



Designation: ~~A488/A488M—18~~^{ε2} A488/A488M – 24

Standard Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel¹

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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

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

^{ε1} NOTE—Grade designations in Table 1 and Table X1.1 were corrected editorially in January 2020.

^{ε2} NOTE—Grade designation HG10MNN in Table 1 was corrected editorially in February 2020.

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 nonconformance 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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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*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 [485 MPa])	A27/A27M	All grades
		A216/A216M	WCA, WCB
		A352/A352M	LCB, LCA
		A356/A356M	1
		A732/A732M	1A, 2A
		A757/A757M	A1Q
2	Carbon steel (tensile strength greater than 70 ksi [485 MPa]) Carbon-manganese steel (tensile strength equal to or greater than 70 ksi [485 MPa]) 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/A958M	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/A958M	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
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
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/A958M	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	GB30†, CG50†
7	Ferritic stainless steel	A743/A743M	CB30, CC50
8	Martensitic stainless steel	A217/A217M	CA15†
8	Martensitic stainless steel	A217/A217M	CA15



TABLE 1 Continued

Category Number	Material Description	ASTM Specification	Grades
		A352/A352M A356/A356M A487/A487M	CA6NM CA6NM CA15-A, CA15-B, CA15-C, CA15-D, CA15M-A, CA6NM-A, CA6NM-B
		A743/A743M A743/A743M A757/A757M	CA15†, CA15M†, CA6NM, CA40†, CA6N, CB6 CA15, CA15M, CA6NM, CA40, CA6N, CB6 E3N
9	Low-carbon austenitic stainless steel (carbon equal to or less than 0.03 %)	A351/A351M	CF3†, CF3A†, CF3M†, CF3MA†, CF3MN†, CK3MCUN†, CG3M, CN3MN
9	Low-carbon austenitic stainless steel (carbon equal to or less than 0.03 %)	<u>A351/A351M</u>	<u>CF3, CF3A, CF3M, CF3MA, CF3MN, CK3MCUN, CG3M, CN3MN</u>
		A743/A743M A743/A743M	CF3†, CF3M†, CF3MN†, CK3MCUN†, CN3M†, CG3M, CN3MN CF3, CF3M, CF3MN, CK3MCUN, CN3M, CG3M, CN3MN
		A744/A744M A744/A744M	CF3†, CF3M†, CK3MCUN†, CG3M, CN3MN CF3, CF3M, CK3MCUN, CG3M, CN3MN
10	Unstabilized austenitic stainless steel (carbon greater than 0.03 %)	A351/A351M	CF8†, CF8A†, CF8M†, CF10†, CF10M†, CG8M†, GH8†, GH10†, GH20†, CG6MMN, CF10SMNN, CE20N
10	Unstabilized austenitic stainless steel (carbon greater than 0.03 %)	<u>A351/A351M</u>	<u>CF8, CF8A, CF8M, CF10, CF10M, CG8M, CH8, CH10, CH20, CG6MMN, CF10SMNN, CE20N</u>
		A447/A447M A743/A743M A743/A743M	Type I CF8†, CG12†, CF20†, CF8M†, CF16F†, CF10SMNN, CH20†, CG8M†, CE30†, CG6MMN, CH10, CF16Fa CF8, CG12, CF20, CF8M, CF16F, CF10SMNN, CH20, CG8M, CE30, CG6MMN, CH10, CF16Fa
		A744/A744M A744/A744M	CF8†, CF8M†, CG8M† CF8, CF8M, CG8M
11	Stabilized austenitic stainless steel	A297/A297M	HG10MNN†
11	Stabilized austenitic stainless steel	<u>A297/A297M</u>	<u>HG10MNN</u>
		A351/A351M A351/A351M	CF8C†, CF10MC†, CK20†, HK30†, HK40†, HT30†, CN7M†, CT15C† CF8C, CF10MC, CK20, HK30, HK40, HT30, CN7M, CT15C
		A447/A447M A743/A743M A743/A743M A744/A744M A744/A744M	Type II CF8C†, CN7M†, CN7MS†, CK20† CF8C, CN7M, CN7MS, CK20 CF8C†, CN7M†, CN7MS† CF8C, CN7M, CN7MS
12	Duplex (austenitic-ferritic) stainless steel	<u>A872/A872M</u>	J93183, J93550
		A890/A890M A995/A995M	1A, 1B, 2A, 3A, 4A, 5A, 6A 1B, 2A, 3A, 4A, 5A, 6A
13	Precipitation-hardened austenitic stainless steel	<u>A747/A747M</u>	CB7CU-1, CB7CU-2
14	Nickel-base alloys	A494/A494M	CW12MW†, CY40† Class 1, CY40† Class 2, GZ100†, M35-1†, M35-2†, M30C†, N12MV†, N7M†, CW6M†, CW2M†, CW6MC†, CX2MW†, CU5MCUC
14	Nickel-base alloys	<u>A494/A494M</u>	<u>CW12MW, CY40 Class 1, CY40 Class 2, CZ100, M35-1, M35-2, M30C, N12MV, N7M, CW6M, CW2M, CW6MC, CX2MW, CU5MCUC CW2M</u>
		A990/A990M	CW2M
15	Steel castings, austenitic manganese	<u>A128/A128M</u>	A, B-1, B-2, B-3, B-4, C, D, E-1, E-2, F

†Editorially corrected.



