INCH-POUND

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DEPARTMENT OF DEFENSE MANUFACTURING PROCESS STANDARD

ARC WELDING OF ARMOR GRADE ALUMINUM

AMSC N/A

AREA THJM

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FORWARD

1. This standard is approved for use by all Departments and Agencies of the Department of Defense (DoD).

2. This standard does not specify armor capability in terms of protection. The user is responsible for defining the threat that the armor system must withstand.

3. Comments, suggestions, or questions on this document should be addressed to U.S. Army Tank-Automotive Research, Development and Engineering Center, ATTN: RDTA-SIE-ES-SI MS #268, 6501 E. 11 Mile Road, Warren, MI 48397-5000 or sent by email to usarmy.detroit.rdecom.mbx.tardec standardization@mail.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla.mil/.

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1. SCOPE

1.1 Scope. This standard provides requirements applicable to various arc welding processes for welding and repairing armor welds which are constructed from qualified armor grade aluminum. This standard defines the requirements for armor grade aluminum weld fabrication, inspection, repair, and qualification of procedures and personnel.

1.2 Classification.

1.2.1 Welding processes. The welding processes are classified as follows:

a. Gas metal arc welding (GMAW) to include pulsed transfer (GMAW-P), globular transfer (GMAW-G), short circuit transfer (GMAW-S), and spray transfer (GMAW-SP)

b. Gas tungsten arc welding (GTAW)

c. Plasma arc welding with variable polarity (PAW-VP)

d. Other fusion welding processes may be used with permission of the procuring engineering activity.

1.2.2 Designation of welded connections. Weld classes do not relate or correlate with material classes as defined in the applicable military specifications for armor grade aluminum. The loading of welded members should be classified as follows:

a. Class I welds. This class of weld is applicable to weld joints that are critical to the structural integrity of a system. The worst case scenario for a failure of any portion of this weld, when subjected to conditions defined by system/sub-system requirements, could result in a loss of system, loss of life, loss of major component, loss of control, unintentional release of critical stores, or a mission-critical failure. A failure of these welds would be considered catastrophic or critical for the severity in the risk assessment matrix in accordance with ATP 5-19.

b. Class II welds. The worst case scenario for a failure of any portion of this weld class, when subjected to conditions defined by system/sub-system requirements, could result in a reduction of overall efficiency of the system or could result in injury, or endangering of personnel. A failure of these welds would be considered negligible to moderate for the severity in the risk assessment matrix in accordance with ATP 5-19.

c. Welds without class designations. When weld class is not specified in the contract or drawing, Class I weld designation will apply.

1.3 Application. This standard covers welding armor grade aluminum to armor grade aluminum, and armor grade aluminum to non-armor grade aluminum.

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1.4 Limitations. Qualifying personnel or processes to this standard does not qualify personnel or processes to any other standard or code.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4 or 5 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4 or 5 of this specification, whether or not they are listed.

2.2 Government documents.

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

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-DTL-12235	-	Projectile, Plate-Proofing (For Impact or Shock Testing) 37mm M1000, 57mm M1001, 75mm M1002, 90mm M1003, 105mm M1004, 20mm M1005, 57mm M1001A, and 75mm M1002A
MIL-DTL-32262	-	Armor Plate, Aluminum Alloy 6055 Weldable and Alloy 6061, Unweldable Applique
MIL-DTL-32341	-	Armor Plate, Aluminum, Alloy 2139 Weldable and Alloy 2195 and 2060 Unweldable Applique
MIL-DTL-32505	-	Armor Plate, Aluminum, Alloy 7017 Weldable and 7020 Applique
MIL-DTL-45225	-	Aluminum Alloy Armor, Forged
MIL-DTL-46027	-	Armor Plate, Aluminum Alloy, Weldable 5083, 5456, and 5059
MIL-DTL-46083	-	Aluminum Alloy Armor, Extruded, Weldable
MIL-DTL-46118	-	Aluminum Alloy Armor, 2219, Rolled Plate and Die Forged Shapes
MIL-DTL-46192	-	Aluminum Alloy Armor Rolled Plate (1/2 to 4 Inches Thick), Weldable (Alloy 2519)

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-2035(SH)	-	Nondestructive Testing Acceptance Criteria
MIL-STD-1895(AT)	-	Radiographic reference standards and Radiographic Procedures for Partial-Penetration Aluminum Welds
MIL-STD-1916	-	DOD Preferred Methods for Acceptance of Product

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NOTE: Naval Sea Systems Command (NAVSEA) will be referred to as Army throughout the referenced MIL-STD.

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

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

ARMY TECHNIQUES PUBLICATIONS

ATP 5-19	-	Risk Management

(Copies of this document are available from http://armypubs.army.mil/doctrine/ATP_1.html.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME Y14.43	-	Dimensioning and Tolerancing Principles for Gages and Fixtures

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

AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING (ASNT)

ASNT CP-189	-	Qualification and Certification of Nondestructive Testing Personnel

(Copies of this document are available online at https://www.asnt.org.)

ASTM INTERNATIONAL

ASTM E164	-	Standard Practice for Contact Ultrasonic Testing of Weldments
ASTM E1032	-	Standard Test Method for Radiographic Examination of Weldments
ASTM E1417/E1417M	-	Standard Practice for Liquid Penetrant Testing
ASTM E2261/E2261M	-	Standard Practice for Examination of Welds Using the Alternating Current Field Measurement Technique

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ASTM E2699	-	Standard Practice for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE) for Digital Radiographic (DR) Test Methods

(Copies of these documents are available from www.astm.org.)

AMERICAN WELDING SOCIETY (AWS)

AWS A2.4	-	Standard Symbols for Welding, Brazing and Nondestructive Examination
AWS A3.0M/A3.0	-	Standard Welding Terms and Definitions (DoD adopted)
AWS A5.32M/A5.32	-	Welding Consumables – Gases and Gas Mixtures for Fusion Welding and Allied Processes
AWS D1.2/D1.2M	-	Structural Welding Code – Aluminum
AWS QC1	-	Specification for AWS Certification of Welding Inspectors
AWS Z49.1	-	Safety in Welding Cutting, and Allied Processes

(Copies of these documents are available from www.aws.org.)

CANADIAN STANDARDS ASSOCIATION

CSA W178.2	-	Certification of Welding Inspectors

(Copies of this document are available online at http://www.csa.ca.)

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO/IEC 17025	-	General Requirements for the Competence of Testing and Calibration Laboratories

(Copies of this document are available online at www.iso.org.)

NATIONAL AEROSPACE STANDARD

NAS410	-	NAS Certification & Qualification of Nondestructive Test Personnel

(Copies of this document are available online at www.aia-aerospace.org.)

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

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3. DEFINITIONS

3.1 Contractor. Also known as the prime contractor; the organization having a direct contract with the procuring activity. In this standard, the term contractor refers to the prime contractor.

3.2 Design engineer. The individual with overall design authority of vehicle, sub-assembly, or component. The design engineer is responsible for determining class of welds in accordance with 1.2.2 and ATP 5-19 with final weld classification approval from procuring engineering activity.

3.3 Engineer. A duly designated individual who acts for and on behalf of the Government, contractor or manufacturer on all matters within the scope of this standard.

3.4 Entity. A complete and separate company, manufacturer, organization or contractor.

3.5 Fixture. A system to secure parts in place during production.

3.6 Functional fixture. A fixture that uses gage elements and makes physical contact with datum features on the fabricated part.

3.7 Manufacturer. The organization actually performing the operations covered by this standard. The contractor may or may not be the manufacturer.

3.8 Nominal thickness. The thickness that is specified on the plans or drawings without application of any allowed tolerance. The abbreviation for nominal thickness is T.

3.9 Procuring engineering activity. The subject matter experts (SME) designated by the procuring activity. Obtaining permission from the procuring engineering activity will be done by contacting the contracting officer and directing the request through the SME.

3.10 Production. The general term used to develop an item for the Government, including, but not limited to an assembly, sub-assembly, or end item. For purposes of this document, this term is used as a synonym for manufacture, fabrication, or other like terms.

3.11 Reference calibration standard. A sample of material acoustically similar to the material to be tested containing known reflectors with which the ultrasonic system is calibrated to establish acceptance/rejection levels.

3.12 Repair. Reprocessing of nonconforming material in accordance with approved written procedures and operations to reduce, but not completely eliminate, the nonconformance. The purpose of repair is to bring nonconforming material into a usable condition. Repair is distinguished from rework in that the item after repair still does not completely conform to all of the applicable drawings, specifications or contract requirements.

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3.13 Rework. Reprocessing of nonconforming material to make it conform completely to the drawings, specifications or contract requirements.

3.14 Root opening. Root openings listed in this document are also known as “design openings”, or the openings which would exist after completion of the weld if the root face had not been melted away. The dimensions in this standard for the root opening are used on drawings to give correct over-all dimensions for the structure. The “design opening” is not ordinarily the root opening which is actually visible before welding, as the opening should include an increase for the amount of contraction across the joint during welding. Therefore, the root opening equals the “design opening” plus the shrinkage allowance.

3.15 Standard welding terms and definitions. All standard welding terms and definitions are located in the latest edition of AWS A3.0M/A3.0.

3.16 Welding symbols. Welding symbols are to be those shown in the latest edition of AWS A2.4.

4. GENERAL REQUIREMENTS

4.1 Safety precautions. Safety precautions shall conform to the latest edition of AWS Z49.1.

Note: This standard may involve hazardous materials, operations, and equipment. This standard does not address any of the safety problems associated with their use. It is the responsibility of the user to establish appropriate safety and health practices. The user should determine the applicability of any regulatory limitations prior to use.

4.2 Joint design. The weld joint design shall be the responsibility of the design engineer and shall be available for review by the procuring engineering activity if requested.

4.3 Restricted welding process. GMAW-short circuit (GMAW-S) and globular transfer (GMAW-G), shall not be allowed for Class I welds unless the welding process passes a ballistic shock test in accordance with 5.3.6.

4.4 Equipment calibration. The contractor shall develop and maintain an equipment calibration program for all welding equipment that has a factory calibrated certification.

4.5 Welding fixtures. Fabricated parts that require fixtures or frames shall use fixtures or frames designed to minimize the distortion of the components being welded and to ensure that drawing tolerances are maintained. When the use of a functional fixture is required, the fixture shall be designed in accordance with ASME Y14.43.

4.6 Weld positions. For descriptions of all welding positions and position limitations, see Position of Test Welds section of AWS D1.2/D1.2M.

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5. DETAILED REQUIREMENTS

5.1 Material.

5.1.1 Base material. Accepted, weldable, armor grade aluminum shall be restricted to the thicknesses, alloys, and armor classes listed in the latest revisions of the following specifications:

a. MIL-DTL-32262
b. MIL-DTL-32341
c. MIL-DTL-32505
d. MIL-DTL-45225
e. MIL-DTL-46027
f. MIL-DTL-46083
g. MIL-DTL-46118
h. MIL-DTL-46192

Any other aluminum thickness, alloy, or armor class shall be approved by the procuring engineering activity prior to use as armor. The base material shall be as specified in the contract documents or the applicable drawing.

5.1.1.1 Base material certification. The material certification from the aluminum manufacturer shall be verified by the contractor against the requirements of the applicable specification prior to its usage. All certification documentation for armor aluminum base material shall be kept by the contractor for the period of performance of the contract, at a minimum.

5.1.2 Backing material.

5.1.2.1 Permanent backing material. Permanent backing for Class I welds shall not be permitted, unless approved by the procuring engineering activity. Class I permanent backing material shall be material qualified under the same military specification as the base material. Permanent backing material for Class II shall be limited to an alloy compatible with the base material in accordance with the Base Metal Group Designations section of AWS D1.2/D1.2M or any weldable alloy listed in the base material specification (see 5.1.1). All certification documentation for Class I weld permanent backing material shall be kept by the contractor for the period of performance of the contract, at a minimum.

5.1.2.2 Removable backing material. Removable backing material of any suitable material shall be allowed for all classes of welds at the discretion of the design engineer. If using aluminum backing material, when both base materials are identical, the backing material shall be in accordance with 5.1.2.1.

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5.1.3 Spacers material. Spacers shall be fabricated from an alloy compatible with the base material in accordance with the Base Metal Group Designations section of AWS D1.2/D1.2M or any weldable alloy listed in the base material specification (see 5.1.1). If aluminum spacers are used for Class I welds, all certification documentation for armor aluminum spacer material shall be kept by the contractor for the period of performance of the contract, at a minimum.

5.1.4 Weld tab material. Weld tab material shall be aluminum material and removed at the completion of welding before nondestructive testing (NDT) or visual inspection. Weld tabs shall be allowed for all classes of welds.

