INCH-POUND

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DETAIL SPECIFICATION

ALUMINUM ALLOY ARMOR, EXTRUDED, WELDABLE

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 extruded aluminum alloy armor shapes up to and including 2 inches in thickness (see 3.3 and 6.2).

1.2 Weldability. The alloys covered by this specification have been demonstrated to be weldable to itself and other weldable alloys (see 6.3).

1.3 Classification. Material furnished under this specification should be one of the following classes (see 6.2).

1.3.1 Class I. Consists of non-heat-treatable aluminum alloy extrusions.

1.3.1.1 Type A. Type A has the alloy designation 5083.

1.3.1.1 Type B. Type B has the alloy designation 5456.

1.3.2 Class II. Consists of heat-treatable aluminum alloy extrusions.

1.3.2.1 Type A. Type A has the alloy designation 7039.

Comments, suggestions, or questions on this document should be addressed to: Director, U.S. Army Research Laboratory, Weapons and Materials Research Directorate, Specifications and Standards Office, Attn: FCDD-RLW-MC, Aberdeen Proving Ground, MD 21005-5069. 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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1.3.2.1 Type B. Type B has the alloy designation 2219.

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 contract or purchase order.

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-662	-	V50 Ballistic Test for Armor
MIL-STD-3057	-	Arc Welding of Armor Grade Aluminum

(Copies of this document are available online at https://quicksearch.dla.mil/.)

2.3 Non-Government publications. The following documents 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.

THE ALUMINUM ASSOCIATION, INC.

ANSI H35.2	-	American National Standard Dimensional Tolerances for Aluminum Mill Products
Teal Sheets	-	International Alloy Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys

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

ASTM INTERNATIONAL

ASTM B557	-	Standard Test Methods for Tension Testing Wrought and Cast Aluminum and Magnesium-Alloy Products
ASTM E716	-	Standard Practices for Sampling and Sample Preparation of Aluminum and Aluminum Alloys for Determination of Chemical Composition by Spark Atomic Emission Spectrometry

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ASTM E1251	-	Standard Test Method for Analysis of Aluminum and Aluminum Alloys by Spark Atomic Emission Spectrometry
ASTM E3061	-	Standard Test Method for Analysis of Aluminum and Aluminum Alloys by Inductively Coupled Plasma Atomic

(Copies of these documents are available online at https://www.astm.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) and before production has commenced, samples of the specified item 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 manufactured by the process proposed for use on production. This process shall be inspected by a cognizant government representative to ensure compliance with the details of this specification. The manufacturer's declared chemical analysis shall be submitted to the contracting agency and to the ballistic test agency. The ballistic test agency shall record the first article ballistic test extrusions submitted, showing the dates tested. Requests from the procuring activity to the ballistic test agency as to prior conformance with first article tests shall be accompanied by copies of the first article test firing records. Any deviation(s) noticed by the ballistic agency shall be brought to the attention of the contracting activity and to the manufacturer. After first article testing has been accepted by the contracting activity, the composition and processing shall be considered fixed. If either of these parameters change outside of the limitations allowed, then a new first article test shall be required.

3.1.1 Change in mill processing. After an armor material has successfully complied with the requirements of this specification, any deliberate change in the mill processing by the manufacturer shall be drawn to the attention of the procuring activity and the contractor. If the material processing is changed, the first article tests of this specification may be again called upon to assure compliance with the requirements of this specification.

3.2 Chemical composition. The chemical composition of the extrusions shall be within the limits shown in table I. The limits specified in table I were listed from the Aluminum Association Teal Sheets dated August 2018, International Alloy Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys. A certification of conformance of the chemical composition of the alloy shall be furnished with the ballistic test extrusions.

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TABLE I. Chemical composition, weight percent. 1/ 2/

ELEMENTS	SYMBOL	Class I		Class II	
		Type A 5083 ALLOY	Type B 5456 ALLOY	Type A 7039 ALLOY	Type B 2219 ALLOY
Silicon	Si	0.40	0.25	0.30	0.20
Iron	Fe	0.40	0.40	0.40	0.30
Copper	Cu	0.10	0.10	0.10	5.8 - 6.8
Manganese	Mn	0.40 - 1.0	0.50 - 1.0	0.10 - 0.40	0.20 - 0.40
Magnesium	Mg	4.0 - 4.9	4.7 - 5.5	2.3 - 3.3	0.02
Chromium	Cr	0.05 - 0.25	0.05 - 0.20	0.15 - 0.25	---
Zinc	Zn	0.25	0.25	3.5 - 4.5	0.10
Titanium	Ti	0.15	0.20	0.10	0.02 - 0.10
Vanadium	V	---	---	---	0.05 - 0.15
Zirconium	Zr	---	---	---	0.10 - 0.25
Other, max. Each	---	0.05	0.05	0.05	0.05
Other, max. Total 3/	---	0.15	0.15	0.15	0.15
Aluminum	Al	Remainder	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 equaling 0.010 percent or more for each, shall be expressed to the second decimal before determining the sum.

