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An American National Standard

Specification for Carbon Steel Electrodes for Flux Cored Arc Welding



American Welding Society

Key Words — Carbon steel, flux cored electrodes,
flux cored arc welding, arc welding

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Specification for Carbon Steel Electrodes for Flux Cored Arc Welding

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Prepared by
AWS Committee on Filler Metal

Under the Direction of
AWS Technical Activities Committee

Approved by
AWS Board of Directors

Abstract

This specification gives the requirements for classification of carbon steel electrodes used for flux cored arc welding. The requirements include chemical composition and mechanical properties of weld metal and certain usability characteristics. Optional limits on diffusible hydrogen also are included. Requirements for standard sizes, marking, manufacturing and packaging are also included.



American Welding Society

550 N.W. LeJeune Road, Miami, Florida 33126

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Foreword

(This Foreword is not a part of ANSI/AWS A5.20-95, *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*, but is included for information purposes only.)

This is the second revision of A5.20 that was issued initially in 1969. During the nearly quarter of a century since it was developed by a subcommittee of the AWS Committee on Filler Metal, the use of flux cored electrodes has expanded greatly. This growth in the use and application of flux cored electrodes has been stimulated by developments in electrode manufacturing technology that have permitted the production of smaller diameter electrodes and by improvements in formulation of the core ingredients. This revision of A5.20 incorporates these developments and improvements and reflects the present "state of the art" of carbon steel electrodes for flux cored arc welding.

Historical Background

AWS A5.20-69	<i>Specification for Mild Steel Electrodes for</i>
ANSI W3.20-1973	<i>Flux Cored Arc Welding</i>
AWS A5.20-79	<i>Specification for Carbon Steel Electrodes for</i>
	<i>Flux Cored Arc Welding</i>

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, Filler Metal Committee, Technical Services Division, American Welding Society, 550 N.W. LeJeune Road, Miami, Florida 33126.

Official interpretations of any of the technical requirements of this standard may be obtained by sending a request, in writing, to the Managing Director, Technical Services Division, American Welding Society. A formal reply will be issued after it has been reviewed by the appropriate personnel following established procedures.

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Specification for Carbon Steel Electrodes for Flux Cored Arc Welding

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*.²

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.³

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

2. AWS standards can be obtained from the American Welding Society, 550 N. W. LeJeune Road, Miami, Florida 33126.

3. See Section A4, Certification (in the Annex), 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)

c. 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.

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 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*.⁴

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 Figure 1 for chemical analysis of the undiluted weld metal

(2) The groove welds shown in Figures 2A and 2B for mechanical properties and, where required, for soundness of the weld metal (Figure 2A for multiple-pass electrodes and 2B for single-pass electrodes)

(3) the fillet weld shown in Figure 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 Figure 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 Figure 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 Figure 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 (1/2 in. [13 mm] minimum thickness). The electrode size shall be 3/32 in. (2.4 mm) or the size the manufacturer produces closest to 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 Figure 1. Testing of this assembly shall be as specified in Section 9, Chemical Analysis.

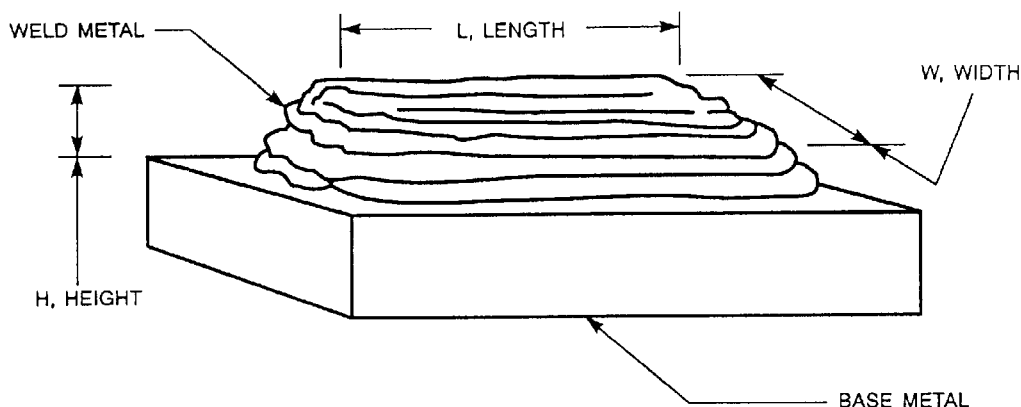
4. ASTM standards can be obtained from the ASTM, 1916 Race Street, Philadelphia, Pennsylvania 19103.

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:

- a. 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.
- b. 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).
- c. Electrodes with supplemental toughness and/or diffusible hydrogen requirements may be further identified as shown in Tables 1 and 8.
- d. Intended for single-pass welding.
- e. Transverse tension test. All others require all-weld-metal tension test.



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.

Figure 1 — Pad for Chemical Analysis of Undiluted Weld Metal**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 Figure 2A. The electrode size shall be 3/32 in. (2.4 mm), or the size the manufacturer produces that is closest to 3/32 in. (2.4 mm), and the welding conditions shall be those listed in Tables 2 and 5 for the classification being tested.

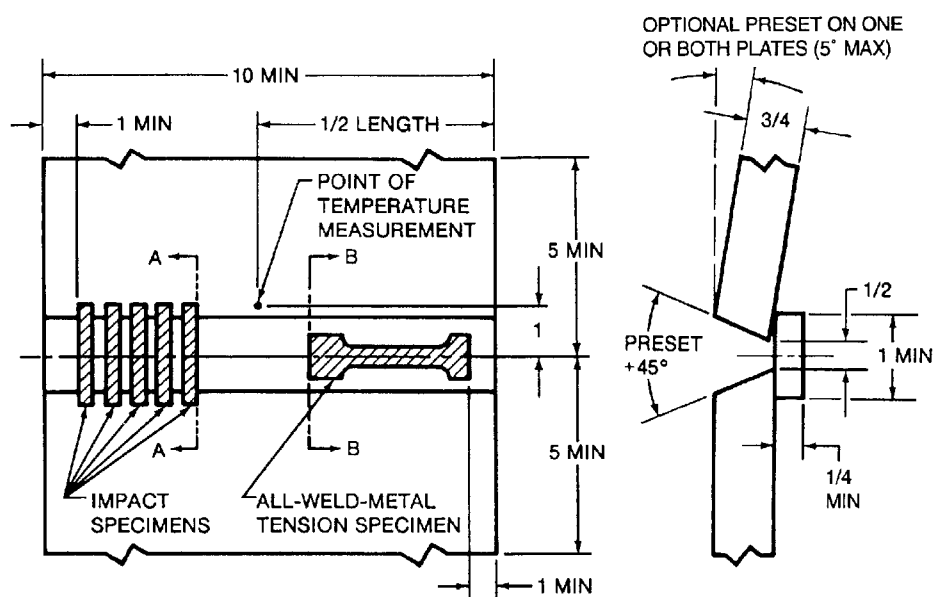
Welding shall be in the flat position and the assembly shall be restrained (or preset) during welding to prevent warpage in excess of 5 degrees. An assembly that is warped more than 5 degrees from plane shall be discarded. It shall not be straightened.

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

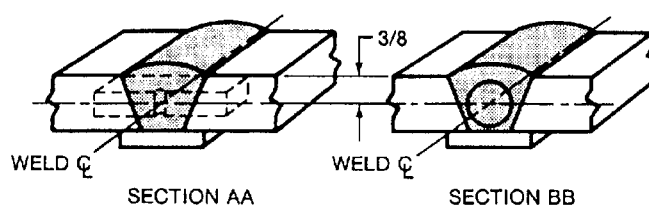
the assembly has reached a temperature of 300 ± 25°F (150 ± 14°C), measured by temperature indicating crayons or surface thermometers at the location shown in Figure 2A. This interpass temperature shall be maintained for the remainder of the weld. Should it be necessary to interrupt welding, the assembly 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, E7XT-10, E7XT-13, E7XT-14, and E7XT-GS, as specified in Table 3), a test assembly using base metal as



(A) TEST PLATE SHOWING LOCATION OF TEST SPECIMENS

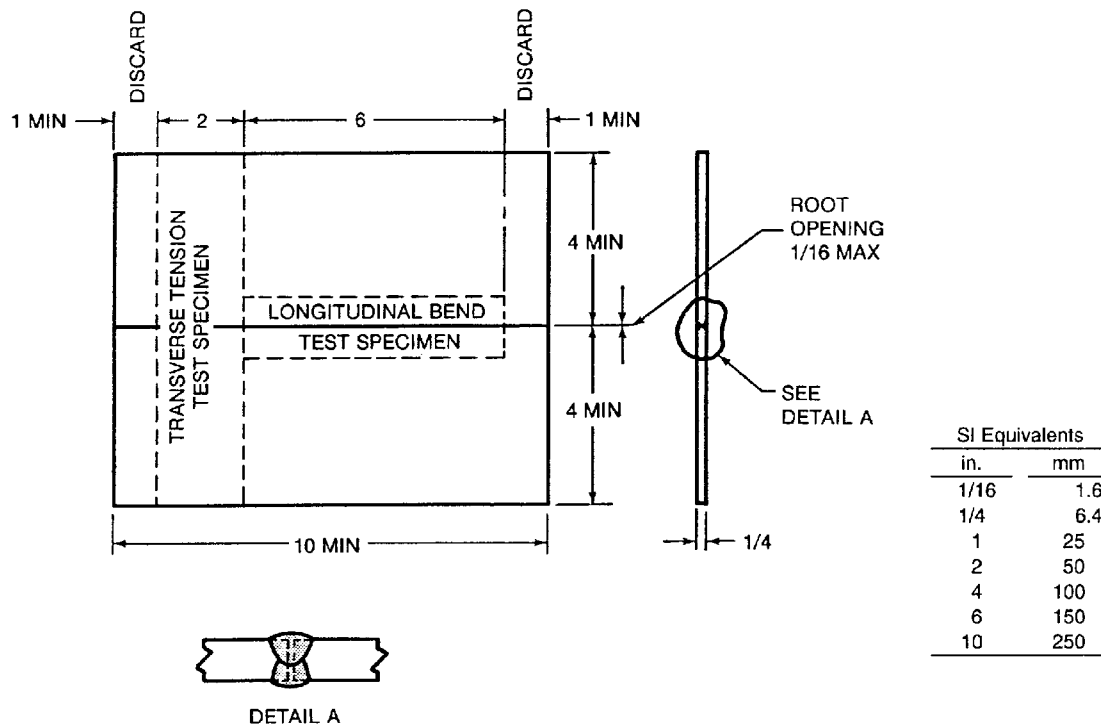
(B) ORIENTATION OF
IMPACT SPECIMEN(C) LOCATION OF ALL-WELD-METAL
TENSION SPECIMEN

SI Equivalents	
in.	mm
1/4	6.4
3/8	9.5
1/2	13
3/4	19
1	25
5	125
10	250

Notes:

1. All dimensions except angles are in inches.
2. Test plate thickness shall be 1/2 in. (13 mm) and maximum root opening shall be 1/4 in. (6.4 mm) for 0.045 in. (1.1 mm) and smaller EXXT-11 electrode classifications.