5.1.5 Shielding gases. All shielding gas or gas mixtures shall be in accordance with AWS A5.32M/A5.32, and shall be certified by the gas manufacturer. All certification documentation shall be kept by the contractor for the period of performance of the contract, at a minimum. A gas or gas mixture used for shielding shall be of a welding grade and shall have a dew point in accordance with the Minimum requirements on purities and moisture contents of gases and gas mixtures table of AWS A5.32M/A5.32. When shielding gas mixers are required, calibrated mass flow meters shall be used for proportioning the percentages of gases to conform to the requirements of the weld procedure specification (WPS) (see 4.4). The procuring engineering activity may conduct reviews of the calibration and certification documentation to assess conformance to this standard.

5.1.6 Weld filler material. Only weld filler identified in the qualified WPS shall be used during production. Table I contains a list of recommended filler materials that may be used when welding various armor grade aluminum alloys. The use of these recommended filler materials does not guarantee successful process qualification testing. All welding processes, regardless of filler material, shall be qualified in accordance with this document. Table I only lists armor grade aluminum alloys that are not listed in AWS D1.2/D1.2M. Alloys not listed in table I shall use filler metal in accordance with the Filler Metal section in AWS D1.2/D1.2M. Filler metal selection for welding one armor grade aluminum alloy to a different alloy, or to an alloy listed in AWS D1.2/D1.2M shall be determined by the design engineer, and subject to qualifications listed in this standard.

TABLE I. Recommended filler materials.

Base material alloy	Recommended filler material
2139	2139, 4043, or 4943
2519	2319
5059	5183
6055	4043 or 4943
7017	5183, 5356, 5556, or 7020
7039	5183 or 5356

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5.1.6.1 Filler metal storage and handling. Welding electrodes shall be handled carefully to prevent damage to their coatings, if coatings exist. Damaged containers shall have their contents examined for excessive moisture content, cracked coatings or other damage to the electrodes. Filler spools or drums shall be examined for distorted spools, entwined winding on spooled wire, or surface contaminates. Filler material damaged to the extent that it does not meet manufacturer's requirements shall not be used for production welding. Filler metal storage and handling shall be in accordance with the Filler Metal section of AWS D1.2/D1.2M.

5.1.6.2 Welding filler material identification. Electrodes and welding wire shall be identified by type up to the point of usage. Each spool or coil of bare electrodes shall carry an identifying label. Each piece of bare filler metal shall have distinguishable color code, type designation or classification number marking.

5.2 Personnel qualification.

5.2.1 Weld personnel qualification. Before assigning any welder or welding operator, the contractor shall possess valid certification that their personnel have passed qualification tests in accordance with 5.2.1.4.

5.2.1.1 Welder Qualification Records (WQR). The contractor shall document the results of the welder or welding operator qualification test in a WQR for every welder or welding operator. The procuring engineering activity may conduct reviews of the WQRs to assess conformance to this standard. The WQRs shall be retained for the period of performance of the contract, at a minimum. A WQR example is shown in figure A-1. The WQR shall include, at a minimum:

a. Contractor/manufacturer

b. Welder or welding operator identification

c. Date of test

d. Information contained in table II

e. Results of qualification test

f. Certifying signature with job title

5.2.1.2 Previous welder or welding operator qualification. Previous qualification tests by welders or welding operators that are properly documented are acceptable with the approval of the procuring engineering activity.

5.2.1.3 Expiration of qualification period. The welder or welding operator shall requalify in accordance with 5.2.1.4 for the following reasons:

a. Has not welded in the qualified process for a period exceeding six months.

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b. As requested by contractor or procuring engineering activity due to a specific reason to question the abilities of the welder or welding operator.

5.2.1.4 Welder and welding operator performance qualification. A qualified WPS (see 5.3.6.1.6 or the WPS Qualification section of AWS D1.2/D1.2M) shall be used for each welder or welding operator qualification plate. Qualifying as a welder shall not qualify the individual as a welding operator or vice versa. A welder's performance qualification is measured in their ability to create a test plate which meets the acceptance criteria of this standard. A welding operator's performance qualification is measured in their ability to successfully operate the welding equipment and produce a test plate which meets the acceptance criteria of this standard. All welder and welding operator qualification records shall be maintained in accordance with 5.2.5.

5.2.1.4.1 Welder and welding operator qualification base material. Test material shall be in accordance with a qualified WPS for the welder or welding operator test coupon.

5.2.1.4.2 Welder and welding operator qualification positions. Each welder and welding operator shall be qualified in the position or positions (see 4.6) required for production welding prior to performing any production welding. Welder and welding operators shall use the Performance Qualification section of AWS D1.2/D1.2M in determining position qualification limitations. Welding in the vertical down direction shall only be authorized in material with a nominal thickness less than 0.25 inches.

5.2.1.4.3 Welder and welding operator essential variables. Each welder or welding operator qualification shall include the information from table II for each qualification required. The applicable information from table II shall be included in the WQR. Welding in the vertical down direction shall only be authorized in material with a nominal thickness less than 0.25 inches.

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TABLE II. Welder and welding operator essential variables.

Essential variable	Requalification of personnel is required when this change occurs	Personnel	
		Welders	Welding operators
Welding process (see 1.2.1)	Change to an unqualified process	X	X
Position	Change to an unqualified position	X	X
Base material thickness	Change to an unqualified thickness	X	X
Backing material	If backing material is removed	X	X
Current type	Change from AC to DC or vice versa (GTAW only)	X	X
Number of electrodes	When going from single electrode to multiple, but not from multiple to single		X
Automated to machine	Change from automated to machine welding or vice versa		X
Arc voltage control	A deletion of automatic arc voltage control (GTAW only)		X
Joint tracking software	A deletion or addition of automatic joint tracking		X

5.2.1.4.4 Class II welds. For Class II welds, welder and welding operator shall qualify in accordance with the Performance Qualification section of AWS D1.2/D1.2M. Qualifying as a welder shall not qualify an individual as a welding operator or vice versa. All welders or welding operators shall qualify for Class II welds before qualifying for Class I welds (see 5.2.1.4.5).

5.2.1.4.5 Class I welds. Before qualifying for Class I welds, individuals shall qualify in accordance with 5.2.1.4.4. For welder or welding operator qualification of Class I welds, the welder or welding operator shall fabricate a test plate in accordance with figure 1 or figure 2. Figure 1 (a single bevel groove) shall be qualified for thicknesses 0.5 inches (13 mm) or less. Figure 2 (a double bevel groove) shall be qualified for thicknesses greater than 0.5 inches (13 mm). When qualified in accordance with figure 2 the welder or welding operator shall be considered qualified for figure 1 and figure 2. Removable backing material shall be permitted. The entire weld of the test plate shall be nondestructively tested via ultrasonic (see 5.5.3.5.3) or radiography (see 5.5.3.5.1). Welders and welding operators shall qualify for the required positions in accordance with 5.2.1.4.2. Figure 1 and figure 2 shall be complete joint penetration (CJP) welds.

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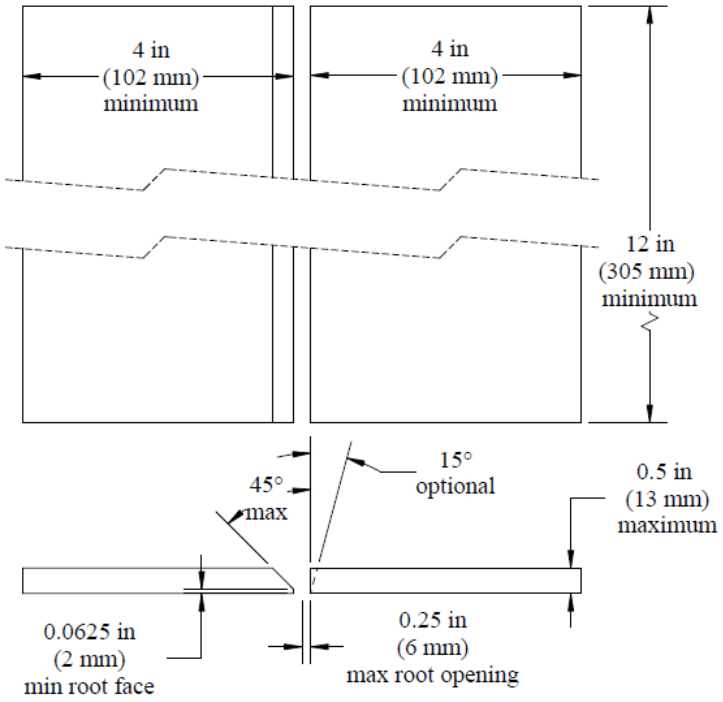


FIGURE 1. Welder and welding operator qualification plate T less than 0.5 inches inclusive.

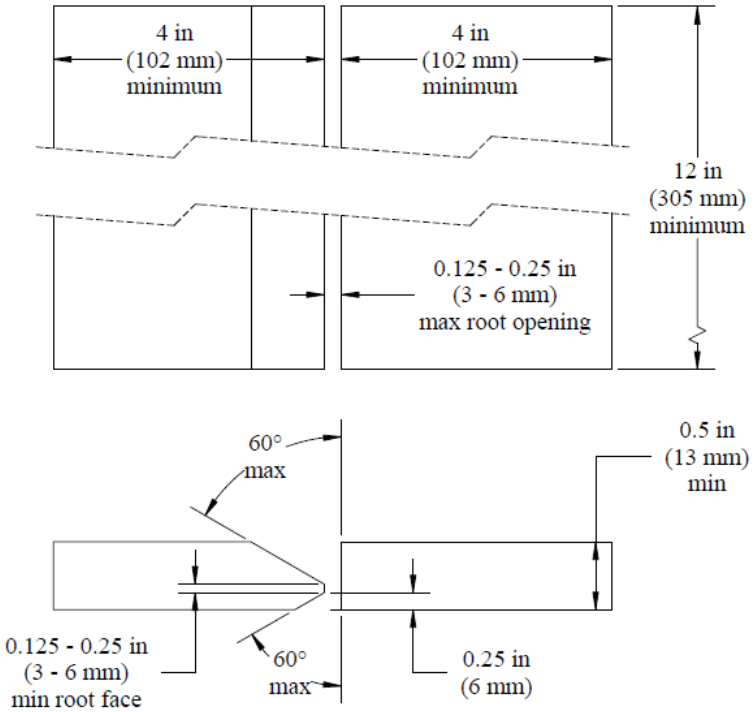


FIGURE 2. Welder and welding operator qualification plate T greater than 0.5 inches.

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5.2.2 Weld inspector qualification. Qualified inspectors shall be used for the verification of weld quality. All qualified weld inspectors shall pass an eye exam every three years at a minimum. The eye exam shall be administered by a qualified, licensed medical professional. The qualified inspector shall have a J2 score on the Jaeger scale at a distance of 12 to 14 inches with or without corrective lenses. All weld inspectors shall be qualified in accordance with at least one of the following:

a. Current certification in accordance with the AWS QC1 for Certified Welding Inspector (CWI) or Senior Certified Welding Inspector (SCWI).

b. Current certified welding inspectors qualified by the Canadian Welding Bureau (CWB) to Level II or the Level III requirements of CSA W178.2.

c. Any other weld inspection certification program through an accredited organization as approved by the procuring engineering activity.

NOTE: A qualified welding inspector is not qualified to perform NDT unless the requirements of 5.2.4 are met.

5.2.3 Mechanical testing personnel qualification. Contractors that complete mechanical testing internally shall develop a training plan for mechanical testing personnel. The training plan shall be made available to the procuring engineering activity if requested. Contractors that sub-contract mechanical testing shall use ISO/IEC 17025 certified test facilities.

5.2.4 Non-Destructive Testing (NDT) personnel qualification. Individuals performing any method of NDT shall meet the qualification requirements for the applicable NDT level of certification in accordance with ASNT CP-189 or NAS410. The required NDT level shall be determined by the contractor's NDT written instruction (see 5.5.3.1). Alternately, any certification through ASNT Central Certification Program (ACCP) shall be recognized as certified at the NDT level of examination.

5.2.4.1 NDT re-examinations. If there is reason to believe that an individual is unable to competently perform at the NDT level that the individual is certified, the Government shall request an operational or written examination be administered in accordance with ASNT CP-189 or NAS410. If an individual transfers from one entity to another, NDT reexamination shall be required in accordance with the new entity's NDT written instruction for personnel qualification. All personnel certified through ACCP shall be exempt from reexamination when transferring entities.

5.2.4.2 Other NDT methods. For NDT methods not covered by ASNT CP-189 or NAS410, personnel shall qualify to comparable levels of competency by the administration of examinations for the particular method involved. A certified NDT Level III shall be responsible for the validity of the examinations.

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5.2.4.3 Alternative NDT specifications and standards. If an alternative inspection program which meets all the requirements of this document is to be used, the alternative program shall be submitted to the procuring engineering activity for approval prior to being used.

5.2.5 Personnel documentation. The procuring engineering activity may conduct reviews of the personnel documentation to assess conformance to this standard. All personnel documentation shall be maintained for the period of performance of the contract, at a minimum.

5.3 Weld procedure qualification. Any welder or welding operator that qualifies a procedure shall be qualified as a welder or welding operator in accordance with 5.2.1.

