

SPECIFICATION FOR CARBON STEEL ELECTRODES FOR FLUX CORED ARC WELDING



SFA-5.20



(Identical with AWS Specification A5.20-95)

1. Scope

This specification prescribes requirements for the classification of carbon steel electrodes for flux cored arc welding.

PART A — GENERAL REQUIREMENTS

2. Classification

2.1 The electrodes covered by this specification are classified according to the following:

(1) The as-welded mechanical properties of the weld metal, as specified in Table 1

(2) Certain usability characteristics of the electrode (including the presence or absence of shielding gas), as specified in Table 2

(3) The positions of welding for which the electrodes are suitable, as specified in Table 2

2.2 Electrodes classified under one classification shall not be classified under any other classification in this specification except for the EXXT-1, EXXT-1M, EXXT-9, EXXT-9M, EXXT-12, and EXXT-12M classifications. In addition, an electrode classified with 100% CO₂ shielding gas may also be classified with the "M" designator. The "M" designator means that the electrode has been classified with a 75-80% argon/balance CO₂ gas mixture.

2.3 The electrodes classified under this specification are intended for flux cored arc welding either with or without an external shielding gas. Electrodes intended for use without external shielding gas, or with the shielding gas as specified in Table 2, are not prohibited from use with any other process or shielding gas for which they are found suitable.

3. Acceptance

Acceptance¹ of the welding electrodes shall be in accordance with the provisions of ANSI/AWS A5.01, *Filler Metal Procurement Guidelines*.

4. Certification

By affixing the AWS specification and classification designations to the packaging, or the classification designations to the product, the manufacturer certifies that the product meets the requirements of this specification.²

5. Units of Measure and Rounding-Off Procedure

5.1 U.S. customary units are the standard units of measure in this specification. The SI units are given as equivalent values to the U.S. customary units. The standard sizes and dimensions in the two systems are not identical and, for this reason, conversion from a standard size or dimension in one system will not always coincide with a standard size or dimension in the other. Suitable conversions, encompassing standard sizes of both, can be made, however, if appropriate tolerances are applied in each case.

5.2 For the purpose of determining conformance with this specification, an observed or calculated value shall

¹ See Section A3, Acceptance (in the Appendix), for further information concerning acceptance, testing of the material shipped, and ANSI/AWS A5.01, *Filler Metal Procurement Guidelines*.

² See Section A4, Certification (in the Appendix), for further information concerning certification and the testing called for to meet this requirement.

TABLE 1
AS-WELDED MECHANICAL PROPERTY REQUIREMENTS^a

AWS Classification	Tensile Strength		Yield Strength ^b		Percent Elongation ^c	Charpy V-Notch Impact Energy ^d
	ksi	MPa	ksi	MPa		
E7XT-1, -1M ^d	70	480	58	400	22	20 ft·lbf at 0°F (27 J at -18°C)
E7XT-2, -2M ^e	70	480	Not Specified		Not Specified	Not Specified
E7XT-3 ^e	70	480	Not Specified		Not Specified	Not Specified
E7XT-4	70	480	58	400	22	Not Specified
E7XT-5, -5M ^d	70	480	58	400	22	20 ft·lbf at -20°F (27 J at -29°C)
E7XT-6 ^d	70	480	58	400	22	20 ft·lbf at -20°F (27 J at -29°C)
E7XT-7	70	480	58	400	22	Not Specified
E7XT-8 ^d	70	480	58	400	22	20 ft·lbf at -20°F (27 J at -29°C)
E7XT-9, -9M ^d	70	480	58	400	22	20 ft·lbf at -20°F (27 J at -29°C)
E7XT-10 ^e	70	480	Not Specified		Not Specified	Not Specified
E7XT-11	70	480	58	400	20	Not Specified
E7XT-12, -12M ^d	70 to 90	480 to 620	58	400	22	20 ft·lbf at -20°F (27 J at -29°C)
E6XT-13 ^e	60	415	Not Specified		Not Specified	Not Specified
E7XT-13 ^e	70	480	Not Specified		Not Specified	Not Specified
E7XT-14 ^e	70	480	Not Specified		Not Specified	Not Specified
E6XT-G	60	415	48	330	22	Not Specified
E7XT-G	70	480	58	400	22	Not Specified
E6XT-GS ^e	60	415	Not Specified		Not Specified	Not Specified
E7XT-GS ^e	70	480	Not Specified		Not Specified	Not Specified

NOTES:

a. Single values are minimums.

b. 0.2% offset.

c. In 2 in. (50 mm) gage length (see Section 11). In 1 in. (25 mm) gage length for 0.045 in. (1.1 mm) and smaller sizes of EXXT-11 classification.

d. Electrodes with the following optional supplemental designations shall meet the lower temperature impact requirements specified below:

AWS Classification	Electrode Designation	Charpy V-Notch Impact Requirements
E7XT-1, -1M	E7XT-1J, -1MJ	20 ft·lbf at -40°F (27 J at -40°C)
E7XT-5, -5M	E7XT-5J, -5MJ	20 ft·lbf at -40°F (27 J at -40°C)
E7XT-6	E7XT-6J	20 ft·lbf at -40°F (27 J at -40°C)
E7XT-8	E7XT-8J	20 ft·lbf at -40°F (27 J at -40°C)
E7XT-9, -9M	E7XT-9J, -9MJ	20 ft·lbf at -40°F (27 J at -40°C)
E7XT-12, -12M	E7XT-12J, -12MJ	20 ft·lbf at -40°F (27 J at -40°C)

e. These classifications are intended for single pass welding. They are not for multiple pass welding. Only tensile strength is specified and, for this reason, only transverse tension and longitudinal guided bend tests are required (see Table 3).

TABLE 2
POSITION OF WELDING, SHIELDING, POLARITY, AND APPLICATION REQUIREMENTS

AWS Classification	Position of Welding ^{a,b}	External Shielding ^c	Polarity ^d	Application ^e
E70T-1	H and F	CO ₂	DCEP	M
E70T-1M	H and F	75-80% Ar/bal CO ₂	DCEP	M
E71T-1	H, F, VU, OH	CO ₂	DCEP	M
E71T-1M	H, F, VU, OH	75-80% Ar/bal CO ₂	DCEP	M
E70T-2	H and F	CO ₂	DCEP	S
E70T-2M	H and F	75-80% Ar/bal CO ₂	DCEP	S
E71T-2	H, F, VU, OH	CO ₂	DCEP	S
E71T-2M	H, F, VU, OH	75-80% Ar/bal CO ₂	DCEP	S
E70T-3	H and F	None	DCEP	S
E70T-4	H and F	None	DCEP	M
E70T-5	H and F	CO ₂	DCEP	M
E70T-5M	H and F	75-80% Ar/bal CO ₂	DCEP	M
E71T-5	H, F, VU, OH	CO ₂	DCEP or DCEN ^f	M
E71T-5M	H, F, VU, OH	75-80% Ar/bal CO ₂	DCEP or DCEN ^f	M
E70T-6	H and F	None	DCEP	M
E70T-7	H and F	None	DCEN	M
E71T-7	H, F, VU, OH	None	DCEN	M
E70T-8	H and F	None	DCEN	M
E71T-8	H, F, VU, OH	None	DCEN	M
E70T-9	H and F	CO ₂	DCEP	M
E70T-9M	H and F	75-80% Ar/bal CO ₂	DCEP	M
E71T-9	H, F, VU, OH	CO ₂	DCEP	M
E71T-9M	H, F, VU, OH	75-80% Ar/bal CO ₂	DCEP	M
E70T-10	H and F	None	DCEN	S
E70T-11	H and F	None	DCEN	M
E71T-11	H, F, VD, OH	None	DCEN	M
E70T-12	H and F	CO ₂	DCEP	M
E70T-12M	H and F	75-80% Ar/bal CO ₂	DCEP	M
E71T-12	H, F, VU, OH	CO ₂	DCEP	M
E71T-12M	H, F, VU, OH	75-80% Ar/bal CO ₂	DCEP	M
E61T-13	H, F, VD, OH	None	DCEN	S
E71T-13	H, F, VD, OH	None	DCEN	S
E71T-14	H, F, VD, OH	None	DCEN	S
EX0T-G ^g	H and F	Not Specified	Not Specified	M
EX1T-G ^g	H, F, VD or VU, OH	Not Specified	Not Specified	M
EX0T-GS ^g	H and F	Not Specified	Not Specified	S
EX1T-GS ^g	H, F, VD or VU, OH	Not Specified	Not specified	S