**Figure 2A — Test Assembly for Mechanical Properties and Soundness
of Weld Metal from Multiple-Pass Electrodes**



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.

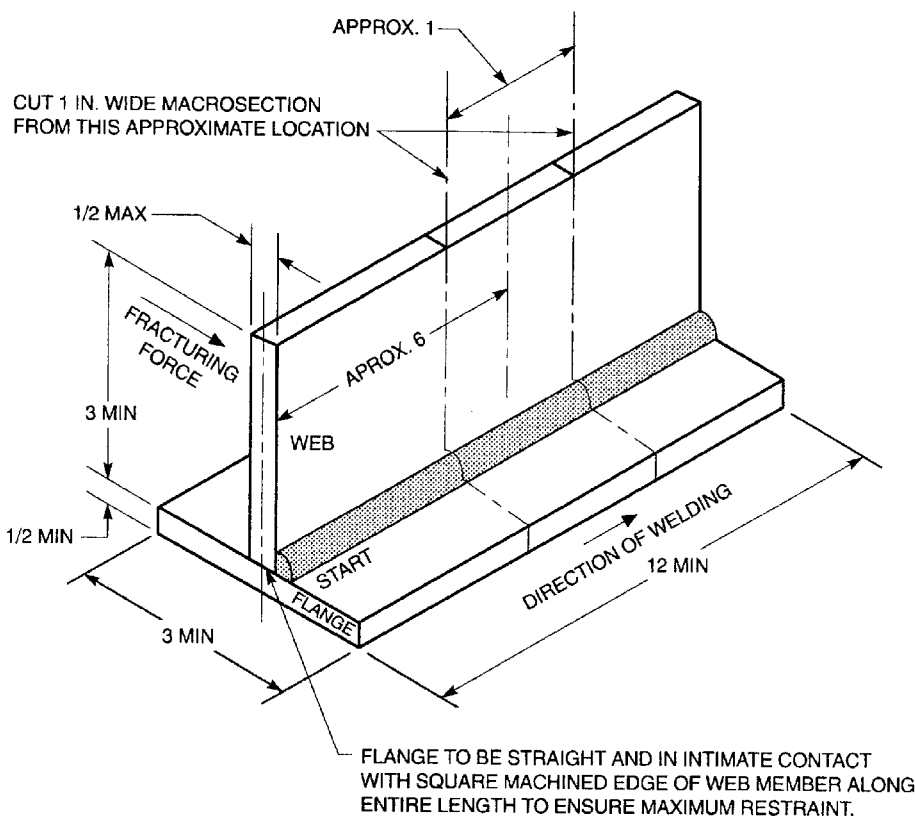
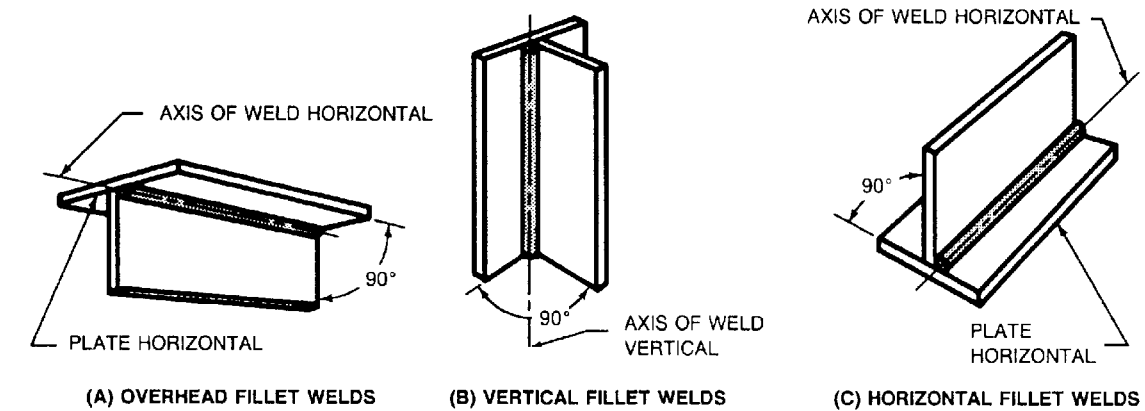
Figure 2B — Test Assembly for Transverse Tension and Longitudinal Guided Bend Tests for Welds Made with Single-Pass Electrodes

specified in Table 4 shall be prepared and welded as shown in Figure 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 Figure 2B. This sequence shall not be interrupted. The electrode size shall be 3/32 in. (2.4 mm) diameter or the size the manufacturer produces that is closest to 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 Figure 3, using base metal of the appropriate type specified in Table 4 for each EXOT-X classification that requires a test assembly welded in the horizontal position. Each EXIT-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 Figure 3. When assembled, the faying surfaces shall 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.



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

Notes:

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.

Figure 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.

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 3/8 in. (9.5 mm). The fillet weld shall be deposited only on one side of the joint as shown in Figure 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 Figure 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 Figure 1, shall be removed and discarded, and a sample for analysis obtained from the underlying metal no closer than 3/8 in. (9.5 mm) to the surface of the base metal in Figure 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 Figure 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 Figure 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 1/64 in. (0.4 mm)

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
E7XT-4 E7XT-6 E7XT-7	7/64	2.8				
	1/8	3.2				
E7XT-8	3/32 ^c	2.4	7–11	1	2	4–6
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).

shall be disregarded. Test assemblies with indications larger than the largest indications permitted in the radiographic standards (Figure 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 Figure 2A, as required in Table 3. The dimensions of the specimen shall be as shown in Figure 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 Figure 2B, as required in Table 3. The dimensions of the specimen shall be as shown in Figure 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 Figure 2B, as required in Table 3. The dimensions of the specimen shall be as shown in Figure 7.

Table 6
Chemical Composition Requirements for Weld Metal

AWS Classifi- cation	UNS Number ^c	Weight Percent ^{a,b}										Copper ^d
		Carbon	Manga- nese	Silicon	Sulfur	Phos- phorus	Chro- mium ^d	Nickel ^d	Molyb- denum ^d	Vana- dium ^d	Alumi- num ^{d,e}	
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	W07604											
E7XT-6	W07606											
E7XT-7	W07607	(f)	1.75	0.60	0.03	0.03	0.20	0.50	0.30	0.08	1.8	0.35
E7XT-8	W07608											
E7XT-11	W07611											
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	W06613											
E7XT-2 } E7XT-2M }	W07602											
E7XT-3	W07603	Not Specified ^h										
E7XT-10	W07610											
E7XT-13	W07613											
E7XT-14	W07614											
EXXT-GS	—											

Notes:

a. The weld metal shall be analyzed for the specific elements for which values are shown in this table.

b. Single values are maximums.

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

d. The analysis of these elements shall be reported only if intentionally added.

e. Applicable to self-shielded electrodes. Electrodes intended for use with gas shielding need not have significant additions of aluminum.

f. The limit of this element is not specified, but the amount shall be determined and reported (see A6.5 in the Annex).

g. The total of all elements listed in this table shall not exceed 5 percent.

h. 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).

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.

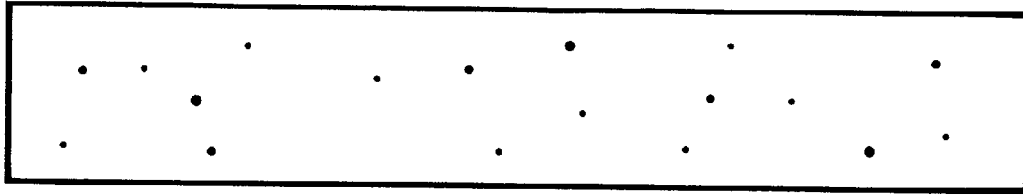
12.3 The specimens shall be tested in the manner described in the bend test section of ANSI/AWS B4.0 on any of the standard bend test jigs shown therein. The bend radius shall be 3/4 in. (19 mm). Positioning of the bend specimen shall be such that the weld face of the last side welded is in tension.

12.4 The specimen, after bending, shall conform to the 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 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 (Figure 8) shall be machined from the test assembly shown in Figure 2A, for those classifications for which impact testing is required in Table 3.

**(A) ASSORTED ROUNDED INDICATIONS**

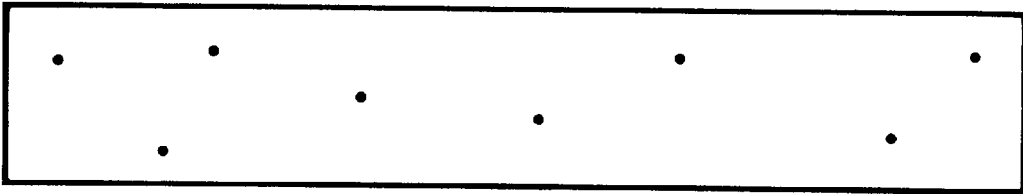
SIZE 1/64 in. (0.4 mm) TO 1/16 in. (1.6 mm) IN DIAMETER OR IN LENGTH.

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.

