

**Specification for
Nickel and Nickel Alloy
Welding Electrodes for
Shielded Metal Arc Welding**



American Welding Society

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welding electrodes

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Specification for Nickel and Nickel Alloy Welding Electrodes for Shielded Metal 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 describes the composition, dimensions, soundness, and properties of weld metal from more than 20 classifications of nickel and nickel alloy covered electrodes. Major topics include general requirements, testing, manufacturing, identification and packaging. A guide to using the specification is included in an appendix.



American Welding Society

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Foreword

(This Foreword is not a part of ANSI/AWS A5.11-90, *Specification for Nickel and Nickel Alloy Welding Electrodes for Shielded Metal Arc Welding*, but is included for information purposes only.)

The first specification for nickel and nickel alloy covered electrodes was issued in 1954 by a joint committee of the American Society for Testing and Materials and the American Welding Society. The first revision in 1964 was also the result of the cooperative effort. This revision is the fourth prepared entirely by the AWS Filler Metal Committee.

Document Development

ASTM B295-54T AWS A5.11-54T	Tentative Specification for Nickel and Nickel Base Alloy Covered Welding Electrodes
AWS A5.11-64T ASTM B295-64T	Tentative Specification for Nickel and Nickel Alloy Covered Welding Electrodes
AWS A5.11-69 ANSI W3.11-1973	Specification for Nickel and Nickel-Alloy Covered Welding Electrodes
AWS A5.11-Add 1-75 A5.11-76	Addenda to Specification for Nickel and Nickel Alloy Covered Welding Electrodes Specification for Nickel and Nickel Alloy Covered Welding Electrodes
ANSI/AWS A5.11-83	Specification for Nickel and Nickel Alloy Covered Welding Electrodes

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, Filler Metal Committee, American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, Florida 33135.

Official interpretations of any of the technical requirements of this standard may be obtained by sending a request, in writing, to the Director of Standards and Publications of the 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 Nickel and Nickel Alloy Welding Electrodes for Shielded Metal Arc Welding

1. Scope

This specification prescribes requirements for the classification of nickel and nickel alloy covered electrodes for shielded metal arc welding. It includes those compositions in which the nickel content exceeds that of any other element.¹

Part A General Requirements

2. Classification

2.1 The welding electrodes covered by this specification are classified according to the chemical composition of their undiluted weld metal, as specified in Table 1.

2.2 Electrodes classified under one classification shall not be classified under any other classification in this specification.

3. Acceptance

Acceptance² of the electrodes shall be in accordance with the provisions of ANSI/AWS A5.01, *Filler Metal Procurement Guidelines*.³

1. Nickel-base covered electrodes for welding cast irons are treated separately in ANSI/AWS A5.15, *Specification for Welding Electrodes and Rods for Cast Iron*. This specification is available from AWS, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, Florida 33135. Phone: (305) 443-9353.

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

3. AWS standards can be obtained from the American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, Florida 33135.

4. Certification

By affixing the AWS specification and classification designations to the packaging, or the classification to the product, the manufacturer certifies that the product meets the requirements of this specification.⁴

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 purposes of determining conformance with this specification, an observed or calculated value shall be rounded to the nearest 1000 psi (7 MPa) 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 ANSI/AWS A1.1, *Metric Practice Guide for the Welding Industry*.

