INCH-POUND

MIL-DTL-32341A (MR)
15 April 2015
SUPERSEDING
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DETAIL SPECIFICATION

ARMOR PLATE, ALUMINUM, ALLOY 2139 WELDABLE & ALLOY 2195 and 2060 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 three wrought aluminum alloy armor plate for both welded and un-welded applications in nominal thicknesses from 0.500 to 4.000 inch, inclusive (see 6.2). The weldability of wrought aluminum alloy AA2139 armor has been determined for Class I armor for these thicknesses, only; 0.500" and 1.500". The weldability for all the other alloys (Class II & Class III) have not been determined and therefore should only be used as appliqué armor.

1.2 Weldability. Class I material covered by this specification has been demonstrated to be weldable to itself and some other weldable alloys (see 6.3 and 6.4).

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

1.3.1 Class I. Class I is wrought aluminum armor that conforms to the Aluminum Association designation for the 2139 aluminum alloy. The applicable gauge range for Class I is 0.500-4.000 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 richard.j.squillacioti.civ@mail.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla.mil/.

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1.3.2 Class II. Class II is wrought aluminum armor that conforms to the Aluminum Association designation for the 2195 aluminum alloy. The applicable gauge range for Class II is 0.500 - 2.250 inches.

1.3.3 Class III. Class III is wrought aluminum armor that conforms to the Aluminum Association designation for the 2060 aluminum alloy. The applicable gauge range for Class III is 0.500 – 2.500 inches.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 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 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

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

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-662	-	V_{50} Ballistic Test for Armor

(Copies of these documents are available online at http://quicksearch.dla.mil/.)

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

THE ALUMINUM ASSOCIATION, INC.

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

(Copies of these documents are available online at http://www.aluminum.org).

ASTM INTERNATIONAL

ASTM B557	-	Standard Test Methods for Tension Testing Wrought and Cast Aluminum and Magnesium-Alloy Products
ASTM E34	-	Standard Test Methods for Chemical Analysis of Aluminum and Aluminum-Base Alloys
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

(Copies of these documents are available online at http://www.astm.org.)

SAE INTERNATIONAL

SAE AMS 2750 - Pyrometry

(Copies of these documents are available online at http://www.sae.org/.)

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, 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 Teal Sheets from the Aluminum Association dated 2009-03-01 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 (L) 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 Weldability. When the vehicle requires weldments the fabricator (OEMs and kit manufacturers, etc.) are required to demonstrate weldability (which includes ballistic shock testing) for armor to armor and armor to non-armor applications in accordance with the Ground Combat Vehicle Welding Code (GCVWC) - Aluminum #19207-12472301. Since the alloys referenced by this specification are not specified in the GCVWC #19207-12472301 or in the revised Military Standard for Weldability of Aluminum Alloys (MIL-STD-1946) it is strongly suggested that the contract or drawing for the vehicle specify weldability requirements as outlined in paragraph 6.3. Aluminum fabricators shall qualify a weld procedure for any new

armor material being used for armor applications and this requires ballistic shock testing. This requirement (ballistic shock testing and the associated striking velocities) are listed in Appendix A and shall also be specified in the contract or drawing for the vehicle if the alloys specified by this specification are to be welded at the following thicknesses; Class I material in the thicknesses of 0.500" and 1.500".

TABLE I. Chemical composition, weight percent. 1/

ELEMENTS	SYMBOL	Class I 2139 ALLOY 2/	Class II 2195 ALLOY 2/	Class III 2060 ALLOY 2/
Silicon	Si	0.10	0.12	0.07
Iron	Fe	0.15	0.15	0.07
Copper	Cu	4.5 -5.5	3.7 - 4.3	3.4 - 4.5
Manganese	Mn	0.20 -0.60	0.25	0.10 - 0.50
Magnesium	Mg	0.20 - 0.80	0.25 - 0.8	0.60 - 1.1
Chromium	Cr	0.005	N/A	N/A
Zinc	Zn	0.25	0.25	0.30 - 0.50
Titanium	Ti	0.15	0.10	0.10
Vanadium	V	0.05	N/A	N/A
Zirconium	Zr	N/A	0.08 - 0.16	0.05 - 0.15
Lithium	Li	N/A	0.8 - 1.2	0.60 - 0.90
Silver	Ag	0.15 - 0.60	0.25 - 0.6	0.05 - 0.50
Other, max. Each	---	0.05	0.05	0.05
Other, max. Total 3/	---	0.15	0.15	0.15
Aluminum	Al	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 Ballistic limit. The protection ballistic limit, BL(P), shall be as specified in Appendix B. When a complete penetration cannot 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 cannot be explicitly determined) above the minimum requirement.

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

3.7 Dimensions. Dimensions for plates delivered for fabrication shall have an overall dimension tolerance of +0.500/-0.000 for width and length unless otherwise 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 shall not vary from the specified ordered dimensions by an amount greater than that specified by ANSI H35.2, except for thickness.