5.3.1 Preparation of weld procedures. Prior to the production of any welds, the contractor shall create procedure qualification records (PQRs) and weld procedure specifications (WPSs) for all welds and make them available to the procuring engineering activity. PQRs and WPSs shall be signed by the contractor's engineer or the engineer's duly designated representative. PQRs and WPSs shall be retained for the period of performance of the contract, at a minimum. Examples of a blank PQR and WPS are located in figure A-2 and figure A-3 respectively.

5.3.2 Previous qualified welding procedures. In order to use a previously qualified welding procedure, a contractor shall submit a written request to the procuring engineering activity for approval to use the welding procedures prior to production.

5.3.3 Company name change. Properly documented WPSs and PQRs qualified under the provisions of this standard by a company that later has a name change due to voluntary action or consolidation with a parent company may utilize the new name on its WPS documents while maintaining the supporting PQR qualification records with the old company name.

5.3.4 Revision. Any changes made to a PQR and WPS shall be identified, authorized and dated on the PQR and WPS by the contractor. The contractor shall notify the procuring engineering activity that a change was made. The revised PQR and WPS shall be made available to the procuring engineering activity upon request.

5.3.5 Class II weld procedure qualification. Prior to any production, a welding procedure qualification record (PQR) shall be prepared for each Class II weld in accordance with AWS D1.2/D1.2M. Each completed Class II PQR shall be submitted to the procuring engineering activity for review. All welded joint procedures shall be qualified using appropriate visual inspection, and mechanical testing in accordance with AWS D1.2/D1.2M. All mechanical and visual results from the Class II qualification testing shall be documented within all Class II PQRs. A qualified Class II procedure shall be completed before qualifying a Class I weld procedure. For tensile testing of aluminum armor alloys not listed in AWS D1.2/D1.2M, the tensile values shall be equal to or greater than the values listed in the aluminum armor military specifications.

5.3.6 Class I procedure qualification.

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5.3.6.1 Procedure qualification records (PQRs). Once a qualified Class II PQR has been completed (see 5.3.5) A Class I procedure shall be qualified for each Class I weld. Qualification of a Class I PQR shall be done prior to any production. Each completed Class I PQR shall be submitted to the procuring engineering activity for review. Each Class I PQR shall require ballistic shock testing only after successful completion of a Class II procedure qualification (see 5.3.5). All mechanical, visual, and NDT results shall be documented within all Class I PQRs, to include the ballistic shock test report, and any testing completed during the Class II qualification.

5.3.6.1.1 PQR base material. Base material used to qualify a PQR shall utilize base material identical to the base material utilized for production. Material groupings shall not apply for Class I welds.

5.3.6.1.2 Filler material. Filler material used to qualify a PQR shall utilize material identical to the filler material utilized for production, and shall be in accordance with 5.1.6.

5.3.6.1.3 Process qualification essential variables. The applicable essential variables listed in the first column of table III shall be included for all PQRs. Each data entry on the PQR shall be the actual value recorded during process qualification welding. All numeric values shall be recorded as single values. There shall be no range of values recorded on any PQR.

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TABLE III. Procedure essential variables Class I only.

Base Material			
Essential variables	Process		
	GMAW	GTAW	PAW-VP
A change in an armor grade aluminum to another armor grade aluminum.	X	X	X
Any change in thickness outside of what was qualified within the tolerance of the material spec.	X	X	X
The coating description or type, if present.	X	X	X
Any change in temper of base materials from what was qualified.	X	X	X
Joint Design			
Essential variables	Process		
	GMAW	GTAW	PAW-VP
A change of dimensions of root opening, root face and included angle outside of the limits in accordance with table IV.	X	X	X
Addition or subtraction of backing or spacer strip, or change of material of backing or spacer strip.	X	X	X
A change in groove type.	X	X	X
Shielding Gas			
Essential variables	Process		
	GMAW	GTAW	PAW-VP
A change in total gas flow rate by an increase of 50% or a decrease of 20%.	X	X	X
A change from one single gas to another single gas or to a gas mixture. Any change in the specified percentage of a gas mixture in accordance with AWS A5.32M/A5.32. A change from no gas to any gas or vice versa.	X	X	X

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TABLE III. Procedure essential variables Class I only – Continued.

General			
Essential variables	Process		
	GMAW	GTAW	PAW-VP
A change to an unqualified position.	X	X	X
Preheat and interpass temperature (see 5.4.6).	X	X	X
Addition or deletion of post weld heat treatment.	X	X	X
A change from a stringer bead to a weave or vice versa on heat treatable alloys.	X	X	X
A change in the number of weld passes per side.	X	X	X
Change of mechanical method to thermal method when preparing root of joint before welding second side or vice versa.	X	X	X
Removal of, but not inclusion of backing material or back gouging.	X	X	X
Procedure Parameters			
Essential variables	Process		
	GMAW	GTAW	PAW-VP
Welding amperage for each diameter used by an increase or decrease of 20%.	X	X	X
A change in voltage for each diameter used by an increase or decrease of 20%.	X	X	X
A change in wire feed speed for each diameter (if not amperage controlled) by an increase or decrease of 10%.	X		
A change in travel speed by an increase or decrease of 25% (automated welding only).	X	X	X
A change in current (AC/DC) or polarity (DC- Electrode + or Electrode -).	X	X	X
A change in the mode of transfer.	X		
A change from Constant Volt to Constant Current output.	X		

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TABLE III. Procedure essential variables Class I only – Continued.

Filler Material			
Essential variables	Process		
	GMAW (G, SP, & P)	GTAW	PAW-VP
Increase or decrease in tensile or yield strength.	X	X	X
An increase or decrease in the number of electrodes.	X	X	X
Addition or deletion of filler metal.		X	X
Change from cold wire feed to hot wire feed or vice versa.		X	X
Change in filler metal diameter.	Any increase or decrease greater than 0.016 inch (0.4 mm)	Any increase or decrease greater than 0.031 inch (0.8 mm)	Any increase or decrease greater than 0.016 inch (0.4 mm)

TABLE IV. Class I groove weld tolerances.

Measurement	Class I
Inclusive angle	+10° -5°
Root face	+0.063 inches (1.6 mm) - 0
Root opening (no backing)	±0.063 inches (1.6 mm)
Root opening (with backing)	+0.188 inches (5 mm) – 0

5.3.6.1.4 Non-destructive testing. Prior to ballistic shock testing, the qualification test plate (see 5.3.6.2) shall be nondestructively tested using UT (see 5.5.3.5.3) or RT (see 5.5.3.5.1).

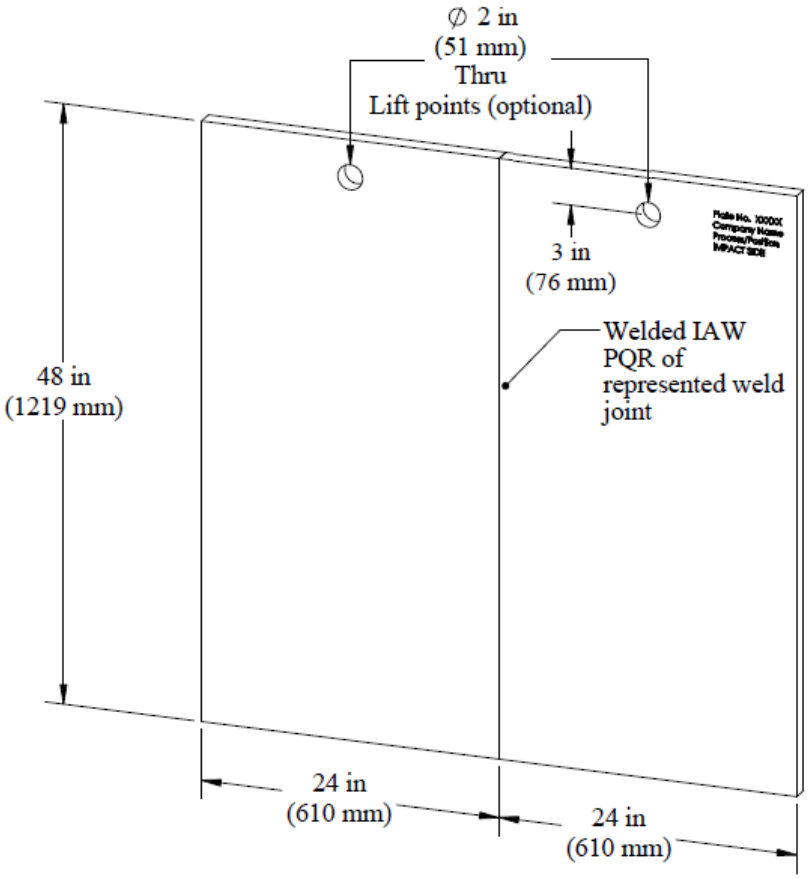
5.3.6.1.5 Mechanical testing. The mechanical test required for Class I procedure qualification shall be the ballistic shock test in accordance with 5.3.6.3, only after successfully completing qualification of a Class II PQR.

5.3.6.1.6 Welding procedure specification (WPS). Prior to any production, a weld procedure specification (WPS) shall be prepared for each weld in accordance with 5.1.6, table III, and the Limits of Qualified Positions for WPSs section of AWS D1.2/D1.2M. The WPS shall be submitted to the procuring engineering activity for approval. The values listed on the WPS shall be determined by the allowable ranges in table III using the actual value recorded for the PQR as the reference point. Any change to an essential variable that falls outside the WPS ranges shall require a new PQR to create a new WPS. Each WPS shall be uniquely identified.

5.3.6.2 Test plate.

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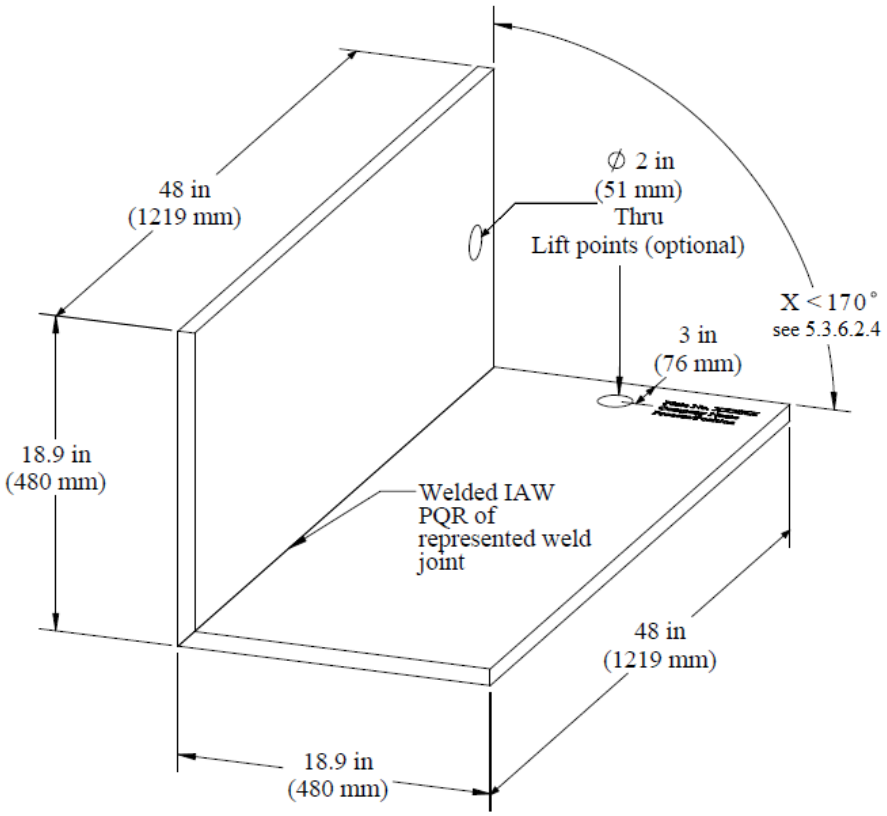
5.3.6.2.1 Dimensions of test plate. The size and shape of all plate samples shall be fabricated in accordance with figure 3 or figure 4. The thickness of the ballistic test plate shall be the same thickness used for production.



Note:
1. Overall plate dimensions are ±0.5 in.
2. Lift point dimensions are -0 +0.25 in.

FIGURE 3. Ballistic test plate (I plate).

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Note:
1. Overall plate dimensions are ±0.5 in.
2. Lift point dimensions are -0 +0.25 in.

FIGURE 4. Ballistic test plate corner joint.

5.3.6.2.2 Different Thicknesses. When welds between plates of different thicknesses are required for production, the test plate shall be welded with the different thicknesses used in production.

5.3.6.2.3 Different alloy types. Any test plate welded using two different alloys shall be welded as welded for production.

5.3.6.2.4 Joint angle. Joint angle for the test plate shall be the as welded joint angle for production. The I-plate shall be used for any joint that is 170° or greater, and 180° or less. Figure 4 shall be used for any joint that is less than 170°. Angle “X” in figure 4 is a representative angle of the angle used in production, and does not require test plates to be a 90° angle.