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

Table 1
Chemical Composition Requirements for Undiluted Weld Metal

		Weight Percent ^{a,b}															Other Elements Total	
AWS Classification	UNS Number ^c	C	Mn	Fe	P	S	Si	Cu	Ni ^d	Co	Al	Ti	Cr	Plus Ta	Mo	V	W	
ENi-1	W82141	0.10	0.75	0.75	0.03	0.02	1.25	0.25	92.0 min.	—	1.0	1.0 to 4.0	—	—	—	—	—	0.50
ENiCu-7	W84190	0.15	4.00	2.5	0.02	0.015	1.5	Rem	62.0 to 69.0	—	0.75	1.0	—	—	—	—	—	0.50
ENiCrFe-1	W86132	0.08	3.5	11.0	0.03	0.015	0.75	0.50	62.0 min.	—	—	—	13.0 to 17.0	1.5 to 4.0 ^f	—	—	—	0.50
ENiCrFe-2	W86133	0.10	1.0 to 3.5	12.0	0.03	0.02	0.75	0.50	62.0 min.	e	—	—	13.0 to 17.0	0.5 to 3.0 ^f	0.50 to 2.50	—	—	0.50
ENiCrFe-3	W86182	0.10	5.0 to 9.5	10.0	0.03	0.015	1.0	0.50	59.0 min.	e	—	1.0	13.0 to 17.0	1.0 to 2.5 ^f	—	—	—	0.50
ENiCrFe-4	W86134	0.20	1.0 to 3.5	12.0	0.03	0.02	1.0	0.50	60.0 min.	—	—	—	13.0 to 17.0	1.0 to 3.5	1.0 to 3.5	—	—	0.50
ENiMo-1	W80001	0.07	1.0	4.0 to 7.0	0.04	0.03	1.0	0.50	Rem	2.5	—	—	1.0	—	26.0 to 30.0	0.60	1.0	0.50
ENiMo-3	W80004	0.12	1.0	4.0 to 7.0	0.04	0.03	1.0	0.50	Rem	2.5	—	—	2.5 to 5.5	—	23.0 to 27.0	0.60	1.0	0.50
ENiMo-7	W80665	0.02	1.75	2.0	0.04	0.03	0.2	0.50	Rem	1.0	—	—	1.0	—	26.0 to 30.0	—	1.0	0.50

(continued)

Table 1 (continued)

AWS Classification		UNS Number ^c	Weight Percent ^{a,b}														Cb Plus Ta		Other Elements Total	
			C	Mn	Fe	P	S	Si	Cu	Ni ^d	Co	Al	Ti	Cr		Ia	Mo	V	W	
ENiCrCoMo-1	W86117	0.05 to 0.15	0.05	0.30 to 2.5	5.0	0.03	0.015	0.75	0.50	Rem	9.0 to 15.0	—	—	21.0 to 26.0	1.0	8.0 to 10.0	—	—	—	0.50
ENiCrMo-1	W86007	0.05	0.05	1.0 to 2.0	18.0 to 21.0	0.04	0.03	1.0	1.5 to 2.5	Rem	2.5	—	—	21.0 to 23.5	1.75 to 2.50	5.5 to 7.5	—	—	1.0	0.50
ENiCrMo-2	W86002	0.05 to 0.15	0.05	1.0	17.0 to 20.0	0.04	0.03	1.0	0.50	Rem	0.50 to 2.50	—	—	20.5 to 23.0	—	8.0 to 10.0	—	—	0.20 to 1.0	0.50
ENiCrMo-3	W86112	0.10	0.10	1.0	7.0	0.03	0.02	0.75	0.50	55.0 min.	e	—	—	20.0 to 23.0	3.15 to 4.15	8.0 to 10.0	—	—	—	0.50
ENiCrMo-4	W80276	0.02	0.02	1.0	4.0 to 7.0	0.04	0.03	0.2	0.50	Rem	2.5	—	—	14.5 to 16.5	—	15.0 to 17.0	0.35	0.35	3.0 to 4.5	0.50
ENiCrMo-5	W80002	0.10	0.10	1.0	4.0 to 7.0	0.04	0.03	1.0	0.50	Rem	2.5	—	—	14.5 to 16.5	—	15.0 to 17.0	0.35	0.35	3.0 to 4.5	0.50
ENiCrMo-6	W86620	0.10	0.10	2.0 to 4.0	10.0	0.03	0.02	1.0	0.50	55.0 min.	—	—	—	12.0 to 17.0	0.5 to 2.0	5.0 to 9.0	—	—	1.0 to 2.0	0.50
ENiCrMo-7	W86455	0.015	0.015	1.5	3.0	0.04	0.03	0.2	0.50	Rem	2.0	—	0.70	14.0 to 18.0	—	14.0 to 17.0	—	—	0.5	0.50
ENiCrMo-9	W86985	0.02	0.02	1.0	18.0 to 21.0	0.04	0.03	1.0	1.5 to 2.5	Rem	5.0	—	—	21.0 to 23.5	0.5	6.0 to 8.0	—	—	1.5	0.50