TABLE II. Minimum mechanical properties. [1/] [2/]

Thickness, inches	Tensile Strength, ksi			Yield Strength, 0.2% Offset, ksi			Elongation percent		
	Class I	Class II	Class III	Class I	Class II	Class III	Class I	Class II	Class III
0.500 to 3.000, incl.	67	71 [3/]	73 [4/]	64	63 [3/]	70 [4/]	9	9 [3/]	7 [4/]
3.001 to 4.000, incl.	67	N/A	N/A	64	N/A	N/A	9	N/A	N/A

[1/] The test specimen gage length shall be 1.400 inch for plates having a nominal thickness of 0.500 inch; all other thicknesses shall have a gage length of 2.000 inches.
[2/] Values are taken in the Longitudinal Direction (see 3.3).
[3/] For alloy 2195 (Class II) the applicable thickness range is 0.500-2.250 inches.
[4/] For alloy 2060 (Class III) the applicable thickness range is 0.500-2.500 inches.

3.7.2 Thickness. Thickness tolerance for production armor and ballistic test plates shall be 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
		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	0.043	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 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 not contain 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 edge in letters 3/8 inch high or greater. Ballistic retest plates shall be marked "R1" and "R2" respectively (see B.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.

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.

3.10.1 Surface and Edge Condition. The surface and edge condition of the plate shall be free of surface cracks, edge cracks, and edge laminations as defined in the contract or purchase order (see 6.2).

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; same source of molten metal representing the ingots poured, 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. When specified in the contract or purchase order, (see 6.2) and before production has commenced, samples of specified material shall be made available to the contracting officer or his authorized representative for approval in accordance with 4.3.1. The approval of the first article samples authorizes the commencement of production but does not relieve the supplier of responsibility for compliance with all applicable provisions of this specification. The first article samples shall be produced using the mill production practice proposed for use on production.

4.3.1 First article inspection, First article inspection except as otherwise indicated in this specification, shall utilize the same requirements and test methods as the conformance inspection or 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.

REQUEST FOR BALLISTIC TEST OF ALUMINUM ALLOY 2xxx 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-32341 (MR)								**REVISION: A**		**AMENDMENT:**	
CONTRACT NO:								ATC PROJECT NO:			
DCAS REGION:								BALLISTIC TEST CONTRACT NO:			
TEST ITEM IDENTIFICATION:											
Lot No. Class:			Plate No.					Ordered Thickness		Alloy and Temper	
PURPOSE: ___ Acceptance ___ First Article ___ Development											
SAMPLE: Primary Retest (Firing Record No. of Failed Sample)											
CHEMICAL ANALYSIS:			OTHERS, Max.: Each:			Total:				Al :	
Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	V	Zr	Li	Ag
MECHANICAL PROPERTIES:											
UTS (ksi):			0.2% YS (ksi):					Elongation (%):			
WELDABILITY: Thickness: Striking Velocity: Required: Actual: Pass / Fail Thickness: Striking Velocity: Required: Actual: Pass / Fail											
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-32341A MR).											
Government Representative			Date			Supplier Representative				Date	

FIGURE 1. Aluminum Armor Test Data Form.

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 B. The orientation of these plates with respect to the rolling direction shall be at the option of the producer (see 6.2).

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.

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.

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.

4.6 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.

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 and as specified in the contract or purchase order (see 6.2). At a minimum, one plate per lot shall be randomly selected for dimensional inspection.

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

4.7.3.1 Ballistic testing facility. Unless otherwise specified in the contract or purchase orders (see 6.2), the ballistic test plates shall be forwarded to the Commander, U.S. Army Aberdeen Test Center, 400 Colleran Road. Bldg. 358, ATTN: CSTE-DTC-AT-SL-V (K. Beavers), Armor Acceptance – B690, Aberdeen Proving Ground, MD 21005-5059 for ballistic testing for first article or lot acceptance.

4.7.3.2 Incomplete penetrations. When a complete penetration cannot 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 cannot be explicitly determined) above the minimum requirement.

TABLE V. Acceptance ballistic test plates.

Ordered Thickness, Inches	Projectile	Angle of Obliquity in Degrees	TABLE	CLASS I (2139)	CLASS II (2195)	CLASS III (2060)
0.500 - 0.749	Cal. .30 AP M2	30	B-I	TBD 1/	LISTED	LISTED
0.750 - 0.950	Cal. .50 FSP	0	B-II	LISTED – SAME V_{50}		LISTED
0.951 - 1.500	20-mm FSP	0	B-III	LISTED - SAME V_{50}		LISTED
0.750 - 1.500	Cal. .30 AP M2	0	B-IV	LISTED - SAME V_{50}		LISTED
1.501 - 2.500	Cal. .50 AP M2	0	B-V	LISTED	LISTED 2/	LISTED
2.501 - 3.500	14.5-mm BS41	0	B-VI	LISTED	N/A 2/	N/A 3/
3.501 – 4.000	20-mm M602	0	B-VII	TBD	N/A 2/	N/A 3/

1/ To be determined.
2/ Class II (alloy 2195) the applicable gauge for ordered thickness ends at 2.250 inches.
3/ Class III (alloy 2060) the applicable gauge for ordered thickness ends at 2.500 inches.

4.8 Rejection and retest. Unless otherwise specified in the contract or purchase 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 B.5.2.

