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MILITARY SPECIFICATION

ARMOR, STEEL, CAST, HOMOGENEOUS, COMBAT-VEHICLE TYPE (1/4 TO 8 INCHES, INCLUSIVE)

This specification is approved for use by the U.S. Army Materials Technology Laboratory, 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 two classes of homogeneous cast steel armor, combat-vehicle type vehicles in thicknesses from 1/4 to 8 inches inclusive (see 6.1).

1.2 Classification.

1.2.1 Class-1. Class-1 cast steel armor is heat treated for maximum resistance to penetration and requires ballistic testing in accordance with Appendix A. No ballistic testing is required for thicknesses less than 5/8 inch.

1.2.2 Class-2. Class-2 cast steel armor is heat treated for maximum resistance to shock. Class 2 is only applicable in the thickness range from 1/4 to 1-1/4 inches and does not require ballistic testing.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

AMSC NO. A4109

/AREA MECA/

STANDARDS

MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-129 - Marking for Shipment and Storage
MIL-STD-367 - Armor Test Data Reporting
MIL-STD-410 - Nondestructive Testing Personnel Qualification and Certification (Eddy Current, Liquid Penetrant, Magnetic Particle, Radiographic and Ultrasonic)
MIL-STD-1264 - Radiographic Inspection for Soundness of Welds in Steel by Comparison to Graded ASTM E 390 Reference Radiographs
MIL-STD-1265 - Radiographic Inspection, Classification, and Soundness Requirements for Steel Castings
MIL-STD-1949 - Inspection, Magnetic Particle
MIL-STD-6866 - Inspection, Liquid Penetrant

(Copies of specifications, standards, handbooks, drawings, publications, and other Government documents required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.)

2.2 Other publications. The following document(s) form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS shall be the issue of the non-Government documents which is current on the date of the solicitation.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS

ASTM A609 - Specification for Steel Castings, Carbon and Low Alloy, Ultrasonic Examination, Thereof
ASTM A751 - Methods, Practices, and Definitions for Chemical Analysis of Steel Products
ASTM A802 - Evaluation of and Specifying Textures and Discontinuities of Steel Castings by Visual Means
ASTM E10 - Brinell Hardness of Metallic Materials
ASTM E18 - Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E23 - Notched Bar Impact Testing of Metallic Materials
ASTM E94 - Standard Guide for of Radiographic Testing
ASTM E125 - Reference Photographs for Magnetic Particle Indications on Ferrous Castings
ASTM E142 - Method for Controlling Quality of Radiographic Testing
ASTM E452 - Method for Calibration of Refractory Metal Thermocouples using an Optional Pyrometer
ASTM E543 - Practice for Determining the Qualification of Nondestructive Testing Agencies
ASTM E709 - Practice for Magnetic Particle Examination
ASTM D3951 - Practice for Commercial Packaging

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103).

(Non-Government standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

STEEL FOUNDERS' SOCIETY OF AMERICA

Steel Castings Handbook, Supplement 3 (Tolerances)

(Applications for copies should be addressed to the Steel Founders Society of America, 455 State Street, Des Plaines, Illinois 60016).

Manufacturers Standardization Society of the Valve and Fittings Industry

SP-55 - Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components

(Application for copies should be addressed to the Manufacturers Standardization Society of the Valve and Fittings Industry, 5203 Leesburg Pike, Suite 502, Falls Church, VA 22041).

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

3. REQUIREMENTS

3.1 First article.

3.1.1 Class 1 Armor. When specified, (see 6.2) the supplier shall prepare cast plates in accordance with Appendix C for first article ballistic tests and for foundry or process qualification (see 3.1.1.1). In addition, simulated weld-repair test plates shall be prepared in accordance with Appendix B. The above plates shall be submitted to Commander, US Army Aberdeen Proving Ground (APG), Transportation Officer, Bldg. 3554, ATTN: STECS-AS-MM, Materials and Structures Branch, Aberdeen Proving Ground, MD 21005. The following tests are required to be performed on the castings material prior to submittal: actual chemistry, impact test, hardness test, and radiographs on the weld-repair plates. When specified in the contract or order, test data shall be prepared in accordance with MIL-STD-367 (see 6.2.2).

3.1.1.1 Requirements for foundry or process qualification. Unless otherwise specified (see 6.2), requirements for foundry or process qualification shall be as specified in Appendix C of this specification.

3.1.2 Class 2 armor. When specified, (see 6.2) the supplier shall prepare simulated cast weld-repair plates in accordance with Appendix B. Radiographs of the weld-repair areas shall be made for evaluation of the weld area. The following tests are required to be performed on the weld-repair test plate base material: declared chemistry, impact test and hardness test. When specified in the contract or order, test data shall be prepared in accordance with MIL-STD-367 (see 6.2.2 & 6.12).

3.1.3 Waiver of first article test. Suppliers who have previously produced cast steel Class 1 or Class 2 armor or potential suppliers who have preformed independent foundry qualification (see 6.7) which meet all the requirements of this specification in the past 37 months, and have not significantly changed production practices, will not be required to perform first article tests, and will not be required to perform the first article foundry or process qualification tests.

3.1.4 First production casting. Unless otherwise specified (see 6.2), the 1st production casting shall be examined and tested for conformance with the requirements of this specification (see 4.2.2.1).

3.1.5 First time producers. First time producers of either Class 1 or Class 2 armor wishing to qualify to this specification should follow the instruction in 6.7.

3.2 Acceptance requirements.

3.2.1 Chemical composition, heat treatment, and processing. The ladle analysis of all heats shall be within the limits established by the contractor and shall conform to the requirements of table I. The heat treatment and process of manufacture shall be such as to produce cast armor that will meet the requirements of this specification. Any deviation from the established heat treatment or process of manufacture shall be approved by the procuring activity.

TABLE I. Maximum ranges and limits for declared chemical composition.

Element	Maximum range for declared chemical analysis	Maximum limit
	percent	percent
Carbon	---	.30
Manganese; Up to 1.00% 1/ incl.	.30	---
Over 1.00%	.50	---
Phosphorous	---	---3/
Sulfur	---	---3/
Silicon	.50	---
Nickel	.70	---
Chromium; Up to 1.50% 1/ incl.	.50	---
Over 1.50%	.70	---
Molybdenum	.20	---
Vanadium	.10	---
Copper	.50	---
Others (additives such as deoxidizers etc.) -----	---	---2/

1/ Average of declared range.
2/ To be reported as amount added.
3/ Phosphorous and sulfur should be controlled to the lowest attainable levels, and actual percentage of each melt shall be reported but in no case shall the combined phosphorous and sulfur content exceed 0.06 percent for Class 1 or Class 2.

3.2.2 Processing controls.

3.2.2.1 Heating after final heat treatment. Unless otherwise approved by the procuring activity, heating above 315°C (600°F), shall not be performed after the final hardening and tempering operation or after post weld stress relieving except as provided in the approved welding procedure.

3.2.2.2 Edge preparation. Edge may be thermally treated after final heat treatment provided the procedure is such that no cracks develop on any thermally-cut edge. Edges shall be inspected for cracks in accordance with 4.6.2.7 or 4.6.2.8.

3.2.2.3 Repair welding. Repair welding on castings produced under this specification, including repair of core-drilled holes shall be performed in accordance with the applicable requirements of Appendix B, and tested in accordance with 4.7.5.1.

3.2.3 Mechanical properties.

3.2.3.1 Hardness. The hardness or average hardness of each casting (see 4.6.2.4.1), test blocks or test bars (see 4.6.2.4.2), or Charpy impact specimens (see 4.6.2.5) shall fall within the applicable range shown in table II for the applicable thickness.

TABLE II. Hardness requirements.

Casting thickness specified - inches	Armor Class	Brinell hardness limits (HB) (3000-kg load)	Rockwell-C hardness limits (HRC)
1/4 to 1-1/4 incl.	1	302-352	32.1-37.8
1/4 to 1-1/4 incl.	2	241-293	22.8-30.9
Over 1-1/4 to 2-1/4 incl.	1	269-321	27.5-34.2
Over 2-1/4 to 3-3/4 incl.	1	255-293	25.2-30.9
Over 3-3/4 to 5-3/4 incl.	1	229-269	20.3-27.5
Over 5-3/4 to 8 incl.	1	207-248	18.3-24.1

3.2.3.2 Impact resistance. The average V-notch Charpy impact resistance shall meet the requirements shown in table III for the applicable hardness where the hardness is determined on the Charpy test specimens of each block or production test bar. When interpolation is necessary, use a linear interpolation between the tabulated charpy impact values.

3.2.4 Ballistic requirements for Class-1 armor. Ballistic requirements for Class-1 cast armor shall be in accordance with Appendix A. Class-2 armor shall not be subject to ballistic requirements.

3.2.4.1 Ballistic testing of production castings. The frequency of ballistically testing production castings shall be specified in the applicable contract or drawing or order (see 6.2).

3.2.5 Weight and dimensions. The weight and dimensions of the castings shall be as specified on the applicable drawings or in the contract or order (see 6.2 and 6.3).

TABLE III. Minimum V-notch Charpy impact resistance requirements in ft. - lbs. at -40°F + 2°F for the applicable hardness.

Brinell Hardness (Avg)	Brinell Indentation Dia (3000 kg Load) (MM)	Rockwell-C Hardness[a] (Avg) 150 kg, Brale	Rockwell-B Hardness[a] (1 /16-in. Ball 100 kg)	Minimum Average Charpy Impact Values[b] (Ft-Lbs)	Minimum Individual Value Requirement (Ft-Lbs)
207	4.20	18.3	94.4	50.0	40.0
212	4.15	18.8	95.3	49.0	39.2
217	4.10	19.2	96.2	48.0	38.4
223	4.05	19.7	97.2	46.0	36.8
230	4.00	20.3		44.0	35.2
235	3.95	21.8		43.0	34.4
241	3.90	22.8		42.0	33.6
248	3.85	24.1		40.0	32.0
255	3.80	25.2		38.0	30.4
262	3.75	26.8		36.0	28.8
269	3.70	27.5		33.0	26.4
277	3.65	28.8		30.0	24.0
285	3.60	29.9		27.0	21.6
293	3.55	30.9		26.0	20.8
302	3.50	32.1		24.0	19.2
311	3.45	33.0		22.0	17.6
321	3.40	34.2		19.0	15.2
331	3.35	35.4		14.0	11.2
341	3.30	36.7		13.0	10.4
352	3.25	37.8		12.0	9.6

a/ Conversions from Brinell hardness is based on table I of ASTM E140.

b/ Average of two or more test specimens.

3.2.5.1 Permissible variations. Unless otherwise specified on the drawing, the thickness tolerance and the weight tolerance shall be in accordance with Steel Castings Handbook (supplement 3) and shall indicate tolerance limits in one direction only. The absence of a tolerance in the other direction does not mean a limitation of zero tolerance. The plus tolerance for thickness shall be controlled by the weight limitations, and the minus tolerance for weight shall be automatically controlled by the limitations on thickness. However, if the official weights have not been established and specified for the casting design, the weights of any casting should not vary by more than 5% from the average weight computed from at least the first 10 castings shipped for production vehicles (see 6.3).

3.2.6 Radiographic inspection. Radiographic requirements for production castings shall provide the necessary coverage to the extent specified on the position chart, drawings or contract (see 6.2). Armor casting shall be classified in accordance with MIL-STD-1265.

3.2.6.1 Radiographic requirements. Each casting subjected to radiographic inspection shall be legibly and indelibly marked "RT" to assure positive identification until after final acceptance is made.

3.2.6.2 Alternate method of inspection. When agreed upon between the procuring activity and the producer, ultrasonic inspection may be used in lieu of radiographic inspection (see 4.6.2.10).

3.2.7 Magnetic particle inspection. When specified on the drawing or in the contract, (see 6.2) magnetic particle inspection for production castings shall be performed in accordance with 4.6.2.7.

3.2.8 Liquid penetrant inspection. When specified on the drawing or in the contract, (see 6.2) liquid penetrant inspection shall be performed in accordance with MIL-STD-6866.

3.2.9 Workmanship. When visually inspected, the surface of the finished casting shall not exceed the linear discontinuities open to the surface as defined in 3.2.9.1 or 3.2.9.2.

3.2.9.1 Surface texture and surface discontinuities. The degree of acceptable surface roughness and surface discontinuities shall be established by agreement between the contractor and the procuring activity using ASTM A802 or SP-55 as the acceptance criteria, or any other established visual acceptance criteria.

3.2.9.2 Machined surfaces. Machined surfaces shall be free of rejectable defects. Specific machined acceptance criteria critical to individual parts shall be addressed on the part number ordering data or part number quality assurance provision (QAR).