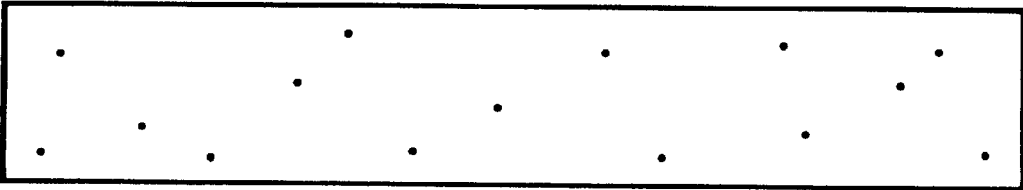
MAXIMUM NUMBER OF MEDIUM 1/32 in. (0.8 mm) TO 3/64 in. (1.2 mm) IN DIAMETER OR IN LENGTH INDICATIONS = 5.

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**

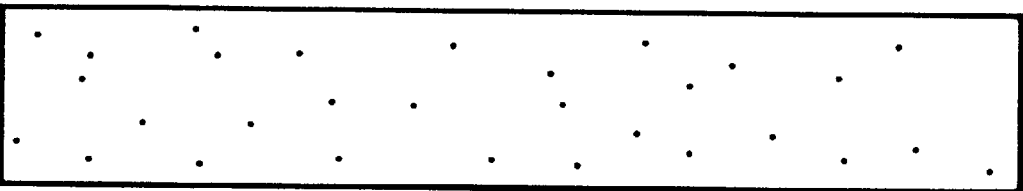
SIZE 3/64 in. (1.2 mm) TO 1/16 in. (1.6 mm) IN DIAMETER OR IN LENGTH.

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**

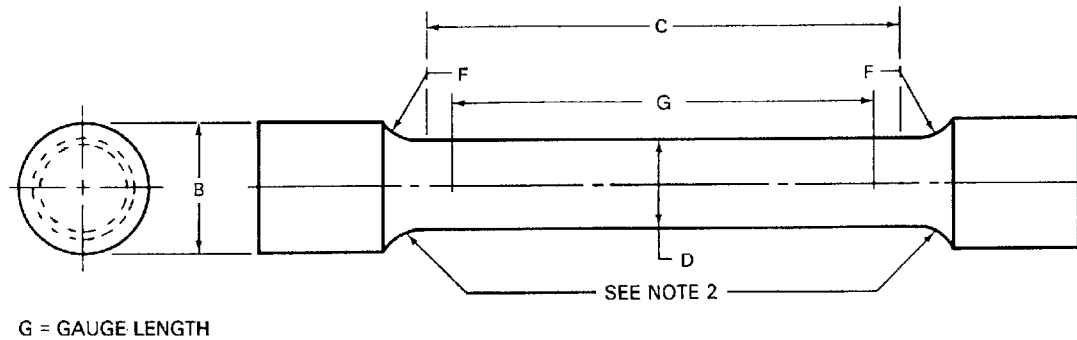
SIZE 1/64 in. (0.4 mm) TO 1/32 in. (0.8 mm) IN DIAMETER OR IN LENGTH.

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.

Figure 4 — Radiographic Standards for Test Assembly in Figure 2A



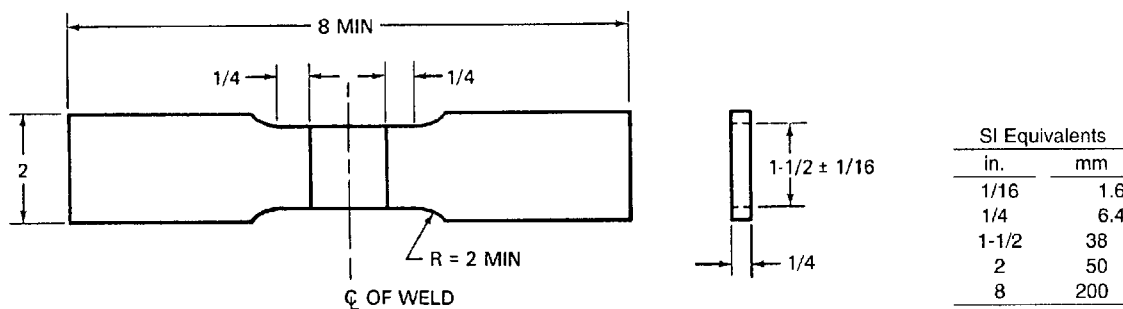
Dimensions of Specimen

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:

1. 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.
2. 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.
3. 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.
4. The surface finish within the C dimension shall be no rougher than 63 μ in. (1.6 μ m).
5. The 0.250 in. (6.4 mm) specimen size shall be used for 0.045 in. (1.1 mm) and smaller EXXT-11 electrodes.

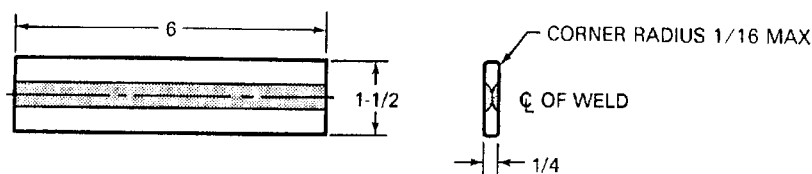
Figure 5 — All-Weld-Metal Tension Test Specimen



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.

Figure 6 — Transverse Tension Test Specimen

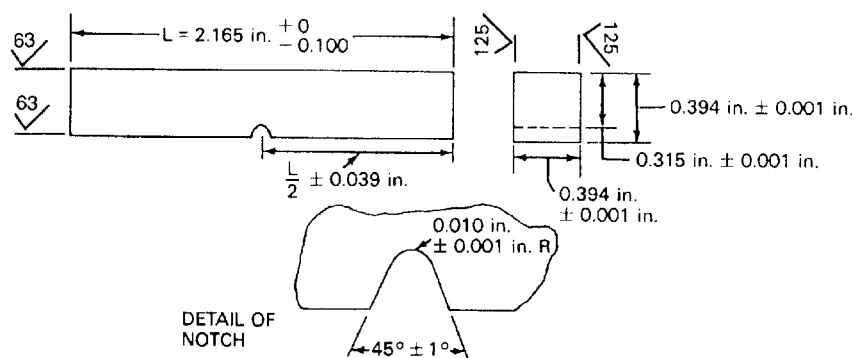


SI Equivalents	
in.	mm
1/16	1.6
1/4	6.4
1-1/2	38
6	150

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.

Figure 7 — Longitudinal Guided Bend Specimen for Welds Made with Single-Pass Electrodes



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 (+).

Figure 8 — Details of Charpy V-Notch Impact Test Specimen

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.

14. Fillet Weld Test

14.1 The required fillet welds shall be made in accordance with 8.5 and Figure 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 Figure 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 Figure 9, and the fillet weld size, fillet weld leg, and convexity of the weld shall be determined to the nearest 1/64 in. (0.4 mm) by actual measurement. These measurements shall meet the requirements specified in 8.5 and Table 7.

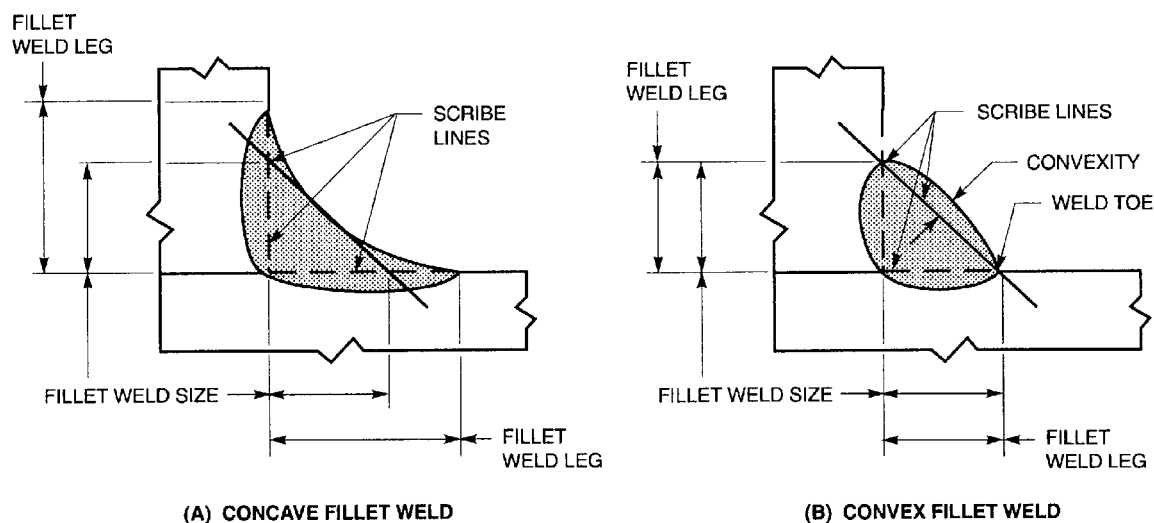
14.3 The remaining two sections of the test assembly shall be broken longitudinally through the fillet weld by a force exerted as shown in Figure 3. When necessary, to facilitate fracture through the fillet, one or more of the following procedures may be used:

(1) A reinforcing bead, as shown in Figure 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 Figure 10(B).

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



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.

Figure 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.

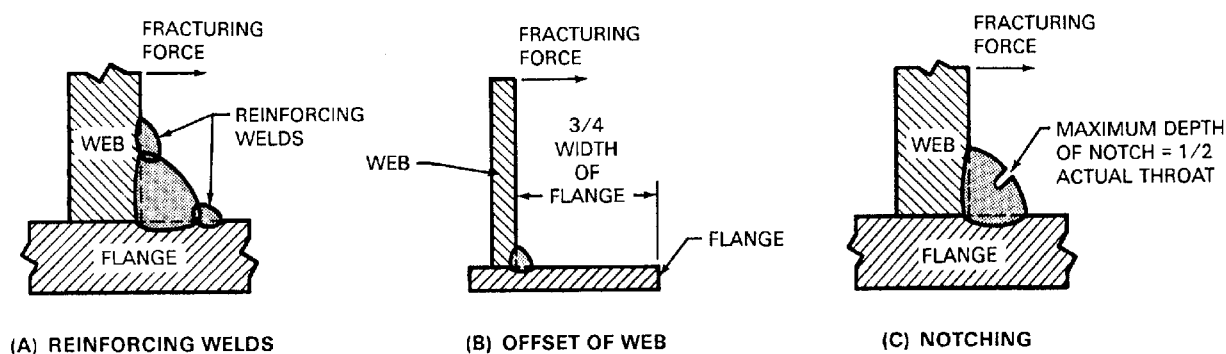


Figure 10 — Alternate Methods for Facilitating Fillet Weld Fracture

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 Figure 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 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.⁵

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

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.⁶ 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.

