

INCH-POUND

MIL-DTL-32505
13 November 2014

DETAIL SPECIFICATION

ARMOR PLATE, ALUMINUM, ALLOY 7017 WELDABLE and 7020 APPLIQUE

This specification is approved for use by the Departments and Agencies of the Department of Defense

1. SCOPE

1.1 Scope. This specification covers two wrought aluminum armor plate alloys for welded and non-welded applications in nominal thicknesses from 0.500 to 4.000 inch, inclusive (see 6.2). The weldability of wrought aluminum alloy AA7017 armor has been determined for Class I armor for these thicknesses, only; 1.000" and 1.500". Class I (AA7017) material is a direct replacement for MIL-DTL-46063H w/Amendment 2 material, namely AA7039 for new design and if specified (see 6.2), for old design or repair/replacement. The acceptance requirements and the weldability of wrought aluminum alloy AA7020 armor have not been determined for Class II armor prior to the publication of this specification. Current testing is on-going and when completed this specification will be revised to contain all pertinent requirements and conditions for Class II (AA7020) armor. Class II aluminum alloy AA7020 is listed in this specification as a place holder until the above mentioned testing program is completed. Tables will be populated with the AA7020 requirements; however, for now the values will be replaced with 'TBD' (to be determined).

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

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

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.squillaciotti.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/>.

AMSC N/A

FSC 9535

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MIL-DTL-32505

1.3.1 Class I. Class I is wrought aluminum armor that conforms to the Aluminum Association designation for the 7017 aluminum alloy. The applicable gauge range for Class I is 0.500 - 4.000 inches.

1.3.2 Class II. Class II is wrought aluminum armor that conforms to the Aluminum Association designation for the 7020 aluminum alloy. The applicable gauge range for Class II is (to be determined) 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 - V₅₀ 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 specified, the issues of these documents are those cited in the solicitation or contract.

THE ALUMINUM ASSOCIATION, INC.

AA 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

MIL-DTL-32505

ASTM E716	-	Standard Practices for Sampling and Sample Preparation of Aluminum and Aluminum Alloys for Determination of Chemical Composition by Spectrochemical Analysis
ASTM E1251	-	Standard Test Method for Analysis of Aluminum and Aluminum Alloys by Spark Atomic Emission Spectrometry
ASTM G38	-	Standard Practice for Making and Using C-Ring Stress-Corrosion Test Specimens
ASTM G47	-	Standard Test Method for Determining Susceptibility to Stress-Corrosion Cracking of 2XXX and 7XXX Aluminum Alloy Products

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

SAE INTERNATIONAL

AMS 2750	-	Pyrometry
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(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 transverse (LT) 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.

MIL-DTL-32505

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

ELEMENTS	SYMBOL	Class I 7017 ALLOY ^{2/}	Class II 7020 ALLOY ^{2/}
Silicon	Si	0.35	0.35
Iron	Fe	0.45	0.40
Copper	Cu	0.20	0.20
Manganese	Mn	0.05 - 0.50	0.05 - 0.50
Magnesium	Mg	2.0 - 3.0	1.0 - 1.4
Chromium	Cr	0.35	0.10 - 0.35
Nickel	Ni	0.10	N/A
Zinc	Zn	4.0 - 5.2	4.0 - 5.0
Titanium	Ti	0.15	N/A
Zirconium	Zr	0.10 - 0.25	0.08 - 0.20
Other, min	(Mn + Cr)	0.15	N/A
Other	(Zr + Ti)	N/A	0.08 - 0.25
Other, max. Each	---	0.05	0.05
Other, max. Total ^{3/}	---	0.15	0.15
Aluminum	Al	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, except for [(Mn + Cr)] these indicate the maximum amounts permitted.

^{3/} The sum of those "others" metallic elements equaling 0.010 percent or more for each, shall be expressed to the second decimal before determining the sum.

3.4 Weldability. The vehicle 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 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 1.000" and 1.500" and Class II material in the thicknesses of (to be determined).

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 V₅₀ (which obviously cannot be explicitly determined) above the minimum requirement.

MIL-DTL-32505

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).

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

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 1.500, incl.	63	TBD ^{2/}	53	TBD	9	TBD
1.501 to 4.000, incl.	60	TBD	50	TBD	8	TBD

^{1/} The 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/} To Be Determined

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 AA H35.2, except for thickness.

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
OVER	THRU	THRU	39.37	59.06	78.74	98.43	118.11	137.80	157.48	177.17
		TOLERANCES - INCHES (PLUS and MINUS)								
0.500	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.

MIL-DTL-32505

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).

3.11 Stress Corrosion Cracking Resistance. Unless otherwise specified in the contract or order (see 6.2) plate material 0.72 inch and thicker in the short transverse direction shall be resistant to stress corrosion cracking. A minimum of 5 of the 9 specimens tested shall show no evidence of cracking at the end of 96 hours when tested as specified in 4.7.4.

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 in 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.