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection

requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary, such as radiographic inspection of welds, to assure supplies and services conform to prescribed requirements.

4.2 Classification of inspection. The inspection requirements specified herein are classified according to 4.2.1 and 4.2.2.

4.2.1 First article inspection.

4.2.1.1 Class-1 armor. When specified (see 3.1.1, 6.2) Class-1 armor flat cast or machined flat test plates samples, representing the cast steel produced to the requirements of this specification, shall meet the chemical, ballistic (see Appendix A) and mechanical properties when tested in accordance with table IV. Cast simulated weld-repair plates shall be prepared in accordance with Appendix B. Unless otherwise specified (see paragraph 3.1.1, 6.2, 6.2.3.1), the first article ballistic test shall not be required provided (a) the manufacturer, within 37 months, has produced acceptable plates within the same nominal thickness ranges of table C-1, P. 47, and (b) his production conditions are the same as for previously accepted plates. Neigher first article nor acceptance ballistic tests will be required for plates ordered to thicknesses of more than 6.25 inches. Acceptance of thicker plates will be based on meeting the other requirements of the specification.

4.2.1.2 Class 2 armor. When specified (see 3.1.2 and 6.2) class 2 armor, cast simulated weld-repair test plates shall be prepared in accordance with Appendix B. The cast simulated weld-repair plates shall represent the cast steel produced and meet chemical and mechanical properties specified in tables I, II and III when tested in accordance with table IV.

4.2.2 Quality conformance inspection. Quality conformance inspection for acceptance of production castings (see 3.2) shall be performed on the sample castings selected in accordance with 4.4. This inspection shall include the examinations of 4.5 and the tests of 4.6.2 (see table IV).

4.2.2.1 1st production casting inspection. Unless otherwise specified (see 6.2), the 1st production casting inspection shall be required. This inspection shall include the examination of 4.5.1, 4.5.2 and the tests of 4.6.1 (see table IV). Failure of the first production casting to pass the examination or any of the tests shall be cause for rejection.

4.2.2.2 Mechanical properties tests on Class-1 production castings. On Class-1 first production casting submitted for ballistic evaluation, weighing 2,000 pounds or more and greater than 3 inches in thickness, one core sample, measuring 1-1/4 inch diameter by "T" long, shall be taken from the location where the thickness of the casting is equal to or greater than the Charpy impact test block thickness, or as agreed upon between the manufacturer and the procuring activity. Thereafter, a core sample shall be taken from each production casting submitted for ballistic testing (see 4.6.2.9).

4.3 Lot. Unless otherwise specified (see 6.2) a lot shall consist of all castings of the same melt of steel.

4.4 Lot sampling.

TABLE IV. Instructions for testing Class-1 and Class-2 armor.

Characteristics	Requirement Applicable to Class 1	Requirement Applicable to Class 2	Specification Paragraph Reference: Requirements	No. of tests	Test Method
Visual Inspection Workmanship					
First Article					
(a) Foundry qualification	X	X	3.1.1	4.1	Appendix C
(b) 1st production casting	X	X	3.1.2	4.1	4.5 & 4.6
Production castings (ongoing)	X	X	3.2	4.1	4.5 & 4.6
Weight & Dimensions					
First Article					
(a) Foundry qualification	-	-	-----	-----	-----
(b) 1st production casting	X	X	3.2.5	4.4.1.2	4.5.2
Production castings (ongoing)	X	X	3.2.5	4.4.1.2	4.5.2
Chemical Composition					
First Article					
(a) Foundry qualification	X	X	Appendix C	Appendix C	Appendix C
(b) 1st production casting	X	X	3.2.1	4.4.2.1	4.6.1.1
Production castings (ongoing)	X	X	3.2.1	4.4.2.1	4.6.2.1
Charpy Impact					
First Article					
(a) Foundry qualification	X	X	Appendix C	Appendix C	Appendix C
(b) 1st production casting	X	X	3.2.3.2	4.4.2.3	4.6.2.4
Production castings (ongoing)	X	X	3.2.3.2	4.4.2.3	4.6.2.4
Hardness					
First Article					
(a) Foundry qualification	X	X	Appendix C	Appendix C	Appendix C
(b) 1st production casting	X	X	3.2.3.2	4.4.2.2	4.6.2.5/4.6.2.6
Production castings (ongoing)	X	X	3.2.3.2	4.4.2.2	4.6.2.5/4.6.2.6
Ballistics					
First Article					
(a) Foundry qualification	X	-	Appendix C	Appendix C	Appendix C
(b) 1st production casting	X	-	3.2.4	4.2.2.1	4.6.2.9
Production castings (ongoing)	X	-	3.2.4	4.4.4	4.6.2.9

TABLE IV. Instructions for testing Class-1 and Class-2 armor (Cont'd).

Characteristics	Requirement Applicable to Class 1	Class 2		Specification Paragraph Reference: Requirements	No. of tests	Test Method
Weld Certification & repair						
First Article						
(a) Foundry qualification	X	X	1/	3.2.2.3	-----	Appendix B
(b) 1st production casting	X	X		3.2.2.3	-----	Appendix B
Production castings (ongoing)	X	X		3.2.2.3	-----	Appendix B
Radiography						
First Article						
(a) Foundry qualification	X	X		3.2.6	4.4.2.3	4.6.2.6
(b) 1st production casting	X	X		3.2.6	4.4.2.3	4.6.2.6
Production castings (ongoing)	X	X		3.2.6	4.4.2.3	4.6.2.6
Ultrasonic Inspection						
First Article						
(a) Foundry qualification	X	X		3.2.6.2	4.4.2.5	4.6.2.10
(b) 1st production casting	X	X		3.2.6.2	4.4.2.5	4.6.2.10
Production castings (ongoing)	X	X		3.2.6.2	4.4.2.5	4.6.2.10
Magnetic Particle Inspection						
First Article						
(a) Foundry qualification	X	X		Appendix C	Appendix C	Appendix C
(b) 1st production casting	X	X		3.2.7	4.4.2.4	4.6.2.7
Production castings (ongoing)	X	X		3.2.7	4.4.2.4	4.6.2.7
Liquid Penetrant Inspection						
First Article						
(a) Foundry qualification	X	X		Appendix C	Appendix C	Appendix C
(b) 1st production casting	X	X		3.2.2	-----	4.6.2.8
Production castings (on going)	X	X		3.2.2	-----	4.6.2.8

NOTE: 1/ = Class 2 armor weld-repair plates do not require ballistic testing.

4.4.1 Sampling for examination.

4.4.1.1 Visual. Unless otherwise specified (see 6.2) all production castings shall be visually inspected.

4.4.1.2 Dimensional. Sampling for dimensional examination shall be as specified on the drawings.

4.4.2 Sampling for acceptance tests.

4.4.2.1. For chemical analysis. Unless otherwise specified (see 6.2) one sample shall be taken from the melt (heat analysis), the casting, or the test coupon representing the casting, as long as this sample represents the heat. Chemical analysis shall be performed in accordance with the applicable method specified in ASTM A 751 (See 6.10).

4.4.2.2 For hardness and impact tests on blocks and bars. Unless otherwise approved by the procuring activity, each "lot" of castings shall have one impact test bar consisting of two 10mm x 10mm impact test specimens. The impact test specimen may be removed from test coupons (See figures 1 and 2 for 9x9xT test coupon) or from sections of the castings where the thickness is equal to or greater than "T" defined on the drawing, etc.

4.4.2.3 For radiographic examination of Class-1 and Class-2 production castings. Radiographic examination shall be in accordance with required drawings.

4.4.2.4 For magnetic particle examination of Class-1 and 2 production castings. Magnetic particle inspection shall be in accordance with drawing requirements.

4.4.2.5 For ultrasonic examination of Class-1 and 2 production castings. Ultrasonic inspection shall be agreed upon between the procuring activity and the manufacturer or in the contract.

4.4.3 Sampling for hardness of castings. Unless otherwise specified (see 6.2) sampling for hardness shall be in accordance with table V. The number of hardness tests required on each casting sample is specified in 4.6.2.4.1.

TABLE V. Sample Size.

Lot size	No. Of Castings	Lot size	No. of Castings
2-5	All	27-36	11
6-8	6	37-51	12
9-11	7	52-82	13
12-15	8	83-162	14
16-20	9	163-971	15
21-26	10	972 and over	16

Acceptance number is 0

4.4.4 Sampling for ballistic tests for ongoing production castings. The frequency of ballistically testing production of Class 1 castings shall be as specified in the contract or drawing.

4.5 Examination.

4.5.1 Visual.

4.5.1.1 Casting defects on non-machined surface. The surface of finished castings shall be free of linear discontinuities open to the surface. The degree of acceptable surface roughness and discontinuities shall be as agreed upon between the contractor and procuring activity using ASTM A802, or SP-55 as the acceptance criteria, or any other established visual acceptance criteria.

4.5.2 Weight and dimensional tolerance. Armor casting samples shall be inspected to determine conformance to the weight and dimensional tolerance requirements (see 3.2.5 and 3.2.5.1).

4.5.3 Packaging, packing and marking. Preparation for delivery shall be examined for conformance to section 5.

4.6 Tests.

4.6.1 First production casting tests. First production castings shall be subjected to chemical analysis test, hardness and impact tests in accordance with table IV. When specified, magnetic particle inspection and liquid penetrant inspection shall be performed in accordance with 4.6.2.7. When specified, Class 1 castings shall be ballistically tested in accordance with Appendix A.

4.6.1.1 Chemical analysis, cross-sectional hardness, impact, magnetic particle inspection and ballistic tests. Chemical analysis, cross-sectional hardness, impact, magnetic particle inspection, liquid penetrant inspection and ballistic tests (for Class-1 only) shall be conducted as specified in the applicable acceptance test paragraphs under 4.6.2.

4.6.2 Acceptance tests (on going production castings).

4.6.2.1 Chemical analysis. Chemical analysis shall be conducted in accordance with the applicable method specified in ASTM A 751(See 6.10). The analysis shall comply with the declared composition established in accordance with the requirements of Table I (see 3.2.1)

4.6.2.2 Heat treatment of test blocks for mechanical properties tests. A test block 9" X 9" X "T" in size shall be attached to the casting and shall accompany the castings which they represent throughout the hardening and tempering cycle. Blocks shall be so placed that their cooling rate during quenching shall be comparable to that of the casting or castings represented. If the castings are of a design and mass such that the cooling rates would be faster than those of the samples representing these castings, the samples may be quenched separately under similar quenching conditions to the same final temperature $\pm$ 200°F as the casting when it is heat treated subject to approval of the procuring activity.

4.6.2.3 Charpy V-notch impact test. At least two Charpy V-notch impact specimens shall be taken from each impact test block or test bar or from each production casting test bar as described in 4.6.2.3.2.1 through 4.6.2.3.1.4 as applicable, and shall be prepared and tested in accordance with ASTM E 23.

Charpy machines used in testing shall have been proof tested (calibrated) within one year prior to the time of inspection testing (see 6.9). The average of two or more test specimens should be at least the minimum average value as specified in table III with no individual value lower than 20% of the minimum average value specified in table III.

4.6.2.3.1 Location of Charpy V-notch impact test specimens in samples.

4.6.2.3.1.1 For blocks up to 2 inches in thickness. For blocks up to and including 2 inches in thickness, specimens shall be taken from the block at a location such that the vertex of the notch is at a location midway between the top and bottom surfaces of the block and at least 2 T from any quenched edge. When, at the option of the manufacturer, blocks thicker than that specified on the casting drawing are substituted, the specimens shall be taken from the block at a location such that the vertex of the notch is at a location 1/2 T from the top or bottom surfaces, where "T" is the casting thickness specified in the drawing.

4.6.2.3.1.2 For blocks over 2 inches in thickness. For blocks over 2 inches in thickness, specimens shall be taken at a location such that the vertex of the notch is at least one inch from the top and bottom surfaces of the block and at least 4 inches from any quenched edge.

4.6.2.3.1.3 For test bars taken from un-heat treated test blocks or production castings 2 inches or greater in thickness. At the option of the manufacturer, specimens representing castings 2 inches or greater in thickness may be taken from a test bar, which is heat treated within a heat treating block as shown in figures 1 or 2. Test bars shall be equivalent in length to the casting thickness they represent. Test bars shall be inserted in and fixed to the test block in such a manner as to prevent the quenching medium from contacting the sides of the test bar. The location and orientation of specimens in production casting test bars shall be as shown in figure 2.