6. See A8.2.5 in the Annex.

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:

- 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*.
- 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.
- The lower diffusible hydrogen levels (H8 and H4) may not be available in some classifications (see A8.2.9).
- 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.
- 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.

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 Figures 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.

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.

Table 10
Packaging Requirements^a

		Package Size		Net Weight of Electrode ^b	
Type of Package		in.	mm	lb	kg
Coils without Support		(See Note c)		(See Note c)	
Coils with Support (see below)	ID	6-3/4	170	14	6.4
	ID	12	300	25, 30, 50, and 60	11, 14, 23, and 27
Spools	OD	4	100	1-1/2 and 2-1/2	0.7 and 1.1
	OD	8	200	10, 15, and 22	4.5, 6.8, and 10
	OD	12	300	25, 30, 35, and 44	11, 14, 16, and 20
	OD	14	360	50 and 60	23 and 27
	OD	22	560	250	110
	OD	24	610	300	140
	OD	30	760	600 and 750	170 and 340
	OD	15-1/2	400	(See Note c)	
Drums	OD	20	500	(See Note c)	
	OD	21	530	500	225
	OD	23	600	300 and 600	140 and 270

Coils with Support — Standard Dimensions and Weights^a

Electrode Size	Coil Net Weight ^b		Coil Dimensions			
	lb	kg	Inside Diameter of Liner		Width of Wound Electrode, max.	
			in.	mm	in.	mm
All	14	6.4	6-3/4 ± 1/8	170 ± 3	3	75
	25 and 30	11 and 14	12 ± 1/8	305 ± 3	2-1/2 or 4-5/8	65 or 120
	50 and 60	23 and 27	12 ± 1/8	305 ± 3	4-5/8	120

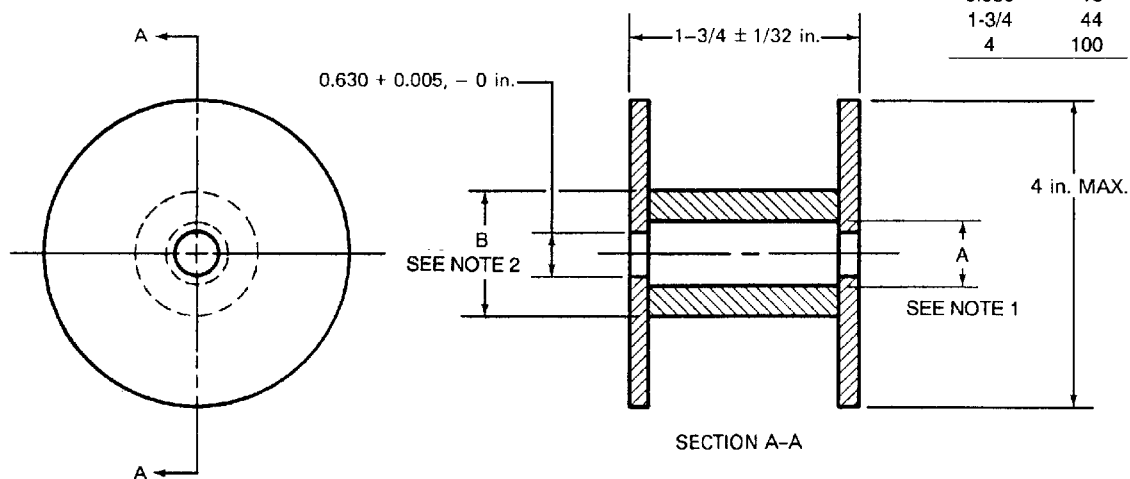
Notes:

a. Sizes and net weights other than those specified may be supplied as agreed between supplier and purchaser.

b. Tolerance on net weight shall be ±10 percent.

c. As agreed between supplier and purchaser.

SI Equivalents	
in.	mm
0.005	0.13
1/32	0.8
0.630	16
1-3/4	44
4	100

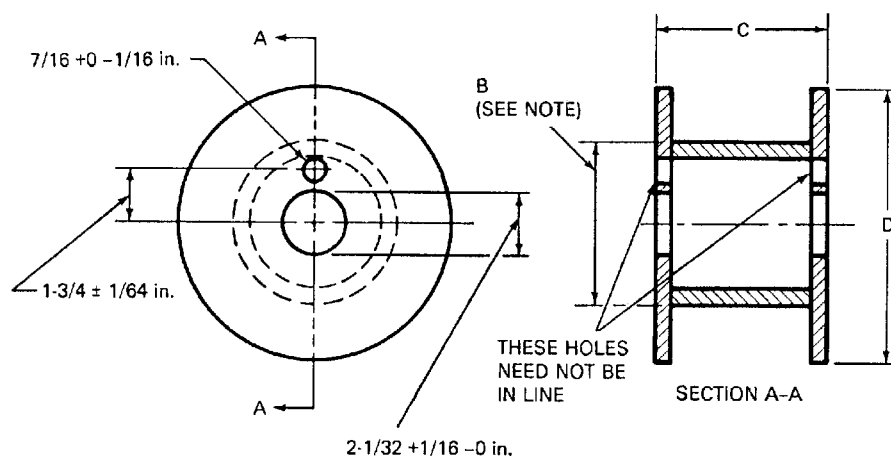


Notes:

1. Dimension A, inside diameter of barrel, shall be such that swelling of the barrel or misalignment of the barrel and flanges will not result in the core of the spool being less than the inside diameter of the flanges.

2. Dimension B, outside diameter of barrel, shall be such as to permit proper feeding of the electrode.

Figure 11 — Dimensions of Standard 4 in. (100 mm) Spool



Spool Size		C Dimension		D Dimension (maximum)		SI Equivalents	
in.	mm	in.	mm	in.	mm	in.	mm
8	200	2-5/32 ± 1/32	55 ± 1	8	205	1/64	0.4
8	200	2-7/8 ± 1/16	75 ± 2	8	205	1/16	1.6
12	300	4 ± 1/16	100 ± 2	12	305	7/16	11
14	350	4 ± 1/16	100 ± 2	14	355	1-3/4	44
						2-1/32	52

Note:

Dimension B, outside diameter of barrel, shall be such as to permit proper feeding of the electrode.

Figure 12 — Dimensions of Standard 8, 12 and 14 in. (200, 300 and 350 mm) Spools

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.

23. Marking of Packages

23.1 The following product information (as a minimum) shall be legibly marked so as to be visible from the outside of each unit package.

- (1) AWS specification and classification designation (year of issue may be excluded)
- (2) Supplier's name and trade designation
- (3) Size and net weight
- (4) Lot, control, or heat number

23.2 The following precautionary information (as a minimum) shall be prominently displayed in legible print on all packages of flux cored electrodes, including individual unit packages enclosed within a larger package:

WARNING:

Protect yourself and others.

Read and understand this information.

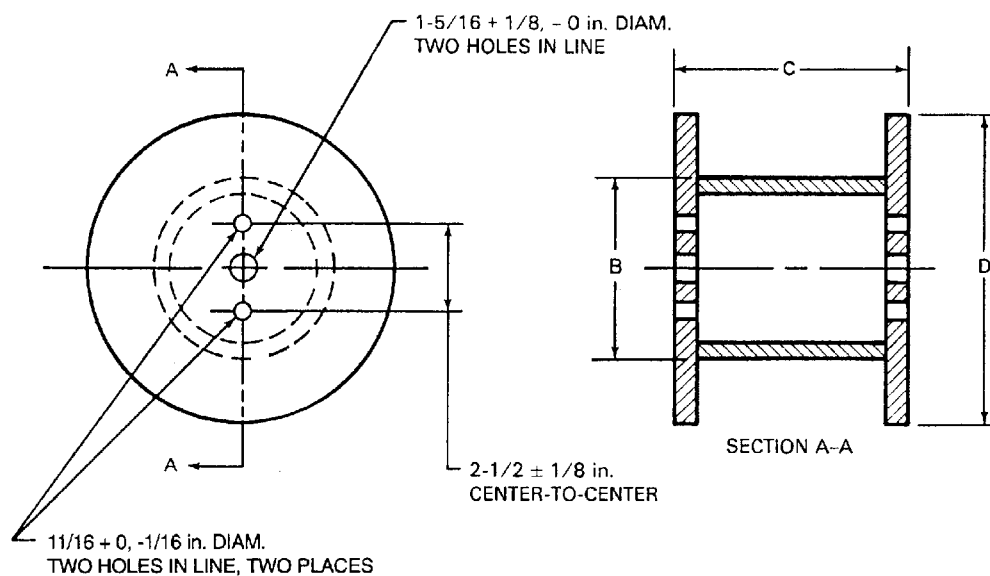
FUMES AND GASES can be dangerous to your health.

ARC RAYS can injure eyes and burn skin.

ELECTRIC SHOCK can kill.

- Before use, read and understand the manufacturer's instructions, the Material Safety Data Sheets (MSDSs), and your employer's safety practices.
- Keep your head out of the fumes.
- Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases away from your breathing zone and the general area.
- Wear correct eye, ear, and body protection.
- Do not touch live electrical parts.
- See American National Standard Z49.1, *Safety in Welding, Cutting, and Allied Processes*, published by the American Welding Society, 550 N.W. LeJeune Road, Miami, Florida 33126; *OSHA Safety and Health Standards*, 29 CFR 1910, available from the U.S. Government Printing Office, Washington, D.C. 20402.

DO NOT REMOVE THIS INFORMATION



Spool Size		D Dimension		Maximum C Dimension		SI Equivalents	
in.	mm	in.	mm	in.	mm	in.	mm
22	560	22 ± 1/2	560 ± 12.7	12	305	1/16	1.6
24	610	24 ± 1/2	610 ± 12.7	13-1/2	345	1/8	3
30	760	30 ± 1/2	760 ± 12.7	13-1/2	345	11/16	18
						1-5/16	33
						2-1/2	63

Note:

Dimension B, outside diameter of barrel, shall be such as to permit proper feeding of the electrode.

