TBD	1597	0.625	TBD	1812	0.730	TBD	2004
0.525	TBD	1608	0.630	TBD	1821	0.735	TBD	2012
0.530	TBD	1619	0.635	TBD	1831	0.740	TBD	2021
0.535	TBD	1630	0.640	TBD	1840	0.745	TBD	2030
0.540	TBD	1640	0.645	TBD	1850	0.749 <sup>2/</sup>	TBD	2037
0.545	TBD	1651	0.650	TBD	1859	0.755	TBD	2047
0.550	TBD	1661	0.655	TBD	1869	0.760	TBD	2055
0.555	TBD	1672	0.660	TBD	1878	0.765	TBD	2064
0.560	TBD	1682	0.665	TBD	1887	0.770	TBD	2072
0.565	TBD	1692	0.670	TBD	1896	0.775	TBD	2081
0.570	TBD	1703	0.675	TBD	1905	0.780	TBD	2089
0.575	TBD	1713	0.680	TBD	1915	0.785	TBD	2097

<sup>1/</sup> Specification requirements begin for this ordered thickness.

<sup>2/</sup> Specification requirements end for this ordered thickness.

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



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

Thickness, inches	Required BL(P), fps	Thickness, inches	Required BL(P), fps	Thickness, inches	Required BL(P), fps
	Class I & II		Class I & II		Class I & II
0.730	1986	0.815	2369	0.900	2826
0.735	2007	0.820	2394	0.905	2856
0.740	2028	0.825	2419	0.910	2885
0.745	2049	0.830	2444	0.915	2915
0.750 <sup>1/</sup>	2070	0.835	2470	0.920	2946
0.755	2092	0.840	2495	0.925	2976
0.760	2114	0.845	2521	0.930	3007
0.765	2136	0.850	2548	0.935	3039
0.770	2158	0.855	2574	0.940	3071
0.775	2181	0.860	2601	0.945	3103
0.780	2203	0.865	2628	0.950 <sup>2/</sup>	3135
0.785	2226	0.870	2656	0.955	3168
0.790	2250	0.875	2683	0.960	3201
0.795	2273	0.880	2711	0.965	3234
0.800	2297	0.885	2739	0.970	3268
0.805	2321	0.890	2768	0.975	3302
0.810	2345	0.895	2797	0.980	3336

<sup>1/</sup> Specification requirements begin for this ordered thickness.

<sup>2/</sup> Specification requirements end for this ordered thickness.

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

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

Thickness, inches	Required BL(P), fps Class I & II	Thickness, inches	Required BL(P), fps Class I & II	Thickness, inches	Required BL(P), fps Class I & II
0.930	1436	1.100	1784	1.270	2216
0.935	1445	1.105	1795	1.275	2230
0.940	1455	1.110	1807	1.280	2244
0.945	1464	1.115	1818	1.285	2258
0.951 <sup>1/</sup>	1475	1.120	1830	1.290	2273
0.955	1483	1.125	1842	1.295	2287
0.960	1492	1.130	1853	1.300	2302
0.965	1502	1.135	1865	1.305	2317
0.970	1511	1.140	1877	1.310	2331
0.975	1521	1.145	1889	1.315	2346
0.980	1531	1.150	1901	1.320	2361
0.985	1541	1.155	1913	1.325	2376
0.990	1550	1.160	1926	1.330	2392
0.995	1560	1.165	1938	1.335	2407
1.000	1570	1.170	1950	1.340	2422
1.005	1580	1.175	1963	1.345	2438
1.010	1590	1.180	1975	1.350	2453
1.015	1601	1.185	1988	1.355	2469
1.020	1611	1.190	2001	1.360	2485
1.025	1621	1.195	2014	1.365	2501
1.030	1632	1.200	2026	1.370	2517
1.035	1642	1.205	2039	1.375	2533
1.040	1652	1.210	2052	1.380	2549
1.045	1663	1.215	2066	1.385	2565
1.050	1674	1.220	2079	1.390	2582
1.055	1684	1.225	2092	1.395	2598
1.060	1695	1.230	2105	1.400	2615
1.065	1706	1.235	2119	1.405	2632
1.070	1717	1.240	2132	1.410	2649
1.075	1728	1.245	2146	1.415	2665
1.080	1739	1.250	2160	1.420	2683
1.085	1750	1.255	2174	1.425	2700
1.090	1761	1.260	2187	1.430	2717
1.095	1772	1.265	2201	1.435	2734

<sup>1/</sup> Specification requirements begin for this ordered thickness.