5.3.6.2.5 Preparation of the ballistic test plate. There shall be a unique ballistic test plate for each PQR developed for Class I welds.

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The ballistic test plate shall be prepared using the same procedure needed for production.

For all welding, the interpass temperature of the plate shall not exceed the maximum allowable interpass temperature in accordance with 5.4.6. The interpass temperature of the base metal shall be measured immediately before deposition of each bead. The measurement shall be taken in accordance with 5.4.6.1.

5.3.6.2.6 Identification marking of test plates. Each ballistic test plate shall be clearly stamped or etched into the metal in the upper right corner for easy identification on the front surface of the plate. Marking shall be in letters 0.25 inches (6 mm) to 0.5 inches (13 mm) in height and shall include the number of the plate, the manufacturer's name, the contractor's name (if different from manufacturer's name), and process and position. Plate numbers shall be any alpha-numeric system designated by the contractor, with the exception that the letter "T" shall not be used on original test plates (see 5.3.6.2.7). All test plates shall be marked with "TOP" at the top of the pate, and "BOTTOM" at the bottom of the plate in the absence of lift points. All lift points, if used, shall be at the top of the test plate. The designation "IMPACT SIDE" shall be added to the front of the flat I-plate (see figure 3). The designation "IMPACT SIDE" shall be added to each plate of the corner joint, on the side that is to be struck by the proofing projectile. All markings shall be fully legible. Chemical etches shall be prohibited. The front of the plate shall be determined as the side of the weld that would face the threat on the armored system.

5.3.6.2.7 Marking of retest plates. Two ballistic test plates shall be submitted for retest. All retest plates shall be marked with all required markings in 5.3.6.2.6 with the number of the original rejected plate, as well as the new test plate number with the suffix "T" indicating retest.

5.3.6.3 Ballistic shock testing.

5.3.6.3.1 Ballistic shock test requirements. The PQR used for each ballistic shock test plate shall be submitted with each ballistic test plate.

5.3.6.3.2 Ballistic testing address. Unless otherwise specified, ballistic test plates shall be directed to either ATTN: Survivability Armor Ballistic Lab (SABL), 6501 E. 11 Mile Road, RDTA-RS/MS 263, Warren, MI 48397-5000, or Commander, U.S. Army Aberdeen Test Center, 400 Colleran Road. Bldg. 358, ATTN: CSTE-DTC-AT-SL-V Armor Acceptance - B690, Aberdeen Proving Ground, MD 21005-5059.

5.3.6.3.3 Visual examination of test plates. Prior to shipping the test plate to the ballistic testing facility, all welds on the test plate shall be examined visually in accordance with 5.5.1.

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5.3.6.3.4 Radiographic inspection of the test plate. Prior to shipping the test plate to the ballistic testing facility, the welded joints in each test plate shall be inspected radiographically in accordance with 5.5.3.5.1. Should the test plate fail to pass the radiographic inspection, the ballistic shock test shall not be performed until the defective weld area has been reworked by the fabricator (see 5.6), and able to pass radiographic inspection.

5.3.6.3.5 Test fixture. The ballistic test sample shall be supported rigidly using wedges as necessary in an appropriate test fixture selected by the test director. A 30-in. distance between supports shall be sustained for flat weldments.

5.3.6.3.6 Temperature conditioning of test plate. Prior to ballistic shock testing, the welded test plate shall be at a temperature of 75°F ±25°F (24°C ± 14°C) for a minimum of eight hours. Testing shall be conducted immediately upon completion of the hold period.

5.3.6.3.7 Test temperature. Ambient temperature during testing shall be 75°F ±25°F (24°C ± 14°C).

5.3.6.3.8 Test obliquity. The line of fire shall be perpendicular (0° ±5° obliquity) to the test plate surface at the impact location.

5.3.6.3.9 Proofing projectile and velocity. The proofing projectile shall be in conformance with MIL-DTL-12235. The size and velocity of the proofing projectile shall be in accordance with table V. Table V lists all currently approved test velocities and proofing projectiles for weldable aluminum armor alloys and thicknesses. This table does not limit the alloys and thicknesses allowed for production. To qualify a Class I weld of an armor alloy not listed in table V, the contractor shall submit no less than three virgin plates of the alloy to be tested. The plates shall measure 48 inches by 48 inches and be equal to the thickness to be used for production. These plates shall be submitted to the ballistic test facility for determination of proofing projectile size and velocity. All costs for testing of the virgin plates to determine the size and velocity of the proofing projectile shall be borne by the contractor. All virgin test plate data obtained for the armor alloy and thickness shall be made available to the Government to be incorporated into later revisions of this standard.

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TABLE V. Proofing projectiles and velocities.

Alloy	Test plate thickness (in.)[1]	Test plate thickness (mm)	Proofing projectile	Impact velocity (ft/s)	Impact velocity (m/s)
2139[2]	0.5	13	57 mm	710 ±33	216 ±10
2139[2]	1.5	38	75 mm	1310 ±33	399 ±10
2519	1.0	25	75 mm	673 ±33	205 ±10
2519	1.25	32	75 mm	1027 ±33	313 ±10
2519	1.5	38	75 mm	1226 ±33	374 ±10
5059	1.0	25	75 mm	800 ±33	244 ±10
5059	1.5	38	75 mm	1230 ±33	375 ±10
5059	2.0	51	105 mm	825 ±33	251 ±10
5083	0.5	13	57 mm	920 ±33	280 ±10
5083	0.625	16	75 mm	595 ±33	181 ±10
5083	0.75	19	75 mm	770 ±33	235 ±10
5083	1.0	25	75 mm	800 ±33	244 ±10
5083	1.125	29	75 mm	900 ±33	274 ±10
5083	1.25	32	75 mm	985 ±33	300 ±10
5083	1.375	35	75 mm	1065 ±33	325 ±10
5083	1.5	38	75 mm	1155 ±33	352 ±10
5083	1.625	41	75 mm	1310 ±33	399 ±10
5083	1.75	45	75 mm	1420 ±33	433 ±10
5083	2.0	51	105 mm	850 ±33	259 ±10
5083	2.25	57	105 mm	1130 ±33	344 ±10
5083	2.5	64	105 mm	1150 ±33	351 ±10
5083	3.0	76	105 mm	1390 ±33	424 ±10
6055	1.5	38	75 mm	1000 ±33	305 ±10
7017	1.0	25	75 mm	900 ±33	274 ±10
7017	1.5	38	75 mm	1130 ±33	344 ±10
7020	1.5	38	75 mm	1200 ±33	366 ±10
7039	0.5	13	57 mm	693 ±33	211 ±10
7039	0.625	16	57 mm	920 ±33	280 ±10
7039	0.875	22	75 mm	550 ±33	168 ±10
7039	1.0	25	75 mm	780 ±33	238 ±10
7039	1.125	29	75 mm	870 ±33	265 ±10
7039	1.25	32	75 mm	965 ±33	294 ±10
7039	1.375	35	75 mm	980 ±33	299 ±10
7039	1.5	38	75 mm	995 ±33	303 ±10
7039	1.625	41	75 mm	1240 ±33	378 ±10
7039	1.75	44	75 mm	1370 ±33	418 ±10
7039	1.875	48	75 mm	1390 ±33	424 ±10
7039	2.0	51	75 mm	1410 ±33	430 ±10

NOTES:
1. Nominal thickness with allowed tolerances in accordance with applicable military detailed specifications.
2. Alloy and thickness apply only to corner joint testing.

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5.3.6.3.10 Impact validity. Impact validity shall be determined by post-test visual inspection.

5.3.6.3.10.1 Valid impact. Fired proofing projectiles shall be considered a valid impact if the location is valid as defined in 5.3.6.3.10.2 through 5.3.6.3.10.4, and the striking velocity of the proofing projectile is in accordance with table V.

5.3.6.3.10.2 Impact location for corner joints (various angles). For corner joints, the impact of the plate is considered the side or sides of the plate that will be exposed to threats as when configured on the system. The distance from the toe of the weld to the center of the projectile impact location shall be no greater than diameter of the proofing projectile plus 1 inch. If the impact side of the weld joint design does not have a weld, then the impact location shall be measured from the toe of the weld opposite of the impact side (see figure 5). The center of the first impact shall be 13 ±1 inches (330 ±25 mm) from the top of the plate. The center of the second impact shall be 13 ±1 inches (330 ±25 mm) from the bottom of the target. Impacts that are not within the tolerances of this section shall not satisfy the test requirements and shall be considered a “no test”. A corner joint shall require one valid impact on each piece of base material that make up the corner joint using the appropriate proofing projectile and velocity for the thickness and alloy of each plate (see table V). If the thicknesses of the base materials differ, the thinnest plate shall be shot first with the correct proofing projectile and velocity for the alloy and thickness of the plate. If either of the two shots fired are a no test, a third shot shall be authorized. No more than three shots shall be allowed on a corner joint. The third shot shall be midway between the first two shots with an allowed ±2 inches tolerance from the center of the impacts. The third shot shall be on the plate that sustained the initial no test shot. If any two shots are considered no tests, a new corner joint test plate will be required for testing.

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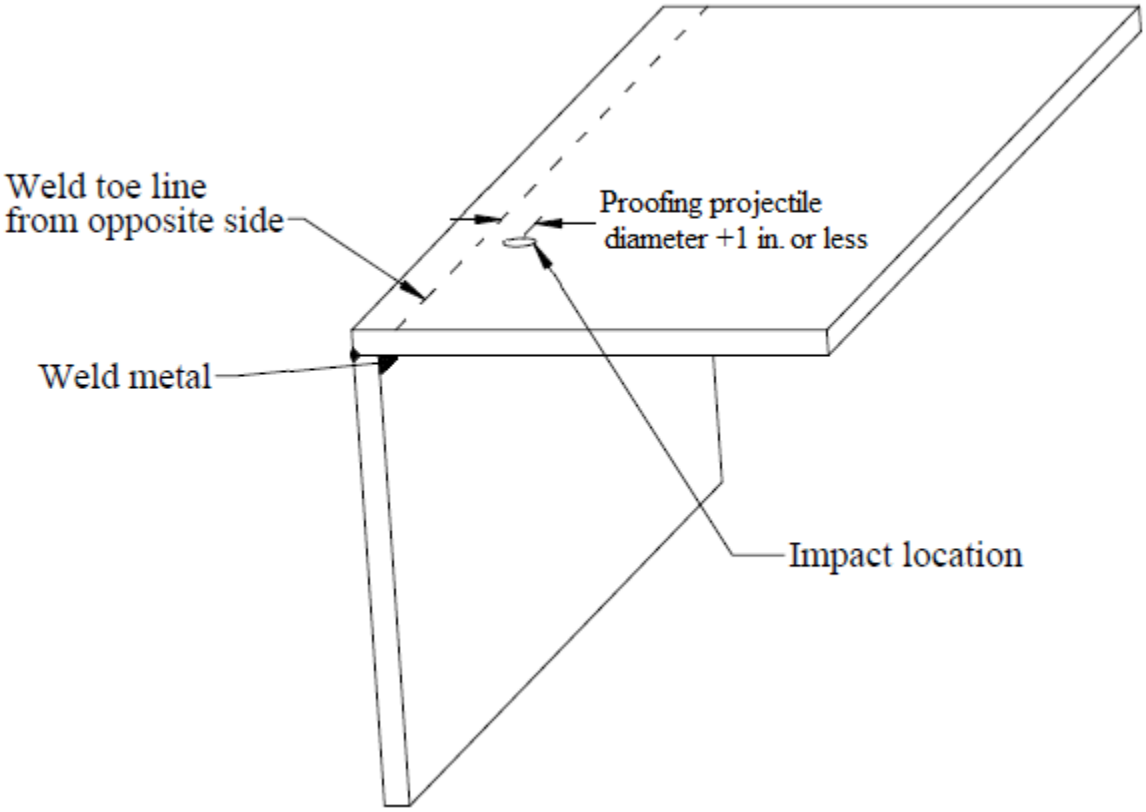


FIGURE 5. Strike location example.

5.3.6.3.10.3 Impact location for flat (I-plate) joints. For the I-plate the center of the impact location shall be no further than 1 inch (25 mm) from the centerline of the weld and shall be 13 ±1 inches (330 ±25 mm) from the top of the plate on the impact side of the plate. All 6xxx series aluminum alloys shall require two valid shots for I-plates. Only one valid shot shall be required for all other weldable aluminum armor alloys the flat joint. If the first shot is a no test, a second shot shall be allowed. No more than two shots shall be allowed on the flat (I-plate) joint. The center of the second shot shall be no further than 1 inch (25 mm) from the centerline of the weld and shall be 13 ±1 inches (330 ±25 mm) from the bottom of the test sample on the impact side of the plate. If the thickness or alloys of the two plates welded together differ, the proofing projectile and velocity shall be that of the thinner material, or of the smaller projectile and lesser velocity in accordance with table V.