ASTM A488 – 24 Recommended Form for the Manufacturer’s Record of Welding - Process Qualification Record

Record Actual Conditions Used to Weld Test Coupon.

Company Name _____
 Procedure Qualification Record No. _____ Date _____
 WPS No. _____
 Welding Process: _____
 Types (Manual, Automatic, Semi-Auto) _____

JOINTS

Groove Design of Test Coupon
 (For combination qualifications, the deposited weld metal thickness shall be recorded for each filler metal or process used.)

BASE METALS Material Spec. _____ Type or Grade _____ P-No. _____ to P-No. _____ Category _____ to Category No. _____ Thickness of Plate _____ Thickness Range Qualified _____ Heat Treat _____ Other _____	POSTWELD HEAT TREATMENT Temperature _____ Time _____ Other _____																		
FILLER METALS Filler Metal F-No. _____ AWS Classification _____ Flux Designation _____ Weld Metal Analysis A-No. _____ Filler Metal Dia. _____ Other _____ Weld Metal Thickness _____	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th rowspan="2"></th> <th colspan="2" style="text-align: center;">Percent Composition</th> </tr> <tr> <th style="text-align: center;">Gas(es)</th> <th style="text-align: center;">(Mixture)</th> <th style="text-align: center;">Flow Rate</th> </tr> </thead> <tbody> <tr> <td>Shielding</td> <td style="text-align: center;">CO2</td> <td></td> <td></td> </tr> <tr> <td>Trailing</td> <td style="text-align: center;">none</td> <td></td> <td></td> </tr> <tr> <td>Backing</td> <td style="text-align: center;">none</td> <td></td> <td></td> </tr> </tbody> </table>		Percent Composition		Gas(es)	(Mixture)	Flow Rate	Shielding	CO2			Trailing	none			Backing	none		
	Percent Composition																		
	Gas(es)	(Mixture)	Flow Rate																
Shielding	CO2																		
Trailing	none																		
Backing	none																		
POSITION Position of Groove _____ Weld Progression (Uphill, Downhill) _____ Other _____	ELECTRICAL CHARACTERISTICS Current _____ Polarity _____ Amps _____ Volts _____ Tungsten Electrode Size _____ Other _____																		
PREHEAT Preheat Temp. Range _____ Interpass Temp. _____ Other _____	TECHNIQUE Travel Speed (in/min) _____ String or Weave Bead _____ Oscillation _____ Multipass or Single Pass (per side) _____ Single or Multiple Electrodes _____ Type of Backing _____ Other _____																		

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of 2

FIG. 1 Report Form 1 Recommended Form for the Manufacturer’s Record of Welding—Procedure Qualification Record



PQR No. _____

TENSILE TEST

Specimen Location	UTS - psi	Yield Stress, psi	Reduction of Area, %	Elongation %	Type of Failure & Location	Comments

GUIDED-BEND TESTS

Type and Figure No.	Result
Side Bend 1	
Side Bend 2	
Side Bend 3	
Side Bend 4	

TOUGHNESS TESTS

Specimen No.	Notch Location	Specimen Size	Test Temp.	Impact Values			Drop Weight Break (Y / N)
				ft - lb	% Shear	Mils	

FILLET - WELD TEST

Result --Satisfactory: _____ Penetration into Parent Metal: _____

Macro -- Results _____

OTHER TESTS

Type of Test _____

Results/Comments _____

Other _____

Welder's Name _____ Clock No. _____ Stamp No. _____

Tests 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 the requirements of ASTM Standard. _____

Signed: _____

(manufacturer or contractor)

Date _____ By _____

Detail of record of tests are illustrative only and may be modified to conform to the type and number of tests required by the Code.

FIG. 1 Recommended Form for the Manufacturer's Record of Welding—Procedure Qualification Record (continued)



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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

iTeh Standards
(<https://standards.itih.ai>)
Document Preview

[ASTM A488/A488M-24](#)

<https://standards.itih.ai/catalog/standards/astm/3da244ad-c5d4-4183-903f-8a5569ec3683/astm-a488-a488m-24>



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	Amperage ^A	Range ^A	Voltage ^A
Diameter ^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. a488-a488m-24

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



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

A297/A297M Specification for Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application

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

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/A958M Specification for Steel Castings, Carbon and Alloy, with Tensile Requirements, Chemical Requirements Similar to Standard Wrought Grades

A990/A990M 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. Any casting definitions not referenced in AWS are listed herein.

3.2 *production welding*—any welding carried out during manufacturing before final delivery to the customer. Production welding is part of the casting production process. Most castings will receive some welding as part of the process of producing a casting to customer requirements.

4. Weld Orientation

4.1 *Orientation*—The orientation of welds with respect to horizontal and vertical planes of reference are classified into four

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.

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>.

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 $\pm 15^\circ$ 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 positions.