(continued)

Table 1 (continued)

Weight Percent ^{a, b}																		
AWS Classification	UNS Number ^c	C	Mn	Fe	P	S	Si	Cu	Ni ^d	Co	Al	Ti	Cr	Cb Plus Ta	Mo	V	W	Other Elements Total
ENiCrMo-10	W86022	0.02	1.0	2.0 to 6.0	0.03	0.015	0.2	0.50	Rem	2.5	—	—	20.0 to 22.5	—	12.5 to 14.5	0.35	2.5 to 3.5	0.50
ENiCrMo-11	W86030	0.03	1.5	13.0 to 17.0	0.04	0.02	1.0	1.0 to 2.4	Rem	5.0	—	—	28.0 to 31.5	0.3 to 1.5	4.0 to 6.0	—	1.5 to 4.0	0.50
ENiCrMo-12	W86040	0.03	2.2	5.0	0.03	0.02	0.7	0.50	Rem	—	—	—	20.5 to 22.5	1.0 to 2.8	8.8 to 10.0	—	—	0.50

Notes:

- a. The weld metal shall be analyzed for the specific elements for which values are shown in this table. If the presence of other elements is indicated in the course of the work, the amount of those elements shall be determined to ensure that their total does not exceed the limit specified for "Other Elements, Total" in the last column of the table.
- b. Single values are maximum, except where otherwise specified.
- c. ASTM/SAE Unified Numbering System for Metals and Alloys.
- d. Includes incidental cobalt.
- e. Cobalt — 0.12 maximum, when specified.
- f. Tantalum — 0.30 maximum, when specified.

Part B

Tests, Procedures and Requirements

6. Summary of Tests

The tests required for classification are specified in Table 2. The purpose of these tests is to determine the chemical composition, the mechanical properties and soundness 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 Section 8, Weld Test Assemblies through Section 12, Bend Test.

7. Retest

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

8. Weld Test Assemblies

8.1 To perform all required tests as specified in Table 2, a minimum of one weld test assembly is required. Two, or even three, may be necessary (according to the classification, size, and manner in which the testing is conducted, i.e., with respect to alternative options).

The weld test assemblies are identified as follows:

- (1) The weld pad in Figure 1 for chemical analysis of the undiluted weld metal
- (2) The groove weld in Figure 2 for mechanical properties and soundness
- (3) The groove weld in Figure 3 for usability of the electrode

The sample for chemical analysis may be taken from a low dilution area in the groove weld in Figure 2, or from the reduced section of the fractured tension test specimen, 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, 8.4.1, and 8.4.2. The base metal for each assembly shall be as required in Table 2 according to the tests to be conducted and shall meet the requirements of the appropriate ASTM specification shown in Table 3 or an equivalent specification.⁵ Testing of the

assemblies shall be as prescribed in Section 9, Chemical Analysis, Section 10, Radiographic Test, Section 11, Tension Test, and Section 12, Bend Test.

8.3 Weld Pad. A weld pad shall be prepared as specified in Table 2 and shown in Figure 1, except when one of the alternatives in 8.1 (taking the sample from the weld metal in the groove or from the tension test specimen) is selected. Base metal of any convenient size, of the type specified in Table 3, 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 beads and layers to obtain undiluted weld metal. The type of current and range of amperage used for welding shall be as recommended by the manufacturer. The preheat temperature shall be not less than 60°F (16°C) and the interpass temperature shall not exceed 300°F (150°C). The slag shall be removed after each pass. The pad may be quenched in water [temperature above 60°F (16°C)] between passes. The dimensions of the completed pad shall be as shown in Figure 1 for each size of electrode. Testing of this assembly shall be as specified in Section 9, Chemical Analysis.

8.4 Groove Weld

8.4.1 Mechanical Properties and Soundness. A test assembly shall be prepared and welded as specified in Figure 2 and Table 2 using base metal of an appropriate type in Table 3. Testing of this assembly shall be as specified in Section 11, Tension Test and Section 12, Bend Test, except when the assembly is also used to satisfy the requirements of the usability test (note c to Table 2). In that case, the assembly shall be radiographed as required in Section 10, Radiographic Test. The assembly shall be tested in the as-welded condition.