NOTES:

- H = horizontal position; F = flat position; OH = overhead position; VD = vertical position with downward progression; VU = vertical position with upward progression
- Electrode sizes suitable for out-of-position welding, i.e., welding positions other than flat or horizontal, usually are those sizes that are smaller than the 3/32 in. (2.4 mm) size or nearest size called for in 8.4.1 for the groove weld. For that reason, electrodes meeting the requirements for the groove weld tests and the fillet weld tests may be classified as EX1T-X or EX1T-XM (where X represents the tensile strength and usability designators) regardless of their size. See Section A7 and Figure A1 in the Annex for more information.
- Properties of weld metal from electrodes that are used with external gas shielding (EXXT-1, EXXT-1M, EXXT-2, EXXT-2M, EXXT-5, EXXT-5M, EXXT-9, EXXT-9M, EXXT-12, and EXXT-12M) vary according to the shielding gas employed. Electrodes classified with the specified shielding gas should not be used with other shielding gases without first consulting the manufacturer of the electrode.
- The term "DCEP" refers to direct current electrode positive (dc, reverse polarity).
The term "DCEN" refers to direct current electrode negative (dc, straight polarity).
- M = single or multiple pass; S = single pass only (see Section A7 in the Annex for more information).
- Some E71T-5 and E71T-5M electrodes may be recommended for use on DCEN for improved out-of-position welding. Consult the manufacturer for the recommended polarity.
- The letter "X" can be replaced with either a "6" or "7" to designate the weld metal's tensile strength.

be rounded to the nearest 1000 psi for tensile and yield strength, and to the "nearest unit" in the last right-hand place of figures used in expressing the limiting value for other quantities in accordance with the rounding-off method given in ASTM E29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance With Specifications*.

PART B — TESTS, PROCEDURES, AND REQUIREMENTS

6. Summary of Tests

The tests required for classification determination are specified in Table 3. The purpose of these tests is to determine the mechanical properties, soundness, and chemical composition of the weld metal, and the usability of the electrode. The base metal for the weld test assemblies, the welding and testing procedures to be employed, and the results required are given in Sections 8 through 14.

The supplemental test for diffusible hydrogen in Section 15 is not required for classification, but is included for an optional electrode designation as agreed to between the purchaser and supplier. Another optional supplemental designator (J) may be used to indicate Charpy impact testing at lower-than-standard temperature.

7. Retest

If any test fails to meet the requirement, that test shall be repeated twice. The results of both retests shall meet the requirement. Specimens for the retest may be taken from the original test assembly or from a new test assembly. For chemical analysis, retest need be only for those specific elements that failed to meet the test requirements.

8. Weld Test Assemblies

8.1 Two or three weld test assemblies are required, depending on the classification of the electrode and the manner in which the tests are conducted. They are as follows:

- (1) The weld pad shown in Fig. 1 for chemical analysis of the undiluted weld metal
- (2) The groove welds shown in Figs. 2A and 2B for mechanical properties and, where required, for soundness of the weld metal (Fig. 2A for multiple-pass electrodes and 2B for single-pass electrodes)
- (3) the fillet weld shown in Fig. 3, for usability of the electrode

The sample for chemical analysis may be taken from the reduced section of the fractured tension test specimen or from a corresponding location (or any location above it) in the weld metal in the groove weld in Fig. 2A, thereby avoiding the need to make the weld pad. In case of dispute, the weld pad shall be the referee method.

8.2 Preparation of each weld test assembly shall be as prescribed in 8.3, 8.4, and 8.5. The base metal for each assembly shall be as required in Table 4 and shall meet the requirements of any of the ASTM specifications shown there, or an equivalent specification. Testing of the assemblies shall be as prescribed in Sections 9 through 14.

8.3 Weld Pad. A weld pad shall be prepared as shown in Fig. 1 except when, as permitted in 8.1, the sample for analysis is taken from the groove weld or the fractured tension test specimen. Base metal of any convenient size which will satisfy the minimum requirements of Fig. 1 and is of a type specified in Table 4 shall be used as the base for the weld pad. The surface of the base metal on which the filler metal is deposited shall be clean. The pad shall be welded in the flat position with multiple layers to obtain undiluted weld metal ($\frac{1}{2}$ in. [13 mm] minimum thickness). The electrode size shall be $\frac{3}{32}$ in. (2.4 mm) or the size the manufacturer produces closest to $\frac{3}{32}$ in. (2.4 mm). The preheat temperature shall not be less than 60°F (16°C) and the interpass temperature shall not exceed 325°F (163°C). The slag shall be removed after each pass. The pad may be quenched in water between passes (temperature unimportant). The dimensions of the completed pad shall be as shown in Fig. 1. Testing of this assembly shall be as specified in Section 9, Chemical Analysis.

8.4 Groove Weld

8.4.1 For multiple-pass electrodes (all classifications except E6XT-13, E6XT-GS, E7XT-2, E7XT-2M, E7XT-3, E7XT-10, E7XT-13, E7XT-14, and E7XT-GS, as specified in Table 3), a test assembly using base metal as specified in Table 4 shall be prepared and welded as shown in Fig. 2A. The electrode size shall be $\frac{3}{32}$ in. (2.4 mm), or the size the manufacturer produces that is closest to $\frac{3}{32}$ in. (2.4 mm), and the welding conditions shall be those listed in Tables 2 and 5 for the classification being tested.

Welding shall be in the flat position and the assembly shall be restrained (or preset) during welding to prevent warpage in excess of 5 degrees. An assembly that is warped more than 5 degrees from plane shall be discarded. It shall not be straightened.

TABLE 3
REQUIRED TESTS^a

AWS Classification ^{b,c}	Chemical Analysis	Radiographic Test	Tension Test	Bend Test	Impact Test	Fillet Weld Test
EX0T-1, -1M	R	R	R	NR	R	R
EX0T-4	R	R	R	NR	NR	R
EX0T-5, -5M	R	R	R	NR	R	R
EX0T-6	R	R	R	NR	R	R
EX0T-7	R	R	R	NR	NR	R
EX0T-8	R	R	R	NR	R	R
EX0T-9, -9M	R	R	R	NR	R	R
EX0T-11	R	R	R	NR	NR	R
EX0T-12, -12M	R	R	R	NR	R	R
EX0T-G	R	R	R	NR	NR	R
EX1T-1, -1M	R	R	R	NR	R	R
EX1T-4	R	R	R	NR	NR	R
EX1T-5, -5M	R	R	R	NR	R	R
EX1T-6	R	R	R	NR	R	R
EX1T-7	R	R	R	NR	NR	R
EX1T-8	R	R	R	NR	R	R
EX1T-9, -9M	R	R	R	NR	R	R
EX1T-11	R	R	R	NR	NR	R
EX1T-12, -12M	R	R	R	NR	R	R
EX1T-G	R	R	R	NR	NR	R
EX0T-2, -2M ^d	NR	NR	R ^e	R	NR	R
EX1T-2, -2M ^d	NR	NR	R ^e	R	NR	R
EX0T-3 ^d	NR	NR	R ^e	R	NR	NR
EX0T-10 ^d	NR	NR	R ^e	R	NR	R
EX1T-13 ^d	NR	NR	R ^e	R	NR	R
EX1T-14 ^d	NR	NR	R ^e	R	NR	R
EX0T-GS ^d	NR	NR	R ^e	R	NR	R
EX1T-GS ^d	NR	NR	R ^e	R	NR	R

NOTES:

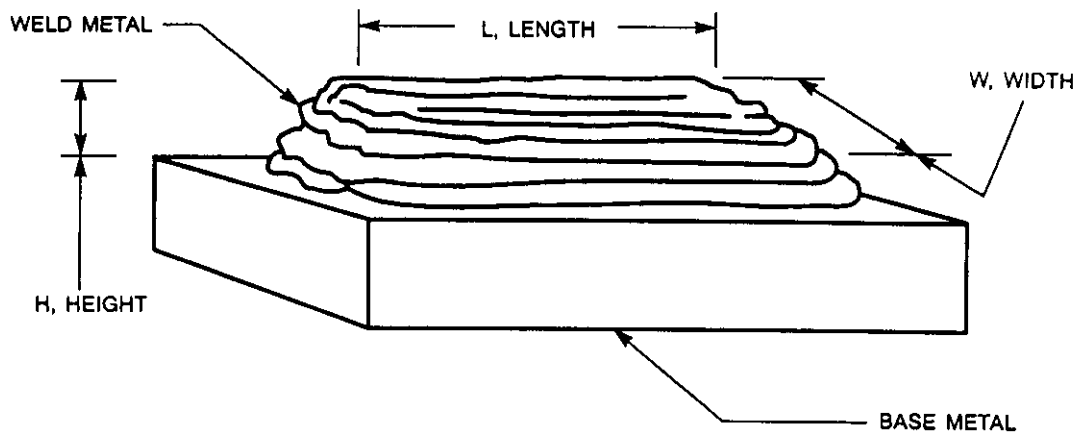
- The letter "R" indicates that the test is required. Where "NR" is shown, the test is not required for that classification. For the fillet weld test, EX0T-X classifications shall be tested in the horizontal position and EX1T-X classifications shall be tested in both the vertical and overhead positions.
- The 0 and 1 before the "T" refer to the position of welding for which the electrode is suitable. See A2.2.
0 = horizontal and flat position.
1 = all position (smaller than 3/32 in. (2.4 mm) diameter), i.e., flat, horizontal, vertical (downward progression) or vertical (upward progression), and overhead (see Table 2).
- Electrodes with supplemental toughness and/or diffusible hydrogen requirements may be further identified as shown in Tables 1 and 8.
- Intended for single-pass welding.
- Transverse tension test. All others require all-weld-metal tension test.

The test assembly shall be tack welded at room temperature and welding shall begin at that temperature (60°F [16°C] minimum). Welding shall continue until the assembly has reached a temperature of 300 ± 25°F (150 ± 14°C), measured by temperature indicating crayons or surface thermometers at the location shown in Fig. 2A. This interpass temperature shall be maintained for the remainder of the weld. Should it be necessary to interrupt welding, the assembly shall be allowed to cool in still air at room temperature. The

assembly shall be heated to a temperature of 300 ± 25°F (150 ± 14°C) before welding is resumed.

When welding has been completed and the assembly has cooled, the assembly shall be prepared and tested, as specified in Section 10, 11.1, and Section 13, in the as-welded condition (except for the aging of the all-weld-metal tension test specimen specified in 11.1).

8.4.2 For single-pass electrodes (classifications E6XT-13, E6XT-GS, E7XT-2, E7XT-2M, E7XT-3,



Weld Pad Size, Minimum

Length, L		Width, W		Height, H	
in.	mm	in.	mm	in.	mm
1-1/2	38	1/2	13	1/2	13

Notes:

1. Base metal of any convenient size, of the type specified in Table 4, shall be used as the base for the weld pad.
2. The surface of the base metal on which the filler metal is to be deposited shall be clean.
3. The pad shall be welded in the flat position with successive layers to obtain undiluted weld metal.
4. The number and size of the beads will vary according to the size of the electrode and the width of the weave as well as with the amperage employed.
5. The preheat temperature shall not be less than 60°F (16°C) and the interpass temperature shall not exceed 325°F (163°C).
6. The test assembly may be quenched in water (temperature unimportant) between passes to control interpass temperature.
7. The minimum completed pad size shall be that shown above. The sample to be tested in Section 9 shall be taken from weld metal that is at least 3/8 in. (9.5 mm) above the original base-metal surface.

FIG. 1 PAD FOR CHEMICAL ANALYSIS OF UNDILUTED WELD METAL

E7XT-10, E7XT-13, E7XT-14, and E7XT-GS, as specified in Table 3), a test assembly using base metal as specified in Table 4 shall be prepared and welded as shown in Fig. 2B. After tack welding the plates at each end, the test assembly shall be welded in the flat position with one bead on each side.

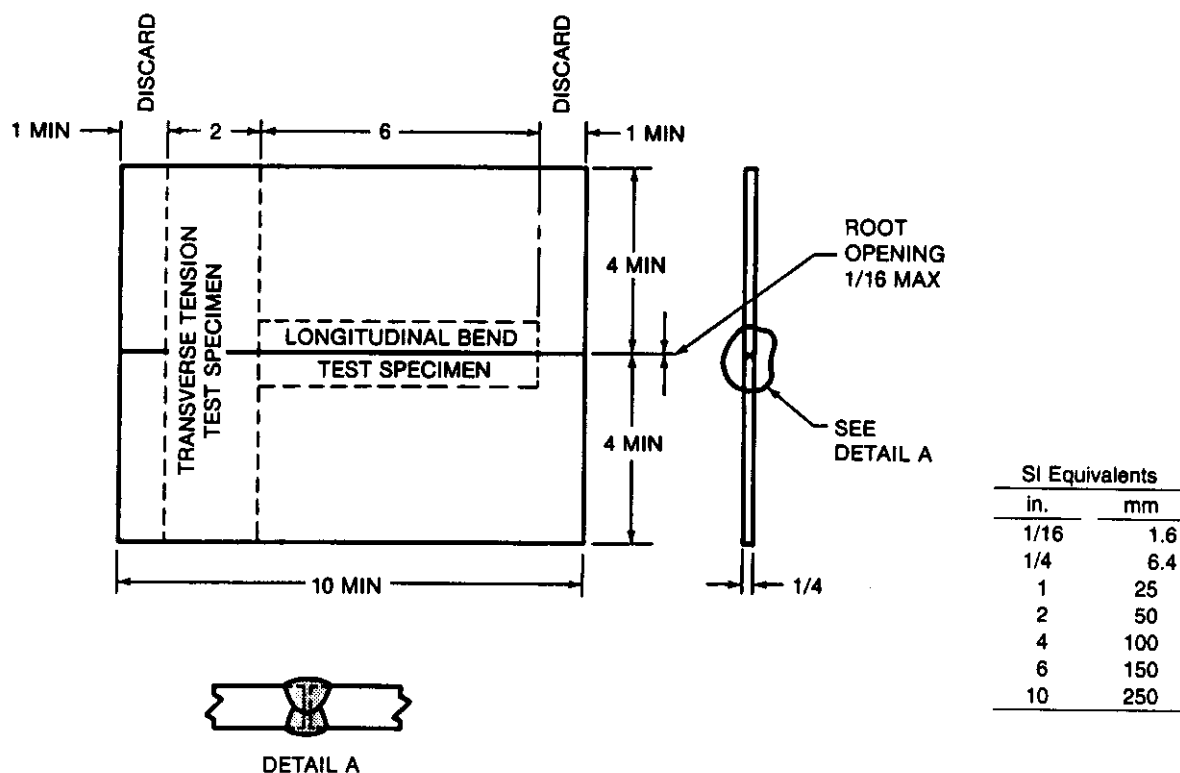
Welding shall begin with the assembly at room temperature (60°F [16°C] minimum). When the weld bead has been completed on the face side, the assembly shall be turned over and the bead deposited on the root side, as shown in Fig. 2B. This sequence shall not be interrupted. The electrode size shall be $\frac{3}{32}$ in. (2.4 mm) diameter or the size the manufacturer produces that is closest to $\frac{3}{32}$ in. (2.4 mm) diameter. The welding conditions shall be those listed in Table 2 for the classification being tested. After welding has been completed and the assembly has cooled, the assembly shall be prepared and tested as specified in 11.2 and Section

12, Bend Test, in the as-welded condition (except for the aging of the bend test specimen specified in 12.2).

8.5 Fillet Weld. A test assembly shall be prepared and welded as required in Table 3 and as specified in Fig. 3, using base metal of the appropriate type specified in Table 4 for each EX0T-X classification that requires a test assembly welded in the horizontal position. Each EX1T-X classification requires two test assemblies, one welded in the vertical position and one welded in the overhead position. The progression for vertical welding may be either upward or downward depending on the classification (see Table 2).

Before assembly, the standing member (web) shall have one edge prepared throughout its length and the base member (flange) side shall be straight, smooth, and clean. The test plates shall be assembled as shown in Fig. 3. When assembled, the faying surfaces shall

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Notes:

1. All dimensions are in inches.
2. Detail A shows the completed joint and approximate weld configuration.
3. Plate thickness may be reduced to 3/16 in. (4.8 mm) for electrode of 0.068 in. (1.7 mm) diameter or smaller.