5.3.6.3.10.4 Additional impacts. When an impact is declared a no test in accordance with 5.3.6.3.11, but the condition of the plate will permit additional impacts in accordance with 5.3.6.3.10.2 or 5.3.6.3.10.3, the plate shall be evaluated on the results of the first additional impact meeting the requirements for velocity (see table V) and location (see 5.3.6.3.10.2 or 5.3.6.3.10.3) in accordance with the following criteria:

a. When cracking exceeds 12 inches (305 mm), the qualification decision shall be a “no test” and a second test plate shall be submitted.

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b. When cracking does not exceed 12 inches (305 mm), the test decision shall be “Test Pass”.

5.3.6.3.11 No test. When test conditions are such that the level of welding procedure performance cannot be determined, a "no test" decision shall be rendered. A “no test” decision shall be rendered when any of the following conditions occur:

a. The point of impact of the proofing projectile is not in accordance with 5.3.6.3.10.2 or 5.3.6.3.10.3, and weld cracking does not exceed 12 inches (305 mm).

b. The striking velocity of the proofing projectile is above the maximum allowed and weld cracking exceeds 12 inches (305 mm).

c. The striking velocity of the proofing projectile is below the minimum allowed and weld cracking does not exceed 12 inches (305 mm).

d. The location of the center of the point of impact of the proofing projectile is less than 12 in. (305 mm) from the top or bottom edge of the plate, or greater than 2 inches from the center point of a third shot on a corner joint, and weld cracking exceeds 12 inches (305 mm).

e. Weld cracking that exceeds 12 inches (305 mm) in length occurs from a second impact on an I-plate or a third impact on a corner joint.

f. Cracks in the plate occur which are greater than 12 inches (305 mm) and do not pass through the point of impact.

g. Cracking of the plate occurs outside a circle of 6 inches (152 mm) radius, the center of which is the center of impact, and weld cracking exceeding 12 inches (305 mm) has not occurred. In this event the contractor shall conduct a failure analysis to determine the reason for the cracking. The failure analysis shall be submitted to the procuring engineering activity for review before a “no test” is determined.

5.3.6.4 Test results.

5.3.6.4.1 Evaluation of test. The plates shall meet the requirements of ≤12 inches (305 mm) of total crack length, and subject to the following requirements:

a. Cracks in the armor plate parallel to the weld and within 0.125 inches (3 mm) of the toe of the weld shall be considered as part of the total weld cracking area.

b. The ballistic test plate shall have 12 inches (305 mm) or less of total crack length after being subjected to the corresponding striking velocities listed in table V.

c. Examples of typical crack situations are depicted in figure 6.

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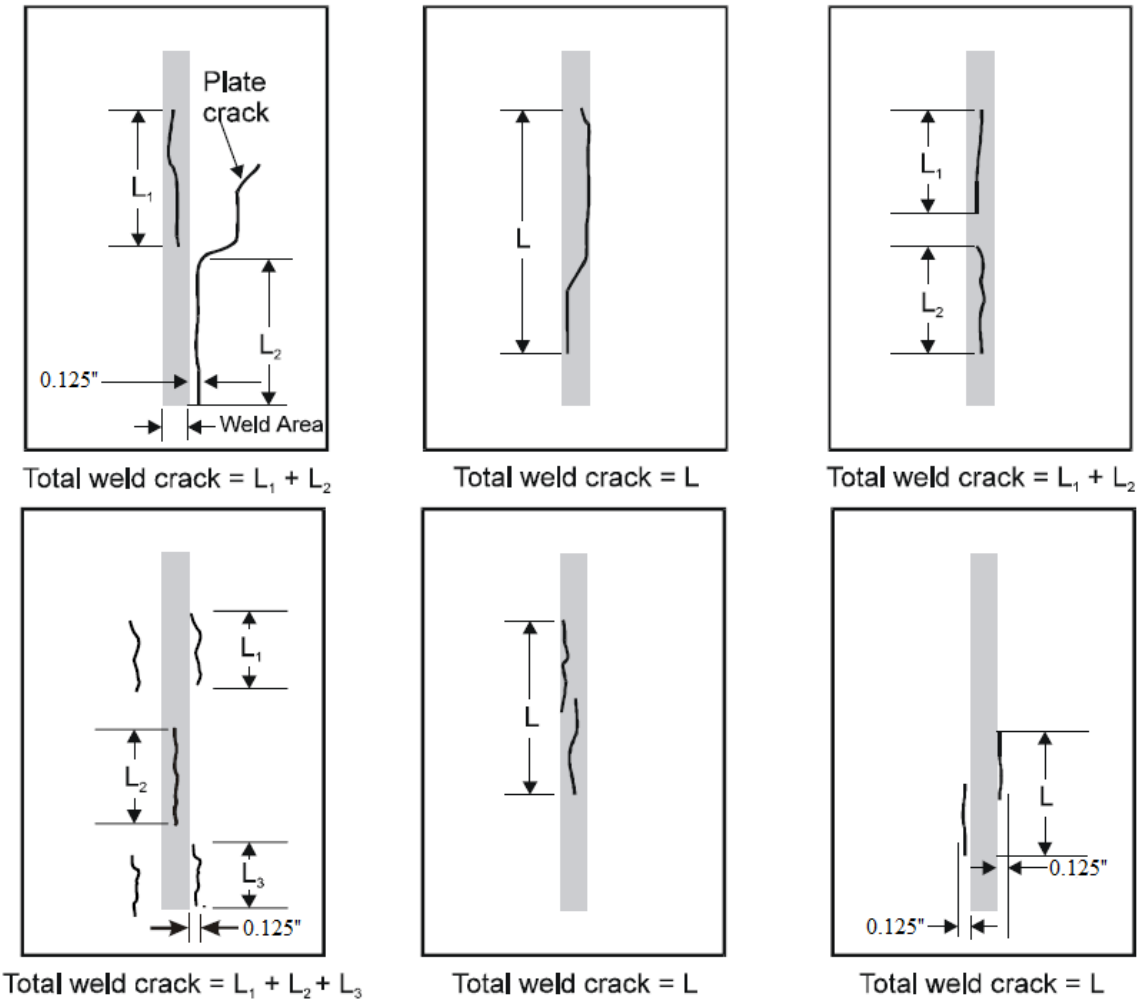


FIGURE 6. Examples of cracks in ballistic shock test plates.

5.3.6.4.2 Test decision. After a valid impact (see 5.3.6.3.10.1) has been evaluated in accordance with 5.3.6.4, the following criteria shall be used to determine a final test decision.

a. Test pass. When cracking does not exceed 12 inches (305 mm) on a valid impact and valid velocity, the test decision shall be “Test pass”. If the striking velocity of the proofing projectile exceeds maximum value in accordance with table V and cracking is within acceptable limits, the test decision shall be “Test pass”.

b. Test fail. When cracking exceeds 12 inches (305 mm) with a valid impact and valid velocity, the test decision shall be “Test fail”.

5.3.6.4.3 Dye penetrant test. In borderline cases, where crack length as measured by visual observation, is close to the maximum allowable, the area in the vicinity of the crack ends shall be inspected with dye penetrant in accordance with 5.5.3.5.2, to assure an accurate determination of the crack length.

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5.3.6.4.4 Photographic record. Photographs shall be taken of the entire front and back of the plate as it sits in the test fixture prior to and after any impacts. Additional close-up photographs of the front and back of the impact area showing any cracks present shall also be taken after each impact. Front, back and length of cracking shall be clearly identified for each photographic record. Each photograph shall include an embedded reference scale.

5.3.6.4.5 Repair of test plate. Weld repair on a test plate shall not exceed a total length of 8 in. (200 mm) and any defective weld zone shall not be repaired more than once. Repairs shall be to correct discontinuities identified during visual or NDT. No repairs shall be allowed after ballistic testing. An amendment to the PQR shall be submitted with the repaired test plate, and shall include, at a minimum, the following information:

a. The reason for repair.

b. The extent of the repair.

c. The location of the repair.

5.3.6.4.6 Rejection of ballistic test plate. Failure of any ballistic test plate, to pass either the ballistic test or the second radiographic inspection after allowable repairs, shall be cause for rejection of the recorded welding procedure.

5.3.6.4.7 Retest. Retests of a rejected test plate may be made upon the request of the contractor. Two additional test plates shall be fabricated using the same WPS as the previously rejected test plate, marked in accordance with 5.3.6.2.7 and submitted to the testing facility for retest. Failure of either of these plates shall be cause for rejection of the WPS represented. Only one retest for a welding procedure shall be allowed.

5.3.7 Documentation. Documentation of the test results for procedure qualification shall be kept by the contractor for the period of performance of the contract, at a minimum. All welding procedures, both PQRs and WPSs, shall be identified in a manner to allow permanent traceability from the WPS to its supporting PQR. PQRs and WPSs shall be signed by the contractor’s engineer or the engineer’s duly designated representative stating that the PQR and WPS conforms to the provisions of this standard.

5.4 Production.

5.4.1 Welding environment. A shelter or structure may be used to segregate the area where the welding process takes place from environmental conditions to meet these requirements.

5.4.1.1 Wind. The maximum wind velocity in the near vicinity of the welding process shall be no greater than five miles per hour (eight kilometers per hour).

5.4.1.2 Ambient air temperature. Welding shall not be performed when the ambient temperature is below 50°F (10°C).

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NOTE: the ambient temperature is referring to the air temperature in the vicinity of the welding process.

5.4.1.3 Precipitation. Welding shall be prohibited when surfaces are exposed to any form of precipitation or if the surfaces are wet.

5.4.2 Weld Procedure Specification (WPS). During production, all welders and welding operators shall have access to the correct WPS and understand how to apply the WPS to production. Any change to an essential variable that falls outside the WPS ranges shall require a new PQR to create a new WPS.

5.4.3 Quality control. It shall be the full responsibility of the contractor to maintain the quality control procedures and inspection standards necessary to assure that the part, the assembly, the sub-assembly or the end product meets the requirements of the drawings and the contract.

5.4.4 Position. Welding positions shall be in accordance with 4.6 and applicable WPS.

5.4.5 Base material temperature. Base material shall be kept at a minimum of 50°F (10°C) for a minimum of 24 hours prior to welding. Welding shall not be performed when the temperature of the base material is below 50°F (10°C).

5.4.6 Preheat, interpass & postweld heat treatment. Preheat, interpass, and post weld heat treatment temperatures shall not exceed 275°F (135°C).

5.4.6.1 Preheating and interpass temperature measurement. Preheat and interpass temperature shall be monitored by temperature indicating crayons, infrared thermometer gun, or a pyrometer. The temperature measurements shall be made parallel to the weld joint at a distance of 1 - 2 inches (25 - 51 mm) from the edge of the weld on both sides of the weld (see figure 7). Crayon material shall not be placed directly in the weld joint. Temperature measurements shall be taken immediately prior to each weld pass to ensure conformance with 5.4.6. Any heating of the base material shall be uniform, and spot heating shall be prohibited. If oxy-fuel is used for heating, only a multi-flame tip with at least four orifices shall be used.

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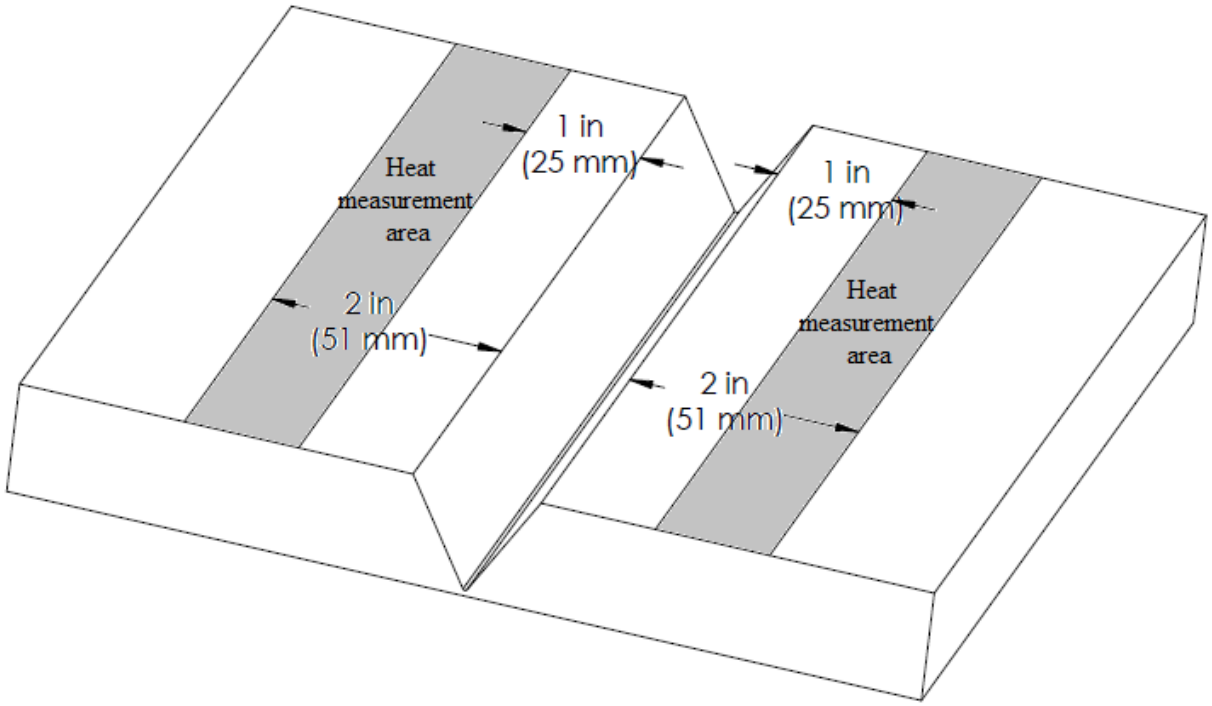


FIGURE 7. Temperature measurement technique.

