Designation: A488/A488M – 09

Standard Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel[1]

This standard is issued under the fixed designation A488/A488M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This practice covers the qualification of procedures, welders, and operators for the fabrication and repair of steel castings by electric arc welding.

1.1.1 Qualifications of a procedure and either or both the operator or welder under Section IX of the ASME Boiler and Pressure Vessel Code shall automatically qualify the procedure and either or both the operator or welder under this practice. P-number designations in the ASME grouping of base metals for qualification may be different than the category numbers listed in Table 1. Refer to Appendix X1 for a comparison of ASTM category numbers with the corresponding ASME P-Number designations.

1.2 Each manufacturer or contractor is responsible for the welding done by his organization and shall conduct the tests required to qualify his welding procedures, welders, and operators.

1.3 Each manufacturer or contractor shall maintain a record of welding procedure qualification tests (Fig. 1), welder or operator performance qualification tests (Fig. 2), and welding procedure specification (Fig. 3), which shall be made available to the purchaser's representative on request.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.4.1 *SI Units*—Within the text, the SI units are shown in brackets.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A27/A27M Specification for Steel Castings, Carbon, for General Application

A128/A128M Specification for Steel Castings, Austenitic Manganese

A148/A148M Specification for Steel Castings, High Strength, for Structural Purposes

A216/A216M Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service

A217/A217M Specification for Steel Castings, Martensitic Stainless and Alloy, for Pressure-Containing Parts, Suitable for High-Temperature Service

A351/A351M Specification for Castings, Austenitic, for Pressure-Containing Parts

A352/A352M Specification for Steel Castings, Ferritic and Martensitic, for Pressure-Containing Parts, Suitable for Low-Temperature Service

A356/A356M Specification for Steel Castings, Carbon, Low Alloy, and Stainless Steel, Heavy-Walled for Steam Turbines

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A389/A389M Specification for Steel Castings, Alloy, Specially Heat-Treated, for Pressure-Containing Parts, Suitable for High-Temperature Service

A447/A447M Specification for Steel Castings, Chromium-Nickel-Iron Alloy (25-12 Class), for High-Temperature Service

A487/A487M Specification for Steel Castings Suitable for Pressure Service

A494/A494M Specification for Castings, Nickel and Nickel Alloy

A732/A732M Specification for Castings, Investment, Carbon and Low Alloy Steel for General Application, and Cobalt Alloy for High Strength at Elevated Temperatures

[1] This practice is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.18 on Castings.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