Figure 13 — Dimensions of 22, 24 and 30 in. (560, 610, 760 mm) Spools

Annex

Guide to Specification for Carbon Steel Electrodes for Flux Cored Arc Welding

(This annex is not a part of ANSI/AWS A5.20-95, *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*, but is included for information purposes only.)

A1. Introduction

The purpose of this guide is to correlate the electrode classifications with their intended applications so the specification can be used effectively. This guide provides examples rather than complete listings of the materials and applications for which each electrode is suitable.

A2. Classification System

A2.1 The system for identifying the electrode classifications in this specification follows, for the most part, the standard pattern used in other AWS filler metal specifications. An illustration of this system is given in Figure A1.

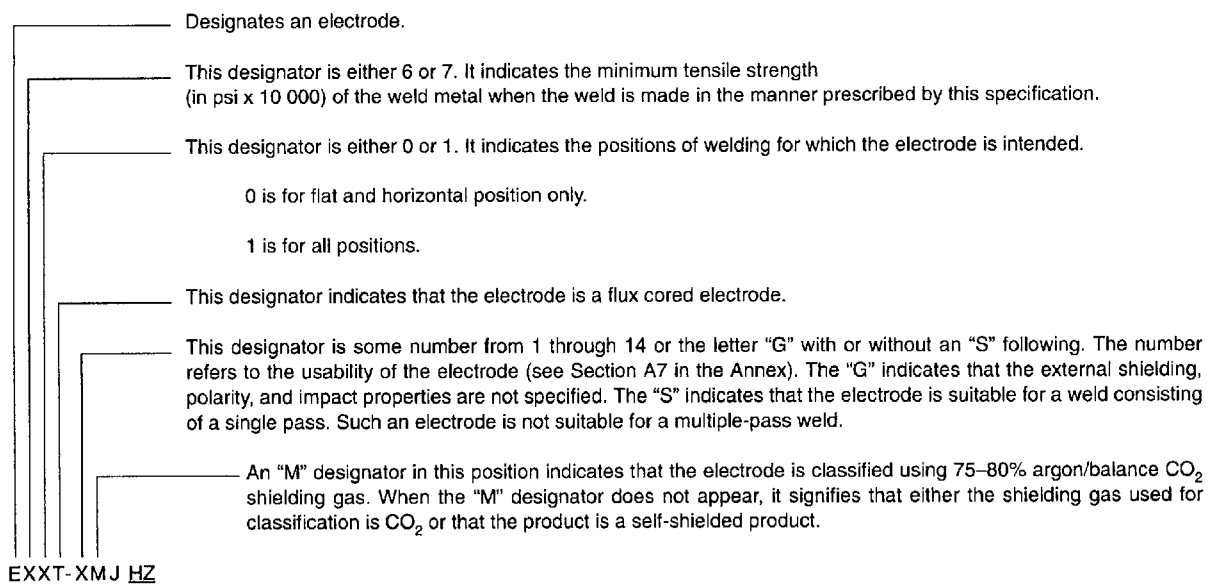
A2.2 Some of the classifications are intended to weld only in the flat and horizontal positions (E70T-5, for example). Others are intended for welding in all positions (E71T-1, for example). As in the case of shielded metal arc electrodes, the smaller sizes of flux cored electrodes are the ones used for the out-of-position work. Flux cored electrodes 5/64 in. (2.0 mm) in diameter and larger usually are used for horizontal fillets and flat position welding.

A2.3 Many of the classifications included in this specification have requirements for impact testing in the as-welded condition as shown in Table 3. In order to include product with improved toughness at lower temperatures, an optional supplemental designator, J, has been added to identify classifications which, when tested, produce weld

metal which exhibits 20 ft-lbf at -40°F (27 J at -40°C). The user is cautioned that although the improved weld metal toughness will be evidenced when welding is performed under conditions similar to the test assembly preparation method specified in this specification, other applications of the electrode, such as long-term postweld heat treatment or vertical up welding with higher heat input, may differ markedly from the improved toughness levels given. The users should always perform their own properties verification testing.

A2.4 "G" Classification

A2.4.1 This specification includes electrodes classified as E6XT-G, E6XT-GS, E7XT-G, and E7XT-GS. The "G" or "GS" indicates that the electrode is of a general classification. It is "general" because not all of the particular requirements specified for each of the other classifications are specified for this classification. The intent, in establishing this classification, is to provide a means by which electrodes that differ in one respect or another (chemical composition, for example) from all other classifications (meaning that the composition of the electrode — in the case of the example — does not meet the composition specified for any of the classifications in the specification) can still be classified according to the specification. The purpose is to allow a useful electrode — one that otherwise would have to await a revision of the specification — to be classified immediately, under the existing specification. This means, then, that two electrodes — each bearing the same "G" classification — may be quite different in some certain respect (chemical composition, again, for example).

Mandatory Classification Designators*Optional Supplemental Designators

- Designates that the electrode meets the requirements of the diffusible hydrogen test (an optional supplemental test of the weld metal with an average value not exceeding "Z" mL of H₂ per 100g of deposited metal where "Z" is 4, 8, or 16). See Table 8, and Annex A8.2.
- Designates that the electrode meets the requirements for improved toughness by meeting a requirement of 20 ft-lbf at -40°F (27J at -40°C). Absence of the "J" indicates normal impact requirements as given in Table 1.

*The combination of these constitutes the electrode classification.

Figure A1 — Classification System for Carbon Steel Flux Cored Electrodes

A2.4.2 The point of difference (although not necessarily the amount of the difference) referred to in A2.4.1 will be readily apparent from the use of the words "not required" and "not specified" in the specification. The use of these words is as follows:

Not Specified is used in those areas of the specification that refer to the results of some particular test. It indicates that the requirements for that test are not specified for that particular classification.

Not Required is used in those areas of the specification that refer to the tests that must be conducted in order to classify an electrode (or a welding material). It indicates that test is not required because the requirements (results) for the test have not been specified for that particular classification. Restating the case, when a requirement is not specified, it is not necessary to conduct the corresponding test in order to classify a electrode to that classification. When purchasers want the information

provided by that test in order to consider a particular product of that classification for a certain application, they will have to arrange for that information with the supplier of the product. They will have to establish with that supplier just what the testing procedure and the acceptance requirements are to be for that test. They may want to incorporate that information (via ANSI/AWS A5.01, *Filler Metal Procurement Guidelines*) in the purchase order.

A2.4.3 When an electrode cannot be classified according to some classification other than a "G" classification, the manufacturer may request that a classification be established for that electrode. This may be done by following the procedure given below. When the manufacturer elects to use the "G" classification, the Filler Metal Committee recommends that they still request that a classification be established for that electrode as long as the electrode is of commercial significance.

A2.4.4 Written requests for establishing a new electrode classification shall provide sufficient detail to permit the Committee or the Subcommittee to decide whether a new classification or the modification of an existing classification is more appropriate, and whether either is necessary to satisfy the need. The request shall state the variables and their limits for such a classification or modification. The request should contain some indication of the time by which completion of the new classification or modification is needed.

A2.4.5 Requests shall be received at AWS Headquarters by the Secretary of the Committee, who will:

- (1) Assign an identifying number to each request. This number shall include the date the request was received.
- (2) Confirm receipt of the request and give the identification number to the person who made the request.
- (3) Send a copy of the request to the Chairman of the Filler Metal Committee and to the Chairman of the particular subcommittee involved.
- (4) File the original request.
- (5) Add outstanding requests to the agenda of meetings of the Committee and the subcommittee.

A3. Acceptance

Acceptance of all welding materials classified under this specification is in accordance with ANSI/AWS A5.01, *Filler Metal Procurement Guidelines*, as the specification states. Any testing a purchaser requires of the supplier, for material shipped in accordance with this specification, shall be clearly stated in the purchase order, according to the provisions of ANSI/AWS A5.01. In the absence of any such statement in the purchase order, the supplier may ship the material with whatever testing is normally conducted on material of that classification, as specified in Schedule F, Table 1, of the ANSI/AWS A5.01. Testing in accordance with any other schedule in that table must be specifically required by the purchase order. In such cases, acceptance of the material shipped will be in accordance with those requirements.

A4. Certification

The act of placing the AWS specification and classification designations on the packaging enclosing the product, or the classification on the product itself, constitutes the supplier's (manufacturer's) certification that the product meets all of the requirements of the specification.

The only testing requirement implicit in this certification is that the manufacturer has actually conducted the tests required by the specification on material that is rep-

resentative of that being shipped, and that the material met the requirements of the specification. Representative material, in this case, is any production run of that classification using the same formulation. "Certification" is not to be construed to mean that tests of any kind were necessarily conducted on samples of the specific material shipped. Tests on such material may or may not have been conducted. The basis for the certification required by the specification is the classification test of "representative material" cited above, and the "Manufacturer's Quality Assurance System" in ANSI/AWS A5.01.

A5. Ventilation During Welding

A5.1 Five major factors govern the quantity of fumes in the atmosphere to which welders and welding operators are exposed during welding:

- (1) Dimensions of the space in which welding is done (with special regard to the height of the ceiling)
- (2) Number of welders and welding operators working in that space
- (3) Rate of evolution of fumes, gases, or dust, according to the materials and processes used
- (4) The proximity of the welders or welding operators to the fumes as the fumes issue from the welding zone, and to the gases and dusts in the space in which they are working
- (5) The ventilation provided to the space in which the welding is done

A5.2 American National Standard Z49.1, *Safety in Welding, Cutting, and Allied Processes* (published by the American Welding Society), discusses the ventilation that is required during welding and should be referred to for details. Attention is drawn particularly to the section of that document entitled Protection of Personnel and the General Area and Ventilation.

A6. Welding Considerations

A6.1 When examining the properties required of weld metal as a result of the tests made according to this specification, it should be recognized that in production, where the conditions and procedures may differ from those in this specification (electrode size, amperage, voltage, type and amount of shielding gas, position of welding, electrode extension, plate thickness, joint geometry, preheat and interpass temperatures, travel speed, surface condition, base-metal composition and dilution, for example), the properties of the weld metal may also differ. Moreover, these differences may be large or small.

A6.2 Since it has not been possible to specify one single detailed welding procedure for all products classified

under any given classification in this specification, details of the welding procedure used in classifying each product should be recorded by the manufacturer and made available to the user, on request. The information should include each of the items referred to in A6.1, as well as the actual number of passes and layers required to complete the weld test assembly.