5.4.7 Tack welding. If tack welding is used as an aid in production, tack welds shall be performed by a qualified welder or welding operator. All tack welds shall be in conformance with the appropriate WPS. Any tack welds that are not removed shall meet all acceptance criteria for applicable welds.

5.4.8 Minimum fillet weld size. Minimum fillet weld size shall be determined by the design engineer and shall meet all qualification requirements of this standard. Fillet welds shall not exceed one and a half times the size specified on the drawing.

5.4.9 Intermittent fillet welds. Intermittent fillet welds shall be allowed for Class II welds only. Minimum fillet weld length shall be no less than 1.5 inches (38 mm).

5.4.10 Weld profiles. All weld profiles shall be in accordance with the Weld Profiles section of AWS D1.2/D1.2M.

5.4.11 Arc strikes. Arc strike inspection and limitations shall be in accordance with MIL-STD-2035(SH). For removal and repair of arc strikes see 5.6.

5.4.12 Weld cleaning. The base material shall be free of all contaminants before welding begins.

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5.4.12.1 In-process cleaning. Any welds requiring multiple passes shall be mechanically cleaned of all surface scale, weld spatter, and weld slag before the next pass is welded. Chemical products shall not be used for in process cleaning. Cleaning methods that may exceed the maximum temperature in 5.4.6 shall require approval by the procuring engineering activity prior to usage.

5.4.12.2 Completed welds. All weld slag, flux, weld spatter, and residues shall be removed. Weld spatter that cannot be removed by standard cleaning methods may remain unless there are functional or cosmetic concerns or the spatter would interfere with NDT. The method or combination of methods used shall be selected to suit the properties of the metal, the type of contaminates and the degree of contamination present.

5.5 Weld inspection.

5.5.1 Visual inspection. All completed welds shall be visually inspected in accordance with MIL-STD-2035(SH) by a qualified weld inspector (see 5.2.2).

5.5.1.1 Welder and welding operator. Prior to welding, welders and welding operators shall ensure base metal is free of foreign materials and discontinuities that would prohibit welding. All weld joints shall be visually checked by the welder or welding operator prior to, during, and after welding. Any deficiency noted by the welder or welding operator shall be reported to a qualified weld inspector (see 5.2.2) for visual inspection. All visual defects shall be reworked or repaired, in accordance with 5.6. The welder or welding operator does not need to be a qualified weld inspector. Any welder or welding operator that is a qualified weld inspector shall not officially inspect their own weldments as a qualified weld inspector.

5.5.1.2 Qualified weld inspector. A qualified weld inspector shall visually inspect all welds and determine if the weld is visually acceptable or needs rework/repair (see 5.6). When the results of the visual inspection are inconclusive, the weld shall be inspected by other forms of NDT for discontinuities. Visual inspection shall only be performed when weld metal reaches approximate ambient temperature.

5.5.1.3 Visual inspection surface illuminance. The surface illuminance shall be 32.5 foot-candles (fc) (350 lux (lx)) at a minimum.

5.5.1.4 Visual inspection access. For direct inspection, access to the weld shall be such that the weld inspector’s eye shall be within 24 inches of the examined weld surface. The angle of inspection shall not be less than 30° from the surface of inspection (see figure 8). The usage of cameras, fiber optic cables, mirrors, and borescopes shall be acceptable for visual inspection when access in accordance with figure 8 is not possible or when required by the applicable standard or drawing.

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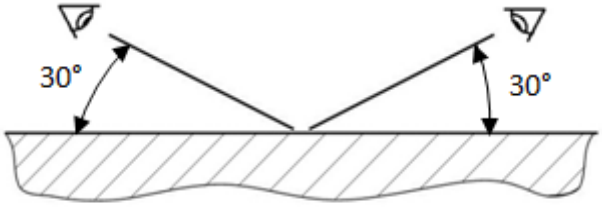


FIGURE 8. Visual inspection access.

5.5.2 Mechanical testing. Contractors conducting mechanical testing in-house shall develop an internal quality document for mechanical testing procedures. This document shall include all equipment used for testing and calibration information for the equipment. This quality document shall be submitted to the procuring engineering activity if requested. Any contractor that sub-contracts mechanical testing shall ensure the test facility is ISO/IEC 17025 certified.

5.5.2.1 Ballistic shock test. See 5.3.6.3.

5.5.2.2 Tension/reduced-section tension testing. Tension test specimens shall be tested in accordance with AWS D1.2/D1.2M.

5.5.2.3 Macroetch testing. All macroetch testing shall be in accordance with AWS D1.2/D1.2M.

5.5.2.4 Fillet weld break test. The fillet weld break test shall be in accordance with AWS D1.2/D1.2M.

5.5.2.5 Mechanical test failures (other than ballistic shock test). Retests for mechanical test failures, other than ballistic shock tests, shall be in accordance with AWS D1.2/D1.2M.

5.5.2.6 Mechanical testing results. All mechanical test results shall be included in the PQR.

5.5.3 Nondestructive Testing (NDT). This section covers the requirements for conducting NDT used in determining the presence of surface and internal discontinuities in welds. Personnel responsible for performing NDT, other than visual inspection, shall be qualified in accordance with 5.2.4. NDT results shall be reviewed and interpreted by a certified NDT Level II or III inspector.

All non-permanent backing material shall be removed prior to NDT (see 5.1.2).

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5.5.3.1 NDT written instructions. When NDT is performed, written instructions for performing the test shall be prepared and uniquely identified. The written instructions shall have written certification from an NDT Level III inspector (see 5.2.4). The procuring engineering activity may conduct reviews of the NDT written instructions to assess conformance to this standard. All NDT procedures shall be performed in accordance with the NDT written instructions.

5.5.3.2 Frequency of NDT inspection. The verification level of NDT during production shall be specified in the contract in accordance with MIL-STD-1916.

5.5.3.3 NDT inspection reports. When NDT is performed, an NDT inspection report shall be prepared. The NDT inspection report shall be made available to the procuring engineering activity if requested. The NDT inspection reports shall include, at a minimum, the requirements listed in each inspection method, and the following:

a. Method of inspection.

b. NDT written instruction identification (see 5.5.3.1).

c. WPS identification (see 5.3.6.1.6).

d. Date of inspection.

e. Certified written instruction identification.

f. Acceptance standard used.

g. Type of material and material thickness.

h. Type of weld joint.

i. State whether original or repair.

j. A detailed description and location of area inspected shall be included. Photographs shall be included for any rejectable defects noted during inspection.

k. Test results (accept or reject).

l. Signatures of test operators and NDT level II or III interpreter.

5.5.3.3.1 Retention of NDT inspection reports. NDT inspection reports shall be retained for the period of performance of the contract, at a minimum.

5.5.3.4 NDT symbols. When NDT symbols are used on drawings, the symbols shall be in accordance with AWS A2.4.

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5.5.3.5 Non-destructive testing (NDT) methods.

5.5.3.5.1 Radiography (RT) or digital radiographic (DR). When required, radiography (RT or DR) inspection shall be used for determining the presence of discontinuities. RT shall be performed in accordance with ASTM E1032 for all class welds. DR shall be performed in accordance with ASTM E2699. The acceptance criteria for complete penetration welds shall be in accordance with radiographic inspection section of MIL-STD-2035(SH). The acceptance criteria for partial-penetration welds shall be in accordance with MIL-STD-1895(AT).

5.5.3.5.1.1 Radiography reports. RT and DR inspection reports shall contain, at a minimum, the following applicable information:

a. Number of films or digital images and film type (RT only).

b. Location of each film or image on the radiographed item.

c. Orientation of location markers.

d. Location of radiation source, including source-to-film distance and beam angle.

e. Kilovolt and focal spot size of x-ray machine.

f. When an isotope is used the physical dimensions and intensity (in curies) shall be reported.

g. Shim or block material, and thickness.

h. Material groups, penetrometer sizes and types, and the required quality level.

i. Source-side or film-side penetrometer.

j. Single-wall or double-wall viewing.

k. Type and thickness of intensifying screens and filters.

l. Notation of acceptable and rejectable discontinuities.

NOTE: Any questionable discontinuity in the area of interest which is due to a surface condition shall be visually verified and noted.

5.5.3.5.2 Liquid penetrant (PT). When required, liquid penetrant (PT) shall be used for detecting the presence of surface discontinuities. PT shall be performed in accordance with ASTM E1417/E1417M for all class welds. The acceptance criteria for the welds shall be in accordance with liquid penetrant inspection section of MIL-STD-2035(SH).

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5.5.3.5.2.1 Liquid penetrant materials. The penetrant inspection materials are classified in accordance with table VI.

TABLE VI. Liquid penetrant material classifications.

Penetrant types	Type I	Florescent dye
	Type II	Visible dye
	Type III	Dual mode dye
Removal methods	Method A	Water washable
	Method B	Post emusifiable, lipophilic
	Method C	Solvent removable
	Method D	Post emusifiable, hydrophilic
Sensitivity level	Level ½	Ultralow
	Level 1	Low
	Level 2	Medium
	Level 3	High
	Level 4	Ultrahigh
Development forms	Form a	Dry powder
	Form b	Water soluble
	Form c	Water suspended
	Form d	Nonaqueous
	Form e	Specific application
Solvent removers	Class I	Halogenated
	Class II	Non-halogenated
	Class III	Special application

5.5.3.5.2.2 Liquid penetrant reports. PT inspection reports shall contain, at a minimum, the penetrant material classification in accordance with table VI.

5.5.3.5.3 Ultrasonic (UT). When required, ultrasonic (UT) shall be used for the detection of discontinuities throughout the volume of material, measurement of wall thickness, and evaluation of bond characteristics in most types of material and in basic geometric configurations. UT shall be performed in accordance with ASTM E164 for all class welds. The acceptance criteria for the welds shall be in accordance with ultrasonic inspection section of MIL-STD-2035(SH).

5.5.3.5.3.1 Ultrasonic inspection reports. UT inspection reports shall contain, at a minimum, the following information:

a. Type and thickness of material.

b. Equipment used for inspection, to include instrument manufacturer, model number, serial number, transducer size and type, and reference block identification.

c. Search beam angle.

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d. Couplant used.

e. Reference calibration standard number.

f. Discontinuities that exceed the disregard level (DRL).

g. If supplemental UT techniques are used that contribute to the final inspection results, they shall be recorded.

5.5.3.5.4 Eddy current (ET). Eddy current (ET) shall only be used when required by the drawing, military specification or with approval from the procuring engineering activity. ET shall be used for the detection of surface cracks. Eddy current shall be performed in accordance with ASTM E2261/E2261M for all class welds. The acceptance criteria for the welds shall be in accordance with eddy current inspection section of MIL-STD-2035(SH).

5.5.3.5.4.1 Eddy current reports. Reports of ET shall contain, at a minimum the following information:

a. Instrument manufacturer and model number.

b. Probe description

c. Material type.

5.5.3.5.5 Other NDT methods. If NDT methods not covered in in this standard, which meets all the requirements of this document are to be used, the alternative program shall be submitted to the procuring engineering activity for approval prior to being used.

5.5.3.6 Rejectable welds. When the inspection process indicates a rejectable defect in a particular joint, the remainder of the joint shall be tested. All defects found in the joint shall be reworked in accordance with 5.6. The entire reworked area shall be retested.

5.6 Repair and rework of welds. All repair and rework procedures shall have a qualified WPS. Contractors that wish to use proprietary repair and/or rework procedures shall submit these procedures for approval by the procuring engineering activity. Approved repair or rework procedures shall conform to this standard, but may supersede 5.6. Only one repair or rework shall be allowed for Class I, heat treatable, aluminum alloy welds.

5.6.1 Limitations. Limitations for the extent allowed for reworking shall be at the discretion of the design engineer. This standard is not intended for specific repairs of individual systems. Individual systems should develop repair procedures, referencing this standard for welding repairs. Repairs 0.625 inches (16 mm) or greater from the weld toe line shall be in accordance with system technical bulletins, technical manuals, or the applicable program office.