TABLE 1 Categories of Base Materials

Category Number	Material Description	ASTM Specification	Grades
1	Carbon steel (carbon less than 0.35 %, tensile strength less than or equal to 70 ksi [480 MPa]).	A27/A27M	all grades
		A216/A216M	WCA, WCB
		A352/A352M	LCB, LCA
		A356/A356M	1
		A732/A732M	1A, 2A
		A757/A757M	A1Q
		A958	SC 1020, SC 1025, SC 1030, SC 1040, SC 1045, CLASSES 65/35, 70/36
2	Carbon steel (tensile strength greater than 70 ksi [480 MPa]). Carbon-manganese steel (tensile strength equal to or greater than 70 ksi but less than 90 ksi [620 MPa]).	A148/A148M	80-40
		A216/A216M	WCC
		A352/A352M	LCC
		A732/A732M	2Q, 3A
		A757/A757M	A2Q
		A958	SC 1030, SC 1040, SC 1045, CLASSES 80/40, 80/50
3	Carbon and carbon-manganese steel (tensile strength equal to or greater than 90 ksi [620 MPa]).	A732/A732M	3Q, 4A, 4Q, 5N
		A958	SC 1045, CLASSES 90/60, 105/85, 115/95
4	Low-alloy steel (annealed, normalized, or normalized and tempered. Tensile strength less than 85 ksi [585 MPa]).	A148/A148M	80-50
		A217/A217M	WC1, WC4, WC5, WC6, WC9
		A352/A352M	LC1, LC2, LC3, LC4
		A356/A356M	2, 5, 6, 8
		A389/A389M	C23, C24
		A487/A487M	11A, 12A, 16A
		A757/A757M	B2N, B3N, B4N
		A958	SC 4130, SC 4140, SC 8620, SC 8625, SC 8630, CLASSES 65/35, 70/36, 80/40, 80/50
5	Low-alloy steel (annealed, normalized, or normalized and tempered. Tensile strength equal to or greater than 85 ksi [585 MPa]).	A148/A148M	90-60, 105-85
		A217/A217M	C5, C12, C12A, WC11
		A356/A356M	9, 10, 12
		A487/A487M	1A, 1C, 2A, 2C, 4A, 4C, 6A, 8A, 9A, 9C, 10A, 13A
		A732/A732M	6N, 15A
		A757/A757M	D1N1, D1N2, D1N3, E2N1, E2N2, E2N3
		A958	SC 4340, CLASSES 90/60, 105/85
6	Low-alloy steel (quenched and tempered)	A148/A148M	90-60, 105-85, 115-95, 130-115, 135-125, 150-135, 160-145, 165-150, 165-150L, 210-180, 210-180L, 260-210, 260-210L
		A352/A352M	LC2-1, LC1, LC2, LC3, LC4, LC9
		A487/A487M	1B, 1C, 2B, 2C, 4B, 4C, 4D, 4E, 6B, 7A, 8B, 8C, 9A, 9B, 9C, 9D, 9E, 10B, 11B, 12B, 13B, 14A
		A732/A732M	7Q, 8Q, 9Q, 10Q, 11Q, 12Q, 13Q, 14Q
		A757/A757M	B2Q, B3Q, B4Q, C1Q, D1Q1, D1Q2, D1Q3, E1Q, E2Q1, E2Q2, E2Q3
		A958	SC 4140, SC 4130, SC 4340, SC 8620, SC 8625, SC 8630, CLASSES 115/95, 130/115, 135/125, 150/135, 160/145, 165/150, 210/180
7	Ferritic stainless steel	A743/A743M	CB-30, CC-50
8	Martensitic stainless steel	A217/A217M	CA-15
		A352/A352M	CA6NM
		A356/A356M	CA6NM
		A487/A487M	CA15-A, CA15-B, CA15-C, CA15-D, CA15M-A, CA6NM-A, CA6NM-B
		A743/A743M	CA-15, CA-15M, CA6NM, CA-40, CA6N, CB6
		A757/A757M	E3N
9	Low-carbon austenitic stainless steel (carbon equal to or less than 0.03 %)	A351/A351M	CF-3, CF-3A, CF-3M, CF-3MA, CF-3MN, CK-3MCUN, CG3M, CN3MN
		A743/A743M	CF-3, CF-3M, CF-3MN, CK-3MCUN, CN-3M, CG3M, CN3MN
		A744/A744M	CF-3, CF-3M, CK-3MCUN, CG3M , CN3MN
10	Unstabilized austenitic stainless steel (carbon greater than 0.03 %)	A351/A351M	CE-8MN, CF-8, CF-8A, CF-8M, CF-10, CF-10M, CG-8M, CH-8, CH-10, CH-20, CG6MMN, CF10S1MNN, CE20N