A6.3 The toughness requirements for the different classifications in this specification can be used as a guide in the selection of electrodes for applications requiring some degree of low temperature notch toughness. For an electrode of any given classification, there can be a considerable difference between the impact test results from one assembly to another, or even from one impact specimen to another, unless particular attention is given to the manner in which the weld is made and the test specimens are prepared (even the location and orientation of the specimen within the weld), the temperature of testing, and the operation of the testing machine.

A6.4 In Table 2, some electrodes are listed as suitable for single- and multiple-pass welds, while others are said to be suitable only for single-pass welds. For more information concerning this, see Section A7, Description and Intended Use of Flux Cored Electrodes.

A6.5 Hardenability. There are inherent differences in the effect of the carbon content of the weld deposit on hardenability, depending on whether the electrode was gas-shielded or self-shielded. Gas shielded electrodes generally employ a Mn-Si deoxidation system. The carbon content affects hardness in a manner which is typical of many carbon equivalent formulas published for carbon steel.

Most self-shielded electrodes utilize an aluminum-based alloy system to provide for protection and deoxidation. One of the effects of the aluminum is to modify the effect of carbon on hardenability. Hardness levels obtained with self-shielded electrodes will therefore be lower than the carbon content would indicate (when considered on the basis of typical carbon equivalent formulas).

A7. Description and Intended Use of Flux Cored Electrodes

This specification contains many different classifications of flux cored electrodes. The suffix in each classification (1 through 14, G and GS), indicates a general grouping of electrodes that contain similar flux or core components and which have similar usability characteristics. Some classifications (Table 2) are listed as being suitable for multiple- and single-pass welding, while others are said to be suitable only for single-pass weld-

ing. An electrode that is suitable for multiple-pass welding may also be suitable for a single pass welding.

The user should understand that the classifications listed for single-pass welding are more highly deoxidizing and can be used on base metals that have some rust or mill scale. When these electrodes are used for more than a single pass, these deoxidizers can build up as alloying elements and act to increase the strength and hardness of the weld metal. These same effects will also be observed when an electrode classified with CO₂ shielding gas is used with a less reactive gas (argon or combinations containing argon, for example).

A7.1 EXXT-1 and EXXT-1M Classifications. Electrodes of the EXXT-1 group are classified with CO₂ shielding gas. However, other gas mixtures (such as argon-CO₂) may be used to improve the arc characteristics, especially for out-of-position work, when recommended by the manufacturer. Increasing the amount of argon in the argon-CO₂ mixture will increase the manganese and silicon contents in the weld metal. The increase in manganese and silicon will increase the yield and tensile strengths and may affect impact properties.

Electrodes of the EXXT-1M group are classified with 75-80% argon/balance CO₂ shielding gas. Their use with argon/CO₂ shielding gas mixtures having reduced amounts of argon or with CO₂ shielding gas may result in some deterioration of arc characteristics and out-of-position welding characteristics. In addition, a reduction of the manganese and silicon contents in the weld will reduce yield and tensile strengths and may affect impact properties.

Both the EXXT-1 and EXXT-1M electrodes are designed for single- and multiple- pass welding using DCEP polarity. The larger diameters (usually 5/64 in. [2.0 mm] and larger) are used for welding in the flat position and for welding fillet welds in the horizontal position (EX0T-1 and EX0T-1M). The smaller diameters (usually 1/16 in. [1.6 mm] and smaller) are generally used for welding in all positions (EX1T-1 and EX1T-1M). The EXXT-1 and EXXT-1M electrodes are characterized by a spray transfer, low spatter loss, flat to slightly convex bead contour, and a moderate volume of slag which completely covers the weld bead. Most electrodes of this classification have a rutile base slag and produce high deposition rates.

A7.2 EXXT-2 and EXXT-2M Classifications. Electrodes of these classifications are essentially EXXT-1 and EXXT-1M with higher manganese or silicon, or both, and are designed primarily for single-pass welding in the flat position and for welding fillet welds in the horizontal position. The higher levels of deoxidizers in these classifications allow single-pass welding of heavily oxidized or rimmed steel.

Weld metal composition requirements are not specified for single-pass electrodes, since checking the composition of the undiluted weld metal will not provide an indication of the composition of a single-pass weld. These electrodes give good mechanical properties in single-pass welds.

The manganese content and the tensile strength of the weld metal of multiple-pass welds made with EXXT-2 and EXXT-2M electrodes will be high. These electrodes can be used for welding base metals which have heavier mill scale, rust, or other foreign matter that cannot be tolerated by some electrodes of the EXXT-1 or EXXT-1M classifications. The arc transfer, welding characteristics and deposition rates of these electrodes are similar to those of the EXXT-1 or EXXT-1M classifications (see A7.1).

A7.3 EXXT-3 Classification. Electrodes of this classification are self-shielded, used on DCEP, and have a spray-type transfer. The slag system is designed to make very high welding speeds possible. The electrodes are used for single-pass welds in the flat, horizontal, and vertical (up to 20 degree incline) positions (downward progression) on sheet metal. Since these electrodes are sensitive to the effects of base-metal quenching, they are not generally recommended for the following:

- (1) T- or lap joints in materials thicker than 3/16 in. (4.8 mm)
- (2) Butt, edge, or corner joints in materials thicker than 1/4 in. (6.4 mm)

The electrode manufacturer should be consulted for specific recommendations.

A7.4 EXXT-4 Classification. Electrodes of this classification are self-shielded, operate on DCEP, and have a globular-type transfer. The slag system is designed to make very high deposition rates possible and to produce a weld that is very low in sulphur, which makes the weld very resistant to hot cracking. These electrodes are designed for low penetration beyond the root of the weld, enabling them to be used on joints which have been poorly fit, and for single- and multiple-pass welding.

A7.5 EXXT-5 and EXXT-5M Classifications. Electrodes of the EXXT-5 classification are designed to be used with CO₂ shielding gas; however, as with the EXXT-1 classification, argon-CO₂ mixtures may be used to reduce spatter. Electrodes of the EXXT-5M classification are designed for use with 75-80% argon/balance CO₂ shielding gas. Electrodes of the EXOT-5 and EXOT-5M classifications are used primarily for single and multiple-pass welds in the flat position and for welding fillet welds in the horizontal position. These electrodes are characterized by a globular transfer, slightly convex bead contour, and a thin slag that may not completely cover the weld bead. These electrodes have a

lime-fluoride base slag. Weld deposits produced by these electrodes typically have impact properties and hot and cold crack resistance that are superior to those obtained with rutile base slags. The EXIT-5 and EXIT-5M electrodes, using DCEN, can be used for welding in all positions. However, the operator appeal of these electrodes is not as good as those with rutile base slags.

A7.6 EXXT-6 Classification. Electrodes of this classification are self-shielded, operate on DCEP, and have a spray-type transfer. The slag system is designed to give good low-temperature impact properties, good penetration into the root of the weld, and excellent slag removal, even in a deep groove. These electrodes are used for single and multiple-pass welding in flat and horizontal positions.

A7.7 EXXT-7 Classification. Electrodes of this classification are self-shielded, operate on DCEN, and have a small droplet transfer to a spray-type transfer. The slag system is designed to allow the larger sizes to be used for high deposition rates in the horizontal and flat positions, and to allow the smaller sizes to be used for all welding positions. The electrodes are used for single- and multiple-pass welding and produce very low sulphur weld metal which is very resistant to cracking.

A7.8 EXXT-8 Classification. Electrodes of this classification are self-shielding, operate on dcen, and have a small droplet or spray-type transfer. The electrodes are suitable for all welding positions and the weld metal has very good low temperature notch toughness and crack resistance. The electrodes are used for single- and multiple-pass welds.

A7.9 EXXT-9 and EXXT-9M Classifications. Electrodes of the EXXT-9 group are classified with CO₂ shielding gas. However, gas mixtures of argon-CO₂ are sometimes used to improve usability, especially for out-of-position applications. Increasing the amount of argon in the argon-CO₂ mixture will affect the weld metal analysis and mechanical properties of weld metal deposited by these electrodes, just as it will for weld metal deposited by EXXT-1 and EXXT-1M electrodes (see A7.1).

Electrodes of the EXXT-9M group are classified with a 75-80% argon/balance CO₂ shielding gas. Their use with argon/CO₂ shielding gas mixtures having reduced amounts of argon, or with CO₂ shielding gas, may result in some deterioration of arc characteristics and out-of-position welding characteristics. In addition, a reduction of the manganese and silicon contents in the weld will result, which will have some effect on properties of weld metal from these electrodes, just as it will on properties of weld metal deposited by EXXT-1 and EXXT-1M electrodes (see A7.1).

Both the EXXT-9 and EXXT-9M electrodes are designed for single- and multiple- pass welding. The larger diameters (usually 5/64 in. [2.0 mm] and larger) are used for welding in the flat position and for welding fillet welds in the horizontal position. The smaller diameters (usually 1/16 in. [1.6 mm] and smaller) are often used for welding in all positions.

The arc transfer, welding characteristics, and deposition rates of the EXXT-9 and EXXT-9M electrodes are similar to those of the EXXT-1 or EXXT-1M classifications (see A7.1). EXXT-9 and EXXT-9M electrodes are essentially EXXT-1 and EXXT-1M electrodes that deposit weld metal with improved impact properties.

Some electrodes in this classification require that joints be relatively clean and free of oil, excessive oxide, and scale in order that welds of radiographic quality can be obtained.

A7.10 EXXT-10 Classification. Electrodes of this classification are self-shielded, operate on DCEN, and have a small droplet transfer. The electrodes are used for single-pass welds at high travel speeds on material of any thickness in the flat, horizontal, and vertical (up to 20 degree incline) positions.

A7.11 EXXT-11 Classification. Electrodes of this classification are self-shielded, operate on DCEN, and have a smooth spray-type transfer. They are general purpose electrodes for single- and multiple-pass welding in all positions. Their use is generally not recommended on thicknesses greater than 3/4 in. (19 mm) unless preheat and interpass temperature control are maintained. The electrode manufacturer should be consulted for specific recommendations.