8.4.2 Usability Test. A test assembly shall be prepared for electrodes of all classifications and welded as shown in Figure 3, using base metal of the appropriate type specified in Table 3. The welding position shall be as specified in the "Usability Test" column of Table 2 for the different electrode sizes and classifications. Testing of the assembly shall be as specified in Section 10, Radiographic Test. The groove weld in Figure 2 may be radiographed (for those classifications for which the usability test is welded in the flat position), thus eliminating the need to make the groove weld in Figure 3, in those cases.

9. Chemical Analysis

9.1 The sample for analysis shall be taken from weld metal obtained from the weld pad, the reduced section of the fractured tension test specimen, or a low dilution area of the groove weld in Figure 2. The top surface of

5. ASTM standards can be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

Table 2^a
Required Tests and Positions

AWS Classification	Electrode Diameter		Chemical Analysis	Required Tests			Positions Usability Test ^{c,d}
	in.	mm		Tension Test	Bend Test ^b	Usability Test	
ENi-1	5/64	2.0	<	Required	>		V
	3/32	2.4					V
	1/8	3.2					V
	5/32	4.0					F
	3/16	4.8					F
ENiCu-7	5/64	2.0	<	Required	>		V
	3/32	2.4					V
	1/8	3.2					V
	5/32	4.0					F
	3/16	4.8					F
	1/4	6.4					F
ENiCrFe-1 ENiCrFe-2 ENiCrFe-3 ENiCrFe-4	5/64	2.0	<	Required	>		V
	3/32	2.4					V
	1/8	3.2					V
	5/32	4.0					F
	3/16	4.8					F
ENiMo-1 ENiMo-3 ENiMo-7	5/64	2.0	<	Required	>		F
	3/32	2.4					F
	1/8	3.2					F
	5/32	4.0					F
	3/16	4.8					F
ENiCrCoMo-1	5/64	2.0	<	Required	>		V
	3/32	2.4					V
	1/8	3.2					F
	5/32	4.0					F
ENiCrMo-2 ENiCrMo-4 ENiCrMo-5 ENiCrMo-7 ENiCrMo-9 ENiCrMo-11	3/32	2.4	<	Required	>		F
	1/8	3.2					F
	5/32	4.0					F
	3/16	4.8					F
ENiCrMo-3 ENiCrMo-6 ENiCrMo-10	5/64	2.0	<	Required	>		V
	3/32	2.4					V
	1/8	3.2					V
	5/32	4.0					F
	3/16	4.8					F
ENiCrMo-12	5/64	2.0	<	Required	>		V
	3/32	2.4					V
	1/8	3.2					V
	5/32	4.0					F

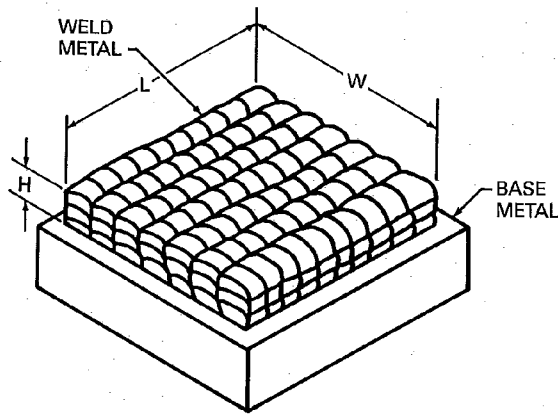
Notes:

a. See Table 3 for base metals to be used in these tests.

b. Three transverse side-bend test specimens are required except for 5/64 in. (2.0 mm) electrodes. For that size, two transverse face-bend specimens are required.

c. The groove weld for mechanical properties (Figure 2) may also be used for the usability test conducted in the flat position. In that case, the test assembly is radiographed before the coupons for the tensile and bend test specimens are removed.

d. The position of welding shown in this column is only for the usability test (V = vertical position with uphill progression, F = flat). All other test assemblies are welded in the flat position.



NOTE: 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 THE AMPERAGE EMPLOYED.