MIL-DTL-32505

REQUEST FOR BALLISTIC TEST OF ALUMINUM ALLOY 7017 / 7020 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-32505						REVISION:			AMENDMENT:		
CONTRACT NO:						ATC PROJECT NO:					
DCAS REGION:						BALLISTIC TEST CONTRACT NO:					
TEST ITEM IDENTIFICATION:											
Lot No.			Plate No.			Ordered			Alloy and Temper		
Class:						Thickness					
PURPOSE: ___ Acceptance ___ First Article ___ Development											
SAMPLE: Primary Retest (Firing Record No. of Failed Sample)											
CHEMICAL ANALYSIS:				OTHERS: Mn+Cr:				Zr+Ti:		Al :	
Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Zr	Ni	Other, max.	
										Each	Total
MECHANICAL PROPERTIES: AA7017/AA7020 Density :											
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-32505.											
Government Representative				Date		Supplier Representative				Date	

FIGURE 1. Aluminum Armor Test Data Form.

MIL-DTL-32505

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

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

4.5.2 Conformance inspection.

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

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

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

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

TABLE IV. Number of tension tests.

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

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

MIL-DTL-32505

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

4.5.2.4 Stress Corrosion Cracking. Nine test specimens shall be removed from one plate from each lot for testing in accordance with 4.7.4.

4.6 Examination.

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

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 transverse (LT) direction. 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 Collieran 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.

MIL-DTL-32505

TABLE V. Acceptance ballistic test plates.

Ordered Thickness, Inches	Projectile	Angle of Obliquity in Degrees	TABLE	CLASS I (7017)	CLASS II (7020)
0.500 - 0.749	Cal. .30 AP M2	30	B-I	Listed	TBD ^{1/}
0.750 - 0.950	Cal. .50 FSP	0	B-II	Listed	TBD ^{1/}
0.951 - 1.500	20-mm FSP	0	B-III	Listed	TBD ^{1/}
0.750 - 1.500	Cal. .30 AP M2	0	B-IV	Listed	TBD ^{1/}
1.501 - 2.500	Cal. .50 AP M2	0	B-V	Listed	TBD ^{1/}
2.501 - 3.500	14.5-mm BS41	0	B-VI	Listed	TBD ^{1/}
3.501 - 4.000	20-mm M602	0	B-VII	TBD ^{1/}	TBD ^{1/}

^{1/} To be determined.

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.

4.7.4 Stress Corrosion. Short transverse stress corrosion test specimens shall be prepared and tested in accordance with procedure outlined in ASTM G38 and ASTM G47. The specimens shall be stressed to 35 ksi. Nine specimens shall be tested per sample per lot. A maximum delay of 3 hours between stressing and initiation of stress corrosion test is permitted.

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, 4.8.2, and 4.8.3.

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.

4.8.3 Stress corrosion. Immediately upon notification of the failure of the stress corrosion specimens, the manufacturer may at their expense submit thirteen additional specimens for retesting. A minimum of seven specimens out of the thirteen additional specimens shall show no cracks upon examination at the end of 96 hours when tested as specified in 4.7.4. If the retest also fails, the manufacturer may elect to resubmit the lot after retreatment of the entire lot. After retreatment, the lot must pass the requirements outlined in 4.7.2, 4.7.3 and 4.7.4.

MIL-DTL-32505

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 that the manufacturer agrees in writing 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.
- (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 different (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 stress corrosion cracking resistance is not required or is different (see 3.11).
- (i) If the weight of finished plate can exceed 50,000 pounds (see 4.2).
- (j) The orientation of the ballistic plate with respect to rolling is different (see 4.5.1.3 and 4.5.2.3).
- (k) Dimensional sampling procedure approved by the procuring activity (see 4.6.2).
- (l) If approval was requested and received for a different ballistic testing facility (see 4.7.3.1)
- (m) Rejection and retest requirement, if different (see 4.8).
- (n) If reduced testing is allowed (see 4.9).
- (o) Packaging requirements (see 5.1).
- (p) Striking velocities for those thicknesses not covered (see A.3.6.1.1).

MIL-DTL-32505

6.3 Weldability. The Army Research Lab has conducted testing and found that Class I, AA7017 and [To be determined Class II, AA7020] alloys can be welded and demonstrate 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 these alloys. 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 will 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 7000, 5000, and 6000 series alloys using a 5000 series filler metal. It is not weldable to 2000 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. Butt joints were successfully welded with AA5556 weld wire for Class I (AA7017) when tested with the required proofing projectile per the Ground Combat Vehicle Welding Code 19207-12472301. For Class II (AA7020) flat weldments (butt joints) (to be determined) weld wire was successfully used in welding the plates for proof testing (see 1.2).