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

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TABLE A-III. Minimum required ballistic limits – 20mm 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
	Class I & II		Class I & II		Class I & II
1.440	2752	1.470	2859	1.500 <sup>2/</sup>	2971
1.445	2769	1.475	2877	1.505	2990
1.450	2787	1.480	2896	1.510	3009
1.455	2805	1.485	2914	1.515	3028
1.460	2823	1.490	2933	1.520	3047
1.465	2841	1.495	2952	1.525	3067

<sup>2/</sup> Specification requirements end for this ordered thickness.

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

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

Thickness, inches	Required BL(P), fps Class I & II	Thickness, inches	Required BL(P), fps Class I & II	Thickness, inches	Required BL(P), fps Class I & II
0.730	1799	0.900	2052	1.070	2277
0.735	1807	0.905	2059	1.075	2283
0.740	1815	0.910	2066	1.080	2289
0.745	1823	0.915	2073	1.085	2295
0.750 <sup>1/</sup>	1831	0.920	2080	1.090	2302
0.755	1839	0.925	2086	1.095	2308
0.760	1846	0.930	2093	1.100	2314
0.765	1854	0.935	2100	1.105	2320
0.770	1862	0.940	2107	1.110	2326
0.775	1870	0.945	2114	1.115	2332
0.780	1877	0.950	2120	1.120	2339
0.785	1885	0.955	2127	1.125	2345
0.790	1892	0.960	2134	1.130	2351
0.795	1900	0.965	2141	1.135	2357
0.800	1907	0.970	2147	1.140	2363
0.805	1915	0.975	2154	1.145	2369
0.810	1922	0.980	2161	1.150	2375
0.815	1930	0.985	2167	1.155	2381
0.820	1937	0.990	2174	1.160	2387
0.825	1945	0.995	2180	1.165	2393
0.830	1952	1.000	2187	1.170	2399
0.835	1959	1.005	2193	1.175	2405
0.840	1966	1.010	2200	1.180	2411
0.845	1974	1.015	2206	1.185	2417
0.850	1981	1.020	2213	1.190	2423
0.855	1988	1.025	2219	1.195	2429
0.860	1995	1.030	2226	1.200	2435
0.865	2003	1.035	2232	1.205	2440
0.870	2010	1.040	2239	1.210	2446
0.875	2017	1.045	2245	1.215	2452
0.880	2024	1.050	2251	1.220	2458
0.885	2031	1.055	2258	1.225	2464
0.890	2038	1.060	2264	1.230	2470
0.895	2045	1.065	2270	1.235	2475

<sup>1/</sup> Specification requirements begin for this ordered thickness.

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

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

Thickness, inches	Required BL(P), fps Class I & II	Thickness, inches	Required BL(P), fps Class I & II	Thickness, inches	Required BL(P), fps Class I & II
1.240	2481	1.335	2588	1.430	2691
1.245	2487	1.340	2594	1.435	2697
1.250	2493	1.345	2599	1.440	2702
1.255	2498	1.350	2605	1.445	2707
1.260	2504	1.355	2610	1.450	2712
1.265	2510	1.360	2616	1.455	2718
1.270	2515	1.365	2621	1.460	2723
1.275	2521	1.370	2627	1.465	2728
1.280	2527	1.375	2632	1.470	2733
1.285	2532	1.380	2638	1.475	2739
1.290	2538	1.385	2643	1.480	2744
1.295	2544	1.390	2648	1.485	2749
1.300	2549	1.395	2654	1.490	2754
1.305	2555	1.400	2659	1.495	2759
1.310	2561	1.405	2665	1.500 <sup>2/</sup>	2765
1.315	2566	1.410	2670	1.505	2770
1.320	2572	1.415	2675	1.510	2775
1.325	2577	1.420	2681	1.515	2780
1.330	2583	1.425	2686	1.520	2785

<sup>2/</sup> Specification requirements end for this ordered thickness.