Electrode Size		Weld Pad Size	
in.	mm	in., min.	mm, min.
5/64	2.0	L = 1-1/2	38
3/32	2.4	W = 1-1/2	38
1/8	3.2	H = 1/2	13
5/32	4.0	L = 2	51
3/16	4.8	W = 2	51
1/4	6.4	H = 7/8	22

Figure 1 — Pad for Chemical Analysis of Undiluted Weld Metal

the pad described in 8.3 and shown in Figure 1 (when the pad is used), shall be removed and discarded. A sample for analysis shall be obtained from the underlying metal by any appropriate mechanical means. The sample shall be free of slag.

For electrodes smaller than 5/32 in. (4.0 mm), the sample shall be taken at least 3/8 in. (9.5 mm) from the nearest surface of the base metal. For electrodes 5/32 in. (4.0 mm) and larger, the sample shall be taken at least 3/4 in. (19 mm) from that surface. The sample from the reduced section of the fractured tension test specimen and the sample from a low dilution area of the groove weld shall be prepared for analysis by any suitable mechanical means.

9.2 The sample shall be analyzed by accepted analytical methods. The referee method shall be either ASTM E38, *Standard Methods for Chemical Analysis of Nickel-Chromium and Nickel-Chromium-Iron Alloys*, or E76, *Standard Methods for Chemical Analysis of Nickel-Copper Alloys*, as appropriate.

9.3 The results of the analysis shall meet the requirements of Table 1 for the classification of electrode under test.

10. Radiographic Test

10.1 The groove weld described in 8.4.2 and shown in Figure 3 (or the groove weld described in 8.4.1 and shown in Figure 2, when that is desired and is permitted by note e of Table 2), shall be radiographed to evaluate the usability of the electrode. 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, *Standard Method for Controlling Quality of Radiographic Testing*. The quality level of inspection shall be 2-2T.

10.3 The usability of the electrode meets the requirements of this specification if the radiograph shows the following:

(1) No cracks, no incomplete fusion, and no incomplete penetration

(2) No slag inclusions in excess of those permitted by note 4 to the radiographic standards in Figures 4 through 8, according to the size of the electrode

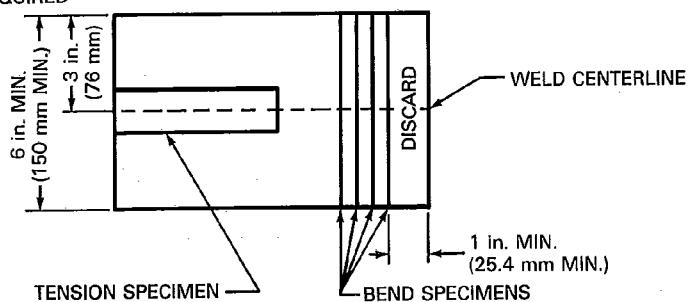
(3) No rounded indications in excess of those permitted by the radiographic standards in Figures 4 through 8, according to the thickness of the test assembly, or the alternative method of evaluation in 10.3.1

In evaluating the radiograph, 1 in. (25 mm) of the weld image on the radiograph on each end of the test assembly shall be disregarded.

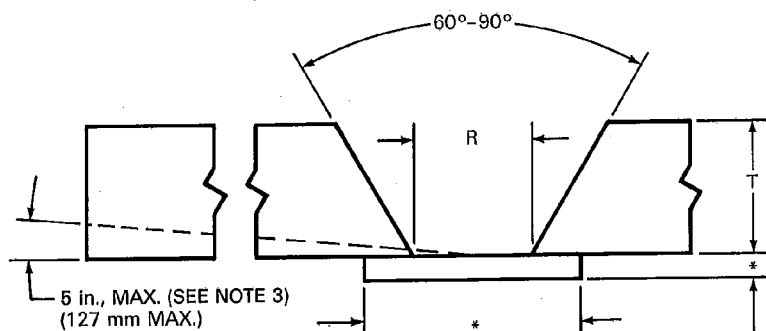
10.3.1 The alternative method of evaluation involves calculation of the total area of the rounded indications as they appear on the radiograph. This total area shall not exceed 1% of the thickness of the test assembly multiplied by the length of the weld used in the evaluation [length of the weld in the test assembly minus 1 in. (25 mm) on each end]. The value given in Note 3 to each of the figures (4 through 8) has been calculated for 6 in. (150 mm) of weld [an 8 in. (200 mm) long test assembly]. The value for weld lengths other than this will differ on a linearly proportional basis.