FIG. 2B TEST ASSEMBLY FOR TRANSVERSE TENSION AND LONGITUDINAL GUIDED BEND TESTS FOR WELDS MADE WITH SINGLE-PASS ELECTRODES

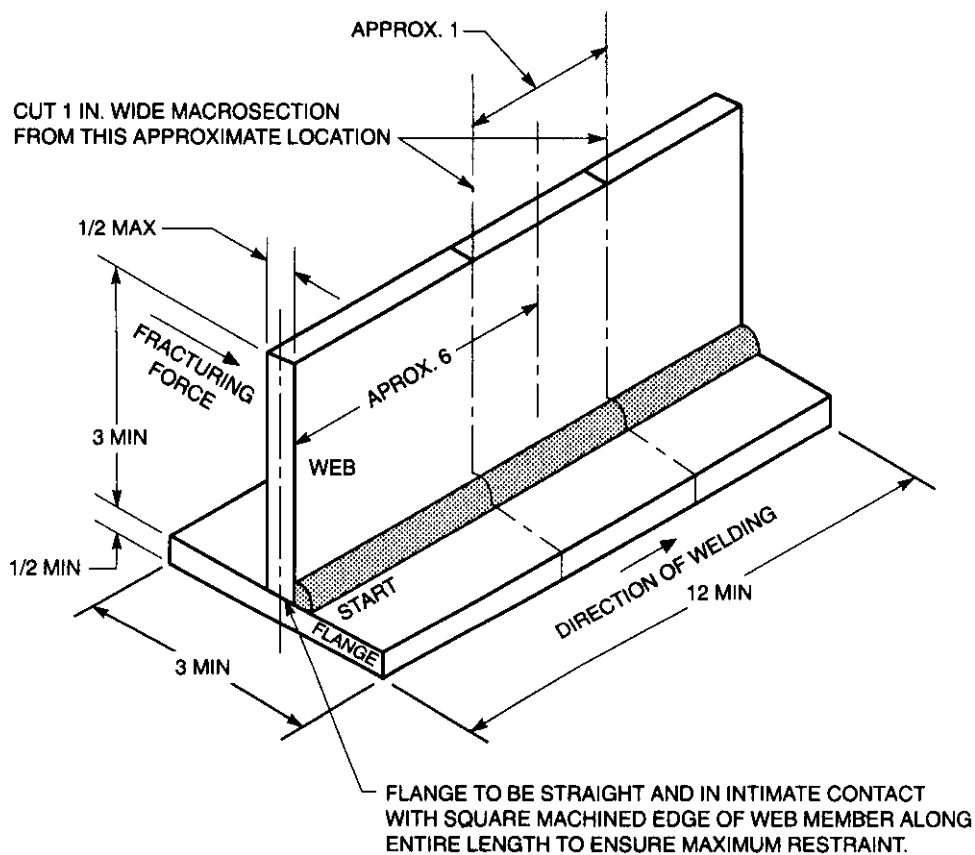
be in intimate contact along the entire length of the joint. The test assembly shall be secured with tack welds deposited at each end of the weld joint. The welding procedure and the size of the electrode to be tested shall be as selected by the manufacturer. The fillet weld shall be a single-pass weld deposited in either the semiautomatic or mechanized mode as selected by the manufacturer. The fillet weld size shall not be greater than $\frac{3}{8}$ in. (9.5 mm). The fillet weld shall be deposited only on one side of the joint as shown in Fig. 3. Weld cleaning shall be limited to chipping, brushing, and needle scaling. Grinding, filing, or other metal cutting of the fillet weld face is prohibited. The testing of the assembly shall be as specified in Section 14, Fillet Weld Test.

9. Chemical Analysis

9.1 A sample for chemical analysis of the weld metal shall be obtained for those electrodes for which chemical analysis is a requirement in Table 3. The samples may be taken from the weld pad prepared in accordance with 8.3, from the reduced section of the fractured tension test specimen or from a corresponding location (or any location above it) in the weld metal in the groove weld in Fig. 2A. In case of dispute, the weld pad is the referee method.

9.2 The top surface of the pad described in 8.3, and shown in Fig. 1, shall be removed and discarded, and a sample for analysis obtained from the underlying metal no closer than $\frac{3}{8}$ in. (9.5 mm) to the surface

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SI Equivalents	
in.	mm
1/2	13
1	25
3	75
6	150
12	300

1. All dimensions are in inches.
2. If the web and flange thicknesses are less than or equal to 1/4 in. (6.4 mm), the web and flange widths shall be 2 in. (51 mm) minimum.
3. The test plate thickness shall be 3/16 in. (4.8 mm) for E70T-3 electrode classification.

FIG. 3 FILLET WELD TEST ASSEMBLY

TABLE 4
BASE METAL FOR TEST ASSEMBLIES

AWS Classification	ASTM Specification	UNS Number*
All except E7XT-2, E7XT-2M, E7XT-3, E7XT-10, E7XT-13, E7XT-14, and E7XT-GS	A36,	K02600
	A285 Grade C,	K02801
	A515 Grade 70,	K03101
	A516 Grade 70,	K02700
	A830 Grade 1015,	G10150
	A830 Grade 1018, or A830 Grade 1020	G10180 G10200
E7XT-2, E7XT-2M, E7XT-3, E7XT-10, E7XT-13, E7XT-14 and E7XT-GS	A515 Grade 70 or A516 Grade 70	K03101 K02700

NOTE:

*SAE/ASTM Unified Numbering System for Metals and Alloys.

TABLE 5
REQUIREMENTS FOR PASS AND LAYER CONTROL FOR MULTIPLE-PASS ELECTRODE CLASSIFICATION^a

AWS Classification	Electrode Size		Required Total Passes	Suggested Passes per Layer		Suggested Number of Layers
	in.	mm		Layer 1	Layer 2 — Top	
E7XT-1, -1M E7XT-5, -5M E7XT-9, -9M E7XT-12, -12M	0.030	0.8	12-19	1 or 2	2 or 3 ^b	6-9
	0.035	0.9				
	0.045	1.1				
	0.052	1.3	10-17	1 or 2	2 or 3 ^b	5-8
	1/16	1.6				
	5/64	2.0				
	3/32	2.4	7-14	1 or 2	2 or 3 ^b	4-7
	7/64	2.8				
	1/8	3.2				
E7XT-4 E7XT-6 E7XT-7	3/32 ^c	2.4	7-11	1	2	4-6
E7XT-8	3/32 ^c	2.4	12-17	1	2 or 3	6-9
E7XT-11	3/32 ^c	2.4	7-11	1	2	4-6
	≤0.045	≤1.1	18-27	2	3	6-9
E6XT-G E7XT-G	Not Specified, To Be Recorded					

NOTES:

a. Actual number of passes, electrode diameter, wire feed speed or amperes, arc voltage, travel speed, and electrode extension (electrical stickout) shall be recorded and made available to the user on request. See A6.2 in the Annex.

b. The final layer may be 4 passes.

c. The electrode size shall be 3/32 in. (2.4 mm) or the size that the manufacturer produces that is closest to 3/32 in. (2.4 mm).