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5.6.2 Base material preparation. Before the repairing or reworking of any component can be accomplished, the base material shall be prepared by removing all paint, oils, or other contaminants that would prohibit welding for a minimum distance of 2.5 inches (64 mm) around the rework/repair area on the front and back of the base material. If the base material is deformed, the material shall be manipulated to allow for a workable surface for rework or repairs to be made.

5.6.3 Rework procedures. All materials fabricated out of tolerances shall be reworked until all tolerances and/or requirements are met. Welds that are out of tolerance or do not meet requirements shall be removed and re-welded (see 5.6.5). After reworking procedures are completed, the fabricated material shall meet all production requirements called out in applicable contracts, standards, or drawings. Reworking of Class I welds shall be completed by qualified welders or welding operators. Reworking of Class I welds shall be documented by the contractor and documentation shall be maintained for the period of performance of the contract at a minimum.

5.6.4 Repair procedures. Repairs to a system are performed after production has been completed and accepted by procuring activity. Repairs will be in accordance with technical bulletins, technical manuals, or the applicable program office. Annotation and tracking of repairs shall be in accordance with maintenance procedures for the specific item.

5.6.5 Weld metal removal. When a defect in the weld metal, other than a crack, is discovered during inspection or testing, the defect shall be removed. Oxy-fuel cutting shall not be used as a removal process. Temperature during grinding shall not exceed the maximum interpass temperature in accordance with 5.4.6. Weld metal containing the defect shall be completely removed to the base material with an included angle in accordance with applicable WPS, and the end of the weld metal removal shall be tapered to approximately a 45° angle (see figure 9). The weld metal shall be removed in a manner that leaves a 0.12 inch (3 mm) minimum sized root. The depth of the removed weld metal is dependent on the depth of the defect. Once weld metal has been removed, the appropriate NDT and visual inspection method shall be performed on the base metal to ensure the original defect has been removed, and no discontinuities have been created during weld metal removal. Excavated area shall be welded in accordance with 5.4. Excessive reinforcement or convexity may be removed by grinding to conform to profile requirements (see 5.4.10) without re-welding.

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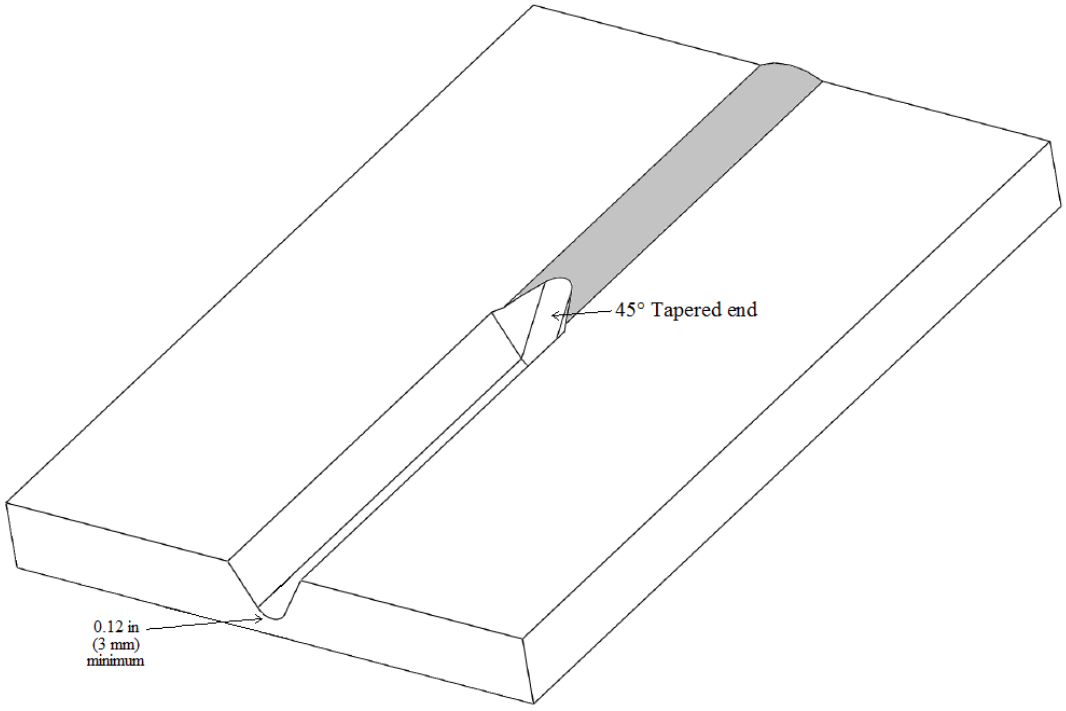


FIGURE 9. Excavated weld metal.

5.6.5.1 Weld metal removal from multiple sides. If welding from both sides of material is required, the weld metal shall be removed from the first side in accordance with 5.6.5. The excavation shall be approximately half the thickness of the base material. Once the weld metal has been removed and NDT is finished, the first side shall be welded in accordance with 5.4. Removal of weld metal from the second side shall be identical to the first side with a depth that reaches the new weld metal. NDT shall be performed on the second side, and shall be welded in accordance with 5.4.

5.6.5.2 Weld metal removal from one side. Materials that are accessible from only one side and were originally welded from both sides shall be repaired in accordance with applicable technical bulletins, technical manuals, or program office. Materials that are accessible from only one side and were originally welded from only one side shall be in accordance with 5.6.5.

5.6.6 Crack repair or rework. Appropriate NDT method shall be used to identify the beginning and ending locations of the crack. See 5.6.1 for cracks that extend greater than 0.625 inches (16 mm) beyond the weld toe line.

5.6.6.1 Crack arresting. A hole, approximately 0.12 to 0.18 inches (3 to 5 mm) in diameter, shall be drilled at each end of the crack.

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5.6.6.2 Crack removal. Grinding or other mechanical methods shall be used to remove the crack. Temperature during crack removal shall not exceed the maximum interpass temperature in accordance with 5.4.6. Cracks starting within the 0.625 inches (16 mm) area beyond the weld toe line shall be excavated from the end of the crack towards the weld metal. There are three types of cracks: partial penetration, full penetration accessible from one side, and full penetration accessible from both sides.

5.6.6.2.1 Partial penetration crack removal. Crack arresting shall be used for partial penetrating cracks.

a. Excavate the crack to the same angle and root opening tolerances as allowed in the WPS, with a 45° tapered end (see figure 9).

b. There shall be a 0.12 in. (3 mm) minimum root at the base of the excavated area.

c. Use the appropriate NDT method to ensure the crack is completely removed.

d. Weld the excavated area in accordance with 5.4. Use of run-off/run-on pads and removable backing material is authorized.

e. The repaired crack shall be inspected with appropriate NDT method.

5.6.6.2.2 Full penetration crack removal accessible from both sides. Use crack arresting to prevent lengthening of the crack.

a. From the first side of the plate, follow 5.6.6.2.1 a - b.

b. The depth of the excavation shall be approximately 0.5 T. Do not use PT NDT method at this time. Weld the excavated area in accordance with 5.4.

c. From the opposite side of the plate follow 5.6.6.2.1 a - e. The excavated area shall be checked with appropriate NDT method to ensure the entire crack has been removed.

d. The depth of excavation on the second side shall be at least to the weld metal from the opposite side. Weld the excavated area in accordance with 5.4.

5.6.6.2.3 Full penetration crack removal accessible from one side. For materials of any thickness that are only accessible from one side, repairs shall be in accordance with applicable technical bulletins, technical manuals, or program office.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

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6.1 Intended use. Armor welding covered in this document is intended for military use. Non-government use of this document is authorized.

6.2 Acquisitions requirements. Acquisition documents should specify the following:

a. Title, number and date of this standard

b. Welding processes not listed (see 1.2.1)

c. Base material not listed in a qualified specification (see 5.1.1)

d. Permanent backing material on a Class I weld (see 5.1.2.1)

e. Welder or welding operator not qualified under this document (see 5.2.1.2)

f. Weld inspection certification program not listed (see 5.2.2)

g. Alternative NDT specification not listed (see 5.2.4.3)

h. Submittal of PQRs (see 5.3.1, 5.3.5, and 5.3.6.1)

i. Welding procedures not qualified under this document (see 5.3.2)

j. Changes to qualified PQRs (see 5.3.4)

k. Submittal of WPSs (see 5.3.6.1.6)

l. Alloys and thicknesses not listed in table V (see 5.3.6.3.9)

m. Cleaning processes exceeding specified temperatures (see 5.4.12.1)

n. Verification level determination (see 5.5.3.2)

o. Using eddy current (ET) (see 5.5.3.5.4)

p. Using alternate NDT methods (see 5.5.3.5.5)

q. Proprietary repair/rework procedures used (see 5.6)

6.3 Standard units of measure. This standard makes use of both U.S. Customary Units and the International System of Units (SI). Throughout the standard, the user will find dimensions in U.S. customary units followed by SI in parentheses ( ), or in appropriate columns in tables and figures. SI units are an estimated value based on U.S. Customary Units.

6.4 Heat input. For heat input conversions and calculations refer to ASME Boiler and Pressure Vessel Code section IX.

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6.5 Subject term (key word) listing.

Electrodes
Filler metal
Nondestructive testing
Plasma
Radiography
Ultrasonic
Weld
Welder
Welding operator
High energy buried

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REFERENCE MATERIALS

A.1 SCOPE

A.1.1 Scope. The documents contained herein are examples of various welding records and forms.

A.1.2 Application. The forms in this appendix may be used in whole or partially as needed.

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WELDER/ WELDING OPERATOR QUALIFICATION RECORD (WQR)

Name _____ Identification # _____

Welder Type _____ Date _____

Welding Procedure Specification (WPS) ID# _____

Variables	Actual Recorded Values Used During Qualification	Range Qualified
Process Type		
Automatic/Machine		
Electrode		
Number of Electrodes		
Current/Polarity		
Position		
Weld Progression (Vertical)		
Backing		
Base Material 1 Grade/Class		
Base Material 2 Grade/Class		
Base Material 1 Thickness		
Base Material 2 Thickness		
Base Material 1 Type		
Base Material 2 Type		
Base Material Weld Configuration		
Filler Material Specification # (MIL-E-XXXXX,MIL-DTL-XXXXX)		
Filler Material Class		
Gas/Flux Composition		
Arc Voltage Control		
Joint Tracking Software		

FIGURE A-1. Welder/welding operator qualification record (WQR) example.

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Welding Procedure Specification (WPS) ID# _____

WQR Test Results

VISUAL INSPECTION

Appearance _____ Pass/Fail _____

Undercut _____

Piping porosity _____ Test date _____

Convexity _____

GUIDED BEND TEST

Specimen No.	Type of bend	Result	Remarks

RADIOGRAPHIC-ULTRASONIC EXAMINATION

UT report no.: _____ Result _____ RT report no.: _____ Result _____

Result _____ Result _____

FILLET WELD TEST RESULTS

Macro-etch Results	Break Test Results	Fillet Size (two locations)
1.) _____	1.) _____	1.) _____
2.) _____		2.) _____

MACRO/RADIOGRAPH IMAGES

Macro Image 1	Macro Image 2	Radiograph 1	Radiograph 2

Test conductor and interpreter

Welders Name _____ Clock No. _____ Stamp No. _____

Test Conducted By _____

Welder Signature _____

Title _____

Date _____

CWI Stamp Location

Test Conductor Signature _____

Title _____

Date _____

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FIGURE A-1. Welder/welding operator qualification record (WQR) example – Continued.

PROCEDURE QUALIFICATION RECORD (PQR)-SHEET 1

MODIFIED ☐ QUALIFIED BY TESTING ☐

Identification # _____
Company Name _____
Welding Process(es) _____

Rev. ___ Date _____ By _____
Performed By _____ Date _____
Authorized By _____ Date _____
Equipment Type
Manual ☐ Semi-Automatic ☐
Mechanized ☐ Automatic ☐

JOINT DESIGN USED
Joint Type: Weld Type:
Single ☐ Double Weld ☐
Backing: Yes ☐ No ☐
Backing Material: _____
Root Opening _____
Root Face Dimension _____
Groove Angle _____ Radius(J-U) _____
Backgouging Method (If Yes) Yes ☐ No ☐

POSITION
Position of Groove: Fillet:
Vertical Progression: UP ☐ DOWN ☐
Other _____

ELECTRICAL CHARACTERISTICS
Transfer Mode (GMAW only)
Short- Circuiting ☐ Globular ☐
Spray ☐ Pulsed ☐
Current: AC ☐ DCEP ☐
DCEN ☐
Other _____
Tungsten Electrode (GTAW)
Size _____
Type _____

BASE METALS

	Base1	Base 2
Material Spec.		
Type/Grade/Class		
Thickness:		

Diameter (Pipe) _____

FILLER METALS
Applicable Specification _____
Applicable Classification _____
Applicable F-Number _____

TECHNIQUE
Stringer or Weave Bead _____
Multi-pass or Single Pass (per side) _____
Number of Electrodes _____
Electrode Spacing Longitudinal _____
Lateral _____
Angle _____

SHIELDING
1.Gas _____ Composition _____
Flow Rate _____
2.Gas _____ Composition _____
Flow Rate _____
Flux Name _____
Electrode-Flux (Class): _____
Contact Tube to Work Distance _____
Peening _____
Interpass Cleaning: _____

PREHEAT
Preheat Temp., Min. _____ Max. _____
Interpass Temp., Min. _____ Max. _____

POSTWELD HEAT TREATMENT
Temp. _____
Time _____

WELDING PROCEDURE

Pass or Weld Layer	Process	Filler Metals: Class	Filler Metals: Dia. (in.)	Current: Type & Polarity	Current: Amps or Wire Feed Speed	Volts	Travel Speed

Other Comments or Remarks

Joint Detail

Joint Detail w/ Weld Pass Locations

FIGURE A-2. Procedure qualification record (PQR) example.