A7.12 EXXT-12 and EXXT-12M Classifications. Electrodes of these classifications are essentially EXXT-1 and EXXT-1M electrodes which have been modified to improve impact toughness and to meet the lower manganese requirements of the A-1 Analysis Group in the ASME *Boiler and Pressure Vessel Code*, Section IX. They, therefore, have an accompanying decrease in tensile strength and hardness. Since welding procedures influence all weld metal properties, users are urged to check hardness on any application where a required hardness level is a requirement.

The arc transfer, welding characteristics, and deposition rates of the EXXT-12 and EXXT-12M electrodes are similar to those of the EXXT-1 and EXXT-1M classifications (see A7.1).

A7.13 EXXT-13 Classification. Electrodes of this classification are self-shielded and operate on DCEN, and are usually welded with a short-arc transfer. The slag system is designed so that these electrodes can be used in all positions for the root pass on circumferential pipe

welds. The electrodes can be used on all pipe wall thicknesses, but are only recommended for the first pass. They generally are not recommended for multiple-pass welding.

A7.14 EXXT-14 Classification. Electrodes of this classification are self-shielded, operate on DCEN, and have a smooth spray-type transfer. The slag system is designed with characteristics so that these electrodes can be used to weld in all positions and also to make welds at high speed. They are used to make welds on sheet metal up to 3/16 in. (4.8 mm) thick, and often are specifically designed for galvanized, aluminized, or other coated steels. Since these welding electrodes are sensitive to the effects of base-metal quenching, they are not generally recommended for the following:

(1) T- or lap joints in materials thicker than 3/16 in. (4.8 mm)

(2) Butt, edge, or corner joints in materials thicker than 1/4 in. (6.4 mm)

The electrode manufacturer should be consulted for specific recommendations.

A7.15 EXXT-G Classification. This classification is for multiple-pass electrodes that are not covered by any presently defined classification. Except for chemical requirements to assure a carbon steel deposit and the tensile strength, which is specified, the requirements for this classification are not specified. They are those that are agreed to by the purchaser and the supplier.

A7.16 EXXT-GS Classification. This classification is for single-pass electrodes that are not covered by any presently defined classification. Except for the tensile strength, which is specified, the requirements for this classification are not specified; they are agreed upon by the purchaser and supplier.

A8. Special Tests

A8.1 It is recognized that supplementary tests may need to be conducted to determine the suitability of these welding electrodes for applications involving properties such as hardness, corrosion resistance, mechanical properties at higher or lower service temperatures, wear resistance, and suitability for welding combinations of dissimilar metals. Supplemental requirements as agreed between purchaser and supplier may be added to the purchase order following the guidance of ANSI/AWS A5.01.

A8.2 Diffusible Hydrogen Test

A8.2.1 Hydrogen-induced cracking of weld metal or the heat-affected zone generally is not a problem with carbon steels containing 0.3% or less carbon, nor with lower

strength alloy steels. However, the electrodes classified in this specification are sometimes used to join higher carbon steels or low alloy, high-strength steels where hydrogen-induced cracking may be a serious problem.

A8.2.2 Flux cored arc welding is generally considered to be a low-hydrogen welding process. However, as the weld metal or heat-affected zone strength or hardness increases, the concentration of diffusible hydrogen that will cause cracking under given conditions of restraint and heat input becomes lower. It may be appropriate to evaluate the diffusible hydrogen produced during welding with a flux cored electrode.

A8.2.3 This specification has, therefore, included the use of optional designators for diffusible hydrogen (see Table 8) to indicate the maximum average value obtained under a clearly defined test condition. An optional supplemental designator "HZ" following the mandatory classification designation, if used, indicates an average diffusible hydrogen content of not more than "Z" ml/100 g of deposited metal when tested in the "as-received" condition 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*. Electrodes that are designated as meeting the lower or lowest hydrogen limits, as specified in Table 8, are also understood to be able to meet any higher hydrogen limits even though these are not necessarily designated along with the electrode classification. Therefore, as an example, an electrode designated as "H4" also meets "H8" and "H16" requirements without being designated as such. See Section 15, Diffusible Hydrogen Test, and Table 8.

A8.2.4 The user of this information is cautioned that actual fabrication conditions may result in different diffusible hydrogen values than those indicated by the designator.

A8.2.5 The use of a reference atmospheric condition during welding is necessitated because the arc is subject to atmospheric contamination when using either self-shielded or gas shielded flux cored electrodes. Moisture from the air, distinct from that in the electrode, can enter the arc and subsequently the weld pool, contributing to the resulting observed diffusible hydrogen. This effect can be minimized by maintaining as short an arc length as possible consistent with a steady arc. Experience has shown that the effect of arc length is minor at the H16 level, but can be very significant at the H4 level. An electrode meeting the H4 requirements under the reference atmospheric conditions may not do so under conditions of high humidity at the time of welding, especially if a long arc length is maintained.

A8.2.6 Electrode extension also affects diffusible hydrogen with flux cored electrodes. In general, a longer electrode extension will preheat the electrode more, which causes some removal of hydrogen-bearing compounds (moisture and lubricants) before they reach the arc. The result of longer electrode extension can be reduced diffusible hydrogen. However, excessive electrode extension with external gas shielded electrodes may cause some loss of gas shielding unless the contact tip is recessed in the gas cup. If the gas shielding is disturbed, more air may enter the arc and increase the diffusible hydrogen. This may also cause porosity due to nitrogen pickup.

A8.2.7 The reader is cautioned that the shielding gas itself can contribute significantly to diffusible hydrogen. Normally, welding grade shielding gases are intended to have very low dew points and very low impurity levels. This, however, is not always the case. Instances have occurred where a contaminated gas cylinder resulted in a significant increase of diffusible hydrogen in the weld metal. In case of doubt, a check of gas dew point is suggested. A dew point of -40°F (-40°C) or lower is considered satisfactory for most applications.

A8.2.8 Some flux cored electrodes can absorb significant moisture if stored in a humid environment in damaged or open packages, or especially if unprotected for long periods of time. In the worst cases of high humidity, even overnight exposure of unprotected electrodes can lead to a significant increase of diffusible hydrogen. In the event the electrode has been exposed, the manufacturer should be consulted regarding probable damage to low-hydrogen characteristics and possible reconditioning of the electrodes.

A8.2.9 Not all flux cored electrode classifications may be available in the H16, H8, or H4 diffusible hydrogen levels. The manufacturer of a given electrode should be consulted for availability of products meeting these limits.

A8.3 Aging of Tensile Specimens. Weld metals may contain significant quantities of hydrogen for some time after they have been made. Most of this hydrogen gradually escapes over time. This may take several weeks at room temperature or several hours at elevated temperatures. As a result of this eventual change in hydrogen level, ductility of the weld metal increases towards its inherent value, while yield, tensile, and impact strengths remain relatively unchanged. This specification permits the aging of the tensile test specimens at elevated temperatures up to 220°F for up to 48 hours before subjecting them to tension testing. The purpose of this treatment is to facilitate removal of hydrogen from the test specimen in order to minimize discrepancies in testing.

Aging treatments are sometimes used for low-hydrogen electrode deposits, especially when testing high-strength deposits. Note that aging may involve holding test specimens at room temperature for several days or holding at a higher temperature for a shorter period of time. Consequently, users are cautioned to employ adequate preheat and interpass temperatures to avoid the deleterious effects of hydrogen in production welds.

A9. Safety Considerations

A9.1 Burn Protection. Molten metal, sparks, slag, and hot work surfaces are produced by welding, cutting, and allied processes. These can cause burns if precautionary measures are not used. Workers should wear protective clothing made of fire-resistant material. Pant cuffs, open pockets, or other places on clothing that can catch and retain molten metal or sparks should not be worn. High-top shoes or leather leggings and fire-resistant gloves should be worn. Pant legs should be worn over the outside of high-top shoes. Helmets or hand shields that provide protection for the face, neck, and ears, and a protective head covering should be used. In addition, appropriate eye protection should be used.

When welding overhead or in confined spaces, ear plugs to prevent weld spatter from entering the ear canal should be worn in combination with goggles, or the equivalent, to give added eye protection. Clothing should be kept free of grease and oil. Combustible materials should not be carried in pockets. If any combustible substance has been spilled on clothing, a change to clean, fire-resistant clothing should be made before working with open arcs or flames. Aprons, cape sleeves, leggings, and shoulder covers with bibs designed for welding service should be used.

Where welding or cutting of unusually thick base metal is involved, sheet metal shields should be used for extra protection. Mechanization of highly hazardous processes or jobs should be considered. Other personnel in the work area should be protected by the use of noncombustible screens or by the use of appropriate protection as described in the previous paragraph.

Before leaving a work area, hot work pieces should be marked to alert other persons of this hazard. No attempt should be made to repair or disconnect electrical equipment when it is under load; disconnection under load produces arcing of the contacts and may cause burns or shock, or both. (Note: Burns can be caused by touching hot equipment such as electrode holders, tips, and nozzles. Therefore, insulated gloves should be worn when these items are handled, unless an adequate cooling period has been allowed before touching.)

The following references are for more detailed information on personal protection:

(1) American National Standards Institute. *Practice for Occupational and Educational Eye and Face Protection*, ANSI/ASC Z87.1. New York: American National Standards Institute.⁷

(2) American National Standards Institute. *Safety-Toe Footwear*, ANSI/ASC Z41.1. New York: American National Standards Institute.

(3) American Welding Society. *Safety in Welding, Cutting, and Allied Processes*, ANSI/ASC Z49.1. Miami, FL: American Welding Society.⁸

(4) OSHA, *Code of Federal Regulations*, Title 29 — Labor, Chapter XVII, Part 1910. Washington, D.C.: U.S. Government Printing Office.⁹

A9.2 Electrical Hazards. Electric shock can kill. However, it can be avoided. Live electrical parts should not be touched. The manufacturer's instructions and recommended safe practices should be read and understood. Faulty installation, improper grounding, and incorrect operation and maintenance of electrical equipment are all sources of danger.

All electrical equipment and workpieces should be grounded. The workpiece lead is not a ground lead; it is used only to complete the welding circuit. A separate connection is required to ground the workpiece.