4.6.2.3.1.4 For test bars taken from unheat treated test blocks or production castings less than 2 inches in thickness. At the option of the manufacturer, specimens representing castings less than 2 inches in thickness may be taken from the production casting or from a test bar which is heat treated in a heat treating block, as shown in figure 1 or figure 2. Test bars shall be of sufficient length that the required number of samples may be obtained therefrom. Test bars shall be inserted in and fixed within the heat treating block in such a manner as to prevent the quenching medium from contacting the sides of the test bar.

4.6.2.4 Brinell hardness tests. Brinell hardness (HB) specimens shall be prepared and tested in accordance with ASTM E10. Readings shall be taken below the decarburization level. Readings on depth of decarburization shall be specified on the contract or drawing.

4.6.2.4.1 Hardness tests on castings. Castings weighing more than 300 pounds shall be subjected to at least two Brinell hardness tests, and castings weighing 300 pounds or less shall be subjected to one hardness test. Surface hardness tests shall be made at a location where the thickness is approximately the same as the specified thickness of the casting.

4.6.2.4.2 Hardness test on test blocks or test bars. Except as provided in 4.6.2.5, each block or bar from which impact test specimens are taken shall have a cross-section hardness check made upon it. For blocks 1/4 inch to 2 inches in thickness, two hardness readings shall be taken at a location midway between the quenched surfaces of the block and at least one "T" from any quenched edge. For blocks or bars greater than 2 inches in thickness, at least two hardness readings shall be taken at a location not less than 1 inch from both the top and bottom surfaces.

4.6.2.5 Hardness test on impact specimens. At the option of the contractor, at least two Rockwell-C hardness tests may be made on each impact test specimen samples from each lot, in lieu of the cross-sectional hardness in 4.6.2.4.2. When this procedure is followed, the results of all tests taken from each lot shall be averaged, and the average obtained shall be compared to the applicable HRC in table II.

4.6.2.6 Radiographic inspection.

4.6.2.6.1 Qualification of inspection personnel. Radiographic inspection personnel shall be qualified in accordance with MIL-STD-410. The testing agency shall be qualified in accordance with ASTM E543.

4.6.2.6.2 Inspection of production castings. When required radiographic inspection on production castings shall be performed in accordance with the requirements of the applicable drawings or contract. Unless otherwise specified, for inspection frequencies specified in ratios (1 out of 30, 1 out of 50, etc.) failure of the selected casting(s) to meet the radiographic acceptance standard specified on the drawing shall require the remainder of the lot which the inspected casting(s) represents to be inspected in accordance with MIL-STD-105, Inspection Level S-4, 6.5% AQL.

4.6.2.6.3 Control of radiographic equipment. Control of radiographic equipment, penetrameters, radiographic film, identification and records of inspection shall be performed in accordance with MIL-STD-453 or ASTM E 94, ASTM E 142 and ASTM E 543.

4.6.2.7 Magnetic particle inspection. When magnetic particle inspection is specified on drawing or contract (see 3.2.7) it shall be performed in accordance with ASTM E 709. Acceptance and rejection standards shall be as specified on the drawings.

4.6.2.8 Liquid penetrant inspection. When liquid penetrant inspection is specified on drawings or in the contract it shall be performed in accordance with type II, methods A, B or C of MIL-STD-6866.

4.6.2.9 Ballistic testing of production castings. When specified on the drawing or contract, (see 6.2) ballistic testing of Class 1 production castings shall be conducted by the government at a government test facility specified in the contract on order. Testing shall be conducted in accordance with the requirements of Appendix A.

4.6.2.10 Ultrasonic inspection. When required, castings shall be ultrasonically inspected in accordance with ASTM A609. The level of acceptance shall be agreed upon between the contractor and the procuring activity.

4.6.3 Reduced testing. At the discretion of the procuring activity, the amount of testing may be reduced provided that results on consecutive lots indicate that a satisfactory uniform product meeting the testing requirements and that no changes to materials or processes will be made by the vendor. Reduced testing shall be in accordance with a system previously approved or established by the procuring activity involved.

4.7 Rejection and retests.

4.7.1 Rejection. Where one or more test specimens fail to meet the requirements of this specification the lot represented by the specimen or specimens shall be subject to rejection.

4.7.2 Resubmitting new first article test sample. To obtain first article approval, the supplier shall submit a new first article test sample for each sample which fails to meet the requirements of this specification.

4.7.3 Retests for impact resistance. Acceptance retests will be permissible in accordance with 4.7.3.1 or, at the option of the manufacturer, individual casting or parts of a lot may be submitted for acceptance. When this latter practice is followed, all castings represented by samples yielding acceptable test results shall be considered acceptable. For batch-type furnaces, a sample shall be considered to represent a casting if it is heat treated with the casting or if both received the same heat treatment, except that castings heat treated with the sample which do not meet the requirements shall not be included. For continuous type furnaces, rejectable sample shall be considered to represent all castings heat treated subsequent to the last acceptable sample and prior to the following acceptable sample.

4.7.3.1 Retests of castings showing low impact resistance after reheat treatment. At the option of the contractor, castings showing low impact resistance may be retested after reheat treatment in accordance with the requirements for original testing. Castings which are retempered only to meet hardness requirements will not be subjected to retest for impact resistance.

4.7.3.2 Retests of castings showing low impact resistance (by taking additional specimens from the lot under consideration.) Castings showing low impact resistance may be retested at the option of the manufacturer by taking additional specimens from the lot under consideration. These additional specimens should be distributed as uniformly as possible among all the samples of the lot. The average from the lot (prior specimens and additional specimens) shall be redetermined. In the event that it is impossible to obtain additional test specimens from samples or test bars, specimens may be taken, at the option of the manufacturer, from a casting at a location the thickness of which is equivalent to the specified casting thickness. If the average from the lot, after redetermination, is less than the minimum average value specified in table III or if any individual value is lower than 20% of the minimum average value specified in table III, the lot represented shall be rejected.

4.7.3.3 Retest of production casting test bars. In the event that a production casting test bar fails to meet the impact requirements, one additional sample may be taken from the casting involved. The results of all values (i.e., from first and second test) shall be used in determining the acceptability of the casting. The individual castings which have been so

tested and found not to meet the impact requirements shall be rejected. In addition, additional impact specimens shall be taken from the remainder of the lot in accordance with the sampling provisions contained in table V. Failure to meet the acceptance number shall result in rejection of that lot of castings.

4.7.4 Ballistic retests of production castings. When a production casting fails to meet the ballistic test requirements of Appendix A, the casting involved shall be subject to rejection. Failure of any Class-1 casting to meet the ballistic test requirements of Appendix A to this specification shall require the selection of the next casting poured following notification of failure under the ballistic test.

4.7.4.1 Shipping of castings from the producing facility. No casting of the pattern involved shall be shipped from the producing facility until the first otherwise acceptable casting has passed the ballistic tests (see 3.1.1).

4.7.4.2 Ballistic retesting of a lot represented by the Class 1 castings exhibiting ballistic performance below the requirements of Appendix A. At the option of the contractor, a lot represented by the castings exhibiting ballistic performance below the requirements of Appendix A, may be retested ballistically after reheat treatment.

4.7.5 Casting surface repair. When production castings fail to meet the surface quality requirements (see 4.5.1.1 and 4.6.2.7), they may be repaired at the option of the contractor by grinding, air-arc scarfing or welding.

4.7.5.1 Casting repair by welding. Prior to repair welding, all procedures and welders shall be qualified in accordance with Appendix B. All weld-repairs shall be visually inspected. The weld deposit shall be ground to blend into the surrounding area to provide a smooth uniform surface to support the visual inspection process. Questionable indications shall be subject to magnetic particle or liquid penetrant inspection. The inspection area shall include the weld deposit and one inch from the weld deposit to assure freedom from cracks in the heat affected zone. The inspected area shall be free of cracks and lack of fusion open to the surface. Indications less than or equal to 1/8 inch shall be considered non-relevant. If magnetic particle inspection is specified on the drawing, all repair welds shall be magnetic particle inspected. The acceptance criteria on the drawing rather than those specified herein shall apply. Radiography is applicable to the extent specified in B-30.2.7.

5. PACKAGING

5.1 Preservation, packaging, packing, and marking. Preservation, packaging, packing, and marking shall be in accordance with the packaging data sheet for the required level of protection specified (see 6.2).

5.2 Marking. Castings (both green and heat treated) shall be indelibly and legibly marked with symbols that will definitely identify the castings with inspection and test reports and with shipping documents in accordance with MIL-STD-129.

6. NOTES

6.1 Intended use. The cast armor specified herein is intended for use on combat vehicles. The thickness of the casting is considered to be that which is most representative of the component's ballistic surface.

6.1.1 Class 1. Class 1 cast armor is intended for use in those areas where maximum toughness and maximum resistance to penetration by armor piercing type of ammunition is required.

6.1.2 Class 2. Class 2 cast armor is intended for use in those areas where maximum resistance to failure under conditions of high rates of shock loading is required and where resistance to penetration by armor piercing ammunition is of secondary importance. It is for protection against anti-tank land mines, hand grenades, bursting shell, and other blast-producing weapons.

6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents should specify the following:

(a) Title, number and date of this specification.
(b) Class of armor required (see 1.2).
(c) If first article is required (see 3.1 and 3.1.3).
(d) If qualification of foundry process is not required (see 3.1.1.1).
(e) If testing of the first production casting is not required (see 3.1.4, 4.2.2.1 and 6.2.3).
(f) Weight and dimensions of castings (see 3.2.5 & 6.3).
(g) Whether patterns are to be furnished by the casting manufacturer or the Government, and provisions for final ownership of the patterns.
(h) If magnetic particle inspection is required (see 3.2.7).
(i) If liquid penetrant inspection is required (see 3.2.8).
(j) If a different lot size is required (see 4.3).
(k) If different sampling for examination is required see (4.4.1).
(l) If different sampling for acceptance testing is required (see 4.4.2.1, 4.4.2.2, 4.4.3, and 4.4.4).
(m) If ballistic testing of production castings is required (see 4.6.2.9).
(n) If different rejection and retest requirements are needed (see 4.7).
(o) Requirement for at least two thermocouple holes for each casting selected for low-temperature ballistic tests) (see A-40.2.1).
(p) Selection of method and applicable method of preservation and packaging and level of packing of referenced specification (see 5.1).

6.2.2 Data requirements. When this specification is used in an acquisition and data are required to be delivered, the data requirements identified below shall be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved Contract Data Requirements List (CDRL), incorporated into the contract. When the provisions of DOD FAR Supplement, Part 27, Sub-Part 27.410-6 (DD Form 1423) are invoked and the DD Form 1423 is not used, the data specified below shall be delivered by the contractor in accordance with the contract or purchase order requirements. Deliverable data required by this specification are cited in the following paragraphs.

Paragraph no.	Data requirement title	Applicable DID no.	Option
B30.1	Qualification Data Welding Procedure	UDI-H-23384	
B30.1	Certification, Welder Qualification	DI-H-24029	
3.1.1, 3.1.2, A-40.2	Armor Material Test Reports	DI-MISC-80073	Format I

(Copies of data item descriptions related to this specification, and identified in section 6 will be approved and listed as such in DOD 5010.12-L, AMSDL. Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the Naval Publications and Forms Center or as directed by the contracting officer.)

6.2.3 First article. When a first article inspection is required, the item will be tested and should be a first article sample, a first production item (a sample selected from the first casting production items) (or it may be a standard production item from the contractor's current inventory as specified in 4.2.2.1). The first article should consist of (one), (two), etc. unit(s). The contracting officer should include specific instructions in acquisition documents regarding arrangements for examinations, test approval of the documents first article.

6.2.3.1 Special first article ballistic test. Special First Article Ballistic Tests are required when the manufacturer changes either the melting procedure or heat treatment or the declared chemistry of the armor.

6.3 Official weight. The official weight of the casting may be reestablished at any time considered necessary for the improvement of military characteristics (see 3.2.5 and 3.2.5.1).

6.4 Thickness. The symbol "T" is used to indicate the thickness of plate, or of castings at the section concerned, and corresponds to that indicated on the drawings as the Charpy-impact-test-block thickness.

6.5. Position chart drawing. A position chart drawing is a drawing that will be supplied by the procuring activity involved, as one of the applicable drawings to a casting. It will show those areas to be radiographed, the radiographic standards which apply, and the frequency of radiographic testing.

6.6 Ownership of ballistic test plates. First article test plates are the property of the government if they meet the minimum ballistic requirements of the specification. Otherwise, ownership remains with the manufacturer. The manufacturer must make arrangements if return of plates is desired.

6.7 Potential suppliers. Potential suppliers who have not previously upplied cast armor to this specification and wish to have their material llistically tested, may do so at their own expense. It is recommended that uiries for such testing be directed to Commander, U.S. Army Combat Systems Activity, ATTN: STECS-AS-MM, Aberdeen Proving Ground, MD 21005-5059.