3.3 Mechanical properties. Unless otherwise specified in the contract or purchase order (see 6.2), the mechanical properties of class I and class II extrusions shall meet the requirements of table II, when tested in accordance with 4.7.2

TABLE II. Minimum mechanical properties.

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
Up to 2.000, incl.	45.0	57.0	35.0	48.0	9	8

3.4 Ballistic requirements. Each ballistic test extrusion shall be proof fired for resistance to penetration by determining a protection ballistic limit, BL(P), at 0° obliquity. The minimum required ballistic limit for class I materials shall be determined from the values shown in tables A-I, A-II and A-III. The minimum required ballistic limit for class II materials shall be determined from the values shown in tables A-I, A-II, A-III and A-IV.

3.5 Thermal processing (class 1 only). After acceptance testing, any thermal processing exceeding 250°F (121°C) performed on the extrusion excluding fabrication by welding, will necessitate revivification for conformance to 3.3 and 3.4. Deviation from this requirement shall be subject to review and approval by the procuring activity.

3.6 Dimensions. Dimensions shall be as shown in the drawing specified in the invitation for bids, contract or order (see 6.2).

3.6.1 Tolerances. Unless otherwise specified in the contract or order (see 6.2), the extrusions submitted for acceptance shall not vary from the specified dimensions shown in ANSI H35.2.

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3.7 Marking for identification. Each extrusion shall be marked in at least one location in characters not less than 3/8 inch high with the following information. Impression stamping shall not be used, except in areas designated by the drawing (see 6.2).

a. Manufacturer's name, trademark or both.
b. Number of this specification.
c. Class and alloy designation.
d. Part or drawing number.
e. Lot number.

3.7.1 Ballistic test extrusions. Ballistic test extrusions for first article and acceptance extrusions shall be marked with the information in 3.7. In addition, first article extrusions shall be marked "PRE" and acceptance test extrusions marked "ACC". This marking shall be impression stamped in at least two opposing locations in letters not less than 1/2-inch high.

3.8 Ballistic test extrusion information. A properly executed armor data report shall be submitted containing the information as specified in MIL-STD-662.

3.9 Workmanship. Extruded shapes shall be clean, smooth, uniform in quality as well as free from buckles, blisters, hard spots, damaged ends, laminations and other defects which may affect their use in fabrication within the limits of good commercial practices.

3.9.1 Surface and edge condition. Surface cracks, edge cracks or edge laminations shall be cause for rejection.

4. VERIFICATION

4.1 Clarification of inspections. The inspection requirements specified herein are classified as conformance inspection (see 4.2)

4.2 Conformance inspection. Acceptance testing of individual lots consists of all requirements specified in section 3. Verification conformance inspection is in accordance with the provisions herein. Ballistic tests shall be performed at a government test activity selected by the procuring activity (see 6.2).

4.3 Classification of inspection. Inspection shall be classified as follows:

a. First article inspection (see 4.3.1).
b. Conformance (acceptance) inspection (see 4.3.2).

4.3.1 First article inspection. First article inspection shall consist of the following:

a. Chemical analysis (see 3.2 and 4.7.1).
b. Mechanical properties (see 3.3 and 4.7.2).
c. Ballistic tests (see 3.4 and 4.7.3).
d. Dimensions (see 3.6 and 4.6.2).
e. Identification marking (see 3.7, 3.7.1 and 4.6.1).
f. Workmanship (see 3.9 and 4.6.1).

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4.3.2 Conformance (acceptance) Inspection. Lot inspection acceptance inspection shall consist of the following:

a. Chemical analysis (see 3.2 and 4.7.1).
b. Mechanical properties (see 3.3 and 4.7.2).
c. Ballistic tests (see 3.4 and 4.7.3).
d. Dimensions (see 3.6 and 4.6.2).
e. Identification marking (see 3.7, 3.7.1 and 4.6.1).
f. Workmanship (see 3.9 and 4.6.1).
g. Preparation for shipment (see section 5).

4.4 Lot. A lot shall consist of finished extrusions, of the same class, shape, dimensions, alloy and temper, which are submitted for inspection as a unit, at essentially the same time and have a total weight of 25,000 pounds or less.