6.5 Density. The density of AA7017 is 0.09971 lb/in³ (2.76 g/cm³). The density of AA7020 is 0.10043 lb/in³ (2.78 g/cm³).

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)

6.7 Subject term (key word) listing.

Ballistic testing
 Caliber .30 AP M2
 Caliber .50 AP M2
 Caliber .50 FSP
 M1114 HMMWV
 Military vehicles
 Stress corrosion
 14.5-mm API
 20-mm FSP

MIL-DTL-32505
APPENDIX A

ARMOR PLATE, ALUMINUM, ALLOY 7017 WELDABLE and 7020 APPLIQUE

A.1 SCOPE

A.1.1 Scope. This appendix covers the minimum welding acceptable requirements (striking velocities, etc.) of aluminum alloy armor plate, AA7017 (and AA7020 when the testing program mentioned in 1.1 is completed) 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 contain 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. Alloys 7017 and 7020 shall be classified as M27 materials.

A3.2 Tensile Strength of Welded Aluminum Alloys (Table 5.1 of 19207-12472301). The minimum tensile strength of 7017, Class I welds, shall be 46 ksi. The minimum tensile strength of 7020, Class II welds, shall be TBD 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).

MIL-DTL-32505

APPENDIX A

A3.5 Base Metal- Ballistic Welds. Material conforming to this specification is permitted for critical 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 Flat Weldments (Butt 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 these tables shall be as agreed upon in the contract or purchase order (see 6.2).

A.3.6.2 Number of Impacts. One fair impact shall be required on the welded butt joint. Should a second round be required, the procedure specified in the TACOM Drawing 19207-12472301 shall be followed.

TABLE A-I. Minimum required striking velocities for Flat Weldments (Butt joints)

ORDERED THICKNESS (Inches)	Plate Proofing Projectile	Class I (AA7017)	Class II (AA7020)
1.000	<u>75-mm Aluminum, M1002A</u>	925 fps	TBD ^{1/}
1.500	<u>75-mm Aluminum, M1002A</u>	1130 fps	TBD ^{1/}

^{1/} To be determined

MIL-DTL-32505
APPENDIX B

ARMOR PLATE, ALUMINUM, ALLOY 7017 WELDABLE and 7020 APPLIQUE

B.1 SCOPE

B.1.1 Scope. This appendix covers the minimum ballistic limits for acceptable requirements of aluminum alloy armor plate, AA7017 and AA7020 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.

MIL-DTL-32505
APPENDIX B

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 $72 \pm 15^{\circ}\text{F}$ ($22 \pm 8^{\circ}\text{C}$).

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)).

MIL-DTL-32505
APPENDIX B

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 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.

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 his 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.

MIL-DTL-32505
APPENDIX B

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 I	Class II		Class I	Class II
0.475	1448	TBD	0.580	1662	TBD	0.685	1865	TBD
0.480	1459	TBD	0.585	1672	TBD	0.690	1874	TBD
0.485	1469	TBD	0.590	1682	TBD	0.695	1883	TBD
0.490	1480	TBD	0.595	1692	TBD	0.700	1893	TBD
0.495	1490	TBD	0.600	1702	TBD	0.705	1902	TBD
0.500 ^{1/}	1500	TBD	0.605	1711	TBD	0.710	1911	TBD
0.505	1511	TBD	0.610	1721	TBD	0.715	1921	TBD
0.510	1521	TBD	0.615	1731	TBD	0.720	1930	TBD
0.515	1531	TBD	0.620	1741	TBD	0.725	1939	TBD
0.520	1541	TBD	0.625	1750	TBD	0.730	1948	TBD
0.525	1552	TBD	0.630	1760	TBD	0.735	1958	TBD
0.530	1562	TBD	0.635	1770	TBD	0.740	1967	TBD
0.535	1572	TBD	0.640	1779	TBD	0.745	1976	TBD
0.540	1582	TBD	0.645	1789	TBD	0.749 ^{2/}	1983	TBD
0.545	1592	TBD	0.650	1798	TBD	0.755	1994	TBD
0.550	1602	TBD	0.655	1808	TBD	0.760	2003	TBD
0.555	1612	TBD	0.660	1817	TBD	0.765	2012	TBD
0.560	1622	TBD	0.665	1827	TBD	0.770	2022	TBD
0.565	1632	TBD	0.670	1836	TBD	0.775	2031	TBD
0.570	1642	TBD	0.675	1846	TBD	0.780	2040	TBD
0.575	1652	TBD	0.680	1855	TBD	0.785	2049	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.

MIL-DTL-32505
APPENDIX B

TABLE B-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	Class II		Class I	Class II		Class I	Class II
0.730	1912	TBD	0.815	2297	TBD	0.900	2759	TBD
0.735	1933	TBD	0.820	2322	TBD	0.905	2789	TBD
0.740	1954	TBD	0.825	2347	TBD	0.910	2819	TBD
0.745	1975	TBD	0.830	2372	TBD	0.915	2849	TBD
0.750 ^{1/}	1996	TBD	0.835	2398	TBD	0.920	2880	TBD
0.755	2018	TBD	0.840	2424	TBD	0.925	2911	TBD
0.760	2040	TBD	0.845	2450	TBD	0.930	2943	TBD
0.765	2062	TBD	0.850	2477	TBD	0.935	2975	TBD
0.770	2084	TBD	0.855	2504	TBD	0.940	3007	TBD
0.775	2107	TBD	0.860	2531	TBD	0.945	3040	TBD
0.780	2130	TBD	0.865	2558	TBD	0.950 ^{2/}	3073	TBD
0.785	2153	TBD	0.870	2586	TBD	0.955	3106	TBD
0.790	2176	TBD	0.875	2614	TBD	0.960	3140	TBD
0.795	2200	TBD	0.880	2642	TBD	0.965	3174	TBD
0.800	2224	TBD	0.885	2671	TBD	0.970	3208	TBD
0.805	2248	TBD	0.890	2700	TBD	0.975	3243	TBD
0.810	2272	TBD	0.895	2729	TBD	0.980	3278	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.