4.9 Reduced testing. At the discretion of the procuring activity and as specified in the contract or purchase order (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. Pratt & Miller Engineering who has been developing the OCP-TECD CAMEL demonstrator plans to use a weldable 2139 aluminum alloy.

6.2 Ordering data. Procurement documents should specify the following:

(a) Title, number and date of this specification.
(b) Specify classification of alloy, and ordered thickness (see 1.1 and 1.3)
(c) When first article is required (see 3.1 and 4.3).
(d) Special mechanical properties and ballistic requirements, if required (see 3.3).
(e) Dimension and tolerance requirements if different (see 3.7 and 3.7.1).
(f) If markings are different and when impression stamping is permissible (see 3.8).
(g) Define surface cracks, edge cracks and edge laminations for the specific application (see 3.10.1)
(h) If the weight of finished plate can exceed 50,000 pounds (see 4.2).
(i) The orientation of the ballistic plate with respect to rolling is different (see 4.5.1.3 and 4.5.2.3).
(j) Dimensional sampling procedure approved by the procuring activity (see 4.6.2).
(k) If approval was requested and received for a different ballistic testing facility (see 4.7.3.1)
(l) Rejection and retest requirement, if different (see 4.8).
(m) If reduced testing is allowed (see 4.9).
(n) Packaging requirements (see 5.1).
(o) Striking velocities for those thicknesses not covered (see A.3.6.1.1).

6.3 Weldability. The Army Research Lab has conducted testing and found that Class I, AA2139 alloys can be welded and demonstrates good shock resistance when tested with the method described in the Ground Combat Vehicle Welding Code, TACOM Drawing 19207-12472301. However, 19207-12472301 does not currently address this alloy. Appendix A provides the additional details to permit welding qualification for armor applications. The fabricator performing welding on these alloys for armor applications is responsible for developing and qualifying welding procedures in accordance with 19207-12472301. Appendix A contains the supplemental information for the welding code. The thickness of the weldments specified in the contract or drawing shall be used to determine the proofing projectile and striking velocity in accordance with Appendix A. Tests have demonstrated that material covered by this specification is weldable to itself and other weldable 2000 series alloys using a 2000 or 4000

series filler and is weldable to 6000 series alloys using a 4000 series filler. It is not weldable to 5000 or 7000 series alloys by conventional welding techniques. Any deviations from these conditions should be demonstrated prior to acceptance by the procuring activity.

6.4 Weld wire. Corner joints were successfully welded with AA4043 weld wire for Class I (AA2139) material when tested with the required proofing projectile per the Ground Combat Vehicle Welding Code 19207-12472301 (see 1.2).

6.5 Density. The density of AA2139 is 0.102 lb/in^3 (2.81 g/cm^3). The density of AA2195 is 0.098 lb/in^3 (2.71 g/cm^3). The density of AA2060 is 0.092 lb/in^3 (2.57 g/cm^3).

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)
pound/cubic inch	27.6799	=	gram (g) per cubic centimeter (cm)

6.6 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

6.7 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.

ARMOR PLATE, ALUMINUM, ALLOY 2139 WELDABLE & ALLOY 2195 and 2060 UNWELDABLE APPLIQUE

A.1 SCOPE

A.1.1 Scope. This appendix covers the minimum welding acceptable requirements (striking velocities) of aluminum alloy armor plate, AA2139 when welded and tested in accordance with the provisions specified in the applicable contract. When the material specified by this specification is to be used in a welded armor application the requirements for weldability should specify the Ground Combat Vehicle Welding Code (GCVWC) - Aluminum 19207-12472301. In lieu of this document (Welding Code) or a welding standard for armor and non-armor applications this appendix and the information contained herein is intended for information only. Until the Welding Code or a welding standard for armor and non-armor applications is updated or revised the information contained herein should be referenced for compliance.

A.2 APPLICABLE DOCUMENTS

A.2.1 Government documents.

A.2.1.1 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

TACOM Drawing 19207-12472301	-	Ground Combat Vehicle Welding Code -- Aluminum, Section 10

(Copies of this document are available online at Ground Combat Vehicle Welding Code - Aluminum, dated 6/03/2003 Drawing Number 12472301).

A.3 REQUIREMENTS

A.3.1 Base Material M Number. Alloy 2139 shall be classified as M24 materials.

A3.2 Tensile Strength of Welded Aluminum Alloys (Table 5.1 of 19207-12472301). The minimum tensile strength of 2139, Class I welds, shall be 35 ksi.

A3.3 Base Metal – Non Critical Welds. Material conforming to this specification is permitted for non-critical welds (paragraph 8.2 of 19207-12472301).

A3.4 Base Metal - Critical Welds. Material conforming to this specification is permitted for critical welds (paragraph 9.2 of 19207-12472301).

A3.5 Base Metal- Ballistic Welds. Material conforming to this specification is permitted for ballistic welds (paragraph 10.2 of 19207-12472301).

A.3.6 Ballistic Shock (Weldments) test. Testing shall be in accordance with TACOM Drawing 19207-12472301, Ground Combat Vehicle Welding Code -- Aluminum, Section 10, except that nothing in that drawing shall be construed to supersede or invalidate the requirements of this specification.

A.3.6.1 Striking Velocities.