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

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TABLE A-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	
	Class I	Class II		Class I	Class II		Class I	Class II
1.480	2070	2083	1.655	2213	2231	1.830	2347	2370
1.485	2074	2087	1.660	2217	2235	1.835	2351	2374
1.490	2079	2092	1.665	2221	2239	1.840	2355	2377
1.495	2083	2096	1.670	2225	2243	1.845	2359	2381
1.501 <sup>1/</sup>	2088	2100	1.675	2229	2247	1.850	2362	2385
1.505	2091	2105	1.680	2233	2251	1.855	2366	2389
1.510	2095	2109	1.685	2237	2255	1.860	2370	2393
1.515	2100	2113	1.690	2241	2259	1.865	2373	2397
1.520	2104	2118	1.695	2245	2263	1.870	2377	2400
1.525	2108	2122	1.700	2248	2267	1.875	2381	2404
1.530	2112	2126	1.705	2252	2271	1.880	2384	2408
1.535	2116	2131	1.710	2256	2275	1.885	2388	2412
1.540	2120	2135	1.715	2260	2279	1.890	2392	2415
1.545	2124	2139	1.720	2264	2283	1.895	2395	2419
1.550	2129	2143	1.725	2268	2287	1.900	2399	2423
1.555	2133	2148	1.730	2272	2291	1.905	2403	2427
1.560	2137	2152	1.735	2276	2295	1.910	2406	2431
1.565	2141	2156	1.740	2279	2299	1.915	2410	2434
1.570	2145	2160	1.745	2283	2303	1.920	2414	2438
1.575	2149	2165	1.750	2287	2307	1.925	2417	2442
1.580	2153	2169	1.755	2291	2311	1.930	2421	2446
1.585	2157	2173	1.760	2295	2315	1.935	2424	2449
1.590	2161	2177	1.765	2298	2319	1.940	2428	2453
1.595	2165	2181	1.770	2302	2323	1.945	2432	2457
1.600	2169	2185	1.775	2306	2327	1.950	2435	2460
1.605	2173	2190	1.780	2310	2331	1.955	2439	2464
1.610	2177	2194	1.785	2314	2335	1.960	2442	2468
1.615	2181	2198	1.790	2317	2339	1.965	2446	2472
1.620	2185	2202	1.795	2321	2343	1.970	2450	2475
1.625	2189	2206	1.800	2325	2346	1.975	2453	2479
1.630	2193	2210	1.805	2329	2350	1.980	2457	2483
1.635	2197	2214	1.810	2332	2354	1.985	2460	2486
1.640	2201	2219	1.815	2336	2358	1.990	2464	2490
1.645	2205	2223	1.820	2340	2362	1.995	2467	2494
1.650	2209	2227	1.825	2344	2366	2.000	2471	2497

<sup>1/</sup> Specification requirements begin for this ordered thickness.

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

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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	
	Class I	Class II		Class I	Class II		Class I	Class II
2.005	2474	2501	2.180	2595	2626	2.355	2711	N/A
2.010	2478	2505	2.185	2599	2629	2.360	2714	N/A
2.015	2482	2508	2.190	2602	2633	2.365	2717	N/A
2.020	2485	2512	2.195	2605	2636	2.370	2720	N/A
2.025	2489	2515	2.200	2609	2640	2.375	2724	N/A
2.030	2492	2519	2.205	2612	2643	2.380	2727	N/A
2.035	2496	2523	2.210	2615	2646	2.385	2730	N/A
2.040	2499	2526	2.215	2619	2650	2.390	2733	N/A
2.045	2503	2530	2.220	2622	2653	2.395	2736	N/A
2.050	2506	2534	2.225	2625	2657	2.400	2740	N/A
2.055	2510	2537	2.230	2629	2660	2.405	2743	N/A
2.060	2513	2541	2.235	2632	2664	2.410	2746	N/A
2.065	2517	2544	2.240	2635	2667	2.415	2749	N/A
2.070	2520	2548	2.245	2639	2671	2.420	2752	N/A
2.075	2523	2552	2.250 <sup>2/</sup>	2642	2674	2.425	2755	N/A
2.080	2527	2555	2.255	2645	2678	2.430	2759	N/A
2.085	2530	2559	2.260	2649	2681	2.435	2762	N/A
2.090	2534	2562	2.265	2652	2685	2.440	2765	N/A
2.095	2537	2566	2.270	2655	2688	2.445	2768	N/A
2.100	2541	2569	2.275	2659	2694	2.450	2771	N/A
2.105	2544	2573	2.280	2662	N/A	2.455	2774	N/A
2.110	2548	2576	2.285	2665	N/A	2.460	2778	N/A
2.115	2551	2580	2.290	2668	N/A	2.465	2781	N/A
2.120	2554	2584	2.295	2672	N/A	2.470	2784	N/A
2.125	2558	2587	2.300	2675	N/A	2.475	2787	N/A
2.130	2561	2591	2.305	2678	N/A	2.480	2790	N/A
2.135	2565	2594	2.310	2681	N/A	2.485	2793	N/A
2.140	2568	2598	2.315	2685	N/A	2.490	2796	N/A
2.145	2572	2601	2.320	2688	N/A	2.495	2800	N/A
2.150	2575	2605	2.325	2691	N/A	2.500 <sup>3/</sup>	2803	N/A
2.155	2578	2608	2.330	2694	N/A	2.505	2806	N/A
2.160	2582	2612	2.335	2698	N/A	2.510	2809	N/A
2.165	2585	2615	2.340	2701	N/A	2.515	2812	N/A
2.170	2588	2619	2.345	2704	N/A	2.520	2815	N/A
2.175	2592	2622	2.350	2707	N/A	2.525	2818	N/A