4.5 Sampling.

4.5.1 First article testing.

4.5.1.1 Chemical composition. Samples for chemical analysis shall be prepared and tested in accordance with one or more ASTM methods of E716, E1251, and E3061. In case of dispute, analysis by method E3061 shall be the basis for acceptance or rejection.

4.5.1.2 Mechanical properties. One tension test specimen for first article shall be removed from each extrusion that has been selected for ballistic test. Location and type of specimen shall be as specified in 4.7.2.

4.5.1.3 Ballistic tests. At least two extruded samples having sufficient area for performance of the ballistic test shall be submitted for each designated thickness and extruded shape shown on the drawing and which the manufacturer has under contract. Because of the variety of possible shapes and sizes, the manufacturer must contact the ballistic test agency to determine the minimum number needed to satisfactorily conduct the ballistic tests.

4.5.2 Acceptance lots.

4.5.2.1 Chemical composition, ingot analysis. At least one sample shall be taken from the molten metal representing the ingots poured from the same source of molten metal. Complete ingot analysis records shall be available to the Government at the producer's facility.

4.5.2.2 Chemical composition, finished product analysis. When sampling has not been made in accordance with 4.5.2.1, one sample shall be randomly taken for each 4,000 pounds (or less) of every lot in accordance with one or more ASTM methods of E716, E1251, and E3061.

4.5.2.3 Mechanical properties. Unless otherwise specified (see 6.2) from material having a nominal weight of less than one pound per lineal foot, one tension test sample shall be selected from each inspection lot weighing l,000 pounds or less; from inspection lots weighing more than 1,000 pounds, one additional sample shall be taken for each 1,000 pounds or fraction thereof in excess of the first 1,000 pounds. From material having a nominal weight of one pound or more per lineal foot, one tension-test sample shall be taken from each inspection lot consisting of 1,000

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feet, or less; from inspection lots consisting of more that 1,000 feet, one additional sample shall be taken from each 1,000 feet or fraction thereof in excess of the first 1,000 feet. Only one tension-test specimen shall be taken from any one piece when more than one piece is available.

4.5.2.4 Ballistic tests. Because of the variety of possible shapes and sizes, the manufacturer must contact the ballistic test agency to determine the minimum number of extrusions per lot which are needed to conduct the ballistic test(s).

4.6 Examination.

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

4.6.2 Dimensional. One extrusion from each lot (see 4.4) shall be measured to determine compliance with the requirements for dimensions and tolerances (see 3.6 and 3.6.1).

4.6.3 Preparation for shipment. Prior to shipment, examination shall be made to determine compliance with section 5.

4.7 Tests.

4.7.1 Chemical composition. Chemical analysis shall be conducted in accordance with one or more ASTM methods of E716, E1251, and E3061.

4.7.2 Mechanical properties. Tension test specimens shall be prepared and tested in accordance with ASTM B557. The specimens shall be taken from the extruded shape in the longitudinal direction. From shapes of nominal thickness of 0.75 to 1.50 inches, inclusive, tension test specimens shall be taken with the axis midway between the extruded surfaces; from shapes of nominal thickness greater than 1.50 inches, the axis of the test specimen shall be three-fourths of the distance from one surface to the other.

4.7.3 Ballistic testing. Ballistic testing shall be in accordance with appendix A. Extrusions shall be tested in accordance with the thickness ranges shown in table III to determine the projectile as well as the required V50 protection ballistic limit (see A.5.1.2). Extruded shape thickness as measured by the ballistic test agency shall be used to determine the required ballistic limit. Individual thickness measurements are read to the nearest 0.001 inch and the average of these readings reported to the nearest 0.005 inch. Thickness measurements of the extruded shape shall be made of the areas to be ballistically tested.

4.7.3.1 Ballistic testing facility. Unless otherwise specified in the contract or purchase order (see 6.2), the ballistic test extrusions shall be forwarded to the Commander, USA ATC, ATTN: TEDT-AT-SL-V, Building 358, 6850 Lanyard Road, APG, MD 21005-5059 or to an approved Government facility for ballistic testing for first article or production acceptance.

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TABLE III. Acceptance ballistic test extrusions.

Class	Ordered Thickness, Inches	Projectile [1/]	Angle of Obliquity in Degrees	TABLE
I	0.750 - 1.000	Cal. .50 FSP	0	A-I
I	1.001 - 2.000	Cal. .30 APM2	0	A-II
I	1.001 - 1.700	20-mm FSP	0	A-III
II	0.750 - 0.950	Cal. .50 FSP	0	A-I
II	0.951 - 1.500	Cal. .30 APM2	0	A-II
II	0.951 - 1.500	20-mm FSP	0	A-III
II	1.501 - 2.000	Cal. .50 APM2	0	A-IV

[1/] FSP denotes fragment simulating projectile and APM2 denotes armor piercing model 2 projectile.