A.3.6.1.1 Welded corner joints. Striking velocities and proofing projectile shall be chosen from table A-I based on the alloy and thickness of the plate to be impacted. Striking velocities on thicknesses not covered by this table shall be as agreed upon in the contract or purchase order (see 6.2).

A.3.6.2 Number of Impacts. One fair impact is required on each of the two pieces making up the welded joint. The thinner of the two plates or components shall be impacted first. Should a third round be required, the procedure of 10.9.13 of the TACOM Drawing 19207-12472301 shall be followed.

TABLE A-I. Minimum required striking velocities for Welded Corner joints

ORDERED THICKNESS (Inches)	**Plate Proofing Projectile**	**Class I (AA2139)**
0.500	57-mm Aluminum, M1001A	700 fps
1.500	75-mm Aluminum, M1002A	1300 fps

ARMOR PLATE, ALUMINUM, ALLOY 2139 WELDABLE & ALLOY 2195 and 2060 UNWELDABLE APPLIQUE

B.1 SCOPE

B.1.1 Scope. This appendix covers the minimum ballistic limits for acceptable requirements of aluminum alloy armor plate, AA2139, AA2195, and AA2060 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.

B.2 APPLICABLE DOCUMENTS

B.2.1 Government documents.

B.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 cited in the solicitation or contract.

STANDARDS

DEPARTMENT OF DEFENSE

MIL-STD-662 - V50 Ballistic Test for Armor

(Copies of these documents are available online at http://quicksearch.dla.mil/.)

B.3 DEFINITIONS

B.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.

B.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.

B.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.

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

B.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.

B.4 REQUIREMENTS

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

B.5 TESTS

B.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.

B.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 ± 15°F (22 ± 8°C).

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

B.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.

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

B.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)).

B.5.2 Rejection and retest of ballistic plates.

B.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.

B.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.

B.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.

B.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 their own 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.

B.5.3 Disposal of ballistic test plates.

B.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 their own expense, unless the plates were destroyed in testing.

B.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 B.5.3.1.

TABLE B-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 III		Class I	Class II	Class III		Class I	Class II	Class III
0.475	1459	1496	1582	0.580	1693	1723	1805	0.685	1890	1924	2002
0.480	1471	1508	1594	0.585	1703	1733	1815	0.690	1899	1933	2011
0.485	1482	1519	1605	0.590	1713	1743	1824	0.695	1908	1942	2020
0.490	1494	1531	1616	0.595	1723	1753	1834	0.700	1916	1951	2029
0.495	1505	1542	1627	0.600	1733	1763	1844	0.705	1925	1960	2038
0.500 [1/]	1516	1553	1638	0.605	1742	1773	1854	0.710	1934	1969	2047
0.505	1527	1564	1649	0.610	1752	1783	1863	0.715	1942	1977	2055
0.510	1538	1575	1660	0.615	1761	1792	1873	0.720	1951	1986	2064
0.515	1549	1586	1670	0.620	1771	1802	1882	0.725	1960	1995	2073
0.520	1559	1597	1681	0.625	1780	1812	1892	0.730	1968	2004	2081
0.525	1570	1608	1692	0.630	1790	1821	1901	0.735	1977	2012	2090
0.530	1581	1619	1702	0.635	1799	1831	1911	0.740	1985	2021	2099
0.535	1591	1630	1713	0.640	1808	1840	1920	0.745	1993	2030	2107
0.540	1602	1640	1723	0.645	1818	1850	1929	0.749 [2/]	2002	2037	2114
0.545	1612	1651	1734	0.650	1827	1859	1939	0.755	2010	2047	2124
0.550	1623	1661	1744	0.655	1836	1869	1948	0.760	2019	2055	2132
0.555	1633	1672	1754	0.660	1845	1878	1957	0.765	2027	2064	2141
0.560	1643	1682	1764	0.665	1854	1887	1966	0.770	2035	2072	2149
0.565	1653	1692	1775	0.670	1863	1896	1975	0.775	2043	2081	2157
0.570	1663	1703	1785	0.675	1872	1905	1984	0.780	2051	2089	2166
0.575	1673	1713	1795	0.680	1881	1915	1993	0.785	2060	2097	2174

[1/] Specification requirements begin for this ordered thickness.
[2/] Specification requirements end for this ordered thickness.

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

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

Thickness, inches	Required BL(P), fps Class I & II	Required BL(P), fps Class III	Thickness, inches	Required BL(P), fps Class I & II	Required BL(P), fps Class III	Thickness, inches	Required BL(P), fps Class I & II	Required BL(P), fps Class III
0.730	1986	2054	0.815	2369	2426	0.900	2826	2866
0.735	2007	2074	0.820	2394	2450	0.905	2856	2894
0.740	2028	2095	0.825	2419	2474	0.910	2885	2923
0.745	2049	2115	0.830	2444	2499	0.915	2915	2952
0.750 [1/]	2070	2136	0.835	2470	2523	0.920	2946	2981
0.755	2092	2157	0.840	2495	2548	0.925	2976	3010
0.760	2114	2178	0.845	2521	2573	0.930	3007	3040
0.765	2136	2200	0.850	2548	2599	0.935	3039	3070
0.770	2158	2222	0.855	2574	2624	0.940	3071	3100
0.775	2181	2243	0.860	2601	2650	0.945	3103	3131
0.780	2203	2266	0.865	2628	2676	0.950 [2/]	3135	3161
0.785	2226	2288	0.870	2656	2703	0.955	3168	3192
0.790	2250	2310	0.875	2683	2729	0.960	3201	3224
0.795	2273	2333	0.880	2711	2756	0.965	3234	3256
0.800	2297	2356	0.885	2739	2783	0.970	3268	3288
0.805	2321	2379	0.890	2768	2811	0.975	3302	3320
0.810	2345	2403	0.895	2797	2838	0.980	3336	3353