<sup>2/</sup> Specification requirements end for this ordered thickness for Class II<sup>3/</sup> Specification requirements end for this ordered thickness for Class I

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

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TABLE A-VI. Minimum required ballistic limits - 14.5mm BS41  
projectiles at 0° obliquity.

Thickness, inches	Required BL(P), fps	Thickness, inches	Required BL(P), fps	Thickness, inches	Required BL(P), fps
	Class I		Class I		Class I
2.480	2601	2.655	2716	2.830	2826
2.485	2605	2.660	2719	2.835	2829
2.490	2608	2.665	2722	2.840	2832
2.495	2611	2.670	2726	2.845	2835
2.501 <sup>1/</sup>	2615	2.675	2729	2.850	2838
2.505	2618	2.680	2732	2.855	2841
2.510	2621	2.685	2735	2.860	2845
2.515	2625	2.690	2738	2.865	2848
2.520	2628	2.695	2742	2.870	2851
2.525	2631	2.700	2745	2.875	2854
2.530	2635	2.705	2748	2.880	2857
2.535	2638	2.710	2751	2.885	2860
2.540	2641	2.715	2754	2.890	2863
2.545	2645	2.720	2757	2.895	2866
2.550	2648	2.725	2761	2.900	2869
2.555	2651	2.730	2764	2.905	2872
2.560	2654	2.735	2767	2.910	2875
2.565	2658	2.740	2770	2.915	2878
2.570	2661	2.745	2773	2.920	2881
2.575	2664	2.750	2776	2.925	2884
2.580	2668	2.755	2779	2.930	2887
2.585	2671	2.760	2783	2.935	2890
2.590	2674	2.765	2786	2.940	2893
2.595	2677	2.770	2789	2.945	2896
2.600	2681	2.775	2792	2.950	2899
2.605	2684	2.780	2795	2.955	2902
2.610	2687	2.785	2798	2.960	2905
2.615	2690	2.790	2801	2.965	2908
2.620	2694	2.795	2804	2.970	2911
2.625	2697	2.800	2808	2.975	2914
2.630	2700	2.805	2811	2.980	2917
2.635	2703	2.810	2814	2.985	2920
2.640	2706	2.815	2817	2.990	2923
2.645	2710	2.820	2820	2.995	2926
2.650	2713	2.825	2823	3.000	2929

<sup>1/</sup> Specification requirements begin for this ordered thickness.

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



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## APPENDIX A

TABLE A-VI. Minimum required ballistic limits - 14.5mm BS41 projectiles at 0° obliquity (continued).