10.3.2 A rounded indication is an indication (on the radiograph) whose length is no more than three 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.

MINIMUM LENGTH IS 6 in. (150 mm) BUT THE ASSEMBLY SHALL BE AS LONG AS NECESSARY TO PROVIDE THE SPECIMENS FOR THE NUMBER AND TYPE OF TESTS REQUIRED



(A) LAYOUT OF TEST ASSEMBLY



(B) GROOVE PREPARATION

Electrode Size		T (Thickness), Min.		R (Root Opening)**		Number of Layers, Min.
in.	mm	in.	mm	in.	mm	
5/64	2.0	3/8	9.5	3/16	4.8	***
3/32	2.4	1/2	13	1/4	6.4	***
1/8	3.2	1/2	13	1/4	6.4	***
5/32	4.0	3/4	19	1/2	13	6
3/16	4.8	3/4	19	1/2	13	6
1/4	6.4	3/4	19	1/2	13	6

*Any suitable dimension

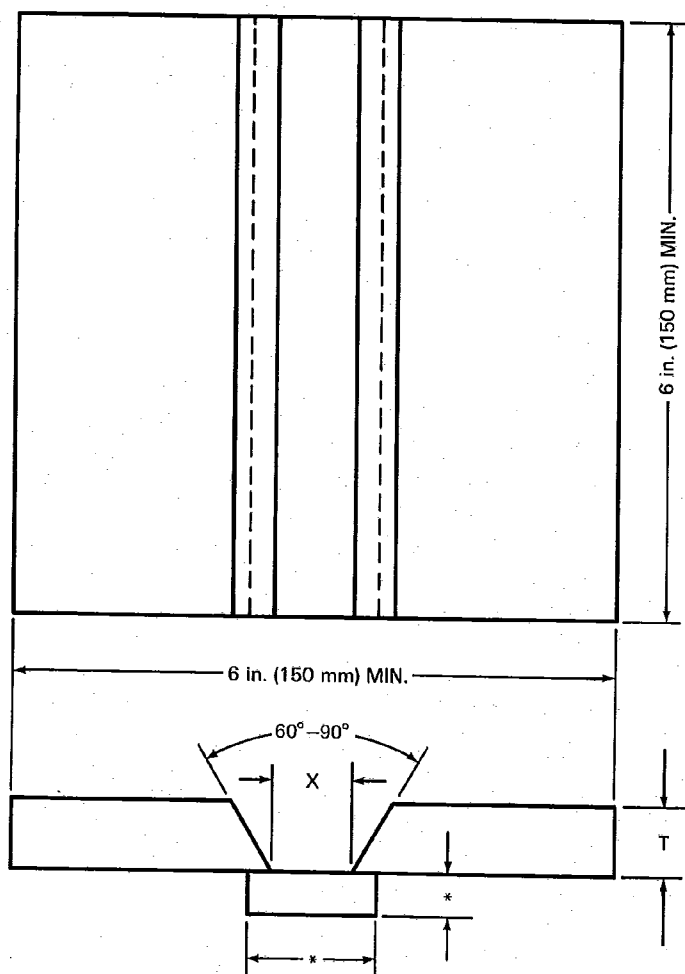
**Tolerance + 1/16 in. (1.6 mm)

***Number of layers not specified, but pass and layer sequence shall be recorded and reported.

Notes:

1. Base metal shall be as specified in Table 3.
2. The surfaces to be welded shall be clean.
3. Prior to welding, the assembly may be preset so that the welded joint will be sufficiently flat to facilitate removal of the test specimens. As an alternate, restraint or a combination of restraint and presetting may be used to keep the welded joint within 5 degrees of plane. A test assembly that is more than 5 degrees out of plane shall be discarded. Straightening of the test assembly is prohibited.
4. Welding shall be performed in the flat position, using the type and range of current and welding technique recommended by the electrode manufacturer.
5. The preheat temperature shall be 60°F (16°C) min. The interpass temperature shall not exceed 300°F (150°C).
6. The welds shall be made with stringer beads or weave beads no wider than four times the diameter of the core wire. The completed weld shall be at least flush with the surface of the test plate. For electrodes larger than 1/8 in. (3.2 mm), the root beads may be deposited with 3/32 or 1/8 in. (2.4 or 3.2 mm) electrodes.
7. The tests shall be conducted without a postweld heat treatment.