4.8 Test specimens.

4.8.1 Rejection. Unless otherwise specified (see 6.2) where one or more test specimens fail to meet the requirements of the specification the lot represented by the specimen or specimens shall be subject to rejection.

4.8.2 Retest. When no sampling plan is provided or approved by the procuring agency (see 6.2) and where there is evidence that indicates that the specimen was not representative of the lot of material, and when the detail specification does not otherwise specify, at least two specimens shall be selected to replace each test specimen which failed. All specimens so selected for retest shall meet the requirements of the specification or the lot shall be subject to rejection.

4.8.3 Ballistic. Rejection and retest of ballistic test extrusions shall be in accordance with A.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 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 purchase order (see 6.2). When packaging of materiel components is 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.

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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. Acquisition documents should specify the following:

a. Title, number, and date of this specification.
b. Nominal thickness of aluminum armor extrusion (see 1.1).
c. Type, class, and alloy (see 1.2).
d. Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.2.1, 2.3 and A.2.1.1).
e. When first article is required (see 3.1).
f. Chemical composition and mechanical properties of aluminum armor (see 3.2 and 3.3).
g. Drawings, dimensions, and tolerances (see 3.6 and 3.6.1).
h. Marking for identification (see 3.7).
i. Destination of tension test samples (see 4.2).
j. Locations of tension test specimens (see 4.5.2 3).
k. Locations for determination of ballistic limits (see 4.7.3).
l. Rejection requirement, if other than in 4.8.1.
m. Retest requirement, if other than in 4.8.2.
n. Packaging requirements (see 5.1).

6.2.1 Armor material test reports. When this specification or specification requirements are used in an acquisition and data are required to be delivered, the data requirements identified in 3.8 should be developed and delivered in accordance with the approved Contract Data Requirements List (CDRL), incorporated into the contract. The data specified should be delivered by the Contractor in accordance with the contract or purchase order requirements.

6.3 Weldability. Previous testing of the alloys covered by this specification in other wrought conditions by the U.S. Army DEVCOM Ground Vehicle System Center & Research Lab, the U.S. Navy, and by NASA have all demonstrated good weldability. Extrusions of these alloys should all be verified for ballistic weld applicability by using the procedures described in MIL-STD-3057, “Arc Welding of Armor Grade Aluminum” prior to acceptance by the procuring activity.

6.4 Ownership of ballistic test extrusions.

6.4.1 First article and acceptance test extrusions. First article and acceptance test extrusions that comply with the requirements of this specification are considered as part of the lot of extrusions that they represent, and ownership of them passes to the Government with acceptance of that lot. First article and acceptance test extrusions that fail to comply with the requirements of this specification are considered as part of the lot they represent and remain the property of the manufacturer as does the rejectable lot which they represent.

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6.4.1.1 Disposal instructions for tested extrusions. At the time of shipment of the first article and acceptance test extrusions the ballistic test agency should be informed by the manufacturer, in writing, as to the disposition of first article and acceptance test extrusions which fail the test. If instructions for disposal of the tested extrusions are not received after 15 days, the proving ground will exercise the prerogative of disposing of the material.

6.5 Stress corrosion. To prevent failure in service due to stress corrosion, care should be exercised in design and fabrication to avoid stressing this material in the short transverse direction. No alkaline etching should be permitted.

6.6 Mechanical to ballistic requirements. The minimum mechanical properties specified (see 3.3) may not assure aluminum armor extrusions meeting the specified ballistic requirements (see 3.4).

6.7 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)

6.8 Definitions.

6.8.1 Contracting officer. The term "contracting officer" means the person executing a contract on behalf of the Government, and any other officer or civilian employee who is properly designated contracting officer; and the term includes, except as otherwise provided, the authorized representative of a contracting officer acting within the limits of his authority.

6.8.2 Contractor. The term “contractor” is defined as the organization having a direct contract with the procuring activity.

6.8.3 Manufacturer. The term “manufacturer” is defined as the organization actually performing the operations covered by this specification.

6.8.4 Procuring activity. The term "procuring activity" is that activity of the Government which actually initiates the request for procurement and maintains the records of the procurement.

6.9 Subject term (key word) listing.
Ballistic requirements

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Obliquity
Projectile
Thermal processing

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

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APPENDIX A

BALLISTIC TESTING OF ALUMINUM ALLOY ARMOR, EXTRUDED, WELDABLE

A.1 SCOPE

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

A.2 APPLICABLE DOCUMENTS

A.2.1 Government documents.