TABLE 6
CHEMICAL COMPOSITION REQUIREMENTS FOR WELD METAL

AWS Classification	UNS Number ^c	Weight Percent ^{a,b}										
		Carbon	Manganese	Silicon	Sulfur	Phosphorus	Chromium ^d	Nickel ^d	Molybdenum ^d	Vanadium ^d	Aluminum ^{d,e}	Copper ^d
E7XT-1 E7XT-1M	W07601											
E7XT-5 E7XT-5M	W07605	0.18	1.75	0.90	0.03	0.03	0.20	0.50	0.30	0.08	—	0.35
E7XT-9 E7XT-9M	W07609											
E7XT-4 E7XT-6 E7XT-7 E7XT-8 E7XT-11	W07604 W07606 W07607 W07608 W07611	(f)	1.75	0.60	0.03	0.03	0.20	0.50	0.30	0.08	1.8	0.35
EXXT-G ^g	—	(f)	1.75	0.90	0.03	0.03	0.20	0.50	0.30	0.08	1.8	0.35
E7XT-12 E7XT-12M	W07612	0.15	1.60	0.90	0.03	0.03	0.20	0.50	0.30	0.08	—	0.35
E6XT-13 E7XT-2 E7XT-2M	W06613 W07602											
E7XT-3 E7XT-10 E7XT-13 E7XT-14 EXXT-GS	W07603 W07610 W07613 W07614 —	Not Specified ^h										

NOTES:

- The weld metal shall be analyzed for the specific elements for which values are shown in this table.
- Single values are maximums.
- SAE/ASTM Unified Numbering System for Metals and Alloys.
- The analysis of these elements shall be reported only if intentionally added.
- Applicable to self-shielded electrodes. Electrodes intended for use with gas shielding need not have significant additions of aluminum.
- The limit of this element is not specified, but the amount shall be determined and reported (see A6.5 in the Annex).
- The total of all elements listed in this table shall not exceed 5 percent.
- The composition of weld metal is not meaningful since electrodes of these classifications are intended only for single pass welds. Dilution from the base metal in such welds usually is quite high (see A7.2 in the Annex).

of the base metal in Fig. 1 by any appropriate mechanical means. The sample shall be free of slag. When the sample is taken from the groove weld or the reduced section of the fractured tension test specimen, that material shall be prepared for analysis by any suitable mechanical means.

9.3 The sample shall be analyzed by accepted analytical methods. The referee method shall be ASTM E350, *Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron*.

9.4 The results of the analysis shall meet the requirements of Table 6 for the classification of electrode under test.

10. Radiographic Test

10.1 The groove weld described in 8.4.1 and shown in Fig. 2A shall be radiographed to evaluate the soundness of the weld metal. In preparation for radiography, the backing shall be removed and both surfaces of the weld shall be machined or ground smooth and flush with the original surfaces of the base metal. Both surfaces of the test assembly, in the area of the weld, shall be smooth enough to avoid difficulty in interpreting the radiograph.

10.2 The weld shall be radiographed in accordance with ASTM E142, *Controlling Quality of Radiographic Testing*. The quality level of inspection shall be 2-2T.

10.3 The soundness of the weld metal meets the requirements of this specification if the radiograph shows no cracks, no incomplete fusion, and no rounded indications in excess of the largest size or numbers permitted by the radiographic standards in Fig. 4. One in. (25 mm) of the weld measured from each end of the assembly shall be excluded from the radiographic evaluation.

A rounded indication is an indication (on the radiograph) whose length is no more than 3 times its width. Rounded indications may be circular, elliptical, conical, or irregular in shape, and they may have tails. The size of a rounded indication is the largest dimension of the indication, including any tail that may be present. The indication may be of porosity or slag. Indications whose largest dimension does not exceed $\frac{1}{64}$ in. (0.4 mm) shall be disregarded. Test assemblies with indications larger than the largest indications permitted in the radiographic standards (Fig. 4) do not meet the requirements of this specification.

11. Tension Test

11.1 One all-weld-metal tension test specimen shall be machined from the groove weld described in 8.4.1 and shown in Fig. 2A, as required in Table 3. The dimensions of the specimen shall be as shown in Fig. 5.

11.1.1 After machining, but before testing, the specimen may be aged at 200 to 220°F (93 to 104°C) for up to 48 hours, then allowed to cool to room temperature. Refer to A8.3 for a discussion on the purpose of aging.

11.1.2 After cooling, the specimen shall be tested in the manner described in the tension test section of ANSI/AWS B4.0, *Standard Methods for Mechanical Testing of Welds*.

11.1.3 The results of the all-weld-metal tension test shall meet the requirements specified in Table 1.

11.2 One transverse tension test specimen shall be machined from the groove weld described in 8.4.2 and shown in Fig. 2B, as required in Table 3. The dimensions of the specimen shall be as shown in Fig. 6.

11.2.1 The specimen shall be tested in the as-welded condition in the manner described in the tension test section of ANSI/AWS B4.0.

11.2.2 The results of the transverse tension test shall meet the requirements specified in Table 1. A test specimen that fractures in the base metal shall be considered to have met those requirements.

12. Bend Test

12.1 One longitudinal bend test specimen shall be machined from the groove weld test assembly described in 8.4.2 and shown in Fig. 2B, as required in Table 3. The dimensions of the specimen shall be as shown in Fig. 7.

12.2 After machining, but before bending, the specimen may be aged at 200 to 220°F (93 to 104°C) for up to 48 hours, then allowed to cool to room temperature. Refer to A8.3 for a discussion on the purpose of aging.

12.3 The specimens shall be tested in the manner described in the bend test section of ANSI/AWS B4.0 on any of the standard bend test jigs shown therein. The bend radius shall be $\frac{3}{4}$ in. (19 mm). Positioning of the bend specimen shall be such that the weld face of the last side welded is in tension.

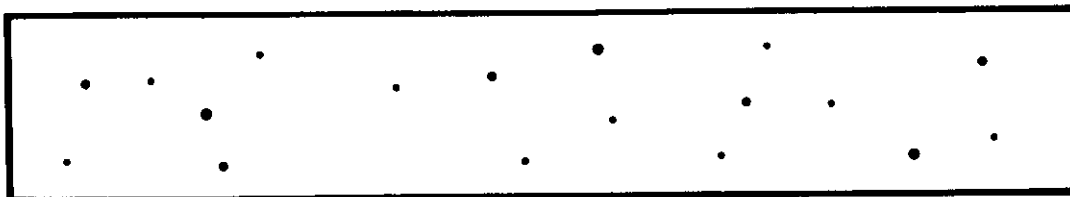
12.4 The specimen, after bending, shall conform to the $\frac{3}{4}$ in. (19 mm) radius, with an appropriate allowance for springback, and the weld metal shall not show any crack or other open defect exceeding $\frac{1}{8}$ in. (3.2 mm) in any direction. Cracks in the base-metal shall be disregarded, as long as they do not enter the weld metal. When base metal openings or cracks enter the weld metal, the test shall be considered invalid. Specimens in which this occurs shall be replaced, specimen for specimen, and the test completed. In this case, the doubling of specimens required for retest in Section 7, Retest, does not apply.

13. Impact Test

13.1 Five Charpy V-notch impact test specimens (Fig. 8) shall be machined from the test assembly shown in Fig. 2A, for those classifications for which impact testing is required in Table 3.

13.2 The five specimens shall be tested in accordance with the impact test section of ANSI/AWS B4.0. The test temperature shall be that specified in Table 1, for the classification under test. For those electrodes to be identified by the optional supplemental impact designator "J," the test temperature shall be as specified in Note d to Table 1.

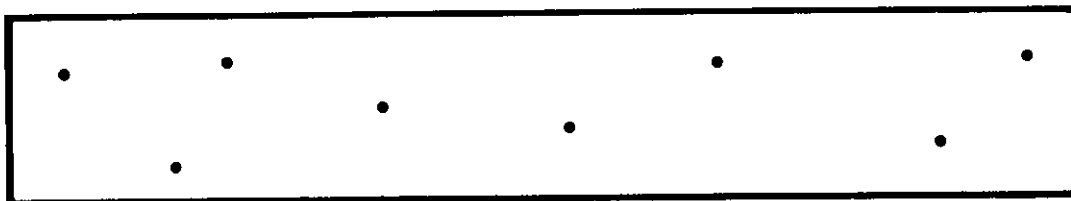
13.3 In evaluating the test results, the lowest and the highest values obtained shall be disregarded. Two of the remaining three values shall equal or exceed the specified 20 ft·lbf (27 J) energy level. One of the three may be lower, but not lower than 15 ft·lbf (20 J), and the average of the three shall be not less than the required 20 ft·lbf (27 J) energy level.