[1/] Specification requirements begin for this ordered thickness.
[2/] Specification requirements end for this ordered thickness.

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

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

Thickness, inches	Required BL(P), fps Class I & II	Required BL(P), fps Class III	Thickness, inches	Required BL(P), fps Class I & II	Required BL(P), fps Class III	Thickness, inches	Required BL(P), fps Class I & II	Required BL(P), fps Class III
0.930	1436	1297	1.100	1784	1654	1.270	2216	2109
0.935	1445	1306	1.105	1795	1666	1.275	2230	2124
0.940	1455	1315	1.110	1807	1677	1.280	2244	2139
0.945	1464	1325	1.115	1818	1690	1.285	2258	2154
0.951 1/	1475	1336	1.120	1830	1702	1.290	2273	2170
0.955	1483	1344	1.125	1842	1714	1.295	2287	2186
0.960	1492	1354	1.130	1853	1726	1.300	2302	2201
0.965	1502	1363	1.135	1865	1739	1.305	2317	2217
0.970	1511	1373	1.140	1877	1751	1.310	2331	2233
0.975	1521	1383	1.145	1889	1764	1.315	2346	2249
0.980	1531	1393	1.150	1901	1776	1.320	2361	2265
0.985	1541	1403	1.155	1913	1789	1.325	2376	2281
0.990	1550	1413	1.160	1926	1802	1.330	2392	2298
0.995	1560	1423	1.165	1938	1815	1.335	2407	2314
1.000	1570	1433	1.170	1950	1828	1.340	2422	2331
1.005	1580	1444	1.175	1963	1841	1.345	2438	2347
1.010	1590	1454	1.180	1975	1854	1.350	2453	2364
1.015	1601	1464	1.185	1988	1867	1.355	2469	2381
1.020	1611	1475	1.190	2001	1881	1.360	2485	2398
1.025	1621	1485	1.195	2014	1894	1.365	2501	2416
1.030	1632	1496	1.200	2026	1908	1.370	2517	2433
1.035	1642	1507	1.205	2039	1922	1.375	2533	2450
1.040	1652	1518	1.210	2052	1935	1.380	2549	2468
1.045	1663	1529	1.215	2066	1949	1.385	2565	2486
1.050	1674	1540	1.220	2079	1963	1.390	2582	2504
1.055	1684	1551	1.225	2092	1977	1.395	2598	2521
1.060	1695	1562	1.230	2105	1992	1.400	2615	2540
1.065	1706	1573	1.235	2119	2006	1.405	2632	2558
1.070	1717	1584	1.240	2132	2020	1.410	2649	2576
1.075	1728	1596	1.245	2146	2035	1.415	2665	2595
1.080	1739	1607	1.250	2160	2049	1.420	2683	2613
1.085	1750	1619	1.255	2174	2064	1.425	2700	2632
1.090	1761	1630	1.260	2187	2079	1.430	2717	2651
1.095	1772	1642	1.265	2201	2094	1.435	2734	2670

1/ 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.

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

Thickness, inches	Required BL(P), fps Class I & II	Required BL(P), fps Class III	Thickness, inches	Required BL(P), fps Class I & II	Required BL(P), fps Class III	Thickness, inches	Required BL(P), fps Class I & II	Required BL(P), fps Class III
1.440	2752	2689	1.470	2859	2807	1.500 2/	2971	2930
1.445	2769	2708	1.475	2877	2827	1.505	2990	2951
1.450	2787	2728	1.480	2896	2847	1.510	3009	2972
1.455	2805	2747	1.485	2914	2868	1.515	3028	2994
1.460	2823	2767	1.490	2933	2888	1.520	3047	3015
1.465	2841	2787	1.495	2952	2909	1.525	3067	3037

2/ Specification requirements end for this ordered thickness.