Figure 2 — Groove Weld Test Assembly for Mechanical Properties and Soundness



Dimensions, in. (mm)						
Electrode Size	5/64 (2.0)	3/32 (2.4)	1/8 (3.2)	5/32 (4.0)	3/16 (4.8)	& 1/4 (6.4)
T = (Thickness) min.	1/8 (3.2)	1/4 (6.4)	3/8 (9.5)	3/8 (9.5)	3/8 (9.5)	1/2 (13)
X = (Root Opening)	1/8 (3.2)	1/4 (6.4)	5/16 (7.9)	3/8 (9.5)	3/8 (9.5)	1/2 (13)
* = (Width and Thickness)	Any suitable dimensions					

Tolerance: +1/16 in. (1.6 mm) - 0

Notes:

1. The base metal shall be as specified in Table 3.
2. The surfaces to be welded shall be clean.
3. Welding shall be conducted in the vertical-up or flat position, as required in Table 2 (see also note e to Table 2) using the type and range of current and technique recommended by the electrode manufacturer.
4. The preheat temperature shall be at least 60°F (16°C) and the interpass temperature shall not exceed 300°F (150°C).
5. The weld shall be made with a stringer bead technique or a weave to produce a bead no wider than 4 times the diameter of the core wire. The root layer in tests of electrodes larger than 1/8 in. (3.2 mm) diameter may be deposited with 3/32 or 1/8 in. (2.4 or 3.2 mm) electrodes of that same classification. In addition to the start and stop at the ends of the weld, each bead shall also contain a start and a stop somewhere in between.
6. A small amount of grinding between beads is permissible for welds in the vertical position, but an inordinate amount should not be required to produce a satisfactory weld.
7. The completed weld shall be at least flush with the surface of the base metal.
8. The backing strip shall be removed and the weld on both sides of the assembly shall be machined or ground smooth and flush with the original surfaces of the base plate.
9. The assembly shall be radiographed as specified in section 10, Radiographic Test.

Figure 3 — Groove Weld Test Assembly For Radiographic Test

Table 3
Base Metals for Test Assemblies

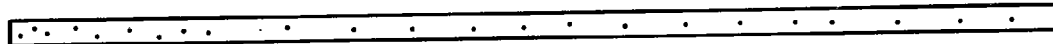
AWS Electrode Classification	Material ^{a, b}	ASTM Specifications ^c	UNS Number
ENi-1	Nickel	B160, B162	N02200, N02201
ENiCu-7	Nickel-Copper Alloy	B127, B164	N04400
ENiCrFe-1, 2, 3, and 4	Nickel-Chromium-Iron Alloy	B166, B168	N06600
ENiMo-1, 3, and 7	Nickel-Molybdenum Alloy	B333	N10001
ENiCrCoMo-1	Nickel-Chromium-Cobalt-Molybdenum Alloy	—	N06617
ENiCrMo-1, 9, and 11	Nickel-Chromium-Molybdenum Alloy	B582	N06007
ENiCrMo-2	Nickel-Chromium-Molybdenum Alloy	B435	N06002
ENiCrMo-3	Nickel-Chromium-Molybdenum Alloy	B433, B446	N06625
ENiCrMo-4, 5, 7, and 10	Low Carbon Nickel-Chromium Molybdenum Alloy	B575	N10276
ENiCrMo-12	Chromium-Nickel-Molybdenum Alloy Austenitic Stainless Steel	A240	S31254
ENiCrMo-6	Nickel-Chromium-Molybdenum Alloy	B166, B168	K81340