(A) ASSORTED ROUNDED INDICATIONS

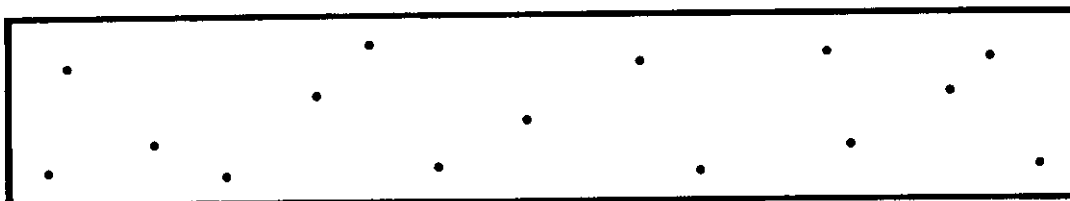
SIZE 1/64 in. (0.4 mm) TO 1/16 in. (1.6 mm) IN DIAMETER OR IN LENGTH.
MAXIMUM NUMBER OF INDICATIONS IN ANY 6 in. (150 mm) OF WELD = 18, WITH THE FOLLOWING
RESTRICTIONS:

MAXIMUM NUMBER OF LARGE 3/64 in. (1.2 mm) TO 1/16 in. (1.6 mm) IN DIAMETER OR IN LENGTH
INDICATIONS = 3.
MAXIMUM NUMBER OF MEDIUM 1/32 in. (0.8 mm) TO 3/64 in. (1.2 mm) IN DIAMETER OR IN LENGTH
INDICATIONS = 5.
MAXIMUM NUMBER OF SMALL 1/64 in. (0.4 mm) TO 1/32 in. (0.8 mm) IN DIAMETER OR IN LENGTH
INDICATIONS = 10.



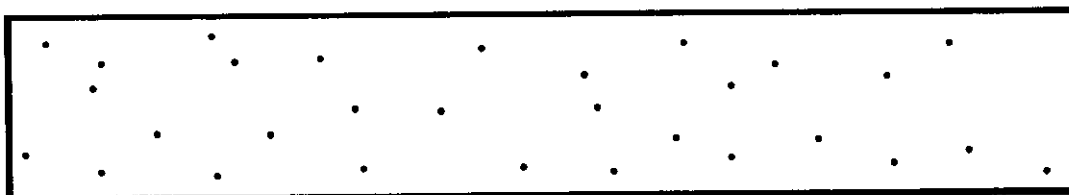
(B) LARGE ROUNDED INDICATIONS

SIZE 3/64 in. (1.2 mm) TO 1/16 in. (1.6 mm) IN DIAMETER OR IN LENGTH.
MAXIMUM NUMBER OF INDICATIONS IN ANY 6 in. (150 mm) OF WELD = 8.



(C) MEDIUM ROUNDED INDICATIONS

SIZE 1/32 in. (0.8 mm) TO 3/64 in. (1.2 mm) IN DIAMETER OR IN LENGTH.
MAXIMUM NUMBER OF INDICATIONS IN ANY 6 in. (150 mm) OF WELD = 15.



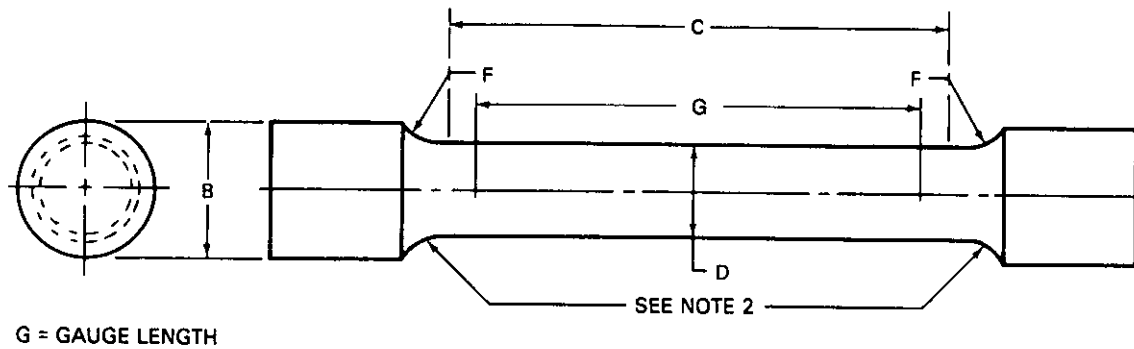
(D) SMALL ROUNDED INDICATIONS

SIZE 1/64 in. (0.4 mm) TO 1/32 in. (0.8 mm) IN DIAMETER OR IN LENGTH.
MAXIMUM NUMBER OF INDICATIONS IN ANY 6 in. (150 mm) OF WELD = 30.

Notes:

1. In using these standards, the chart which is most representative of the size of the rounded indications present in the test specimen radiograph shall be used for determining conformance to these radiographic standards.
2. Since these are test welds specifically made in the laboratory for classification purposes, the radiographic requirements for these test welds are more rigid than those which may be required for general fabrication.
3. Indications where the largest dimension does not exceed 1/64 in. (0.4 mm) diameter or length shall be disregarded.

FIG. 4 RADIOGRAPHIC STANDARDS FOR TEST ASSEMBLY IN FIGURE 2A



Dimensions of Specimen													
Test Plate Thickness		D		G		C		B		F, min.		Approximate Area	
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	sq. in.	sq. mm
3/4	19.1	0.500 ±0.010	12.70 ±0.25	2.000 ±0.005	50.80 ±0.13	2-1/4	57.1	3/4	19.1	0.375	9.5	1/5	130
1/2	12.7	0.250 ±0.005	6.40 ±0.13	1.000 ±0.005	25.40 ±0.13	1-1/4	31.8	1/2	12.70	0.187	4.8	1/20	32

Notes:

- Dimensions G and C shall be as shown, but the ends of the specimen may be of any shape required to fit the testing machine as long as the load is kept axial.
- The diameter of the specimen, within the gauge length, shall be slightly smaller at the center than at the ends. The difference shall not exceed one percent of the diameter.
- When the extensometer is required to determine yield strength or other elastic properties, dimension C may be modified. However, the percent of the elongation shall be based on dimension G.
- The surface finish within the C dimension shall be no rougher than 63 μ in. (1.6 μ m).
- The 0.250 in. (6.4 mm) specimen size shall be used for 0.045 in. (1.1 mm) and smaller EXXT-11 electrodes.

FIG. 5 ALL-WELD-METAL TENSION TEST SPECIMEN

14. Fillet Weld Test

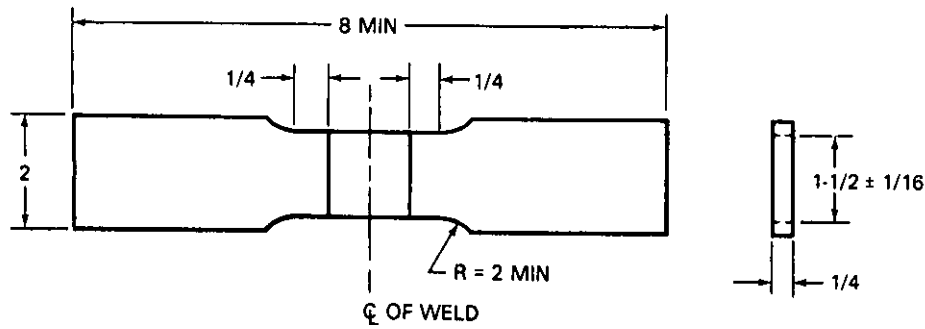
14.1 The required fillet welds shall be made in accordance with 8.5 and Fig. 3, and shall be examined visually over the entire face of each weld. There shall be no indication of cracks, and the weld shall be reasonably free of undercut, overlap, trapped slag, and surface porosity. After the visual examination, a specimen containing approximately 1 in. (25 mm) of the length of the weld shall be removed as shown in Fig. 3. One cross-sectional surface of the specimen shall be polished and etched, and then examined as required in 14.2.

14.2 Scribe lines shall be placed on the prepared surface, as shown in Fig. 9, and the fillet weld size,

fillet weld leg, and convexity of the weld shall be determined to the nearest $\frac{1}{64}$ in. (0.4 mm) by actual measurement. These measurements shall meet the requirements specified in 8.5 and Table 7.

14.3 The remaining two sections of the test assembly shall be broken longitudinally through the fillet weld by a force exerted as shown in Fig. 3. When necessary, to facilitate fracture through the fillet, one or more of the following procedures may be used:

- (1) A reinforcing bead, as shown in Fig. 10(A), may be added to each leg of the weld.
- (2) The position of the web on the flange may be changed, as shown in Fig. 10(B).