A.2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the contract or purchase order.

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-662 - V50 Ballistic Test for Armor

(Copies of these documents are available online at https://assist.dla.mil/).

A.3 DEFINITIONS

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

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

A.3.3 Gap. A gap is the difference in fps between the high partial penetration velocity and the low complete penetration velocity used to compute the ballistic limit when the high partial penetration velocity is lower than the low complete penetration velocity.

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

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

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APPENDIX A

A.4 REQUIREMENTS

A.4.1 Resistance to penetration. The minimum required ballistic limit shall be in accordance with the values shown in tables A-I through A-IV. 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 table will be performed. The average extrusion thickness, computed to the nearest 0.001 inch, will be used to determine the minimum required ballistic limit.

A.5 TESTS

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

A.5.1.1 Temperature conditioning. Prior to the test, the test item(s) shall be temperature conditioned at least eight hours. Thermostatic control shall be such that the average temperature of the item during the test shall be 72 ± 15°F (22 ± 8°C).

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

A.5.1.2.1 Normal circumstances. The BL(P) shall consist of an equal number of fair impact complete and partial penetration velocities attained by the up-and-down firing method. All BL(P)'s shall be computed using the highest partial penetration velocities and the lowest complete penetration velocities. Firing shall continue until either a 4-round BL(P) having a maximum velocity spread of 60 fps or a 6-round BL(P) having a maximum velocity spread of 90 fps has been attained, whichever comes first in the normal sequence of firing. If both occur simultaneously, the 6-round BL(P) shall be reported.

A.5.1.2.2 Large zone of mixed results. In the event that the zone of mixed results (difference between the high partial penetration velocity and the low complete penetration velocity, the PP[P] velocity being higher than the low CP[P] velocity) exceeds 90 fps, the firing data shall be compared with the specification minimum ballistic requirements. If the lowest complete penetration velocity is equal to or above the minimum specified ballistic limit velocity for the extrusion 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

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

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APPENDIX A

A.5.2 Rejection and retest of ballistic extrusions.

A.5.2.1 First article tests (rejection). Unless otherwise specified in the contract or purchase order, failure of any of the first article test extrusions to meet the minimum ballistic requirements shown in the appendix of this specification indicates failure of the product and process.

A.5.2.2 First article (retests). Resubmission of ballistic retest extrusions 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 extrusions shall be submitted for first article testing, and both tests shall pass; otherwise, the armor material shall be rejected.

A.5.2.3 Acceptance tests (rejection). Unless otherwise specified in the contract or purchase order, failure of a test extrusion to meet the ballistic requirements indicates failure of the lot; however, the final decision shall depend on the outcome of retests, if submitted.

A.5.2.4 Acceptance tests (retests). If a test extrusion representing a lot fails to meet the ballistic requirement, the manufacturer, upon notification of the failure may submit at their expense two additional test extrusions from the same lot for ballistic retest. If either of these extrusions 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 extrusions. If either of these extrusions fails, the lot shall be permanently rejected. Ballistic retest extrusions shall be marked "R1" and "R2" respectively in addition to the requirements of 3.7.

A.5.3 Disposition of ballistic test extrusions.

A.5.3.1 First article test extrusions. Upon request of the applicant within 15 days after ballistic testing, first article extrusions will be returned "as is" to the applicant, at their expense, unless the extrusions were destroyed in testing.

A.5.3.2 Acceptance test extrusions. Acceptance test extrusions that comply with the requirements of this specification are considered as part of the lot they represent, and ownership of the test extrusions passes to the Government with the acceptance of that lot. Acceptance test extrusions that fail to comply with the requirements of this specification are considered as part of the lot they represent and remain the property of the producer just as the rejectable lot does. The failed extrusions will be returned, upon request, as in A.5.3.1.

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APPENDIX A

TABLE A-I. 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
0.720	1689	1700	0.835	2029	2173	0.950 2/	2438	2770
0.725	1702	1718	0.840	2045	2196	0.955	2458	2799
0.730	1716	1737	0.845	2062	2219	0.960	2478	2829
0.735	1730	1756	0.850	2078	2243	0.965	2498	2858
0.740	1743	1774	0.855	2095	2267	0.970	2518	2889
0.745	1757	1794	0.860	2112	2291	0.975	2538	2919
0.750 1/	1771	1813	0.865	2129	2315	0.980	2558	2950
0.755	1786	1832	0.870	2146	2340	0.985	2579	---
0.760	1800	1852	0.875	2163	2365	0.990	2599	---
0.765	1814	1872	0.880	2180	2390	0.995	2620	---
0.770	1829	1892	0.885	2198	2415	1.000 3/	2641	---
0.775	1844	1912	0.890	2216	2441	1.005	2662	---
0.780	1858	1933	0.895	2233	2467	1.010	2684	---
0.785	1873	1954	0.900	2251	2493	1.015	2705	---
0.790	1888	1975	0.905	2269	2519	1.020	2727	---
0.795	1904	1996	0.910	2287	2546	1.025	2749	---
0.800	1919	2017	0.915	2306	2573	1.030	2771	---
0.805	1934	2039	0.920	2324	2600	1.035	2793	---
0.810	1950	2060	0.925	2343	2628	1.040	2815	---
0.815	1965	2082	0.930	2362	2656	1.045	2838	---
0.820	1981	2105	0.935	2381	2684	1.050	2861	---
0.825	1997	2127	0.940	2400	2712	---	---	---
0.830	2013	2150	0.945	2419	2741	---	---	---