The correct cable size should be used since sustained overloading will cause cable failure and can result in possible electrical shock or fire hazard. All electrical connections should be tight, clean, and dry. Poor connections can overheat and even melt. Further, they can produce dangerous arcs and sparks. Water, grease, or dirt should not be allowed to accumulate on plugs, sockets, or electrical units. Moisture can conduct electricity. To prevent shock, the work area, equipment, and clothing should be kept dry at all times. Welders should wear dry gloves and rubber-soled shoes, or stand on a dry board or insulated platform. Cables and connections should be kept in good condition. Improper or worn electrical connections may create conditions that could cause electrical shock or short circuits. Worn, damaged, or bare cables should not be used. Open circuit voltage should be avoided. When several welders are working with arcs of different polarities, or when a number of alternating current machines are being used, the open circuit voltages

7. ANSI standards may be obtained from the American National Standards Institute, 11 West 42 Street, New York, NY 10036.

8. AWS standards may be obtained from the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

9. OSHA standards may be obtained from the U.S. Government Printing Office, Washington, D.C. 20402.

can be additive. The added voltages increase the severity of the shock hazard.

In case of electric shock, the power should be turned off. If the rescuer must resort to pulling the victim from the live contact, nonconducting materials should be used. If the victim is not breathing, cardiopulmonary resuscitation (CPR) should be administered as soon as contact with the electrical source is broken. A physician should be called and CPR continued until breathing has been restored, or until a physician has arrived. Electrical burns are treated as thermal burns; that is, clean, cold (iced) compresses should be applied. Contamination should be avoided; the area should be covered with a clean, dry dressing; and the patient should be transported to medical assistance.

Recognized safety standards such as ANSI/ASC Z49.1 and NFPA No. 70, *The National Electrical Code* should be followed.¹⁰

A9.3 Fumes and Gases. Many welding, cutting, and allied processes produce fumes and gases which may be harmful to health. Fumes are solid particles which originate from welding electrodes and fluxes, the base metal, and any coatings present on the base metal. Gases are produced during the welding process or may be produced by the effects of process radiation on the surrounding environment. Management, welders, and other personnel should be aware of the effects of these fumes and gases. The amount and composition of these fumes and gases depend upon the composition of the electrode and base metal, welding process, current level, arc length, and other factors.

The possible effects of overexposure range from irritation of eyes, skin, and respiratory system to more severe complications. Effects may occur immediately or at some later time. Fumes can cause symptoms such as nausea, headaches, dizziness, and metal fume fever. The possibility of more serious health effects exists when especially toxic materials are involved. In confined spaces, the shielding gases and fumes might displace breathing air and cause asphyxiation. One's head should always be kept out of the fumes. Sufficient ventilation, exhaust at the arc, or both, should be used to keep fumes and gases from your breathing zone and the general area.

In some cases, natural air movement will provide enough ventilation. Where ventilation may be questionable, air sampling should be used to determine if corrective measures should be applied.

More detailed information on fumes and gases produced by the various welding processes may be found in the following:

(1) The permissible exposure limits required by OSHA can be found in *Code of Federal Regulations*, Title 29 — Labor, Chapter XVII, Part 1910.

(2) The recommended threshold limit values for these fumes and gases may be found in *Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment* published by the American Conference of Governmental Industrial Hygienists (ACGIH).¹¹

(3) The results of an AWS-funded study are available in a report entitled, *Fumes and Gases in the Welding Environment*.

A9.4 Radiation. Welding, cutting, and allied operations may produce radiant energy (radiation) harmful to health. One should become acquainted with the effects of this radiant energy.

Radiant energy may be ionizing (such as x-rays), or nonionizing (such as ultraviolet, visible light, or infrared). Radiation can produce a variety of effects such as skin burns and eye damage, depending on the radiant energy's wavelength and intensity, if excessive exposure occurs.

A9.4.1 Ionizing Radiation. Ionizing radiation is produced by the electron beam welding process. It is ordinarily controlled within acceptance limits by use of suitable shielding enclosing the welding area.

A9.4.2 Nonionizing Radiation. The intensity and wavelengths of nonionizing radiant energy produced depend on many factors, such as the process, welding parameters, electrode and base-metal composition, fluxes, and any coating or plating on the base metal. Some processes such as resistance welding and cold pressure welding ordinarily produce negligible quantities of radiant energy. However, most arc welding and cutting processes (except submerged arc when used properly), laser welding and torch welding, cutting, brazing, or soldering can produce quantities of nonionizing radiation such that precautionary measures are necessary.

Protection from possible harmful effects caused by non-ionizing radiant energy from welding include the following measures:

(1) One should not look at welding arcs except through welding filter plates which meet the requirements of ANSI/ASC Z87.1, *Practice for Occupational and Educational Eye and Face Protection*. It should be noted that transparent welding curtains are not intended as welding filter plates, but rather are intended to protect a passerby from incidental exposure.

10. NFPA documents are available from the National Fire Protection Association, Battery March Park, Quincy, MA 02269

11. ACGIH documents are available from the American Conference of Governmental Industrial Hygienists, 6550 Glenway Avenue, Building D-5, Cincinnati, OH 45211.

(2) Exposed skin should be protected with adequate gloves and clothing as specified in ANSI/ASC Z49.1, *Safety in Welding, Cutting, and Allied Processes*.

(3) Reflections from welding arcs should be avoided, and all personnel should be protected from intense reflections. (Note: Paints using pigments of substantially zinc oxide or titanium dioxide have a lower reflectance for ultraviolet radiation.)

(4) Screens, curtains, or adequate distance from aisles, walkways, etc., should be used to avoid exposing passersby to welding operations.

(5) Safety glasses with UV protective side shields have been shown to provide some beneficial protection from ultraviolet radiation produced by welding arcs.

A9.4.3 Ionizing radiation information sources include the following:

(1) American Welding Society. AWS F2.1-78, *Recommended Safe Practices for Electron Beam Welding and Cutting*. Miami, FL: American Welding Society.

(2) Manufacturer's product information literature.

A9.4.4 Nonionizing radiation information sources include:

(1) American National Standards Institute. *Safe Use of Lasers*, ANSI/ASC Z136.1. New York: American National Standards Institute.

(2) American National Standards Institute. *Practice for Occupational and Educational Eye and Face Protection*, ANSI/ASC Z87.1. New York: American National Standards Institute.

(3) American Welding Society. *Safety in Welding, Cutting, and Allied Processes*, ANSI/ASC Z87.1. Miami, FL: American Welding Society.

(4) Hinrichs, J. F. "Project committee on radiation-summary report." *Welding Journal* 57(1):62-65, 1978.

(5) Marshall, W. J., Sliney, D. H., et al. "Optical radiation levels produced by air-carbon arc cutting processes." *Welding Journal* 59(3):43-46, 1980.

(6) Moss, C. E. and Murray, W. E. "Optical radiation levels produced in gas welding, torch brazing, and oxygen cutting." *Welding Journal* 58(9):37-46, 1979.

(7) Moss, C. E. "Optical radiation transmission levels through transparent welding Curtains." *Welding Journal* 58(3):69s-75s, 1979.

(8) National Technical Information Service. Nonionizing Radiation Protection Special Study No. 42-0053-77, *Evaluation of the Potential Hazards from Actinic Ultraviolet Radiation Generated by Electric Welding and Cutting Arcs*. Springfield, VA: National Technical Information Service.¹²

(9) -----, Non-Ionizing Radiation Protection Special Study No. 42-0312-77, *Evaluation of the Potential Retina Hazards from Optical Radiation Generated by Electrical Welding and Cutting Arcs*. Springfield, VA: National Technical Information Service.

12. National Technical Information documents are available from the National Technical Information Service, Springfield, VA 22161.

AWS Filler Metal Specifications and Related Documents

AWS Designation	Title
FMC	Filler Metal Comparison Charts
A4.2	Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Austenitic-Ferritic Stainless Steel Weld Metal
A4.3	Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding
A5.01	Filler Metal Procurement Guidelines
A5.1	Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding
A5.2	Specification for Carbon and Low Alloy Steel Rods for Oxyfuel Gas Welding
A5.3	Specification for Aluminum and Aluminum Alloy Electrodes for Shielded Metal Arc Welding
A5.4	Specification for Stainless Steel Welding Electrodes for Shielded Metal Arc Welding
A5.5	Specification for Low Alloy Steel Covered Arc Welding Electrodes
A5.6	Specification for Covered Copper and Copper Alloy Arc Welding Electrodes
A5.7	Specification for Copper and Copper Alloy Bare Welding Rods and Electrodes
A5.8	Specification for Filler Metals for Brazing and Braze Welding
A5.9	Specification for Bare Stainless Steel Welding Electrodes and Rods
A5.10	Specification for Bare Aluminum and Aluminum Alloy Welding Electrodes and Rods
A5.11	Specification for Nickel and Nickel Alloy Welding Electrodes for Shielded Metal Arc Welding
A5.12	Specification for Tungsten and Tungsten Alloy Electrodes for Arc Welding and Cutting
A5.13	Specification for Solid Surfacing Welding Rods and Electrodes
A5.14	Specification for Nickel and Nickel Alloy Bare Welding Electrodes and Rods
A5.15	Specification for Welding Electrodes and Rods for Cast Iron
A5.16	Specification for Titanium and Titanium Alloy Welding Electrodes and Rods
A5.17	Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding
A5.18	Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding
A5.19	Specification for Magnesium Alloy Welding Electrodes and Rods
A5.20	Specification for Carbon Steel Electrodes for Flux Cored Arc Welding
A5.21	Specification for Composite Surfacing Welding Rods and Electrodes
A5.22	Specification for Flux Cored Corrosion-Resisting Chromium and Chromium-Nickel Steel
A5.23	Specification for Low Alloy Steel Electrodes and Fluxes for Submerged Arc Welding
A5.24	Specification for Zirconium and Zirconium Alloy Welding Electrodes and Rods
A5.25	Specification for Carbon and Low Alloy Steel Electrodes and Fluxes for Electroslag
A5.26	Specification for Carbon and Low Alloy Steel Electrodes for Electrogas Welding
A5.28	Specification for Low Alloy Steel Filler Metals for Gas Shielded Arc Welding
A5.29	Specification for Low Alloy Steel Electrodes for Flux Cored Arc Welding
A5.30	Specification for Consumable Inserts
A5.31	Specification for Fluxes for Brazing and Braze Welding

For ordering information, contact the Order Department, American Welding Society, 550 N.W. LeJeune Road Miami, Florida 33126. Phone: 1-800-334-9353.