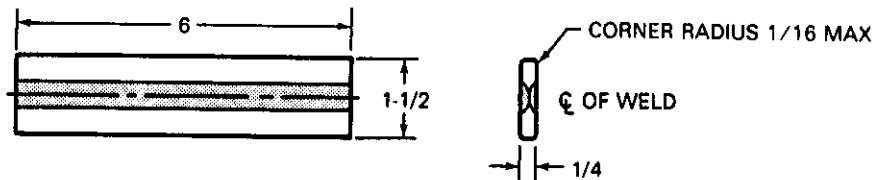


SI Equivalents	
in.	mm
1/16	1.6
1/4	6.4
1-1/2	38
2	50
8	200

Notes:

1. All dimensions are in inches.
2. Weld reinforcement shall be ground or machined flush with the surfaces of the specimen. Grinding or machining marks shall be parallel to the length of the longest dimension of the specimen.
3. Thickness shall be 3/16 in. (4.8 mm) if 3/16 in. (4.8 mm) plate is used for the preparation of the test assembly shown in Figure 2B.

FIG. 6 TRANSVERSE TENSION TEST SPECIMEN



SI Equivalents	
in.	mm
1/16	1.6
1/4	6.4
1-1/2	38
6	150

Notes:

1. All dimensions are in inches.
2. Thickness shall be 3/16 in. (4.8 mm) if 3/16 in. (4.8 mm) plate is used for the preparation of the test assembly shown in Figure 2B.

FIG. 7 LONGITUDINAL GUIDED BEND SPECIMEN FOR WELDS MADE WITH SINGLE-PASS ELECTRODES

(3) The face of the fillet may be notched, as shown in Fig. 10(C).

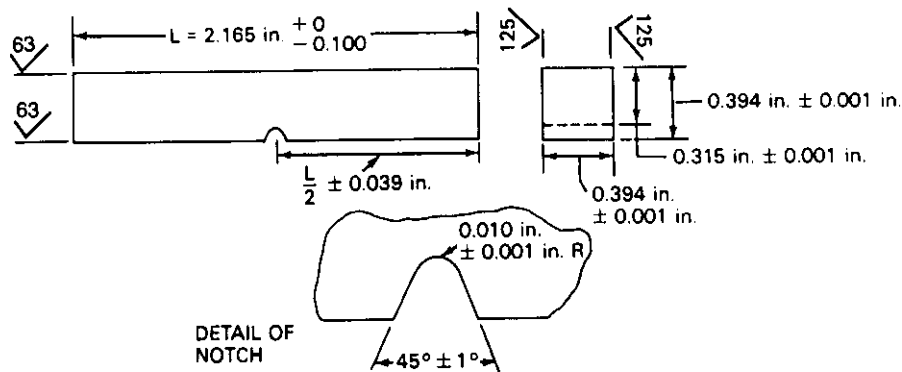
Tests in which the weld metal pulls out of the base metal during bending are invalid tests. Specimens in which this occurs shall be replaced, specimen for specimen, and the test completed. In this case, the doubling of specimens required for retest in Section 7, Retest, does not apply.

14.4 The fractured surfaces shall be examined visually. They shall be free of cracks and shall be reasonably free of porosity and trapped slag. Incomplete fusion at the root of the weld shall not exceed 20 percent of the total length of the weld. Slag beyond the vertex

of the isosceles triangle with the hypotenuse as the base, as shown in Fig. 9, shall not be considered incomplete fusion.

15. Diffusible Hydrogen Test

15.1 The smallest and largest size of an electrode to be identified by an optional supplemental diffusible hydrogen designator shall be tested according to one of the methods given in ANSI/AWS A4.3, *Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding*. Based upon the average



SI Equivalents	
in.	mm
0.001	0.025
0.010	0.255
0.039	1.0
0.100	2.5
0.315	8.0
0.394	10.0
1.082	27.5
2.165	55.0

Notes:

1. All dimensions except angles are in inches.
2. The notched surface and the surface to be struck shall be parallel within 0.002 in. (0.05 mm) and have at least a 63 μ in. (1.6 μ m) finish. The other two surfaces shall be square with the notched or struck surface within ± 10 minutes of the degree and have at least a 125 μ in. (3.2 μ m) finish.
3. The notch shall be smoothly cut by mechanical means and shall be square with the longitudinal edge of the specimen within one degree.
4. The geometry of the notch shall be measured on at least one specimen in a set of five specimens. Measurement shall be done at minimum 50 times magnification on either a shadowgraph or a metallograph.
5. The correct location of the notch shall be verified by etching before or after machining.
6. If a specimen does not break upon being struck, the value for energy absorbed shall be reported as the capacity of the impact testing machine followed by a plus sign (+).

FIG. 8 DETAILS OF CHARPY V-NOTCH IMPACT TEST SPECIMEN

value of test results which satisfy the requirements of Table 8, the appropriate diffusible hydrogen designator may be added at the end of the classification. If the actual test results for an electrode meet the requirements for the lower or lowest hydrogen designator, as specified in Table 8, the electrode also meets the requirements for all higher hydrogen designators without the need to retest.

15.2 Testing shall be done with electrodes in the "as-received" condition. Conditioning of the electrode prior to testing is not permitted.³

The use of electrical stickouts in excess of those which would be used in the routine application of the electrode is not permitted.

15.3 For purposes of certifying compliance with diffusible hydrogen requirements, the reference atmospheric condition shall be an absolute humidity of 10 grains of moisture per pound (1.43 g per kg) of dry

air at the time of welding.⁴ The actual atmospheric conditions shall be reported along with the average value for the tests according to ANSI/AWS A4.3.

15.4 When the absolute humidity equals or exceeds the reference condition at the time of preparation of the test assembly, the test shall be acceptable as demonstrating compliance with the requirements of this specification, provided the actual test results satisfy the diffusible hydrogen requirements for the applicable designator, as specified in Table 8.

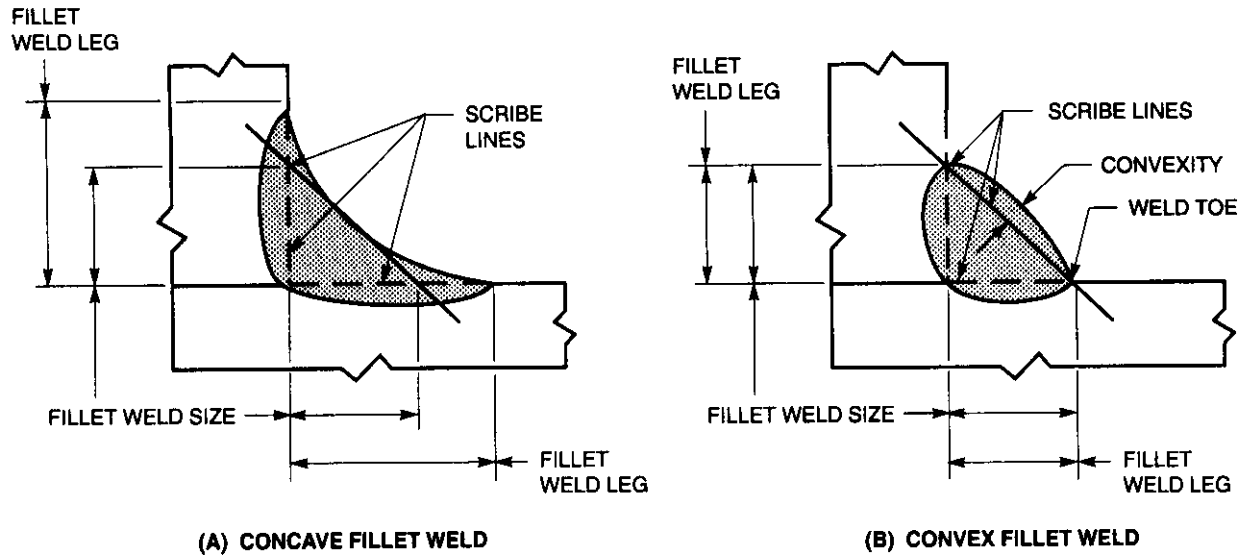
PART C — MANUFACTURE, IDENTIFICATION, AND PACKAGING

16. Method of Manufacture

The electrodes classified according to this specification may be manufactured by any method that will produce electrodes that meet the requirements of this specification.

³Conditioning can be considered to be any special preparation or procedure, such as baking the electrode, which the user would not normally practice.

⁴See A8.2.5 in the Annex.