MIL-DTL-32505
APPENDIX B

TABLE B-III. Minimum required ballistic limits – 20mm 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	Class II		Class I	Class II		Class I	Class II
0.930	1284	TBD	1.100	1623	TBD	1.270	2052	TBD
0.935	1293	TBD	1.105	1634	TBD	1.275	2066	TBD
0.940	1302	TBD	1.110	1645	TBD	1.280	2080	TBD
0.945	1311	TBD	1.115	1657	TBD	1.285	2094	TBD
0.951 ^{1/}	1321	TBD	1.120	1668	TBD	1.290	2109	TBD
0.955	1329	TBD	1.125	1680	TBD	1.295	2123	TBD
0.960	1338	TBD	1.130	1691	TBD	1.300	2138	TBD
0.965	1347	TBD	1.135	1703	TBD	1.305	2153	TBD
0.970	1356	TBD	1.140	1715	TBD	1.310	2168	TBD
0.975	1366	TBD	1.145	1727	TBD	1.315	2183	TBD
0.980	1375	TBD	1.150	1739	TBD	1.320	2198	TBD
0.985	1385	TBD	1.155	1751	TBD	1.325	2213	TBD
0.990	1394	TBD	1.160	1763	TBD	1.330	2228	TBD
0.995	1404	TBD	1.165	1775	TBD	1.335	2244	TBD
1.000	1414	TBD	1.170	1787	TBD	1.340	2259	TBD
1.005	1424	TBD	1.175	1800	TBD	1.345	2275	TBD
1.010	1433	TBD	1.180	1812	TBD	1.350	2291	TBD
1.015	1443	TBD	1.185	1825	TBD	1.355	2307	TBD
1.020	1453	TBD	1.190	1837	TBD	1.360	2323	TBD
1.025	1463	TBD	1.195	1850	TBD	1.365	2339	TBD
1.030	1473	TBD	1.200	1863	TBD	1.370	2355	TBD
1.035	1484	TBD	1.205	1876	TBD	1.375	2371	TBD
1.040	1494	TBD	1.210	1889	TBD	1.380	2388	TBD
1.045	1504	TBD	1.215	1902	TBD	1.385	2404	TBD
1.050	1515	TBD	1.220	1915	TBD	1.390	2421	TBD
1.055	1525	TBD	1.225	1928	TBD	1.395	2437	TBD
1.060	1536	TBD	1.230	1941	TBD	1.400	2454	TBD
1.065	1546	TBD	1.235	1955	TBD	1.405	2471	TBD
1.070	1557	TBD	1.240	1968	TBD	1.410	2488	TBD
1.075	1568	TBD	1.245	1982	TBD	1.415	2506	TBD
1.080	1579	TBD	1.250	1996	TBD	1.420	2523	TBD
1.085	1590	TBD	1.255	2010	TBD	1.425	2540	TBD
1.090	1601	TBD	1.260	2023	TBD	1.430	2558	TBD
1.095	1612	TBD	1.265	2037	TBD	1.435	2576	TBD

^{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.

MIL-DTL-32505
APPENDIX B

TABLE B-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	Class II		Class I	Class II		Class I	Class II
1.440	2593	TBD	1.470	2703	TBD	1.500 ^{2/}	2817	TBD
1.445	2611	TBD	1.475	2722	TBD	1.505	2837	TBD
1.450	2629	TBD	1.480	2741	TBD	1.510	2856	TBD
1.455	2648	TBD	1.485	2759	TBD	1.515	2876	TBD
1.460	2666	TBD	1.490	2779	TBD	1.520	2896	TBD
1.465	2684	TBD	1.495	2798	TBD	1.525	2916	TBD

^{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.