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

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

Thickness, inches	Required BL(P), fps Class I & II	Required BL(P), fps Class III	Thickness, inches	Required BL(P), fps Class I & II	Required BL(P), fps Class III	Thickness, inches	Required BL(P), fps Class I & II	Required BL(P), fps Class III
0.730	1799	1828	0.900	2052	2105	1.070	2277	2349
0.735	1807	1837	0.905	2059	2112	1.075	2283	2356
0.740	1815	1846	0.910	2066	2120	1.080	2289	2363
0.745	1823	1854	0.915	2073	2127	1.085	2295	2369
0.750 1/	1831	1863	0.920	2080	2135	1.090	2302	2376
0.755	1839	1871	0.925	2086	2142	1.095	2308	2383
0.760	1846	1880	0.930	2093	2150	1.100	2314	2390
0.765	1854	1888	0.935	2100	2157	1.105	2320	2396
0.770	1862	1897	0.940	2107	2165	1.110	2326	2403
0.775	1870	1905	0.945	2114	2172	1.115	2332	2410
0.780	1877	1914	0.950	2120	2179	1.120	2339	2416
0.785	1885	1922	0.955	2127	2187	1.125	2345	2423
0.790	1892	1930	0.960	2134	2194	1.130	2351	2429
0.795	1900	1939	0.965	2141	2201	1.135	2357	2436
0.800	1907	1947	0.970	2147	2209	1.140	2363	2443
0.805	1915	1955	0.975	2154	2216	1.145	2369	2449
0.810	1922	1963	0.980	2161	2223	1.150	2375	2456
0.815	1930	1971	0.985	2167	2230	1.155	2381	2462
0.820	1937	1979	0.990	2174	2237	1.160	2387	2469
0.825	1945	1987	0.995	2180	2245	1.165	2393	2475
0.830	1952	1995	1.000	2187	2252	1.170	2399	2482
0.835	1959	2003	1.005	2193	2259	1.175	2405	2488
0.840	1966	2011	1.010	2200	2266	1.180	2411	2494
0.845	1974	2019	1.015	2206	2273	1.185	2417	2501
0.850	1981	2027	1.020	2213	2280	1.190	2423	2507
0.855	1988	2035	1.025	2219	2287	1.195	2429	2514
0.860	1995	2043	1.030	2226	2294	1.200	2435	2520
0.865	2003	2051	1.035	2232	2301	1.205	2440	2526
0.870	2010	2059	1.040	2239	2308	1.210	2446	2533
0.875	2017	2066	1.045	2245	2315	1.215	2452	2539
0.880	2024	2074	1.050	2251	2322	1.220	2458	2545
0.885	2031	2082	1.055	2258	2329	1.225	2464	2551
0.890	2038	2089	1.060	2264	2335	1.230	2470	2558
0.895	2045	2097	1.065	2270	2342	1.235	2475	2564

1/ 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.

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

Thickness, inches	Required BL(P), fps Class I & II	Required BL(P), fps Class III	Thickness, inches	Required BL(P), fps Class I & II	Required BL(P), fps Class III	Thickness, inches	Required BL(P), fps Class I & II	Required BL(P), fps Class III
1.240	2481	2570	1.335	2588	2686	1.430	2691	2797
1.245	2487	2576	1.340	2594	2692	1.435	2697	2802
1.250	2493	2583	1.345	2599	2698	1.440	2702	2808
1.255	2498	2589	1.350	2605	2704	1.445	2707	2814
1.260	2504	2595	1.355	2610	2710	1.450	2712	2820
1.265	2510	2601	1.360	2616	2716	1.455	2718	2825
1.270	2515	2607	1.365	2621	2721	1.460	2723	2831
1.275	2521	2613	1.370	2627	2727	1.465	2728	2837
1.280	2527	2620	1.375	2632	2733	1.470	2733	2842
1.285	2532	2626	1.380	2638	2739	1.475	2739	2848
1.290	2538	2632	1.385	2643	2745	1.480	2744	2853
1.295	2544	2638	1.390	2648	2751	1.485	2749	2859
1.300	2549	2644	1.395	2654	2756	1.490	2754	2865
1.305	2555	2650	1.400	2659	2762	1.495	2759	2870
1.310	2561	2656	1.405	2665	2768	1.500 [2/]	2765	2876
1.315	2566	2662	1.410	2670	2774	1.505	2770	2881
1.320	2572	2668	1.415	2675	2780	1.510	2775	2887
1.325	2577	2674	1.420	2681	2785	1.515	2780	2892
1.330	2583	2680	1.425	2686	2791	1.520	2785	2898

[2/] Specification requirements end for this ordered thickness.