Thickness, inches	Required BL(P), fps	Thickness, inches	Required BL(P), fps	Thickness, inches	Required BL(P), fps
	Class I		Class I		Class I
3.005	2932	3.180	3034	3.355	3133
3.010	2935	3.185	3037	3.360	3136
3.015	2938	3.190	3040	3.365	3139
3.020	2941	3.195	3043	3.370	3141
3.025	2944	3.200	3046	3.375	3144
3.030	2947	3.205	3049	3.380	3147
3.035	2950	3.210	3051	3.385	3150
3.040	2953	3.215	3054	3.390	3153
3.045	2956	3.220	3057	3.395	3155
3.050	2959	3.225	3060	3.400	3158
3.055	2962	3.230	3063	3.405	3161
3.060	2965	3.235	3066	3.410	3164
3.065	2967	3.240	3069	3.415	3166
3.070	2970	3.245	3071	3.420	3169
3.075	2973	3.250	3074	3.425	3172
3.080	2976	3.255	3077	3.430	3175
3.085	2979	3.260	3080	3.435	3177
3.090	2982	3.265	3083	3.440	3180
3.095	2985	3.270	3086	3.445	3183
3.100	2988	3.275	3088	3.450	3186
3.105	2991	3.280	3091	3.455	3188
3.110	2994	3.285	3094	3.460	3191
3.115	2997	3.290	3097	3.465	3194
3.120	3000	3.295	3100	3.470	3196
3.125	3003	3.300	3102	3.475	3199
3.130	3005	3.305	3105	3.480	3202
3.135	3008	3.310	3108	3.485	3205
3.140	3011	3.315	3111	3.490	3207
3.145	3014	3.320	3114	3.495	3210
3.150	3017	3.325	3116	3.500 <sup>2/</sup>	3213
3.155	3020	3.330	3119	3.505	3215
3.160	3023	3.335	3122	3.510	3218
3.165	3026	3.340	3125	3.515	3221
3.170	3029	3.345	3128	3.520	3224
3.175	3031	3.350	3130	3.525	3226

<sup>2/</sup> Specification requirements end for this ordered thickness.

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

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## APPENDIX A

TABLE A-VII. Minimum required ballistic limits - 20mm M602 projectiles at 0° obliquity.

Thickness, inches	Required BL(P), fps Class I	Thickness, inches	Required BL(P), fps Class I	Thickness, inches	Required BL(P), fps Class I
3.480	TBD	3.665	TBD	3.850	TBD
3.485	TBD	3.670	TBD	3.855	TBD
3.490	TBD	3.675	TBD	3.860	TBD
3.495	TBD	3.680	TBD	3.865	TBD
3.501 <sup>1/</sup>	TBD	3.685	TBD	3.870	TBD
3.505	TBD	3.690	TBD	3.875	TBD
3.510	TBD	3.695	TBD	3.880	TBD
3.515	TBD	3.700	TBD	3.885	TBD
3.520	TBD	3.705	TBD	3.890	TBD
3.525	TBD	3.710	TBD	3.895	TBD
3.530	TBD	3.715	TBD	3.900	TBD
3.535	TBD	3.720	TBD	3.905	TBD
3.540	TBD	3.725	TBD	3.910	TBD
3.545	TBD	3.730	TBD	3.915	TBD
3.550	TBD	3.735	TBD	3.920	TBD
3.555	TBD	3.740	TBD	3.925	TBD
3.560	TBD	3.745	TBD	3.930	TBD
3.565	TBD	3.750	TBD	3.935	TBD
3.570	TBD	3.755	TBD	3.940	TBD
3.575	TBD	3.760	TBD	3.945	TBD
3.580	TBD	3.765	TBD	3.950	TBD
3.585	TBD	3.770	TBD	3.955	TBD
3.590	TBD	3.775	TBD	3.960	TBD
3.595	TBD	3.780	TBD	3.965	TBD
3.600	TBD	3.785	TBD	3.970	TBD
3.605	TBD	3.790	TBD	3.975	TBD
3.610	TBD	3.795	TBD	3.980	TBD
3.615	TBD	3.800	TBD	3.985	TBD
3.620	TBD	3.805	TBD	3.990	TBD
3.625	TBD	3.810	TBD	3.995	TBD
3.630	TBD	3.815	TBD	4.000 <sup>2/</sup>	TBD
3.635	TBD	3.820	TBD	4.010	TBD
3.640	TBD	3.825	TBD	4.015	TBD
3.645	TBD	3.830	TBD	4.020	TBD
3.650	TBD	3.835	TBD	4.025	TBD
3.655	TBD	3.840	TBD	4.030	TBD
3.660	TBD	3.845	TBD	4.035	TBD

<sup>1/</sup> Specification requirements begin for this ordered thickness.<sup>2/</sup> Specification requirements end for this ordered thickness.

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

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## CONCLUDING MATERIAL

Custodians:  
Army – MR

Preparing activity:  
ARMY – MR  
(Project 9535-2008-004)

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 <https://assist.daps.dla.mil/>.