MIL-DTL-32505
APPENDIX B

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

Thickness, inches	Required BL(P), fps		Thickness, inches	Required BL(P), fps		Thickness, inches	Required BL(P), fps	
	Class I	Class II		Class I	Class II		Class I	Class II
0.730	1732	TBD	0.900	1969	TBD	1.070	2189	TBD
0.735	1739	TBD	0.905	1976	TBD	1.075	2196	TBD
0.740	1746	TBD	0.910	1982	TBD	1.080	2202	TBD
0.745	1754	TBD	0.915	1989	TBD	1.085	2208	TBD
0.750 ^{1/}	1761	TBD	0.920	1996	TBD	1.090	2214	TBD
0.755	1768	TBD	0.925	2002	TBD	1.095	2221	TBD
0.760	1775	TBD	0.930	2009	TBD	1.100	2227	TBD
0.765	1782	TBD	0.935	2016	TBD	1.105	2233	TBD
0.770	1789	TBD	0.940	2022	TBD	1.110	2239	TBD
0.775	1796	TBD	0.945	2029	TBD	1.115	2245	TBD
0.780	1804	TBD	0.950	2037	TBD	1.120	2252	TBD
0.785	1811	TBD	0.955	2042	TBD	1.125	2258	TBD
0.790	1818	TBD	0.960	2048	TBD	1.130	2264	TBD
0.795	1825	TBD	0.965	2055	TBD	1.135	2270	TBD
0.800	1832	TBD	0.970	2062	TBD	1.140	2276	TBD
0.805	1839	TBD	0.975	2068	TBD	1.145	2282	TBD
0.810	1846	TBD	0.980	2075	TBD	1.150	2288	TBD
0.815	1853	TBD	0.985	2081	TBD	1.155	2294	TBD
0.820	1860	TBD	0.990	2087	TBD	1.160	2301	TBD
0.825	1867	TBD	0.995	2094	TBD	1.165	2307	TBD
0.830	1874	TBD	1.000	2100	TBD	1.170	2313	TBD
0.835	1881	TBD	1.005	2107	TBD	1.175	2319	TBD
0.840	1887	TBD	1.010	2113	TBD	1.180	2325	TBD
0.845	1894	TBD	1.015	2120	TBD	1.185	2331	TBD
0.850	1901	TBD	1.020	2126	TBD	1.190	2337	TBD
0.855	1908	TBD	1.025	2132	TBD	1.195	2343	TBD
0.860	1915	TBD	1.030	2139	TBD	1.200	2349	TBD
0.865	1922	TBD	1.035	2145	TBD	1.205	2355	TBD
0.870	1928	TBD	1.040	2152	TBD	1.210	2361	TBD
0.875	1935	TBD	1.045	2158	TBD	1.215	2367	TBD
0.880	1942	TBD	1.050	2164	TBD	1.220	2373	TBD
0.885	1949	TBD	1.055	2171	TBD	1.225	2379	TBD
0.890	1956	TBD	1.060	2177	TBD	1.230	2385	TBD
0.895	1962	TBD	1.065	2183	TBD	1.235	2391	TBD

^{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.

MIL-DTL-32505
APPENDIX B

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

Thickness, inches	Required BL(P), fps		Thickness, inches	Required BL(P), fps		Thickness, inches	Required BL(P), fps	
	Class I	Class II		Class I	Class II		Class I	Class II
1.240	2397	TBD	1.335	2508	TBD	1.430	2615	TBD
1.245	2402	TBD	1.340	2513	TBD	1.435	2621	TBD
1.250	2408	TBD	1.345	2519	TBD	1.440	2627	TBD
1.255	2414	TBD	1.350	2525	TBD	1.445	2632	TBD
1.260	2420	TBD	1.355	2531	TBD	1.450	2638	TBD
1.265	2426	TBD	1.360	2536	TBD	1.455	2643	TBD
1.270	2432	TBD	1.365	2542	TBD	1.460	2649	TBD
1.275	2438	TBD	1.370	2548	TBD	1.465	2655	TBD
1.280	2444	TBD	1.375	2553	TBD	1.470	2660	TBD
1.285	2450	TBD	1.380	2559	TBD	1.475	2666	TBD
1.290	2455	TBD	1.385	2565	TBD	1.480	2671	TBD
1.295	2461	TBD	1.390	2570	TBD	1.485	2677	TBD
1.300	2467	TBD	1.395	2576	TBD	1.490	2682	TBD
1.305	2473	TBD	1.400	2582	TBD	1.495	2688	TBD
1.310	2479	TBD	1.405	2587	TBD	1.500 ^{2/}	2693	TBD
1.315	2484	TBD	1.410	2593	TBD	1.505	2699	TBD
1.320	2490	TBD	1.415	2599	TBD	1.510	2704	TBD
1.325	2496	TBD	1.420	2604	TBD	1.515	2710	TBD
1.330	2502	TBD	1.425	2610	TBD	1.520	2715	TBD

^{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.