1/ Class I and class II specification requirements begin for this ordered thickness.
2/ Class II specification requirements end for this ordered thickness.
3/ Class I 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 extrusions.

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APPENDIX A

TABLE A-II. 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
0.920	---	1906	1.090	1888	2113	1.260	2069	2303
0.925	---	1912	1.095	1893	2119	1.265	2075	2308
0.930	---	1919	1.100	1899	2125	1.270	2080	2313
0.935	---	1925	1.105	1904	2130	1.275	2085	2319
0.940	---	1931	1.110	1910	2136	1.280	2090	2324
0.945	---	1938	1.115	1916	2142	1.285	2095	2329
0.950 /1	---	1944	1.120	1921	2148	1.290	2100	2334
0.955	---	1950	1.125	1927	2153	1.295	2105	2340
0.960	---	1957	1.130	1932	2159	1.300	2110	2345
0.965	---	1963	1.135	1937	2165	1.305	2115	2350
0.970	1749	1969	1.140	1943	2170	1.310	2120	2355
0.975	1755	1975	1.145	1948	2176	1.315	2125	2361
0.980	1761	1981	1.150	1954	2182	1.320	2130	2366
0.985	1767	1988	1.155	1959	2187	1.325	2135	2371
0.990	1773	1994	1.160	1965	2193	1.330	2140	2376
0.995	1779	2000	1.165	1970	2199	1.335	2145	2382
1.000 /2	1784	2006	1.170	1975	2204	1.340	2150	2387
1.005	1790	2012	1.175	1981	2210	1.345	2155	2392
1.010	1796	2018	1.180	1986	2215	1.350	2160	2397
1.015	1802	2024	1.185	1991	2221	1.355	2165	2402
1.020	1808	2030	1.190	1997	2226	1.360	2170	2407
1.025	1814	2036	1.195	2002	2232	1.365	2174	2412
1.030	1819	2042	1.200	2007	2237	1.370	2179	2418
1.035	1825	2048	1.205	2012	2243	1.375	2184	2423
1.040	1831	2054	1.210	2018	2248	1.380	2189	2428
1.045	1837	2060	1.215	2023	2254	1.385	2194	2433
1.050	1843	2066	1.220	2028	2259	1.390	2199	2438
1.055	1848	2072	1.225	2033	2265	1.395	2204	2443
1.060	1854	2078	1.230	2039	2270	1.400	2208	2448
1.065	1860	2084	1.235	2044	2276	1.405	2213	2453
1.070	1865	2090	1.240	2049	2281	1.410	2218	2458
1.075	1871	2096	1.245	2054	2286	1.415	2223	2463
1.080	1877	2101	1.250	2059	2292	1.420	2228	2468
1.085	1882	2107	1.255	2064	2297	1.425	2232	2473

1/ Class II specification requirements begin with 0.951 inch ordered thickness. Required BL(P) = 1945 fps.
2/ Class I specification requirements begin with 1.001 inch ordered thickness. Required BL(P) = 1785 fps.