TABLE 1 *Continued*

Category Number	Material Description	ASTM Specification	Grades
		A447/A447M	Type I
		A743/A743M	CF-8, CG-12, CF-20, CF-8M, CF-16F, CF10SMNN, CH-20, CG-8M, CE-30, CG6MMN, CH10, CF16Fa
		A744/A744M	CF-8, CF-8M, CG-8M
11	Stabilized austenitic stainless steel	A351/A351M	CF-8C, CF-10MC, CK-20, HK-30, HK-40, HT-30, CN-7M, CT-15C
		A447/A447M	Type II
		A743/A743M	CF-8C, CN-7M, CN-7MS, CK-20
		A744/A744M	CF-8C, CN-7M, CN-7MS
12	Duplex (austenitic-ferritic) stainless steel	A351/A351M	CD3MWCuN, CD-4MCU
		A872/A872M	J93183, J93550
		A890/A890M	1A, 1B, 2A, 3A, 4A, 5A, 6A
		A995/A995M	1B, 2A, 3A, 4A, 5A, 6A
13	Precipitation-hardened austenitic stainless steel	A747/A747M	CB7CU-1, CB7CU-2
14	Nickel-base alloys	A494/A494M	CW-12MW, CY-40 Class 1, CY-40 Class 2, CZ-100, M-35-1, M-35-2, M-30C, N-12MV, N-7M, CW-6M, CW-2M, CW-6MC, CX-2MW, CU5MCUC
		A990	CW2M
15	Steel Castings, Austenitic Manganese	A128/A128M	A, B-1, B-2, B-3, B-4, C, D, E-1, E-2, F

A743/A743M Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application

A744/A744M Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service

A747/A747M Specification for Steel Castings, Stainless, Precipitation Hardening

A757/A757M Specification for Steel Castings, Ferritic and Martensitic, for Pressure-Containing and Other Applications, for Low-Temperature Service

A872/A872M Specification for Centrifugally Cast Ferritic/Austenitic Stainless Steel Pipe for Corrosive Environments

A890/A890M Specification for Castings, Iron-Chromium-Nickel-Molybdenum Corrosion-Resistant, Duplex (Austenitic/Ferritic) for General Application

A958 Specification for Steel Castings, Carbon and Alloy, with Tensile Requirements, Chemical Requirements Similar to Standard Wrought Grades

A990 Specification for Castings, Iron-Nickel-Chromium and Nickel Alloys, Specially Controlled for Pressure Retaining Parts for Corrosive Service

A995/A995M Specification for Castings, Austenitic-Ferritic (Duplex) Stainless Steel, for Pressure-Containing Parts

2.2 *American Society of Mechanical Engineers:*[3]

ASME Boiler and Pressure Vessel Code, Section IX

2.3 *American Welding Society:*[4]

ANSI/AWS 3.0 Definitions for Welding and Cutting

3. Terminology

3.1 *Definitions*—Definitions of terms relating to welding shall be in agreement with the definitions of the American Welding Society, ANSI/AWS A3.0.

4. Weld Orientation

4.1 *Orientation*—The orientation of welds with respect to horizontal and vertical planes of reference are classified into four positions, namely, flat, horizontal, vertical, and overhead as shown in Fig. 4. Test material shall be oriented as shown in Fig. 4; however, an angular deviation of ±15° from the specified horizontal and vertical planes is permitted during welding.

4.2 *Flat Position* (Fig. 4(*a*))—This position covers plate in a horizontal plane with the weld metal deposited from above, or pipe or a cylindrical casting with its axis horizontal and rolled during welding so that the weld metal is deposited from above.

4.3 *Horizontal Position* (Fig. 4(*b*))—This position covers plate in a vertical plane with the axis of the weld horizontal, or pipe or a cylindrical casting with its axis vertical and the axis of the weld horizontal.

4.4 *Vertical Position* (Fig. 4(*c*))—In this position, the plate is in a vertical plane with the axis of the weld vertical.

4.5 *Overhead Position* (Fig. 4(*d*))—In this position, the plate is in a horizontal plane with the weld metal deposited from underneath.

4.6 *Horizontal Fixed Position* (Fig. 4(*e*))—In this position, the pipe or cylindrical casting has its axis horizontal and the welding groove in a vertical plane. Welding shall be done without rotating the pipe or casting so that the weld metal is deposited from the flat, vertical, and overhead position.

4.7 *Qualification*—Qualification in the horizontal, vertical, or overhead position shall qualify also for the flat position.