? Definitions.

6.8.1 Homogeneous cast steel armor. Homogeneous cast steel armor is armor having a uniform composition and heat treatment which satisfies the requirements of this specification.

6.8.2 Test blocks. Test blocks are representations of the actual castings. They are of the same material and chemical composition.

6.8.3 Heat treating blocks. Heat treating blocks are holders for test bars during a heat treating operation. They are made of steel with any chemical composition.

6.8.4 Linear indication. For the purpose of this specification, a linear indication is a length of three times the width.

6.9 Charpy specimens for comparison tests. Charpy specimens used for comparison tests should be obtained from the local DSA (DCASR) office or, in cases where DCASR does not have responsibility over a particular contract, from the US Army Materials Technology Laboratory, ATTN: SLCMT-MSI-MR Watertown, MA 02172.

6.10 Chemical analysis. Suggested ASTM instrumental Methods that can be used for chemical analysis are E415, E282, E484 and E322. ASTM A751 should be consulted for a list of available methods.

6.11 Metric units. When metric dimensions are required, units for inch, foot, foot-pounds and feet per second 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	=	metre (m)
foot	0.3048	=	metre (m)
foot-lb	1.355	=	Joules
feet per second	0.3048	=	metre per second (m/s)

Note: Conversion factors can be associated with ASTM E 380 entitled "Standard for Metric Practice."

6.12 Radiographs. It is recommended that the procuring activity request radiographs of the weld-repair plates when test data is prepared in accordance with MIL-STD-367.

6.13 Changes from previous issue. The margins of this specification are marked with vertical lines to indicate where changes (additions, modifications, corrections, deletions) from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

6.14 Key Words.

Armor
Ballistic Testing
Casting Repair
Casting Steel, Homogeneous
Heat Treated Castings
Welding

Custodian:
Army - MR

Preparing Activity:
Army - MR

Review activities:
Army - AT, AR, AL, TE,

Project MECA-A071

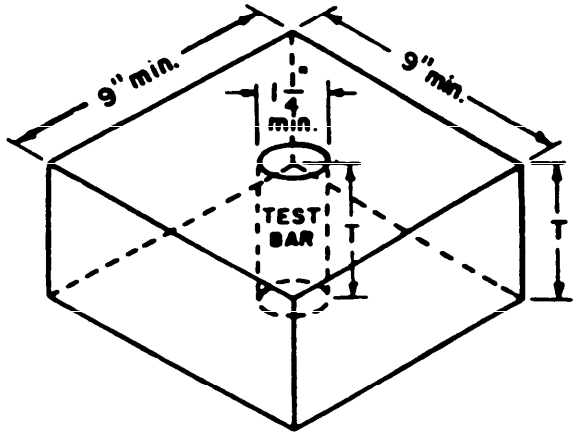
User activities:
Army - ME

(WP# ID-1289A/DISC-0210A. FOR AMTL USE ONLY)

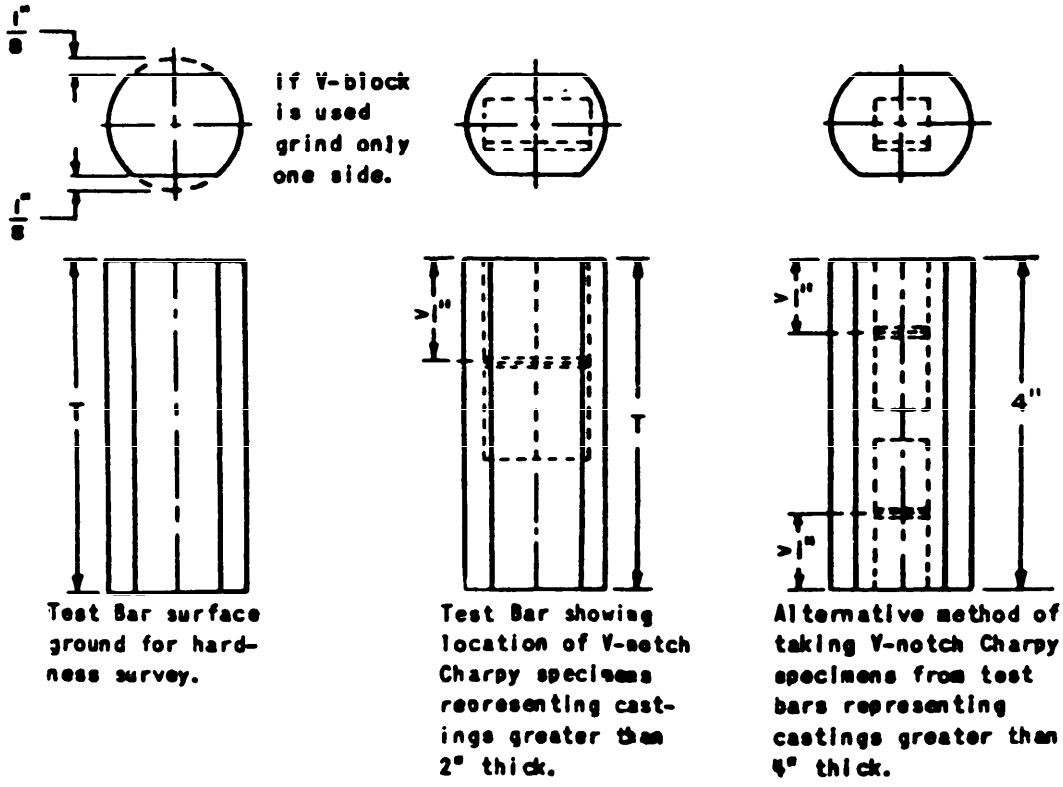
HEAT TREATING BLOCK WITH TEST BAR INSERTED THROUGH THE THICKNESS

NOTES

1. Steel of any chemical composition may be used for test block.
2. Minimum thickness shall be "T" or 2", whichever is larger.



TEST BAR AND HEAT TREATING BLOCK



Test Bar surface ground for hardness survey.

Test Bar showing location of V-notch Charpy specimens representing castings greater than 2" thick.

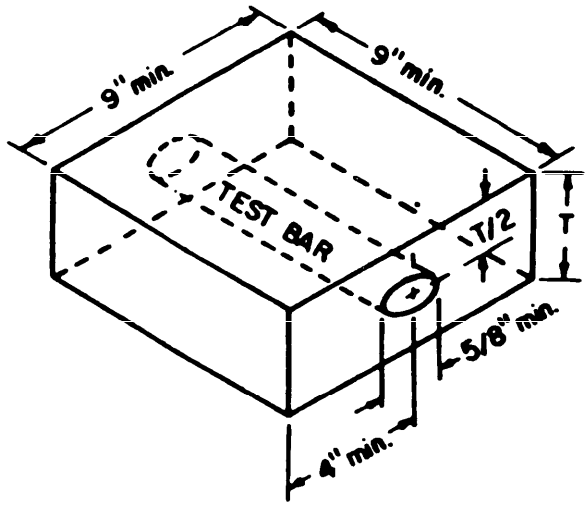
Alternative method of taking V-notch Charpy specimens from test bars representing castings greater than 4" thick.

FIGURE 1. Details of insertion and location: Test bars through heat treating test block thickness: Impact specimens in test bars.

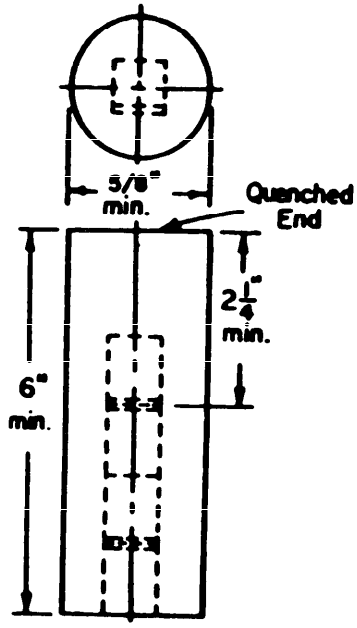
HEAT TREATING BLOCK WITH TEST BAR INSERTED IN SIDE OF BLOCK

NOTES

1. Steel of any chemical composition may be used for test block.
2. Minimum thickness shall be "T" or 2", whichever is larger.



TEST BAR & HEAT TREATING BLOCK FOR ARMOR UP TO 2" THICK



Test Bar showing location of V-notch Charpy specimens representing castings up to 2" thick.

FIGURE 2. Details of insertion and location of test bar through side of impact specimens in test bars in heat treating test block.

APPENDIX A

BALLISTIC TESTING OF CAST STEEL ARMOR

A-10 SCOPE

A-10.1 Scope. This appendix covers the requirements for ballistic testing of cast armor. This appendix is a mandatory part of the specification. The information is intended for compliance.

A-20 APPLICABLE DOCUMENTS

A-20.1 Government Documents.

A-20.1.1 Other government documents, drawings and publications.

A-30 DEFINITIONS

A-30.1 Fair impact.

A-30.1.1 Caliber .50 AP through 20mm APIT, M602 tests. A fair impact is an impact resulting from the striking of the test plate by a projectile in normal flight (no excessive yawing, see A-30.1.3) and separated from another impact or the edge of the plate, hole, crack, or spalled area by an undisturbed area of at least two test projectile diameters.

A-30.1.2 75mm AP and larger calibers. A fair impact is an impact resulting from the striking of the test plate by a projectile in normal flight (no excessive yawing, see A-30.1.3) and separated from another impact or from the edge of plate hole, crack or spalled area by at least one test projectile diameter of undisturbed area.

A-30.1.3 Allowable yaw.

Projectile type	Allowable yaw (degrees)
Cal. 30 AP, M2	3
Cal. 50 AP, M2	3
20-mm APIT, M602	3
75-mm AP, M72	2
90-mm AP, M318	1.5

At the discretion of the test director yaw cards will be placed at target locations (target removed) whenever yaw is suspected to be near borderline of acceptability. Should excessive yaw occur or reoccur the weapon shall be replaced or other appropriate steps will be taken to eliminate yaw. Questionable rounds shall be reported as disregard.

A-30.2 Witness plate. A witness plate is normally a 0.014 inch thick sheet of 5052 - H36 aluminum alloy (or a 0.020 inch thick sheet of 2024-T3 aluminum alloy placed 6 $\pm$ 1/2 inches behind and parallel to the test plates or other ballistic sample.

APPENDIX A

A-30.3 Complete penetration, protection, CP (P).

A-30.3.1 For caliber .50AP through 20mm APIT, M602. A complete penetration occurs when the projectile or one or more fragments of a projectile or plate pass beyond the back of the test plate and perforate the witness plate.

A-30.3.2 For projectile larger than 20mm APIT, M602. A complete penetration occurs when one or more fragments of a projectile or plate has been ejected from the rear of the plate as determined by visual inspection.

A-30.4 Partial penetration, protection, PP(P). A partial penetration is any impact that is not a complete penetration.

A-30.5 Protection ballistic limit, BL (P) for plates.

A-30.5.1 Caliber 30 AP, M2 through 20 mm APIT, M602 penetration tests. 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) will be reported.

A-30.5.1.1 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 will be compared with the specification minimum acceptable 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 will 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 will continue until a ten round ballistic limit has been attained using the smallest velocity spread. Ten round ballistic limits will be reported as such on the armor data form MIL-STD -367, format I.

A-30.5.2 75 mm AP, M72 and larger caliber projectiles. For the purpose of this specification, the protection ballistic limit is the average of four fair protection criteria impact velocities comprising the first two lowest velocities in the firing order resulting in complete penetrations and the first two highest velocities in the firing order resulting in partial penetration which meet the condition that the velocity spread for the 4 rounds shall not exceed 100 fps. In the event that this BL(p) is within $\pm$ 10 fps of the minimum required BL(p) and the velocity difference between the high partial penetration velocity and the low complete penetration velocity (the partial penetration velocity being lower than the complete penetration velocity) is 30 fps or more, firing will continue by the up and down method until the gap is reduced to less than 30 fps.

APPENDIX A

A-40 BALLISTIC TESTS

A-40.1 Ballistic performance of ballistic test plates.

A-40.1.1 Resistance to penetration at normal obliquity. A four- or six-round V_{50} protection ballistic limit, BL(P) on cast plates 3 inches and under in thickness and a four-round V_{50} BL(P) on cast plates over 3 inches in thickness shall be determined at ambient temperatures. On cast plates over three inches in thickness the four-round V_{50} protection ballistic limit shall be obtained by firing the first round while the cast plate is at a temperature of -35 ± 1°C (-30° ± 2°F). The first round is to be fired while the plate is at this temperature (see footnote "a" to tables A-I and A-II on page 29). Other test conditions including the minimum ballistic limit requirements are in table A-1.