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

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TABLE A-II. 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
1.430	2237	2478	1.575	2371	---	1.720	2498	---
1.435	2242	2483	1.580	2376	---	1.725	2502	---
1.440	2247	2488	1.585	2380	---	1.730	2507	---
1.445	2251	2493	1.590	2384	---	1.735	2511	---
1.450	2256	2498	1.595	2389	---	1.740	2515	---
1.455	2261	2503	1.600	2393	---	1.745	2519	---
1.460	2265	2508	1.605	2398	---	1.750	2524	---
1.465	2270	2513	1.610	2402	---	1.755	2528	---
1.470	2275	2518	1.615	2407	---	1.760	2532	---
1.475	2279	2523	1.620	2411	---	1.765	2536	---
1.480	2284	2528	1.625	2416	---	1.770	2540	---
1.485	2289	2533	1.630	2420	---	1.775	2545	---
1.490	2293	2537	1.635	2424	---	1.780	2549	---
1.495	2298	2542	1.640	2429	---	1.785	2553	---
1.500 [3/]	2303	2547	1.645	2433	---	1.790	2557	---
1.505	2307	2552	1.650	2438	---	1.795	2561	---
1.510	2312	2557	1.655	2442	---	1.800	2566	---
1.515	2317	2562	1.660	2446	---	1.805	2570	---
1.520	2321	2567	1.665	2451	---	1.810	2574	---
1.525	2326	2570	1.670	2455	---	1.815	2578	---
1.530	2330	2576	1.675	2459	---	1.820	2582	---
1.535	2335	---	1.680	2464	---	1.825	2586	---
1.540	2339	---	1.685	2468	---	1.830	2590	---
1.545	2344	---	1.690	2472	---	1.835	2595	---
1.550	2348	---	1.695	2477	---	1.840	2599	---
1.555	2353	---	1.700	2481	---	1.845	2603	---
1.560	2358	---	1.705	2485	---	1.850	2607	---
1.565	2362	---	1.710	2490	---	1.855	2611	---
1.570	2367	---	1.715	2494	---	1.860	2615	---

[3/] Class II 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 extrusions.

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TABLE A-II. 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
1.865	2619	---	1.925	2668	---	1.985	2715	---
1.870	2623	---	1.930	2672	---	1.990	2719	---
1.875	2627	---	1.935	2676	---	1.995	2723	---
1.880	2631	---	1.940	2680	---	2.000 [4/]	2727	---
1.885	2635	---	1.945	2684	---	2.005	2731	---
1.890	2640	---	1.950	2688	---	2.010	2735	---
1.895	2644	---	1.955	2692	---	2.015	2739	---
1.900	2648	---	1.960	2696	---	2.020	2743	---
1.905	2652	---	1.965	2700	---	2.025	2747	---
1.910	2656	---	1.970	2704	---	2.030	2751	---
1.915	2660	---	1.975	2708	---	---	---	---
1.920	2664	---	1.980	2712	---	---	---	---

[4/] Class I 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 extrusions.

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APPENDIX A

TABLE A-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
0.920	---	1137	1.085	1489	1441	1.250	1785	1816
0.925	---	1146	1.090	1497	1451	1.255	1795	1828
0.930	---	1154	1.095	1506	1461	1.260	1805	1841
0.935	---	1162	1.100	1514	1472	1.265	1815	1854
0.940	---	1171	1.105	1522	1482	1.270	1825	1867
0.945	---	1179	1.110	1531	1493	1.275	1835	1880
0.950 1/	---	1188	1.115	1539	1503	1.280	1845	1893
0.955	---	1197	1.120	1548	1514	1.285	1855	1906
0.960	---	1205	1.125	1556	1525	1.290	1865	1919
0.965	---	1214	1.130	1565	1535	1.295	1875	1932
0.970	1310	1223	1.135	1574	1546	1.300	1885	1946
0.975	1317	1232	1.140	1582	1557	1.305	1895	1959
0.980	1325	1240	1.145	1591	1568	1.310	1906	1973
0.985	1332	1249	1.150	1600	1579	1.315	1916	1986
0.990	1340	1258	1.155	1609	1590	1.320	1927	2000
0.995	1347	1267	1.160	1618	1602	1.325	1937	2014
1.000 2/	1355	1277	1.165	1627	1613	1.330	1948	2028
1.005	1362	1286	1.170	1636	1624	1.335	1958	2042
1.010	1370	1295	1.175	1645	1636	1.340	1969	2056
1.015	1378	1304	1.180	1654	1647	1.345	1979	2070
1.020	1385	1314	1.185	1663	1659	1.350	1990	2084
1.025	1393	1323	1.190	1672	1670	1.355	2001	2099
1.030	1401	1333	1.195	1681	1682	1.360	2012	2113
1.035	1409	1342	1.200	1690	1694	1.365	2023	2128
1.040	1417	1352	1.205	1700	1706	1.370	2034	2142
1.045	1424	1361	1.210	1709	1717	1.375	2045	2157
1.050	1432	1371	1.215	1718	1729	1.380	2056	2172
1.055	1440	1381	1.220	1728	1742	1.385	2067	2187
1.060	1448	1391	1.225	1737	1754	1.390	2078	2202
1.065	1456	1401	1.230	1747	1766	1.395	2089	2217
1.070	1465	1411	1.235	1756	1778	1.400	2101	2232
1.075	1473	1421	1.240	1766	1791	1.405	2112	2247
1.080	1481	1431	1.245	1776	1803	1.410	2124	2263

1/ Class II specification requirements begin with 0.951 inch ordered thickness. Required BL(P) = 1190 fps.
2/ Class I specification requirements begin with 1.001 inch ordered thickness. Required BL(P) = 1356 fps.