MIL-DTL-32505
APPENDIX B

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 I	Class II		Class I	Class II
1.480	2000	TBD	1.655	2135	TBD	1.830	2264	TBD
1.485	2004	TBD	1.660	2139	TBD	1.835	2268	TBD
1.490	2008	TBD	1.665	2142	TBD	1.840	2272	TBD
1.495	2012	TBD	1.670	2146	TBD	1.845	2275	TBD
1.501 ^{1/2}	2016	TBD	1.675	2150	TBD	1.850	2279	TBD
1.505	2019	TBD	1.680	2154	TBD	1.855	2282	TBD
1.510	2023	TBD	1.685	2158	TBD	1.860	2286	TBD
1.515	2027	TBD	1.690	2161	TBD	1.865	2290	TBD
1.520	2031	TBD	1.695	2165	TBD	1.870	2293	TBD
1.525	2035	TBD	1.700	2169	TBD	1.875	2297	TBD
1.530	2039	TBD	1.705	2172	TBD	1.880	2300	TBD
1.535	2043	TBD	1.710	2176	TBD	1.885	2304	TBD
1.540	2047	TBD	1.715	2180	TBD	1.890	2308	TBD
1.545	2051	TBD	1.720	2184	TBD	1.895	2311	TBD
1.550	2055	TBD	1.725	2187	TBD	1.900	2315	TBD
1.555	2058	TBD	1.730	2191	TBD	1.905	2318	TBD
1.560	2062	TBD	1.735	2195	TBD	1.910	2322	TBD
1.565	2066	TBD	1.740	2198	TBD	1.915	2325	TBD
1.570	2070	TBD	1.745	2202	TBD	1.920	2329	TBD
1.575	2074	TBD	1.750	2206	TBD	1.925	2333	TBD
1.580	2078	TBD	1.755	2210	TBD	1.930	2336	TBD
1.585	2082	TBD	1.760	2213	TBD	1.935	2340	TBD
1.590	2085	TBD	1.765	2217	TBD	1.940	2343	TBD
1.595	2089	TBD	1.770	2221	TBD	1.945	2347	TBD
1.600	2093	TBD	1.775	2224	TBD	1.950	2350	TBD
1.605	2097	TBD	1.780	2228	TBD	1.955	2354	TBD
1.610	2101	TBD	1.785	2232	TBD	1.960	2357	TBD
1.615	2105	TBD	1.790	2235	TBD	1.965	2361	TBD
1.620	2108	TBD	1.795	2239	TBD	1.970	2364	TBD
1.625	2112	TBD	1.800	2243	TBD	1.975	2368	TBD
1.630	2116	TBD	1.805	2246	TBD	1.980	2371	TBD
1.635	2120	TBD	1.810	2250	TBD	1.985	2375	TBD
1.640	2124	TBD	1.815	2253	TBD	1.990	2378	TBD
1.645	2127	TBD	1.820	2257	TBD	1.995	2382	TBD
1.650	2131	TBD	1.825	2261	TBD	2.000	2385	TBD

^{1/2} 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.

MIL-DTL-32505
APPENDIX B

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 I	Class II		Class I	Class II
2.005	2389	TBD	2.180	2509	TBD	2.355	2625	TBD
2.010	2392	TBD	2.185	2512	TBD	2.360	2628	TBD
2.015	2396	TBD	2.190	2516	TBD	2.365	2631	TBD
2.020	2399	TBD	2.195	2519	TBD	2.370	2635	TBD
2.025	2403	TBD	2.200	2522	TBD	2.375	2638	TBD
2.030	2406	TBD	2.205	2526	TBD	2.380	2641	TBD
2.035	2410	TBD	2.210	2529	TBD	2.385	2644	TBD
2.040	2413	TBD	2.215	2532	TBD	2.390	2648	TBD
2.045	2417	TBD	2.220	2536	TBD	2.395	2651	TBD
2.050	2420	TBD	2.225	2539	TBD	2.400	2654	TBD
2.055	2424	TBD	2.230	2542	TBD	2.405	2657	TBD
2.060	2427	TBD	2.235	2546	TBD	2.410	2661	TBD
2.065	2430	TBD	2.240	2549	TBD	2.415	2664	TBD
2.070	2434	TBD	2.245	2552	TBD	2.420	2667	TBD
2.075	2437	TBD	2.250	2556	TBD	2.425	2670	TBD
2.080	2441	TBD	2.255	2559	TBD	2.430	2674	TBD
2.085	2444	TBD	2.260	2562	TBD	2.435	2677	TBD
2.090	2448	TBD	2.265	2566	TBD	2.440	2680	TBD
2.095	2451	TBD	2.270	2569	TBD	2.445	2683	TBD
2.100	2454	TBD	2.275	2572	TBD	2.450	2686	TBD
2.105	2458	TBD	2.280	2576	TBD	2.455	2690	TBD
2.110	2461	TBD	2.285	2579	TBD	2.460	2693	TBD
2.115	2465	TBD	2.290	2582	TBD	2.465	2696	TBD
2.120	2468	TBD	2.295	2585	TBD	2.470	2699	TBD
2.125	2472	TBD	2.300	2589	TBD	2.475	2702	TBD
2.130	2475	TBD	2.305	2592	TBD	2.480	2706	TBD
2.135	2478	TBD	2.310	2592	TBD	2.485	2709	TBD
2.140	2482	TBD	2.315	2599	TBD	2.490	2712	TBD
2.145	2485	TBD	2.320	2602	TBD	2.495	2715	TBD
2.150	2489	TBD	2.325	2605	TBD	2.500 ^{2/}	2718	TBD
2.155	2492	TBD	2.330	2609	TBD	2.505	2722	TBD
2.160	2495	TBD	2.335	2612	TBD	2.510	2725	TBD
2.165	2499	TBD	2.340	2615	TBD	2.515	2728	TBD
2.170	2502	TBD	2.345	2618	TBD	2.520	2731	TBD
2.175	2505	TBD	2.350	2622	TBD	2.525	2734	TBD

^{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.