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

TABLE B-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 III		Class I	Class II	Class III		Class I	Class II	Class III
1.480	2070	2083	2066	1.655	2213	2231	2213	1.830	2347	2370	2351
1.485	2074	2087	2070	1.660	2217	2235	2217	1.835	2351	2374	2355
1.490	2079	2092	2075	1.665	2221	2239	2221	1.840	2355	2377	2359
1.495	2083	2096	2079	1.670	2225	2243	2225	1.845	2359	2381	2363
1.501 1/	2088	2100	2084	1.675	2229	2247	2229	1.850	2362	2385	2366
1.505	2091	2105	2088	1.680	2233	2251	2233	1.855	2366	2389	2370
1.510	2095	2109	2092	1.685	2237	2255	2237	1.860	2370	2393	2374
1.515	2100	2113	2096	1.690	2241	2259	2241	1.865	2373	2397	2378
1.520	2104	2118	2100	1.695	2245	2263	2245	1.870	2377	2400	2382
1.525	2108	2122	2105	1.700	2248	2267	2249	1.875	2381	2404	2385
1.530	2112	2126	2109	1.705	2252	2271	2253	1.880	2384	2408	2389
1.535	2116	2131	2113	1.710	2256	2275	2257	1.885	2388	2412	2393
1.540	2120	2135	2118	1.715	2260	2279	2261	1.890	2392	2415	2397
1.545	2124	2139	2122	1.720	2264	2283	2265	1.895	2395	2419	2400
1.550	2129	2143	2126	1.725	2268	2287	2269	1.900	2399	2423	2404
1.555	2133	2148	2130	1.730	2272	2291	2273	1.905	2403	2427	2408
1.560	2137	2152	2134	1.735	2276	2295	2277	1.910	2406	2431	2412
1.565	2141	2156	2139	1.740	2279	2299	2281	1.915	2410	2434	2415
1.570	2145	2160	2143	1.745	2283	2303	2285	1.920	2414	2438	2419
1.575	2149	2165	2147	1.750	2287	2307	2289	1.925	2417	2442	2423
1.580	2153	2169	2151	1.755	2291	2311	2293	1.930	2421	2446	2427
1.585	2157	2173	2155	1.760	2295	2315	2297	1.935	2424	2449	2430
1.590	2161	2177	2160	1.765	2298	2319	2301	1.940	2428	2453	2434
1.595	2165	2181	2164	1.770	2302	2323	2305	1.945	2432	2457	2438
1.600	2169	2185	2168	1.775	2306	2327	2309	1.950	2435	2460	2441
1.605	2173	2190	2172	1.780	2310	2331	2313	1.955	2439	2464	2445
1.610	2177	2194	2176	1.785	2314	2335	2316	1.960	2442	2468	2449
1.615	2181	2198	2180	1.790	2317	2339	2320	1.965	2446	2472	2452
1.620	2185	2202	2184	1.795	2321	2343	2324	1.970	2450	2475	2456
1.625	2189	2206	2189	1.800	2325	2346	2328	1.975	2453	2479	2460
1.630	2193	2210	2193	1.805	2329	2350	2332	1.980	2457	2483	2463
1.635	2197	2214	2197	1.810	2332	2354	2336	1.985	2460	2486	2467
1.640	2201	2219	2201	1.815	2336	2358	2340	1.990	2464	2490	2471
1.645	2205	2223	2205	1.820	2340	2362	2344	1.995	2467	2494	2474
1.650	2209	2227	2209	1.825	2344	2366	2347	2.000	2471	2497	2478

1/ 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.

TABLE B-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 III		Class I	Class II	Class III		Class I	Class II	Class III
2.005	2474	2501	2482	2.180	2595	2626	2605	2.355	2711	N/A	2724
2.010	2478	2505	2485	2.185	2599	2629	2609	2.360	2714	N/A	2727
2.015	2482	2508	2489	2.190	2602	2633	2612	2.365	2717	N/A	2730
2.020	2485	2512	2492	2.195	2605	2636	2616	2.370	2720	N/A	2733
2.025	2489	2515	2496	2.200	2609	2640	2619	2.375	2724	N/A	2737
2.030	2492	2519	2500	2.205	2612	2643	2623	2.380	2727	N/A	2740
2.035	2496	2523	2503	2.210	2615	2646	2626	2.385	2730	N/A	2743
2.040	2499	2526	2507	2.215	2619	2650	2629	2.390	2733	N/A	2747
2.045	2503	2530	2510	2.220	2622	2653	2633	2.395	2736	N/A	2750
2.050	2506	2534	2514	2.225	2625	2657	2636	2.400	2740	N/A	2753
2.055	2510	2537	2518	2.230	2629	2660	2640	2.405	2743	N/A	2756
2.060	2513	2541	2521	2.235	2632	2664	2643	2.410	2746	N/A	2760
2.065	2517	2544	2525	2.240	2635	2667	2647	2.415	2749	N/A	2763
2.070	2520	2548	2528	2.245	2639	2671	2650	2.420	2752	N/A	2766
2.075	2523	2552	2532	2.250 [2/]	2642	2674	2653	2.425	2755	N/A	2769
2.080	2527	2555	2535	2.255	2645	2678	2657	2.430	2759	N/A	2773
2.085	2530	2559	2539	2.260	2649	2681	2660	2.435	2762	N/A	2776
2.090	2534	2562	2542	2.265	2652	2685	2663	2.440	2765	N/A	2779
2.095	2537	2566	2546	2.270	2655	2688	2667	2.445	2768	N/A	2782
2.100	2541	2569	2550	2.275	2659	2694	2670	2.450	2771	N/A	2786
2.105	2544	2573	2553	2.280	2662	N/A	2674	2.455	2774	N/A	2789
2.110	2548	2576	2557	2.285	2665	N/A	2677	2.460	2778	N/A	2792
2.115	2551	2580	2560	2.290	2668	N/A	2680	2.465	2781	N/A	2795
2.120	2554	2584	2564	2.295	2672	N/A	2684	2.470	2784	N/A	2799
2.125	2558	2587	2567	2.300	2675	N/A	2687	2.475	2787	N/A	2802
2.130	2561	2591	2571	2.305	2678	N/A	2690	2.480	2790	N/A	2805
2.135	2565	2594	2574	2.310	2681	N/A	2694	2.485	2793	N/A	2808
2.140	2568	2598	2578	2.315	2685	N/A	2697	2.490	2796	N/A	2811
2.145	2572	2601	2581	2.320	2688	N/A	2700	2.495	2800	N/A	2815
2.150	2575	2605	2585	2.325	2691	N/A	2704	2.500 [3/]	2803	N/A	2818
2.155	2578	2608	2588	2.330	2694	N/A	2707	2.505	2806	N/A	2821
2.160	2582	2612	2592	2.335	2698	N/A	2710	2.510	2809	N/A	2824
2.165	2585	2615	2595	2.340	2701	N/A	2714	2.515	2812	N/A	2827
2.170	2588	2619	2598	2.345	2704	N/A	2717	2.520	2815	N/A	2831
2.175	2592	2622	2602	2.350	2707	N/A	2720	2.525	2818	N/A	2834