A-40.1.2 Resistance to oblique attack. A four round V_{50} protection ballistic limit BL(P), at 45 degrees obliquity, on PLATES over three inches in thickness, shall be obtained by firing the first round while the cast armor is at a temperature -35° ± 1°C (-30° ± 2°F). The first round is to be fired while the plate is at this temperature (see footnote "a" to tables A-I and A-II on page 27). Other test conditions including the minimum ballistic limit requirements are in table A-2. A 4 round BL(p) will be determined on 3-inch thick cast plates at 45° at ambient temperature.

A-40.1.3 Ballistic test plates greater than 3 inches in thickness. Ballistic test plates greater than 3 inches in thickness shall have a 3 inch diameter lifting hole at the center of the longest edge (see table C-I) with the center hole positioned 3 -0.000 +0.500 inches from the edge of the plate.

A-40.1.4 Location of holes in test plates to house thermocouples. Two holes for thermocouples shall be drilled in each test plate which is to be subjected to low temperature testing. The holes shall be positioned one in the center of each of the two plate edges adjacent to the edge in which the lifting hole is located. The thermocouple holes shall be drilled to a depth of 2 inches with a 0.339 inch diameter tap drill, letter R and shall have a 1/8 national pipe thread (NPT) 27-1 x 3/8. A 0.339 inch bottom drill shall be used to finish the holes.

A-40.1.5 Correction factors to determine the required ballistic limit of test plates. The required ballistic limit of any test plate, the thickness of which is between two consecutive tabulated thicknesses, shall be determined by the correction factors shown in Tables A-I and A-II, as applicable.

A-40.1.6 Length of crack developed by a single impact. Any crack extending in one direction developed by a single impact shall not exceed a length of 10 inches unless it can be attributed to causes other than base material (i.e., repairs, etc., in which case a "no test" result will be declared and a retest will be required).

A-40.1.7 Test plate sizes. Test plate sizes, length and width, shall be as shown in table C-1.

APPENDIX A

A-40.2 Ballistic performance of castings other than plates. Ballistic performance and ballistic test areas shall be in accordance with the requirements specified in the contract or order or on the applicable drawings. Castings shall be ballistically tested at ambient temperature except for castings over 3 inches thick. Castings over 3 inches thick shall be tested at the low temperature described in A-40.2.2. (See 6.2.2)

A-40.2.1 Location of holes to house thermocouples in castings other than plates. Two thermocouple holes shall be provided in each production casting submitted for low temperature ballistic test. The thermocouple holes shall be drilled to a depth of 2 inches with a 0.339 inch diameter tap drill, letter R and shall have a 1/8 national pipe thread (NPT) 27-1 x 3/8. A 0.359 inch bottom drill shall be used to finish the holes. The location of these thermocouple holes shall be as specified in the contract or order or on the drawings (see 6.2).

A-40.2.2 Temperature of casting during major caliber impact testing. The first major caliber impact on a casting shall occur when the casting temperature is -55° + 1°C (-30° +2°F). Firing should continue until the temperature rises to -18°C (0°F) or until the four round ballistic limit has been determined. If an evaluation of resistance to penetration cannot be made before the casting temperature rises above zero degrees Fahrenheit, the production casting will be recooled and firing will continue as required.

A-40.2.3 Castings meeting ballistic requirements. The casting shall be considered to meet the ballistic requirements when each ballistic limit obtained is equal to or greater than that specified on each drawing.

A-40.2.4 Partial penetrations. Where the test area is limited, the casting shall be considered acceptable if partial penetrations are attained within the limits specified.

A-40.2.5 Length of crack developed by a single impact. Any crack developed by a single impact and running in the same general direction, such as horizontal or vertical shall not exceed a length of 10 inches, unless it can be attributed to causes other than base material (i.e., repairs, etc.).

A-50 NOTES

A-50.1 Identification of cast plates and other castings. Plates and castings shall be indelibly and legibly marked with symbols that will definitely identify them with inspection and test reports and with the shipping documents. The key to identification symbols shall be furnished to the inspector prior to submittal for inspection and tests.

2 Information required. The manufacturer shall furnish for the files of the proving ground making the ballistic tests, a statement showing the analysis of each melt and the complete details of the heat treatment

NAME Mr. Frank Leland TELEPHONE (Include Area Code)

of each casting or group of cast plates. All elements of the chemical composition shall be shown in the statement, including special additives or hardening agents, whether shown in table I of the specification or not. This information shall be forwarded in accordance with MIL-STD-367(See 6.2.2). The results of hardness tests and notched-bar impact tests shall also be provided.

A-50.3 Reference document. U.S. Army Test and Evaluation Command, Test Operating Procedure 2-2-710, Ballistic Test of Armor Materials, 7 February 1984 may be used as a reference for general and detailed ballistic test procedures covered by this specification. Nothing in the reference document shall be construed to supersede or to invalidate the requirements of the specification.

TABLE A-I. Minimum required ballistic limits at 0° obliquity impact.

Thickness of Plate (In.)	Test Projectile Type to be Used	Test Temp.	Required 4 rd, V_{50} BL(P) fps	Allowable Velocity Spread (fps)	Velocity Correction for 0.01-Inch Thickness Change (fps)
5/8	Cal .30 AP	Amb	2575	60 (4 rd BL); 90 (6 rd BL)	18
1	Cal .50 AP, M2	Amb	2472	60 (4 rd BL); 90 (6 rd BL)	4
1-1/2	20-mm APIT, M602	Amb	2170	60 (4 rd BL); 90 (6 rd BL)	11
2	20-mm-APIT, M602	Amb	2655	60 (4 rd BL); 90 (6 rd BL)	9
3	75-mm AP, M72	Amb	1300	100	4
4	90-mm AP, M318	Amb	1450	100	2
5	90-mm-AP, M318	Amb	1775	100	2
6	90-mm-AP, M319	Amb	1990	100	2

TABLE A-II. Minimum required ballistic limits at 45° obliquity impact projectile type, 90-mm AP, M318.(a)

Thickness of Plate (In.)	Test Temp.	Required 4 rd, V_{50} BL(P) fps	Allowable Velocity Spread (fps)	Velocity Correction for 0.01-Inch Thickness Change (fps)
3	Amb	1950	100	3
4	[a]-35°F (-37°C)	2350	100	3
5	[a]-35°F (-37°C)	2850	100	3
6	[a]-35°F (-37°C)	2900	100	3

(a) The first round is to be fired when the casting temperature is -35°F (-37°C). Subsequent rounds are to be fired as quickly as possible without recooling the casting unless an evaluation cannot be made before the temperature rises above 0°F (-18°C). In this event, the casting will be recooled and additional round(s) will be fired starting at a temperature of -35°F (-37°C) until the 4-round V_{50} BL(P) has been determined.

APPENDIX B

QUALIFICATION PROCEDURE AND REPAIR-WELDING REQUIREMENTS FOR THE REPAIR OF ARMOR CASTINGS

B-10 SCOPE

B-10.1 Scope. This appendix covers the requirements for the qualification of welding procedures and welders involved in the repair of armor castings. This appendix is a mandatory part of the specification. The information contained herein is for compliance.

B-10.1.1 Ballistic testing of simulated weld-repair cast plates. Only Class 1 armor cast simulated weld-repair plates shall be ballistically tested.

B-20 APPLICABLE DOCUMENTS

B-20.1 Government documents. The following documents (in addition to those specified in section 2 of the specification) of the issue in effect on the date of invitation for bids or request for proposal, form a part of this appendix to the extent specified herein.

SPECIFICATION

MILITARY

MIL-E-8697 - Electrodes, Welding, Coated, Low Hydrogen, Heat-treatable Steel
MIL-E-22200/1 - Electrodes, Welding, Mineral Covered, Iron Powder, Low Hydrogen, Medium and High Tensile Steel, As Welded or Stress-Relieved Weld Application
MIL-E-22200/6 - Electrodes, Welding, Mineral Covered, Low Hydrogen, Medium and High Tensile Steel
MIL-E-23765/1 - Electrodes and Rods, Welding, Bare, Solid and Alloyed Cored, Ordinary Strength and Low-Alloy Steel.
MIL-E-23765/2 - Electrodes and Rods, Welding, Bare, Solid or Alloyed Cored, Low-Alloy Steel
MIL-E-24403/1 - Electrodes, Welding, Flux Cored, Ordinary Strength and Low Alloy Steel
MIL-E-24403/2 - Electrodes, Welding, Flux Cored, Low Alloy Steel

STANDARDS

MILITARY

MIL-STD-367 - Armor Test Data Reporting
MIL-STD-1264 - Radiographic Inspection for Soundness of Welds in Steel by Comparison to Graded ASTM E390 Reference Radiographs
MIL-STD-1941 - Metal-Arc Welding of Homogeneous Armor.

(Copies of specifications, standards, handbooks, drawings, publications, and other Government documents required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.)

B-20.2 Other publications. The following document(s) form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS shall be the issue of the non-Government documents which is current on the date of the solicitation.

American Welding Society (AWS)

AWS A3.0 - Welding Terms and Definitions

(Applications for copies should be addressed to the American Welding Society, 550 North West LeJeune Road, P.O. Box 351040, Miami, FL 33135).

AMERICAN SOCIETY OF TESTING AND MATERIALS (ASTM)

ASTM A488 Qualification of Procedures and Personnel for the Welding of Steel Castings

(Non-Government specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

B-30 REQUIREMENTS

B-30.1 Qualification. Prior to the repair welding of Class 1 or Class 2 production castings, the contractor shall qualify the welding procedure to be used and the welders who are to perform the work. (See 6.2.2) Qualification of the welding procedure and welders for production fabrication weldments is to be in accordance with MIL-STD-1941(MR). Paragraph B-30.1.1 of this specification specifies the factors required in the qualification of the weld-repair procedure including the ballistic testing of the simulated weld-repair plates. (Note Class 2 simulated weld-repair plates do not require ballistic testing, but do require the welds to be radiographed to determine their soundness.) Paragraph B-30.1.2 specifies the requirements for the qualification of the welders. Class 2 simulated weld-repair plates shall conform to figure B-3.

B-30.1.1 Qualification of procedure.

B-30.1.1.1 Contractor's recorded procedure for repair welding. The manufacturer shall establish the recorded repair-welding procedures, using welding terms and definitions in accordance with AWS A3.0, for the repair of castings. The recorded repair-welding procedure shall include all the factors listed in Table B-I.

APPENDIX B

TABLE B-I. Factors in the recorded repair-welding procedures and changes.

Factor included in recorded welding procedure	Recorded welding procedure shall be revised and procedure requalified as indicated below	Welder shall be requalified as indicated
1. Declared analysis.	When a change in composition outside of the declared range established in accordance with this specification is made, unless a specific waiver is granted by the procuring activity involved.	Not required.
2. Electrode; type, class, manufacturer, size, deposit and weld metal analysis not qualified under specifications outlined in B-30.2.5.	When the brand of electrode used for procedure qualification has been qualified but does not meet the requirements of specifications listed in paragraph B-30.2.5, substitution of any other brand will require requalification. However, when the brand used for procedure qualifications has met the requirements of said specifications for a specific type and class and provided that all other factors remain the same, any other brand that has met the requirements of said specifications for this same type and class may be substituted without requalification of procedure.	Not required.
3. Process: Welding	(a) Any change in process (e.g. SMAW to GMAW) (b) A change from manual to semi-automatic or vice-versa (c) A change from semi-automatic to automatic (including robotic)	Not required
4. Welding current and voltage range for diameter of electrode.	When the limits established in the recorded repair-welding procedure are exceeded.	When the limits established in the recorded welding procedure are exceeded.
5. Preheat temperature range local or general which shall be specified.	When the minimum temperature is reduced, or interpass temperature changes.	Not required.
6. Thermal treatment after welding.	When any temperature in the thermal treatment established in the original procedure is changed unless otherwise authorized by the procuring activity involved.	Not required.

APPENDIX B

TABLE B-I. Factors in the recorded repair-welding procedures and changes (Cont'd)

Factor included in recorded welding procedure	Recorded welding procedure shall be revised and procedure requalified as indicated below	Welder shall be requalified as indicated
7. Defect removal repair method of preparing area to be re-welded: i.e., thermal or mechanical or both.	In case of change from mechanical to thermal method only.	Not required.
8. Position in which welding will be performed.	When change is made in welding position.	See para. B-30.1. 2.2
9. Type and sequence of passes.	In case of change from stringer bead to weaving only.	See para. B-30.1
10. Source of power, a.c. or d.c. (polarity if d.c. is used).	When change is made from a.c. to d.c., or vice-versa; of if d.c., when polarity is changed.	Not required.