MIL-DTL-32505
APPENDIX B

TABLE B-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 II		Class I	Class II		Class I	Class II
2.480	2456	TBD	2.655	2560	TBD	2.830	2662	TBD
2.485	2459	TBD	2.660	2563	TBD	2.835	2664	TBD
2.490	2462	TBD	2.665	2566	TBD	2.840	2667	TBD
2.495	2465	TBD	2.670	2569	TBD	2.845	2670	TBD
2.501 ^{1/}	2469	TBD	2.675	2572	TBD	2.850	2673	TBD
2.505	2471	TBD	2.680	2675	TBD	2.855	2676	TBD
2.510	2474	TBD	2.685	2678	TBD	2.860	2679	TBD
2.515	2477	TBD	2.690	2581	TBD	2.865	2682	TBD
2.520	2480	TBD	2.695	2584	TBD	2.870	2684	TBD
2.525	2483	TBD	2.700	2586	TBD	2.875	2687	TBD
2.530	2486	TBD	2.705	2589	TBD	2.880	2690	TBD
2.535	2489	TBD	2.710	2592	TBD	2.885	2693	TBD
2.540	2492	TBD	2.715	2595	TBD	2.890	2696	TBD
2.545	2495	TBD	2.720	2598	TBD	2.895	2699	TBD
2.550	2498	TBD	2.725	2601	TBD	2.900	2701	TBD
2.555	2501	TBD	2.730	2604	TBD	2.905	2704	TBD
2.560	2504	TBD	2.735	2607	TBD	2.910	2707	TBD
2.565	2507	TBD	2.740	2610	TBD	2.915	2710	TBD
2.570	2510	TBD	2.745	2613	TBD	2.920	2713	TBD
2.575	2513	TBD	2.750	2616	TBD	2.925	2716	TBD
2.580	2516	TBD	2.755	2618	TBD	2.930	2718	TBD
2.585	2519	TBD	2.760	2621	TBD	2.935	2721	TBD
2.590	2522	TBD	2.765	2624	TBD	2.940	2724	TBD
2.595	2525	TBD	2.770	2627	TBD	2.945	2727	TBD
2.600	2528	TBD	2.775	2630	TBD	2.950	2730	TBD
2.605	2531	TBD	2.780	2633	TBD	2.955	2732	TBD
2.610	2534	TBD	2.785	2638	TBD	2.960	2735	TBD
2.615	2537	TBD	2.790	2639	TBD	2.965	2738	TBD
2.620	2540	TBD	2.795	2641	TBD	2.970	2741	TBD
2.625	2543	TBD	2.800	2644	TBD	2.975	2744	TBD
2.630	2545	TBD	2.805	2647	TBD	2.980	2746	TBD
2.635	2548	TBD	2.810	2650	TBD	2.985	2749	TBD
2.640	2551	TBD	2.815	2653	TBD	2.990	2752	TBD
2.645	2554	TBD	2.820	2656	TBD	2.995	2755	TBD
2.650	2557	TBD	2.825	2659	TBD	3.000	2758	TBD

^{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.

MIL-DTL-32505
APPENDIX B

TABLE B-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 II		Class I	Class II		Class I	Class II
3.005	2760	TBD	3.180	2857	TBD	3.355	2952	TBD
3.010	2763	TBD	3.185	2860	TBD	3.360	2955	TBD
3.015	2766	TBD	3.190	2963	TBD	3.365	2957	TBD
3.020	2769	TBD	3.195	2865	TBD	3.370	2960	TBD
3.025	2772	TBD	3.200	2868	TBD	3.375	2963	TBD
3.030	2774	TBD	3.205	2871	TBD	3.380	2965	TBD
3.035	2777	TBD	3.210	2874	TBD	3.385	2968	TBD
3.040	2780	TBD	3.215	2876	TBD	3.390	2971	TBD
3.045	2783	TBD	3.220	2879	TBD	3.395	2973	TBD
3.050	2786	TBD	3.225	2882	TBD	3.400	2976	TBD
3.055	2788	TBD	3.230	2884	TBD	3.405	2979	TBD
3.060	2791	TBD	3.235	2887	TBD	3.410	2981	TBD
3.065	2794	TBD	3.240	2890	TBD	3.415	2984	TBD
3.070	2797	TBD	3.245	2893	TBD	3.420	2987	TBD
3.075	2799	TBD	3.250	2895	TBD	3.425	2989	TBD
3.080	2802	TBD	3.255	2898	TBD	3.430	2992	TBD
3.085	2805	TBD	3.260	2901	TBD	3.435	2994	TBD
3.090	2808	TBD	3.265	2903	TBD	3.440	2997	TBD
3.095	2810	TBD	3.270	2906	TBD	3.445	3000	TBD
3.100	2813	TBD	3.275	2909	TBD	3.450	3002	TBD
3.105	2816	TBD	3.280	2912	TBD	3.455	3005	TBD
3.110	2819	TBD	3.285	2914	TBD	3.460	3008	TBD
3.115	2822	TBD	3.290	2917	TBD	3.465	3010	TBD
3.120	28824	TBD	3.295	2920	TBD	3.470	3013	TBD
3.125	2827	TBD	3.300	2922	TBD	3.475	3016	TBD
3.130	2830	TBD	3.305	2925	TBD	3.480	3018	TBD
3.135	2833	TBD	3.310	2928	TBD	3.485	3021	TBD
3.140	2835	TBD	3.315	2930	TBD	3.490	3024	TBD
3.145	2838	TBD	3.320	2933	TBD	3.495	3026	TBD
3.150	2841	TBD	3.325	2936	TBD	3.500 ^{2/}	3029	TBD
3.155	2844	TBD	3.330	2938	TBD	3.505	3031	TBD
3.160	2846	TBD	3.335	2941	TBD	3.510	3034	TBD
3.165	2849	TBD	3.340	2944	TBD	3.515	3037	TBD
3.170	2852	TBD	3.345	2947	TBD	3.520	3039	TBD
3.175	2854	TBD	3.350	2949	TBD	3.525	3042	TBD