[2/] Specification requirements end for this ordered thickness for Class II
[3/] Specification requirements end for this ordered thickness for Class I & III

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

TABLE B-VI. Minimum required ballistic limits - 14.5mm BS41 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
2.480	2577	2.655	2689	2.830	2797
2.485	2580	2.660	2692	2.835	2800
2.490	2583	2.665	2695	2.840	2803
2.495	2586	2.670	2698	2.845	2806
2.501 1/	2590	2.675	2702	2.850	2809
2.505	2593	2.680	2705	2.855	2812
2.510	2596	2.685	2708	2.860	2815
2.515	2600	2.690	2711	2.865	2818
2.520	2603	2.695	2714	2.870	2821
2.525	2606	2.700	2717	2.875	2824
2.530	2609	2.705	2720	2.880	2827
2.535	2613	2.710	2723	2.885	2830
2.540	2616	2.715	2727	2.890	2833
2.545	2619	2.720	2730	2.895	2836
2.550	2622	2.725	2733	2.900	2839
2.555	2625	2.730	2736	2.905	2842
2.560	2629	2.735	2739	2.910	2845
2.565	2632	2.740	2742	2.915	2848
2.570	2635	2.745	2745	2.920	2851
2.575	2638	2.750	2748	2.925	2854
2.580	2641	2.755	2751	2.930	2857
2.585	2645	2.760	2754	2.935	2860
2.590	2648	2.765	2757	2.940	2863
2.595	2651	2.770	2760	2.945	2866
2.600	2654	2.775	2763	2.950	2869
2.605	2657	2.780	2767	2.955	2872
2.610	2661	2.785	2770	2.960	2874
2.615	2664	2.790	2773	2.965	2877
2.620	2667	2.795	2776	2.970	2880
2.625	2670	2.800	2779	2.975	2883
2.630	2673	2.805	2782	2.980	2886
2.635	2676	2.810	2785	2.985	2889
2.640	2680	2.815	2788	2.990	2892
2.645	2683	2.820	2791	2.995	2895
2.650	2686	2.825	2794	3.000	2898

1/ 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.

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

Thickness, inches	Required BL(P), fps Class I	Thickness, inches	Required BL(P), fps Class I	Thickness, inches	Required BL(P), fps Class I
3.005	2901	3.180	3001	3.355	3098
3.010	2904	3.185	3004	3.360	3101
3.015	2907	3.190	3007	3.365	3104
3.020	2910	3.195	3010	3.370	3106
3.025	2912	3.200	3012	3.375	3109
3.030	2915	3.205	3015	3.380	3112
3.035	2918	3.210	3018	3.385	3114
3.040	2921	3.215	3021	3.390	3117
3.045	2924	3.220	3024	3.395	3120
3.050	2927	3.225	3026	3.400	3123
3.055	2930	3.230	3029	3.405	3125
3.060	2933	3.235	3032	3.410	3128
3.065	2936	3.240	3035	3.415	3131
3.070	2938	3.245	3037	3.420	3133
3.075	2941	3.250	3040	3.425	3136
3.080	2944	3.255	3043	3.430	3139
3.085	2947	3.260	3046	3.435	3141
3.090	2950	3.265	3049	3.440	3144
3.095	2953	3.270	3051	3.445	3147
3.100	2956	3.275	3054	3.450	3150
3.105	2959	3.280	3057	3.455	3152
3.110	2961	3.285	3060	3.460	3155
3.115	2964	3.290	3062	3.465	3158
3.120	2967	3.295	3065	3.470	3160
3.125	2970	3.300	3068	3.475	3163
3.130	2973	3.305	3071	3.480	3166
3.135	2976	3.310	3073	3.485	3168
3.140	2978	3.315	3076	3.490	3171
3.145	2981	3.320	3079	3.495	3174
3.150	2984	3.325	3082	3.500 [2/]	3176
3.155	2987	3.330	3084	3.505	3179
3.160	2990	3.335	3087	3.510	3182
3.165	2993	3.340	3090	3.515	3184
3.170	2995	3.345	3093	3.520	3187
3.175	2998	3.350	3095	3.525	3190

[2/] Specification requirements end for this ordered thickness.

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

TABLE B-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 1/	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 2/	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

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

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

CONCLUDING MATERIAL

Custodians:
Army – MR

Preparing activity:
ARMY – MR
(Project 9535-2015-001)

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.dla.mil/.