B-30.1.1.2 Weld repair test plate requirements. Based on requirement guide-lines set forth in Tables B-II, Table B-III and B-IV test plates shall be submitted for testing to Aberdeen Proving Ground (see 3.1.1). These plates will contain repair welds of the sizes and conditions (repair Class A, Class B, or Class C) required by the manufacturer to meet his production casting requirements. Where full area weld-repair allowances of table B-III and table B-IV are desired, these must be qualified using simulated repair weld sizes shown in figure B-1 or B-2 as applicable. Where requirements are less, actual repairs anticipated for production should be declared and qualified by a simulated repair test plate for actual sizes declared. The test plate side to be impacted shall be stenciled "IMPACT SIDE" with letters at least 2 inches high. Weld-repair areas will be clearly outlined with paint on the impact side of the plate.

B-30.1.1.2.1 Class A repair welding. This kind of repair requires complete heat treatment after welding (hardening and tempering). The manufacturer shall submit test plate(s) of the type shown in figure B-1 for radiographic and ballistic tests. Each test plate shall be welded before the final hardening and tempering heat treatment required to produce the hardness for the thickness of the plate involved. Any thermal preconditioning of the plate, i.e., normalizing, etc., before welding must be consistent with practice intended for production.

B-30.1.1.2.2 Class B repair welding. This kind of repair requires tempering only after welding. The manufacturer shall submit a test plate(s) of the type shown in figure B-1 for radiographic and ballistic tests. Each plate shall be welded in the fully heat treated state and tempered after welding at a temperature within 28° (50°F). of the original tempering temperature.

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B-30.1.1.2.3 Class C repair welding. This kind of repair requires no thermal treatment after welding. For making size 1 repairs, the manufacturer shall submit a test plate of the type shown in figure B-2 for radiographic and ballistic tests. For sizes 2 and 3 repairs, the manufacturer shall prepare a representative weld-repair to the maximum dimensions for the size category. Each plate to be welded shall be in the fully heat treated condition.

B-30.1.1.2.4 Coverage of test plates. Test plate requirements for weld-repair procedure certification shall be established in accordance with con- ditions listed in Table B-II and Table B-III. If repair welding is contem- plated in more than one position, a separate plate for each position must be prepared and acknowledged within the repair procedure submitted.

B-30.1.1.2.5 Interpass temperature not to exceed 315°C (600°F). The interpass temperature of qualification plates shall not be more than 315°C (600°F) (see 3.2.2.1). The interpass temperature shall be measured at a location approximately 3 inches from the edge of the weld on the base metal according to the approved recorded repair-welding procedure.

B-30.1.1.3 Soundness. Repair weld procedure qualification test plates shall comply with ASTM E390 Level 3 when radiographed in accordance with the requirements of 4.6.2.6 of the specification.

B-30.1.1.4 Ballistic testing of welding procedure certification of cast plates for class 1 armor castings.

B-30.1.1.4.1 Simulated weld repair cast test plate. Simulated repair welds will be required for repair of defects in armor castings. For repair of armor thicknesses less than 1 inch, a 3/4-inch thick nonballistic simulated repair cast plate shall be prepared (see B-30.1.1.5). For repair in cast thicknesses of 1 inch up to and including 2 1/2 inches thick, the simulated repair plate shall be 1 1/2 inches thick. For repairs in cast thicknesses greater than 2 1/2 inches, the simulated repair plate shall be 4 inches thick with the dimensions shown in figures B-1 and B-2. All designated sizes of repairs may be qualified as a single plate as shown in figure B-1 or B-2. Alternatively individual simulated repairs may be made in 36" X 36" plates. A simulated repair plate shall be prepared for each position of welding in which the procedure application is intended. In addition, the condition of the final repair weld surface should be the same as that intended for production application, i.e., as deposited, ground or machined. When three repair areas are submitted on one plate the first impact is to be on size 1, the second impact on size 2, and the third impact on size 3. The first impact shall occur at -35 ± 1°C (-30 ± 2°F). Firing shall continue without recooling the plate. The contractor shall outline the perimeter of the repair welded areas.

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TABLE B-II. Cast test plate requirements for simulated weld repairs.

Armor Thick (in.)	Repair Plate Thick (in.)	Test Type Ballistic	Nonballistic	References
Less than 1	3/4 (a)		X	B-30.1.1.5.1, Figure B-4
1 to 2-1/2	1-1/2 (a)	X	(b)	TABLE B-IV, Fig B-1, B-2
Over 2-1/2	4	(c)	(b)	TABLE B-IV

(a) Individual simulated weld-repairs may be made on 36" by 36" plates.

(b) Repair Class C, Sizes 2 and 3.

(c) See B-30.1.1.4.1

B-30.1.1.4.2 Ballistic shock test conditions for simulated cast weld repair Plates. The 1-1/2-inch thick simulated cast weld-repair plate shall be tested at -35°C (-30°F) (see B-30.1.1.4.1) at 0° obliquity by impacting each "repair" area with one 75mm, M1002 plate-proofing projectile at a velocity of 1050 ± 25 fps. The 4-inch thick simulated repair plates shall be cooled to -35°C (-30°F) and tested at 60° obliquity by impacting each "repair" area with one 105 mm, AP-T, T182 or T182E1 projectile at a striking velocity of 225 ± 25 fps below the protection ballistic limit for the exact thickness of the plate. The direction of impact of each simulated repair is noted on figures B-1 and B-2. Where applicable, more than one size repair on a test plate, the order of impacts shall be located on the repaired area as follows: The first impact on size 1, the second impact on size 2 and the third impact on size 3. The letters "IMPACT SIDE" are to be paint stenciled with letters at least 1 inch high on the impact side of each simulated weld-repair plate. The contractor shall outline the perimeter of each weld-repair area.

B-30.1.1.4.3 Evaluation of test results. Spalling or complete penetration of the welded areas will be cause for rejection of the repair procedure. On 1-1/2-inch thick weld-repair test plates any cracking incurred extending beyond the boundry of a 10-inch diameter circle, centered on the point opposite of the projectile impact, shall also be cause for rejection. On 4-inch thick weld-repair test plates, any cracking incurred extending beyond the boundry of a 10-inch diameter circle, where the center of the circle will originate opposite the point where projectile penetration is maximum, shall also be cause for rejection. However, cracking of the plate material, outside of the weld-repair and heat affected zone areas and not propagating from the weld-repair area will not be cause for rejection of the weld-repair but will be declared a no-test (see B-30.1.1.4.3 (d)).

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The manufacturer must make arrangements within 30 days if return of plates is desired. The procedure will be accepted for each repair size that meets the ballistic requirements. Retests will be permitted at the cost of the manufacturer.

When the test conditions are such that the level of performance of welding procedure can not be determined, a "no test" decision will be rendered. These conditions are as follows:

a. The projectile impact is not fairly located (i.e., at least 70 percent of the projectile impact should be within the area of the weld for fair impact) and no spalling or perforation occurred. On questionable impacts, measure the distance from the edge of the impact to the edge of the weld. If the distance exceeds 25.5 mm, (1 in.) then a "no test" condition exists (see figure B-4).

b. The projectile striking velocity is below the minimum allowed and no spalling or perforation occurred.

c. The projectile striking velocity is above the maximum allowed and spalling or perforation occurs.

d. Cracking of the plate material outside of the weld-repair area and not propagating from weld-repair area.

e. In the event that condition a or b occurs on the 1st impact and enough area remains for a fair impact on the same area, a second round will be fired. If this round produces excessive cracking, then a "no test" decision will be rendered. Otherwise, if a fair impact occurs on the second impact, and excessive cracking does not occur, the weld-repair will be considered acceptable.

B-30.1.1.4.4 Data required. Welding data, such as material welded, sketches of weldments, electrodes used, equipment used, and equipment settings shall be submitted in accordance with MIL-STD-367, and forwarded to the Government test proving ground along with the test plate (See 6.2.2).

B-30.1.1.5 Non-ballistic evaluation of welding procedure certification simulated repair plates of Class-2 armor.

B-30.1.1.5.1 Simulated non-ballistic test plates for Class-2 armor. A Class C simulated repair weld of largest weld(s) declared will be prepared in accordance with the proposed repair practices and the required inspection method (see B-III). Welds meeting the requirements of Grade II in MIL-STD-1264 shall determine the qualification of A, B and C repair weld practice for all sizes for armor classes less than one (1) inch thick.

B-30.1.1.6 Firing record number. After completion of ballistic tests, firing record numbers shall be assigned by the Government testing agency. This number shall be recorded and become part of the recorded welding procedure book, validating the qualification of the procedure.

B-30.1.2 Qualification of welders.

B-30.1.2.1 Welder qualification. Qualification of a welder by one manufacturer shall not serve as qualification when the welder is employed by another manufacturer.

B-30.1.2.2 Qualification procedure. The welding procedure prescribed for production repair welding, shall be used for qualification of the welder for making repairs. The type of joint and positions each welder is to qualify for, shall be in accordance with ASTM A488.

B-30.1.2.3 Soundness of welds. Finished welded qualification test plates shall comply with Grade II of MIL-STD-1264 when radiographed in accordance with the requirements of 4.6.2.5. Any cracks or under cutting is unacceptable.

B-30.2 Requirements for repair of armor castings.

B-30.2.1 General. All weld-repairs shall be made in accordance with a procedure prepared under the requirement presented herein and by welders qualified in accordance with this appendix.

B-30.2.2 Repairable defects. Defects which may be repaired by welding shall not exceed the weld area dimensions specified for each class and size shown in table B-III and Table B-IV. The total amount of repair welding permitted on any casting shall be limited to 12 percent of the total surface area (inside and outside) except for Class C, defect size 3. The size of the defect shall be considered as the size of the cavity resulting from chipping, grinding, or oxygen cutting to remove the defect. Size 2 and 3 Class "C" repairs shall not be permitted on the interior of major ballistic surfaces of any casting. Unless otherwise specified on the drawing, a major ballistic surface is defined as any area presenting a continuous surface greater than 4 square feet and a thickness of 2 1/2 inches or greater. Limited surface repair can be accomplished in many cases by blend grinding.

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TABLE B-III. Repair limitation for Class-1 armor castings thicknesses 1/4 to 8 inches inclusive.

Repair Class	Size of defect	Depth 1/ maximum, inches	Subject to 3/ inspection	Surface area 4/ maximum
A or B 2/	1	T	R	100 sq. in.
	2	1/4 T	R	250 sq. in.
	3	1/8 T for 1/4 ≤ T ≤ 1 1/2 in. 3/16 for 1 1/2 < T ≤ 8 in.	R	See B-30.2.2
C 2/	1	T to 2 1/2	R	30 sq. in
	2	1/4 T 5/	R or M 6/	48 sq. in.
	3	1/8 T for 1/4 ≤ T ≤ 1 1/2 in. 3/16 for 1 1/2 < T ≤ 8 in.	R or M 6/	No limit

1/ The symbol "T" as used in this table represents the thickness of casting at the location involved.

2/ The repair of a size 1 defect which occurs within the boundaries of any other size defect may be accomplished provided the allowable dimensions for each size of defect are not exceeded. This repair consideration also applies to succeeding defect sizes for all classes of repairs shown above.

3/ All weld-repairs are subject to the same inspection methods applied to the base material and to the same acceptance criteria required of the base material. Methods of inspection include radiograph (R) and magnetic particle (M).

4/ Only applies if defect sizes of figure B-1 or B-2 are tested, otherwise, maximum surface area will be limited to sizes declared by casting producer and qualified through applicable test plate requirements, see B-30.1.1.2.

5/ For armor castings with thicknesses 4 to 8 inches inclusive, the maximum defect depth shall not exceed 1 inch.

6/ Any cracks found by magnetic particle inspection will be cause for rejection.

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TABLE B-IV. Weld repair size and depth requirements for simulated repair of Class-1 armor cast test plates. 1/, 7/

Treatment Type	Class "A" 2/ Complete Heat Treatment	Class "B" 2/ Tempering	Class "C" 2/ None
Size of Defect			
1	10" x 12" x T	10" x 12" x T	2-1/2" X 12" X T 3/ 2 1/2" x 12" x 1/2 T 4/
2 5/	14" x 20" x 1/4T	14" x 20" x 1/4T	4" x 12" x 1/4T
3 6/	18" x 20" x 1/8T to 3/16" max.	18" x 20" x 1/8T to 3/16" max.	18" x 20" x 1/8T 3/16" max.

1/ The dimensions of the overall cast test plate shall be as shown in figures B-1 and B-2.

2/ The symbol "T" as used in this table represents the thickness of the test plate.