^{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.

MIL-DTL-32505
APPENDIX B

TABLE B-VII. Minimum required ballistic limits - 20mm M602
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
3.480	TBD	TBD	3.665	TBD	TBD	3.850	TBD	TBD
3.485	TBD	TBD	3.670	TBD	TBD	3.855	TBD	TBD
3.490	TBD	TBD	3.675	TBD	TBD	3.860	TBD	TBD
3.495	TBD	TBD	3.680	TBD	TBD	3.865	TBD	TBD
3.501 ^{1/}	TBD	TBD	3.685	TBD	TBD	3.870	TBD	TBD
3.505	TBD	TBD	3.690	TBD	TBD	3.875	TBD	TBD
3.510	TBD	TBD	3.695	TBD	TBD	3.880	TBD	TBD
3.515	TBD	TBD	3.700	TBD	TBD	3.885	TBD	TBD
3.520	TBD	TBD	3.705	TBD	TBD	3.890	TBD	TBD
3.525	TBD	TBD	3.710	TBD	TBD	3.895	TBD	TBD
3.530	TBD	TBD	3.715	TBD	TBD	3.900	TBD	TBD
3.535	TBD	TBD	3.720	TBD	TBD	3.905	TBD	TBD
3.540	TBD	TBD	3.725	TBD	TBD	3.910	TBD	TBD
3.545	TBD	TBD	3.730	TBD	TBD	3.915	TBD	TBD
3.550	TBD	TBD	3.735	TBD	TBD	3.920	TBD	TBD
3.555	TBD	TBD	3.740	TBD	TBD	3.925	TBD	TBD
3.560	TBD	TBD	3.745	TBD	TBD	3.930	TBD	TBD
3.565	TBD	TBD	3.750	TBD	TBD	3.935	TBD	TBD
3.570	TBD	TBD	3.755	TBD	TBD	3.940	TBD	TBD
3.575	TBD	TBD	3.760	TBD	TBD	3.945	TBD	TBD
3.580	TBD	TBD	3.765	TBD	TBD	3.950	TBD	TBD
3.585	TBD	TBD	3.770	TBD	TBD	3.955	TBD	TBD
3.590	TBD	TBD	3.775	TBD	TBD	3.960	TBD	TBD
3.595	TBD	TBD	3.780	TBD	TBD	3.965	TBD	TBD
3.600	TBD	TBD	3.785	TBD	TBD	3.970	TBD	TBD
3.605	TBD	TBD	3.790	TBD	TBD	3.975	TBD	TBD
3.610	TBD	TBD	3.795	TBD	TBD	3.980	TBD	TBD
3.615	TBD	TBD	3.800	TBD	TBD	3.985	TBD	TBD
3.620	TBD	TBD	3.805	TBD	TBD	3.990	TBD	TBD
3.625	TBD	TBD	3.810	TBD	TBD	3.995	TBD	TBD
3.630	TBD	TBD	3.815	TBD	TBD	4.000 ^{2/}	TBD	TBD
3.635	TBD	TBD	3.820	TBD	TBD	4.010	TBD	TBD
3.640	TBD	TBD	3.825	TBD	TBD	4.015	TBD	TBD
3.645	TBD	TBD	3.830	TBD	TBD	4.020	TBD	TBD
3.650	TBD	TBD	3.835	TBD	TBD	4.025	TBD	TBD
3.655	TBD	TBD	3.840	TBD	TBD	4.030	TBD	TBD
3.660	TBD	TBD	3.845	TBD	TBD	4.035	TBD	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.

MIL-DTL-32505

CONCLUDING MATERIAL

Custodians:

Army – MR

Navy – AS

Air Force - 11

Preparing activity:

ARMY – MR

(Project 9535-2014-003)

Review activities:

Army – AT, TE

Navy – SH

Air Force – 84, 99

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/>.