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

5. Preparation of Test Plate

5.1 Procedure qualification testing shall be performed on cast or wrought material having the same category number as the casting being welded. Test material shall be subjected to the same heat treatment before and after welding as will be applied to the casting. If the castings are not to be postweldpost-weld heat treated, then the test material is not to be postweldpost-weld heat treated. Test plate material for performance qualification testing is covered in 12.2.

5.2 The dimensions of the test plate shall be such as to provide the required number of test specimens.

5.3 The test joint shall be welded using the type of welding groove proposed in the welding procedure. The dimensions of the welding groove are not essential variables of the welding procedure.

5.4 The thickness of the test plate shall depend on the range of thickness to be qualified as shown in Tables 2 and 3.

5.5 The joint preparation shown in Fig. 5 shall qualify the supplier for all welding on steel castings.

5.6 Where pipe or a cylindrical casting is used for qualification, it is recommended that a minimum nominal diameter of 5 in. [125 mm] and a minimum thickness of $\frac{3}{8}$ in. [10 mm] be used.

6. Types of Tests

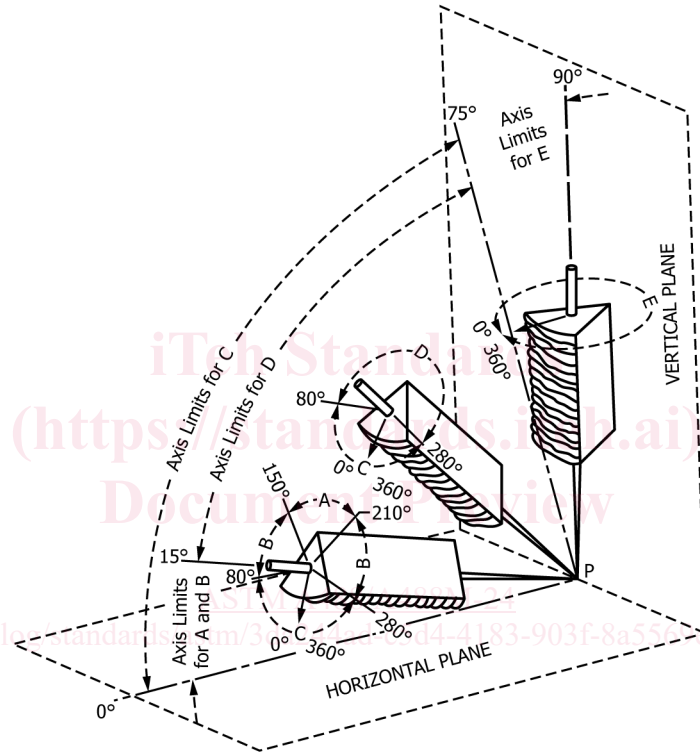
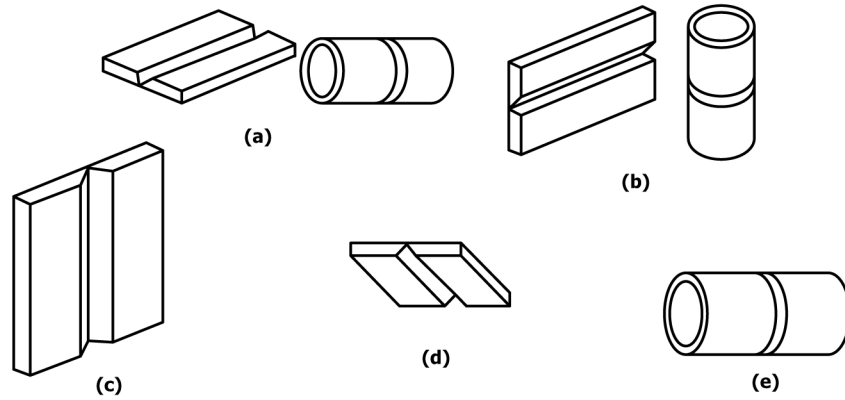
6.1 Four types of tests are used in the qualification procedure as follows:

6.1.1 *Tension Test*—Tests in direct tension are used in the procedure qualification to measure the strength of groove-weld joints.

6.1.2 *Bend Test*—Guided bend tests are used in the procedure and performance qualification tests to check the degree of soundness and ductility of groove-weld joints.

6.1.3 *Charpy Impact Test*—Charpy V-notch impact test specimens are used in the procedure qualification to determine the impact strength of weld metal deposited in groove-type joints.

6.1.4 *Radiographic Test*—Radiographic examination in accordance with 12.6 of a length of weld may be used to prove the ability of operators and welders to make sound welds.



Tabulation of Positions of Groove Welds

Position	Diagram Reference	Inclination of Axis, °	Rotation of Face, °
Flat	A	0 to 15	150 to 210
Horizontal	B	0 to 15	80 to 150 210 to 280
Overhead	C	0 to 80	0 to 80 280 to 360
Vertical	D	15 to 80	80 to 280
	E	80 to 90	0 to 360

NOTE 1—(a) Flat Position; (b) Horizontal Position; (c) Vertical Position; (d) Overhead Position; (e) Horizontal Fixed Position.

FIG. 4 Orientation of Welds