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PROCEDURE QUALIFICATION RECORD (PQR)-SHEET 2

Test Results

Tensile Test

Specimen	Width (in.)	Thickness (in.)	Area (in.)	Unlimited tensile Load lb.	Ultimate Unit stress, psi	Character of failure and location
#1						
#2						
#3						
#4						

GUIDED BEND TEST

Specimen No.	Type of bend	Result	Remarks

VISUAL

Appearance _____
Undercut _____
Piping porosity _____
Convexity _____
Test date _____

RADIOGRAPHIC-ULTRASONIC EXAMINATION

RT report no.: _____ Result _____
UT report no.: _____ Result _____

Test conductor and interpreter

_____ Print
_____ Signature
_____ Title
_____ Date

Stamp Location

ALL-WELD-METAL TENSION TEST

Tensile Strength _____
Yield Strength _____
Elongation in 2 in. % _____
Laboratory tests no. _____

FILLET/GROOVE WELD TEST RESULTS

Minimum size multiple pass = N/A

Macro-etch
1.) _____ 3.) _____
2.) _____

Bend Break
1.) _____
2.) _____

Welders name _____ Clock No. _____ Stamp No. _____

Test Conducted By _____

Test number Per _____

IMPACT TEST

Size of Specimen _____
Test Temp _____
Ft-lb ☐ Joules ☐

1.) ☐ 4.) ☐
2.) ☐ 5.) ☐
3.) ☐ 6.) ☐

Average ☐
High ☐
Low ☐

Signed by _____
Title _____
Date _____

CWI Stamp Location

Signed By _____
Title _____
Date _____

FIGURE A-2. Procedure qualification record (PQR) example – Continued.

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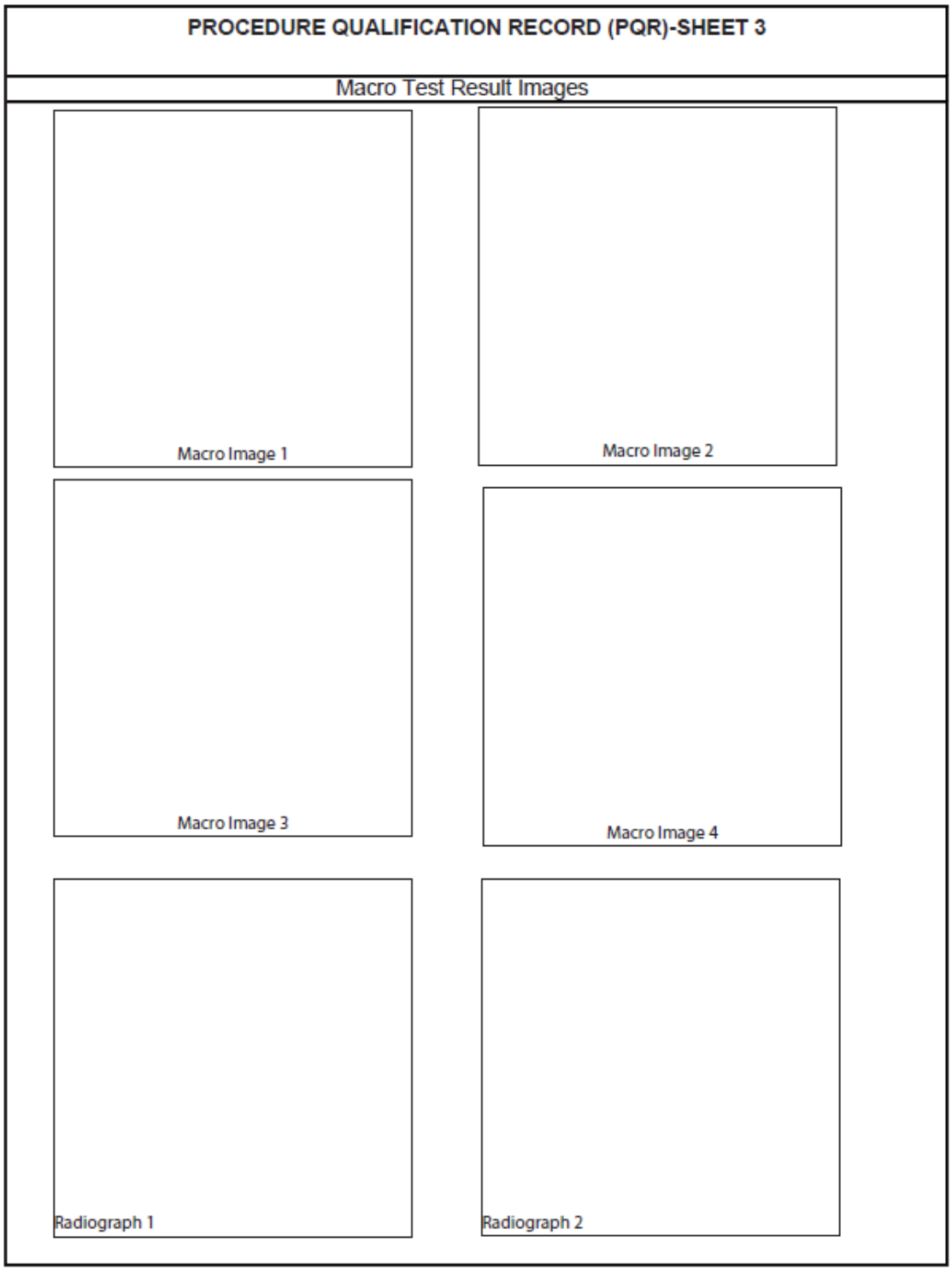
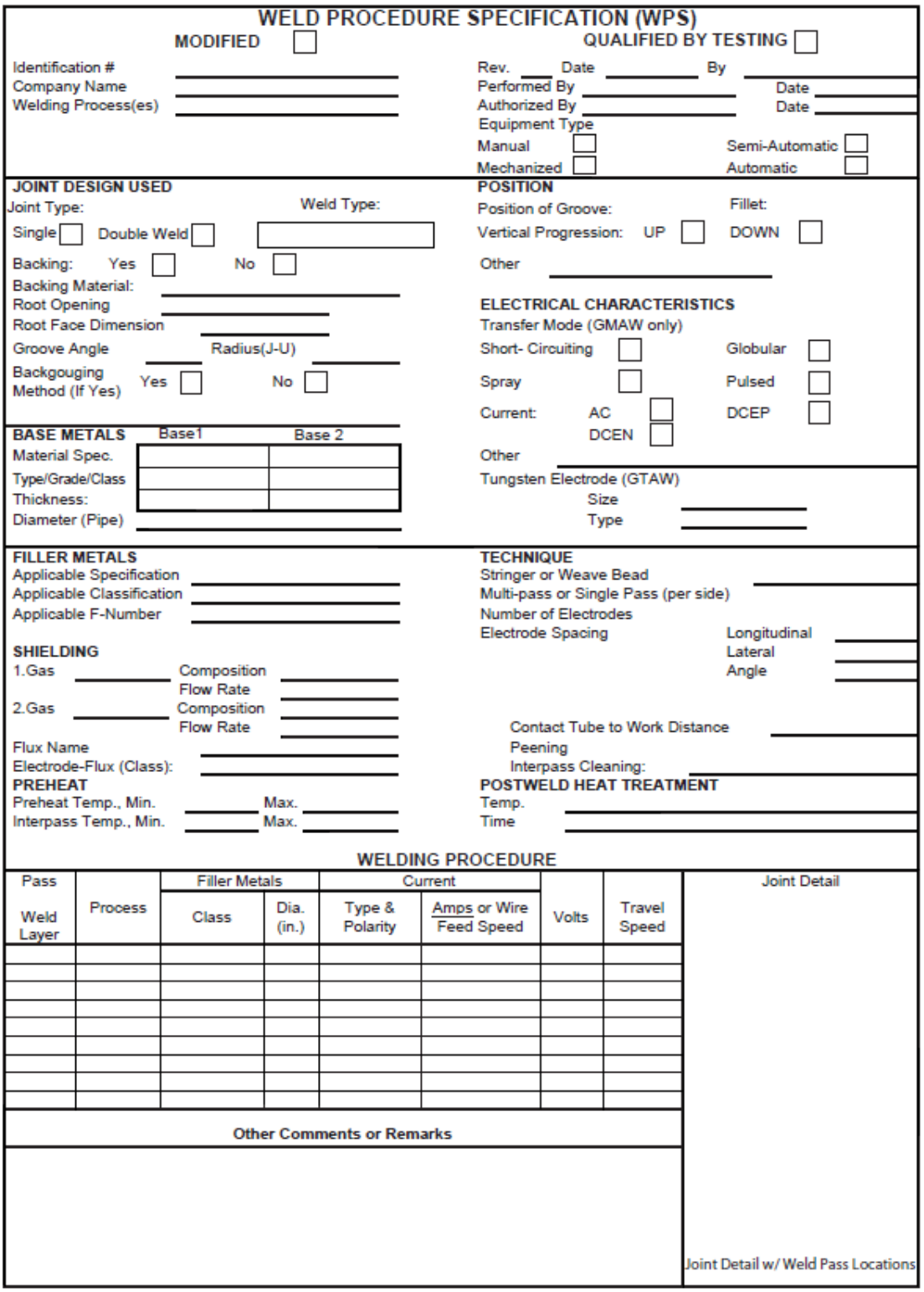


FIGURE A-2. Procedure qualification record (PQR) example – Continued.

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WELD PROCEDURE SPECIFICATION (WPS)

MODIFIED ☐ QUALIFIED BY TESTING ☐

Identification # _____ Rev. ____ Date _____ By _____
Company Name _____ Performed By _____ Date _____
Welding Process(es) _____ Authorized By _____ Date _____
Equipment Type
Manual ☐ Semi-Automatic ☐
Mechanized ☐ Automatic ☐

JOINT DESIGN USED
Joint Type: Weld Type:
Single ☐ Double Weld ☐
Backing: Yes ☐ No ☐
Backing Material: _____
Root Opening _____
Root Face Dimension _____
Groove Angle _____ Radius(J-U) _____
Backgouging Method (If Yes) Yes ☐ No ☐

POSITION
Position of Groove: Fillet:
Vertical Progression: UP ☐ DOWN ☐
Other _____

ELECTRICAL CHARACTERISTICS
Transfer Mode (GMAW only)
Short- Circuiting ☐ Globular ☐
Spray ☐ Pulsed ☐
Current: AC ☐ DCEP ☐
DCEN ☐
Other _____
Tungsten Electrode (GTAW)
Size _____
Type _____

BASE METALS

	Base1	Base 2
Material Spec.		
Type/Grade/Class		
Thickness:		

Diameter (Pipe) _____

FILLER METALS
Applicable Specification _____
Applicable Classification _____
Applicable F-Number _____

SHIELDING
1.Gas _____ Composition _____
Flow Rate _____
2.Gas _____ Composition _____
Flow Rate _____
Flux Name _____
Electrode-Flux (Class): _____

PREHEAT
Preheat Temp., Min. _____ Max. _____
Interpass Temp., Min. _____ Max. _____

TECHNIQUE
Stringer or Weave Bead _____
Multi-pass or Single Pass (per side) _____
Number of Electrodes _____
Electrode Spacing Longitudinal _____
Lateral _____
Angle _____
Contact Tube to Work Distance _____
Peening _____
Interpass Cleaning: _____

POSTWELD HEAT TREATMENT
Temp. _____
Time _____

WELDING PROCEDURE

Pass Weld Layer	Process	Filler Metals Class	Filler Metals Dia. (in.)	Current Type & Polarity	Current Amps or Wire Feed Speed	Volts	Travel Speed

Other Comments or Remarks

Joint Detail

Joint Detail w/ Weld Pass Locations

FIGURE A-3. Welding procedure specification (WPS) example.

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CONCLUDING MATERIAL

Custodians:
ARMY – AT
NAVY – SH
Air Force – 11

Preparing activity:
Army – AT
(Project THJM-2017-001)

Review activities:
Army –AV, MI, MR, TE, CR
Air Force –20
DLA – DH

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil/.

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