Notes:

1. Fillet weld size is the leg lengths of the largest isosceles right triangle which can be inscribed within the fillet weld cross section.
2. Convexity is the maximum distance from the face of a convex fillet weld perpendicular to a line joining the weld toes.
3. Fillet weld leg is the distance from the joint root to the toe of the fillet weld.

FIG. 9 DIMENSIONS OF FILLET WELDS

TABLE 7
DIMENSIONAL REQUIREMENTS FOR FILLET WELD USABILITY TEST SPECIMENS

Measured Fillet Weld Size		Maximum Convexity*		Maximum Difference Between Fillet Weld Legs	
in.	mm	in.	mm	in.	mm
1/8 or less	3.2	5/64	2.0	1/32	0.8
9/64	3.6	5/64	2.0	3/64	1.2
5/32	4.0	5/64	2.0	3/64	1.2
11/64	4.4	5/64	2.0	1/16	1.6
3/16	4.8	5/64	2.0	1/16	1.6
13/64	5.2	5/64	2.0	5/64	2.0
7/32	5.6	5/64	2.0	5/64	2.0
15/64	6.0	5/64	2.0	3/32	2.4
1/4	6.4	5/64	2.0	3/32	2.4
17/64	6.7	3/32	2.4	7/64	2.8
9/32	7.1	3/32	2.4	7/64	2.8
19/64	7.5	3/32	2.4	1/8	3.2
5/16	8.0	3/32	2.4	1/8	3.2
21/64	8.3	3/32	2.4	9/64	3.6
11/32	8.7	3/32	2.4	9/64	3.6
23/64	9.1	3/32	2.4	5/32	4.0
3/8 or more	9.5	3/32	2.4	5/32	4.0

NOTE:

*Maximum convexity for fillet welds made using EXXT-5 and EXXT-5M electrodes may be 1/32 in. (0.8 mm) larger than listed requirements.

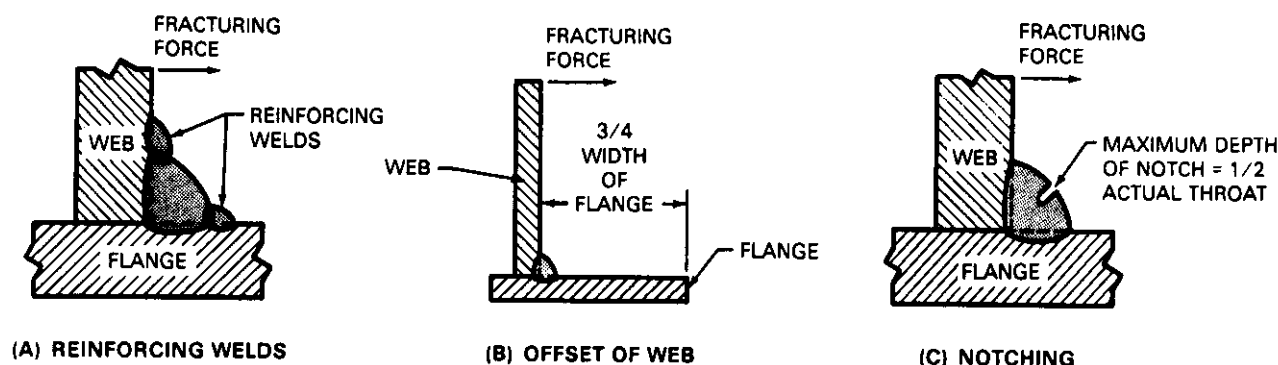


FIG. 10 ALTERNATE METHODS FOR FACILITATING FILLET WELD FRACTURE

TABLE 8
OPTIONAL AVERAGE DIFFUSIBLE HYDROGEN LIMITS^a

AWS Classification	Hydrogen Category Designator ^{b,c,d}	Diffusible Hydrogen Limit ^e ml/100 g Deposited Metal
All Classifications	H16	16.0 max
	H8	8.0 max
	H4	4.0 max

NOTES:

- a. Limits on the diffusible hydrogen when tested in accordance with ANSI/AWS A4.3, *Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding*.
- b. See Annex Figure A1 for proper placement of the hydrogen designator. These hydrogen designators are optional designators only and do not constitute part of the AWS classification. For example, the AWS classification for an electrode designated E70T-XH8 is E70T-X. Similarly, the classification for an electrode designated E71T-XMH4 is E71T-XM.
- c. The lower diffusible hydrogen levels (H8 and H4) may not be available in some classifications (see A8.2.9).
- d. Electrodes which satisfy the diffusible hydrogen limits for the H4 category also satisfy the limits for the H8 and H16 categories. Electrodes which satisfy the diffusible hydrogen limits for the H8 category also satisfy the limits for the H16 category.
- e. These hydrogen limits are based on welding in air containing a maximum of 10 grains of water per pound (1.43 g/kg) of dry air. Testing at any higher atmospheric moisture level is acceptable, provided these limits are satisfied (see 15.3).

17. Standard Sizes

Standard sizes for filler metal in the different package forms such as coils with support, coils without support, drums, and spools are as shown in Table 9 (see Section 19, Standard Package Forms).

18. Finish and Uniformity

18.1 All electrodes shall have a smooth finish that is free from slivers, depressions, scratches, scale, seams, laps (exclusive of the longitudinal joint), and foreign matter that would adversely affect the welding characteristics, the operation of the welding equipment, or the properties of the weld metal.

18.2 Each continuous length of electrode shall be from a single lot of material as defined in ANSI/AWS A5.01, and welds, when present, shall have been made so as not to interfere with the uniform, uninterrupted feeding of the electrode on automatic and semiautomatic equipment.

18.3 Core ingredients shall be distributed with sufficient uniformity throughout the length of the electrode so as not to adversely affect the performance of the electrode or the properties of the weld metal.

18.4 A suitable protective coating may be applied to any electrode in this specification.

TABLE 9
STANDARD SIZES AND TOLERANCES OF ELECTRODES*

AWS Classification	Electrode Size (Diameter)		Diameter Tolerance	
	in.	mm	in.	mm
All Classifications	0.030	0.8	±0.002	±0.05
	0.035	0.9		
	0.045	1.1		
	0.052	1.3		
	1/16 (0.062)	1.6		
All Classifications	0.068	1.7	±0.003	±0.08
	0.072	1.8		
	5/64 (0.078)	2.0		
	3/32 (0.094)	2.4		
	7/64 (0.109)	2.8		
	0.120	3.0		
	1/8 (0.125)	3.2		
	5/32 (0.156)	4.0		

NOTE:

*Electrodes produced in sizes other than those shown may be classified by using similar tolerances as shown.

19. Standard Package Forms

19.1 Standard package forms are coils with support, coils without support, spools, and drums. Standard package dimensions and weights for each form are given in Table 10 and Figs. 11, 12, and 13. Package forms, sizes, and weights other than these shall be as agreed by purchaser and supplier.

19.2 The liners in coils with support shall be designed and constructed to prevent distortion of the coil during normal handling and use and shall be clean and dry enough to maintain the cleanliness of the electrode.

19.3 Spools shall be designed and constructed to prevent distortion of the electrode during normal handling and use and shall be clean and dry enough to maintain the cleanliness of the electrode.

20. Winding Requirements

20.1 Electrodes on spools and in coils (including drums) shall be wound so that kinks, waves, sharp bends, overlapping, or wedging are not encountered, leaving the electrode free to unwind without restriction. The outside end of the electrode (the end with which welding is to begin) shall be identified so it can be readily located and shall be fastened to avoid unwinding.

20.2 The cast and helix of electrode in coils, spools, and drums shall be such that the electrode will feed in

an uninterrupted manner in automatic and semiautomatic equipment.

21. Electrode Identification

21.1 The product information and the precautionary information required in Section 23, Marking of Packages, for marking each package shall also appear on each coil, spool, and drum.

21.2 Coils without support shall have a tag containing this information securely attached to the electrode at the inside end of the coil.

21.3 Coils with support shall have the information securely affixed in a prominent location on the support.

21.4 Spools shall have the information securely affixed in a prominent location on the outside of at least one flange of the spool.

21.5 Drums shall have the information securely affixed in a prominent location on the outside of the drum.

22. Packaging

Electrodes shall be suitably packaged to ensure against damage during shipment and storage under normal conditions.