3/ For Class "C" Size 1 defect where the test plate is 1-1/2 inches thick, the repair will be made through the plate.

4/ For Class "C" Size 1 defect where the test plate is 4 inches thick, the repair will be made to a maximum depth of 2 inches

5/ Size 2 - prepared to a depth of 1/4T from back of plate for Classes A and B and from the front of the plate for Class C.

6/ Size 3 - prepared to depth of 1/8T to 3/16" from back of plate for Classes A and B and from the front of the plate for Class C.

7/ The individual simulated repair may be made on 36" x 36" plates of the respective thickness for each size and class.

B-30.2.2.1 Large defects. Defects larger than those referenced in B-30.2.2 may be repair-welded only when authorized by the procuring activity.

B-30.2.3 Class C weld repair. If the first repair weld is defective, removal of defective weld metal shall be beyond the heat affected zone of base metal from the weld-repair. A Class C weld-repair shall not be performed more than twice. If the second repair is defective, the repair shall be classified as a Class B weld-repair. The post-weld heat treatment is required to reduce the adverse effects of the amount of heat input due to the number of repairs and to maintain ballistic integrity.

B-30.2.4 Interpass temperature. The interpass temperature for production castings shall be not less than the minimum preheat temperature and shall not exceed 315°C (600°F). Frequency and sequence of the interpasses are recorded in the repair-welding procedure. The interpass temperature shall be measured at a location approximately 3 inches from the edge of the weld on the base metal according to the recorded repair welding procedure.

accordance with MIL-STD-

APPENDIX B

B-30.2.5 Type of electrode. Unless otherwise authorized by the procuring activity, repair welding shall be performed using ferritic type electrodes as follows: MIL-E-22200/1, MIL-E-22200/6, MIL-E-23765/1, MIL-E-23765/2, MIL-E-24403/1, or MIL-E-24403/2 for Class B or C weld-repair and MIL-E-8697 for repairing of Class-A defects. The manufacturer, however, may use any process and/or electrode not approved under the above specifications for the classes of repair indicated, provided the test requirements for qualifying the repair weld are satisfactorily met and have passed magnetic particle inspection (see B30.2.6).

B-30.2.6 Magnetic particle inspection of weld repaired castings. See 4.7.5.1.

B-30.2.7 Radiography of repaired castings. When radiography is required on the drawing or contract unless otherwise specified weld-repairs 1/2 T or greater in depth shall be radiographed in accordance with 4.6.2.6. The frequency of testing shall be at twice the frequency for the casting. For example, for required production radiography at 1 out of 30, weld-repair radiography shall be done at 1 out of 15. The weld-repair shall be inspected to assure that the defect has been removed and meets Level III of ASTM E390 for both lack of fusion and penetration. No cracks are permissable. If the casting selected for radiography is rejected, the remainder of the lot shall be sampled in accordance with MIL-STD-105D, Inspection Level S-4, 6.5 % AQL.

B-30.2.7.1 Ultrasonic inspection (UT) of repaired castings. The use of UT inspection as a substitute for radiography shall require the approval of the procuring activity.

measurement results shall conform to 4.5.4 at the conclusion of the test (see

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PG. 40
Figure B-1.

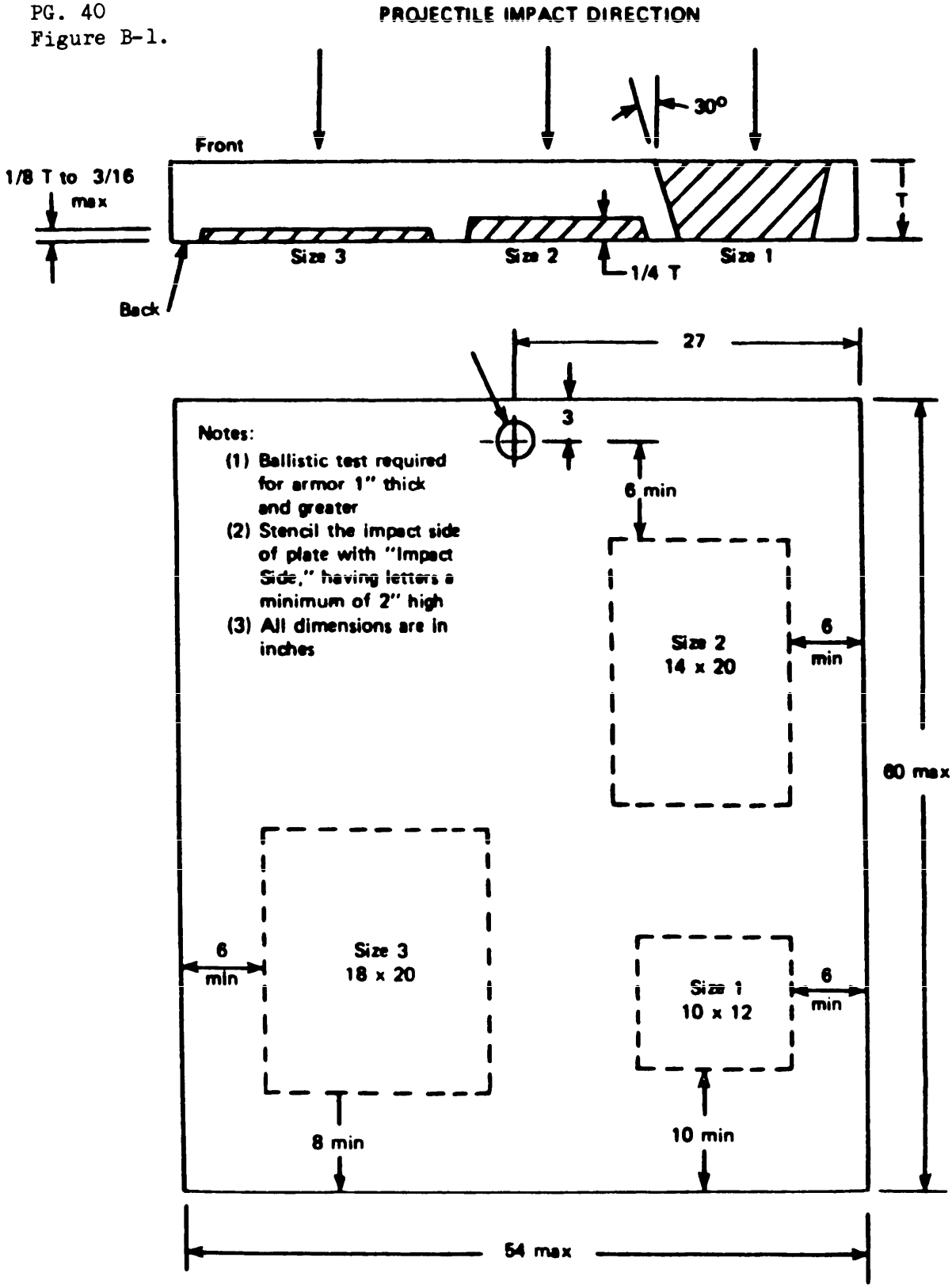

Figure B-1. Simulated Repair Cast Test Plate for Classes A and B

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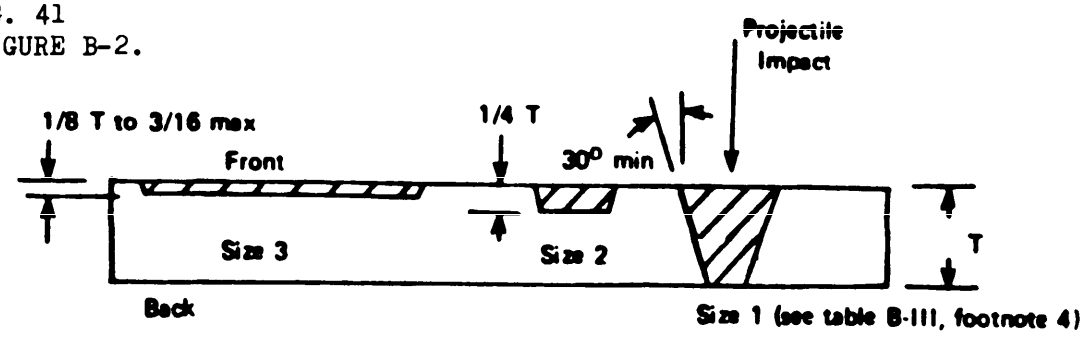
PG. 41
FIGURE B-2.



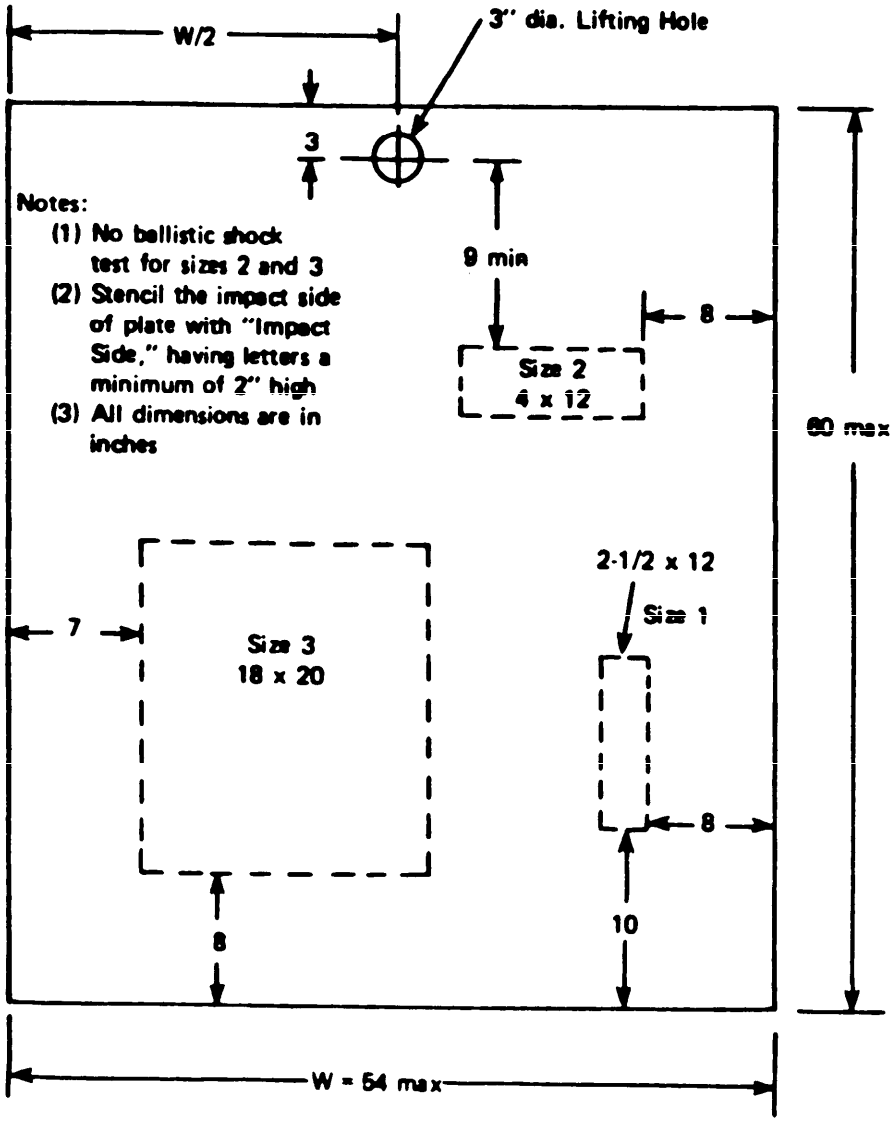


Figure B-2. Simulated Repair Cast Test Plate for Class C

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PG. 42
FIGURE B-3.