[3] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.

[4] Available from American Welding Society (AWS), 550 NW LeJeune Rd., Miami, FL 33126, http://www.aws.org.

RECOMMENDED FORM FOR MANUFACTURER'S RECORD OF WELDING PROCEDURE QUALIFICATION TESTS

Procedure No. _____ Date: _____ Welding Process: _____
Material Specification: _____ to _____ of category No. _____ to category No. _____
Plate Thickness: _____ Thickness Range Qualified _____
Filler Metal F Group No. _____ Weld Deposit A-Group No.: _____
Flux Designation: _____ Gas Composition: _____
Gas Flow Rate: _____ Backing Strip, if any: _____
Preheat Temperature Range: _____ Single or Multiple Pass: _____
Position of Groove: _____ Filler Wire Diameter: _____
Trade Name: _____ Type of Backing: _____
Forehand or Backhand: _____Amps: _____ Volts _____ Inches/min: _____
Postheat Temperature _____ Time at Temperature _____

TENSION TEST RESULTS

Specimen No.	Dimensions Width	Thickness	Area	Ultimate Total Load, lb	Ultimate Unit Stress, psi	Nature of Failure and Location

GUIDED BEND TEST RESULTS

Specimen No.	Results	Specimen No.	Results

Welder's Name: _____ Clock No. _____ Stamp. No. _____
Who by virtue of these tests meets the welder performance qualification.
Test Conducted By: _____ Test No. _____
per _____
We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of ASTM Standard _____
Signed: _____
Manufacturer or Contractor
Date: _____

FIG. 1 Report Form 1

RECOMMENDED FORM FOR MANUFACTURER'S OR CONTRACTOR'S RECORD OF WELDER OR OPERATOR PERFORMANCE QUALIFICATION TESTS

Welder or Operator's Name: Stamp No. _____
Clock No. _____ Welding Process: _____
Position: _____
In accordance with Procedure No. _____
Material Specification: _____ to _____ of category No. _____ to category No. _____
Plate Thickness: _____ Range of Thickness Qualified: _____
Filler Metal Specification No. _____ Group No. F. _____
Filler Metal A-Group No. _____ Filler Metal Diameter _____
Trade Name: _____ Flux Designation or Gas Analysis: _____
Was Backing Strip Used? _____

GUIDED BEND TEST RESULTS

Specimen No.	Results	Specimen No.	Results

Test Conducted By: _____ Laboratory Test No. _____
per _____
We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with ASTM Standard _____ .
Signed: _____
Manufacturer or Contractor
Date: _____

FIG. 2 Report Form 2

REPORT FORM 3

RECOMMENDED FORM FOR WELDING PROCEDURE SPECIFICATION

1. Title

Welding of[A]_____ steel castings.

[A] Indicate general material description, such as carbon, Cr-Mo, 12 Cr, etc.

2. Specification No. _____ Rev. _____
Date _____

3. Scope

3.1 Procedure Specification No. _____ covers the welding of[A]_____ steel castings using the[B]_____ welding process.

[A] Indicate general material description in the Title.

[B] Indicate specific welding process, such as shielded metal arc, etc.

4. Base Material

4.1 The base material shall conform to the specification for[A]_____ which is found in materials category number[B]_____.

[A] Insert reference to ASTM designation or indicate chemical analysis and physical properties.

[B] Indicate category number from Table 1.

4.2 Base material shall be in the[A]_____ heat treated condition before welding.

[A] Indicate heat treatment before welding.

5. Filler Metal

5.1 The filler metal shall conform to ANSI/AWS Specification[A]_____ which is found in weld metal analysis group A _____[B].

[A] Indicate appropriate American Welding Society specification number and filler metal classification (e.g., A5.1 E7018).

[B] Indicate A Number from Table 4.

5.2 Flux for submerged arc welding shall conform to the following nominal composition:[A]_____.

[A] Indicate chemical composition or trade designation.