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

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

Thickness, inches	Required BL(P), fps		Thickness, inches	Required BL(P), fps		Thickness, inches	Required BL(P), fps	
	Class I	Class II		Class I	Class II		Class I	Class II
1.415	2135	2278	1.525	2403	2645	1.635	2702	---
1.420	2147	2294	1.530	2416	2663	1.640	2716	---
1.425	2158	2310	1.535	2429	---	1.645	2731	---
1.430	2170	2325	1.540	2442	---	1.650	2745	---
1.435	2182	2341	1.545	2455	---	1.655	2760	---
1.440	2193	2357	1.550	2468	---	1.660	2775	---
1.445	2205	2373	1.555	2481	---	1.665	2789	---
1.450	2217	2390	1.560	2494	---	1.670	2804	---
1.455	2229	2406	1.565	2508	---	1.675	2819	---
1.460	2241	2422	1.570	2521	---	1.680	2834	---
1.465	2253	2439	1.575	2535	---	1.685	2849	---
1.470	2265	2455	1.580	2548	---	1.690	2864	---
1.475	2277	2472	1.585	2562	---	1.695	2880	---
1.480	2290	2489	1.590	2575	---	1.700 [4/]	2895	---
1.485	2302	2506	1.595	2589	---	1.705	2910	---
1.490	2314	2523	1.600	2603	---	1.710	2926	---
1.495	2327	2540	1.605	2617	---	1.715	2941	---
1.500 [3/]	2339	2557	1.610	2631	---	1.720	2957	---
1.505	2352	2575	1.615	2645	---	1.725	2973	---
1.510	2364	2592	1.620	2659	---	1.730	2988	---
1.515	2377	2610	1.625	2673	---	---	---	---
1.520	2390	2628	1.630	2688	---	---	---	---

[3/] Class II specification requirements end for this ordered thickness.
[4/] Class I 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 extrusions.

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TABLE A-IV. Minimum required ballistic limits for class II - 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	Thickness, inches	Required BL(P), fps
1.470	1865	1.615	1975	1.760	2080	1.905	2180
1.475	1869	1.620	1979	1.765	2083	1.910	2183
1.480	1872	1.625	1982	1.770	2087	1.915	2186
1.485	1876	1.630	1986	1.775	2090	1.920	2190
1.490	1880	1.635	1990	1.780	2094	1.925	2193
1.495	1884	1.640	1993	1.785	2097	1.930	2197
1.500 1/	1888	1.645	1997	1.790	2101	1.935	2200
1.505	1892	1.650	2001	1.795	2104	1.940	2203
1.510	1896	1.655	2004	1.800	2108	1.945	2207
1.515	1900	1.660	2008	1.805	2111	1.950	2210
1.520	1903	1.665	2012	1.810	2115	1.955	2213
1.525	1907	1.670	2015	1.815	2118	1.960	2217
1.530	1911	1.675	2019	1.820	2122	1.965	2220
1.535	1915	1.680	2023	1.825	2125	1.970	2223
1.540	1919	1.685	2026	1.830	2129	1.975	2226
1.545	1922	1.690	2030	1.835	2132	1.980	2230
1.550	1926	1.695	2033	1.840	2135	1.985	2233
1.555	1930	1.700	2037	1.845	2139	1.990	2236
1.560	1934	1.705	2041	1.850	2142	1.995	2240
1.565	1938	1.710	2044	1.855	2146	2.000 2/	2243
1.570	1941	1.715	2048	1.860	2149	2.005	2246
1.575	1945	1.720	2051	1.865	2153	2.010	2249
1.580	1949	1.725	2055	1.870	2156	2.015	2253
1.585	1953	1.730	2059	1.875	2159	2.020	2256
1.590	1956	1.735	2062	1.880	2163	2.025	2259
1.595	1960	1.740	2066	1.885	2166	2.030	2263
1.600	1964	1.745	2069	1.890	2170	---	---
1.605	1968	1.750	2073	1.895	2173	---	---
1.610	1971	1.755	2076	1.900	2176	---	---

1/ Specification requirements begin with 1.501 inch ordered thickness. Required BL(P) = 1889 fps.
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 extrusions.

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Custodian:
Army - MR

Preparing activity:
Army - MR

Review activities:
Army - AR, AT, TE
DLA - CQ

Project FORG-2019-003

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