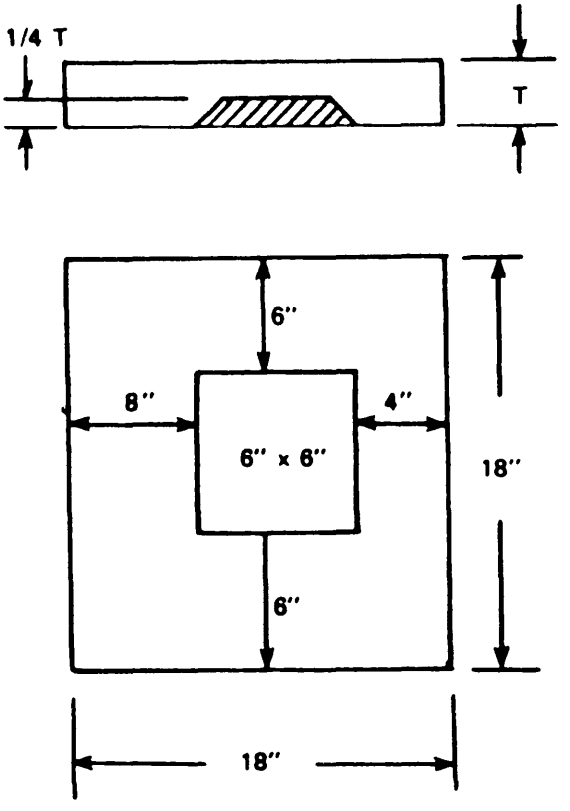
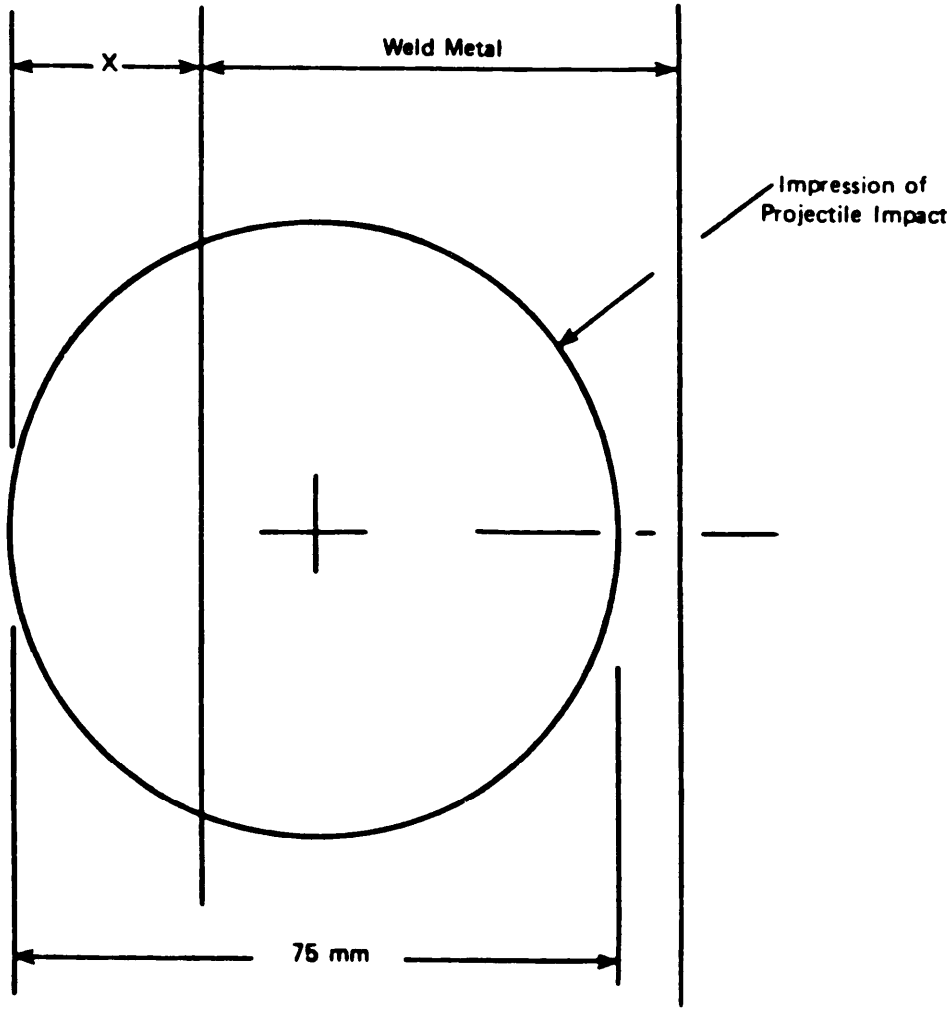


Figure B-3. Class 2 Armor Simulated Repair Cast Test Plate for Class C Welds

Figure B-4



If X > 25.5 mm, then a no-test condition exists.

Figure B-4. Ballistic Shock Test: Impact Location Required for Fair Impact

APPENDIX C

REQUIREMENTS FOR FOUNDRY OR PROCESS QUALIFICATION

C-10 SCOPE

C-10.1 Class-1 armor. This appendix covers the requirements for first article testing of cast flat Class-1 material for the purpose of foundry or process qualification. The cast test plates shall be tested to determine, chemical, ballistic and mechanical properties of Class-1 material. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

C-10.2 Class-2 armor. Foundry or process qualification of Class-2 armor shall involve preparing weld-repair plates in accordance with Appendix B. The weld-repair plates shall be radiographed for internal soundness examination. The weld-repair plates base material shall be tested to determine the chemical and mechanical properties (see 3.1.2) of this specification.

C-10.2.1 Purpose of foundry or process qualification. The purpose of foundry or process qualification is to allow the supplier to provide and the purchaser to obtain, satisfactory pre-contractual evidence that the supplier is competent to manufacture cast armor to the requirements of this specification. Potential suppliers should refer to 6.7 of this specification.

C-10.2.2 Intent of foundry or process qualification. The intent of foundry or process qualification is to:

a. Standardize the requirements for evidence of supplier capability in advance of procurement action.
b. Reduce procurement lead time.
c. Minimize redundant, long/expensive test requirements: test(s) whose only function(s) are to demonstrate supplier capability should not be repeated except for testing actual end item castings during first article inspection and quality conformance inspection.
d. Allow avoidance of situations where competition is unequal because one or more suppliers have established competence via prior procurements.
e. Provide an additional tool for optimizing the relationship between engineering risk and quality assurance cost.

C-20 APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

C-30 Definitions.

C-30.1 Test plate. For the purpose of this specification a test plate shall mean an as-cast metal surface that has been cast into a flat rectangular configuration of the dimensions specified in table C-I.

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C-30.2 First article requirement for foundry or process qualification. The requirements for obtaining foundry or process qualification includes sucessfully complying with the ballistic tests (Class-1 only), surface hardness, hardenability, impact resistance, magnetic particle inspection, soundness and workmanship requirements of this specification for the plate thickness tested. Meeting the requirements of this specification does not relieve the manufacturer of the obligation to test the first production casting of the design required or any on-going production castings.

C-30.3 Symbol "T". The symbol "T" is used to indicate the thickness of plate casting and corresponds to that indicated on the drawings as Charpy-impact-test-block-thickness.

C-40 REQUIREMENTS

C-40.1 First acticle requirements for test plates.

C-40.1.1 Declared chemical composition, heat treatment, and processing. The requirements for chemical composition of the steel, (see 3.2.1 and table I), heat treatment, and process of manufacturer shall be the same as the applicable requirements shown for the acceptance of production armor. A statement of the declared composition, declared heat treatment, and the declared manufacturing process to be employed shall be submitted to the procuring activity along with the first article test plates.

C-40.1.2 Mechanical properties.

C-40.1.2.1 Hardness (Class-1 and Class-2 armor). The average surface hardness of each first article test plate and the average cross-sectional hardness of each test block or bar shall be within the range specified in table II of the casting thickness represented when tested as specified (see C-40).

C-40.1.2.2 Impact (Class-1 and Class-2 armor). The average Charpy V-notch resistance value of each plate or test block shall meet the requirements in Table III when tested in accordance with C-50.

C-40.1.3 Ballistic requirements (Class-1 armor). The ballistic requirements for Class 1 cast armor shall be as specified in Appendix A (see C-50.7 of this specification). Class 2 armor shall not be ballistically tested.

C-40.1.3.1 Ballistic requirements for simulated Class-1 armor weld repair test plates. The ballistic requirements for classes A, B, and C repair welds shall conform to the requirements of Appendix B of this specification.

C-40.1.4 Soundness (Class-1 and Class-2 armor). Casting surface defects upon visual examination shall meet the acceptance requirements as agreed upon between the contractor and procuring activity (see 3.2.9.1) of this specification. There shall be no evidence of surface cracks or hot tears.

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C-40.1.5 Thickness (Class-1 and Class-2 armor). The average thickness of the first article test plates shall not differ from the required thickness by more than plus or minus 5 percent.

C-40.1.6 Magnetic particle inspection (Class-1 and Class-2 armor). See C-50.5.

C-40.1.7 Liquid penetrant inspection (Class-1 and Class-2 armor). See 4.6.2.8 of this specification.

C-50 TESTS

C-50.1 Declared chemical composition (Class-1 and Class-2 cast armor). A statement of the declared chemical composition and a copy of the chemical analysis shall be submitted to the procuring activity along with the 1st article test plates.

C-50.1.1 Chemical analysis (Class-1 and Class-2 armor). Chemical analysis shall be conducted in accordance with the applicable method specified in ASTM A751 (see 6.10). The chemical analysis shall comply with the declared composition as established by the contractor in accordance with the requirements of table 1 (see 3.2.1).

C-50.2 Hardness and impact tests.

C-50.2.1 For approval of thicknesses less than 3 inches for Class-1 and Class-2 armor. A test block 9"x9"xT" (see C-30.3) in size shall be tack-welded to each test plate so that it can accompany the plate through the quenching and tempering cycles. The block shall be attached at such a location that neither the thickness of the block nor the thickness of the test plate will be sufficiently increased during heat treatment to significantly affect test results.

C-50.2.2 For approval to thicknesses of 3 to 8 inches for Class-1 armor. A cored test bar shall be trepanned from each test plate of three to six inch thickness (see table C-I). The center of the trepanned test bar shall be no closer than four inches from any edge, and no more than two samples shall be taken from any one plate.

C-50.2.3 Surface hardness on test plates of Class-1 and Class-2 armor. Each first article test plate shall be subjected to three Brinell hardness tests on each face where acccesible and practicable. If hardness cannot be made practicably on both faces, five tests shall be made on one face, one near the middle of each side and one in the middle of the plate area. The samples shall be prepared and tested in accordance with ASTM E10.

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C-50.3 Charpy V-notch impact test for Class-1 and Class-2 armor. At least two charpy V-notch impact specimens shall be taken from each impact test block or test bar and prepared and tested in accordance with ASTM E-23. Charpy machines used in testing shall have been proof tested (calibrated) within one year prior to the time of inspection (see 6.9).

C-50.4 Thickness measurement of test plate for Class-1 and Class-2 armor. The average thickness of test plate shall be determined from five measurements, one near each corner of the plate two inches from either edge and one at the center. Thickness measurements shall be taken to the nearest 0.001 inch.

C-50.5 Magnetic particle inspection for Class-1 and Class-2 armor. A magnetic particle examination shall be performed over 100% of casting surface in accordance with ASTM E 709 to insure a crack and hot tear free surface.

C-50.6 Radiography of Class 1-and Class-2 armor test plates. Radiographic tests shall be performed on test plates in accordance with the requirements of the applicable drawings or contract. For inspection purpose test plates shall be classified in accordance with Class-3, Grade C of table II, III and IV, of MIL-STD-1265 whichever is applicable for the thickness involved.

C-50.7 Ballistic test for cast plates for Class 1 armor. The manufacturer shall submit for approval ballistic test plates in accordance with table C-1. Plates shall be ballistically tested in accordance with Appendix A of this specification.

C-50.8 Ballisitic testing of Class-1 simulated weld repair test plates. The manufacturer shall submit for approval simulated repair weld test plates. The plates shall be prepared and tested in accordance with Appendix B.

APPENDIX C

TABLE C-1. Ballistic test plates for foundry or process certification.

Thickness of Plates inches	Number of Plates	Minimum Size of Plates (inches)	Thickness Ranges (inches)
5/8	2	12 x 36	1/4 to 3/4, incl
1	2	12 x 36	over 3/4 to 1 1/4, incl
1 1/2	2	12 x 36	over 1 1/4 to 1 3/4, incl
2	2	12 x 36	over 1 3/4 to 2 1/4, incl
3	2 1/	72 x 72	over 2 1/4 to 3 3/4, incl
4	2 1/	72 x 72	over 3 3/4 to 4 3/4, incl
5	2 1/	72 x 72	over 4 3/4 to 5 3/4, incl
6	2 1/	72 x 72	over 5 3/4 to 8, incl

1/ Alternately, 4 plates of size 48" x 60" could be submitted.

Note: With prior approval of the procuring activity, the manufacturer may establish first article acceptability for foundry or process certification, provided the hardness of the test plates meet the Brinell hardness requirements of table II, Charpies of table III, Chemistry from table I and blastic test requirements in Appendix A of this specification for the thickness ranges encompassed by the following submittal:

Thickness of Plate inches	Number of Plates	Minimum Size of Plates (inches)	Thickness Ranges (inches)
1 1/2	2	12 x 36	1 1/4 through 1 3/4
5	2 1/	72 x 72	3 3/4 through 5 3/4
6	2 1/	72 x 72	5 3/4 through 8

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