5.3 Shielding gas for gas shielded arc welding shall conform to the following nominal composition:[A]_____.

[A] Indicate the single gas or proportional parts of mixed gases and flow rates.

6. Preparation of Base Material

6.1 Metal removal shall be performed by[A]_____.

[A] Indicate method of metal removal, such as chipping, grinding, carbon arc cutting, frame cutting, etc. Also indicate whether preheat is required during metal removal.

6.2 Configuration of the weld preparation for partial penetration welds shall conform to the following geometry:[A]_____.

[A] Indicate minimum root radius and minimum side wall angle.

6.3 Configuration of the weld preparation for full penetration welds shall conform to the following geometry:[A]_____.

[A] Indicate minimum side wall angle.

6.4 Backing plates shall be used for welding full penetration welds. Backing plates shall be made from[A]_____ steel and shall fit the back of the cavity with a minimum gap of[B]_____.

[A] Indicate material of backing plate.

[B] Indicate dimension of maximum gap.

6.5 Surfaces of the weld preparation shall be cleaned of all oil, grease, dirt, scale, slag, shot blasting grit, or any foreign material which may be harmful to the quality of the weld. Surfaces of backing plates when used shall also meet the same cleanliness requirements.

6.6 All surfaces of the weld preparation shall be inspected as follows:[A]_____.

[A] Indicate type of inspection.

7. Preheat

7.1 Preheat and interpass temperature shall be maintained in the range from[A]_____ to[B]_____ during _____[C].

[A] Indicate minimum temperature.

[B] Indicate maximum temperature.

[C] Indicate if preheat maintenance is during welding or until postweld heat treatment is performed.

7.2 Preheat for tack welding of backing plates is the same as required for welding.

7.3 Minimum temperature before applying heat shall be[A]_____.

[A] Indicate temperature.

7.4 Local preheating to the temperatures indicated may be performed so that the heated area completely surrounds the weld preparation for a minimum distance of[A]_____ in any direction.

[A] Indicate minimum distance for local preheating.

8. Welding Position

8.1 Welds shall be made in the[A]_____ position.

[A] Indicate position or positions in which the welding will be performed. See Fig. 4.

9. Electrical Characteristics

9.1 The current used shall be _____[A]. The base material shall be attached to the _____[B] welding electrode lead.

[A] Indicate whether direct or alternating current. If direct, state whether non-pulsed or pulsed. If pulsed, state frequency.

[B] Indicate whether electrode positive (EP) or electrode negative (EN) output terminal of power supply is used.

Electrode Wire Diameter[A]	Amperage[A]	Range[A]	Voltage[A]
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

[A] Indicate for each diameter of electrode, the amperage, the range of amperage permitted, and the voltage requirements. For welding processes using wire, indicate wire diameter, wire feed speed, and current requirements.

9.2 Electrodes subject to moisture absorption must be stored and handled to maintain dryness according to the following:[A]_____.

[A] Where applicable, indicate electrode care instructions.

10. Welding Details

10.1 The width of any pass of welding shall not exceed[A]_____ times the size of the filler metal used.

[A] Indicate the number for controlling the maximum width.

10.2 Craters shall be properly filled before each interruption of the arc.

10.3 Slag or flux shall be removed on any bead before depositing the next successive bead.

10.4 Interpass inspection shall be performed according to the following:[A]_____.

[A] Indicate degree of interpass inspection required.

10.5 Peening shall be performed according to the following:[A]_____.

[A] Indicate the degree of peening required. Indicate any limits on peening first and last layers.

11. Post-Weld Heat Treatment

11.1 Post-weld heat treatment shall consist of the following:[A]_____.

[A] Indicate the heating and cooking rates, holding temperatures and times.

12. Inspection

12.1 Inspection of the completed weld shall be performed according to the following:[A]_____.

[A] Indicate degree of inspection.

FIG. 3 Report Form 3