Notes:

- a. Either the base metals specified or carbon steel (A131, A285, A515) may be used. If carbon steel is used, two layers of buttering shall be applied to the surface and backing strip if appropriate. For chemical analysis, base metals other than those specified may be used as the base for the undiluted weld pad provided that, for electrodes of the 1/8 in. (3.2 mm) size and smaller, the minimum pad height shown in Figure 1 is 3/4 in. (19 mm) and the sample for analysis is taken at least 5/8 in. (16 mm) from the nearest surface of the base metal. For electrode sizes 5/32 in. (4 mm) through 1/4 in. (6.4 mm), these dimensions are 1 in. (25 mm) and 7/8 in. (22 mm), respectively.
- b. All specified base metals shall be in the annealed condition prior to welding.
- c. Equivalent material specifications may be used.

**(A) MEDIUM ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.020 in. (0.51 mm) TO 0.025 in. (0.6 mm).
NUMBER PERMITTED IN ANY 6 in. (150 mm) OF WELD IS 14.

**(B) SMALL ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.015 in. (0.38 mm) TO 0.020 in. (0.51 mm).
NUMBER PERMITTED IN ANY 6 in. (150 mm) OF WELD IS 23.

Notes:

- The chart that is most representative of the size of the rounded indications in the radiograph of the test assembly shall be used to determine conformance with this specification. Rounded indications 1/64 in. (0.40 mm) and smaller shall be disregarded. The largest dimension of the indication (including any tail) is the size of the indication.
- These radiographic requirements are for test welds made in the laboratory specifically for classification purposes. They are more restrictive than those usually encountered in general fabrication.
- When using the alternative method of evaluation described in 10.3.1, the total cross-sectional area of the rounded indications (calculated from measurements taken from the radiograph) shall not exceed 0.008 in.² (5.2 mm²) in any 6 in. (150 mm) of weld.
- The acceptance standard for slag inclusions in this test assembly is:
 - Length of each individual slag indication: 1/16 in. (1.6 mm) maximum
 - Total length of all slag indications: 1/8 in. (3.2 mm) maximum

Figure 4 — Radiographic Standards for 1/8 in. (3.2 mm) Test Assembly

**(A) ASSORTED ROUNDED INDICATIONS**

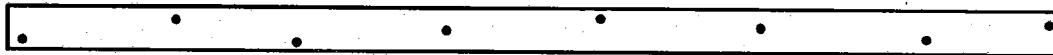
SIZE PERMITTED IS 1/64 in. (0.4 mm) TO 0.050 in. (1.3 mm)

NUMBER PERMITTED IN ANY 6 in. (150 mm) OF WELD IS 21, WITH THE FOLLOWING RESTRICTIONS:

LARGE: OVER 0.031 in. (0.79 mm) TO 0.050 in. (1.3 mm) — 4 PERMITTED

MEDIUM: OVER 0.020 in. (0.51 mm) TO 0.031 in. (0.79 mm) — 5 PERMITTED

SMALL: OVER 0.015 in. (0.38 mm) TO 0.020 in. (0.51 mm) — 12 PERMITTED

**(B) LARGE ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.031 in. (0.79 mm) TO 0.050 in. (1.3 mm).

NUMBER PERMITTED IN ANY 6 in. (150 mm) OF WELD IS 8.

**(C) MEDIUM ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.020 in. (0.51 mm) TO 0.031 in. (0.79 mm).

NUMBER PERMITTED IN ANY 6 in. (150 mm) OF WELD IS 19.

**(D) SMALL ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.015 in. (0.38 mm) TO 0.020 in. (0.51 mm).

NUMBER PERMITTED IN ANY 6 in. (150 mm) OF WELD IS 48.

Notes:

1. The chart that is most representative of the size of the rounded indications in the radiograph of the test assembly shall be used to determine conformance with this specification. Rounded indications 1/64 in. (0.4 mm) and smaller shall be disregarded. The largest dimension of the indication (including any tail) is the size of the indication.
2. These radiographic requirements are for test welds made in the laboratory specifically for classification purposes. They are more restrictive than those usually encountered in general fabrication.
3. When using the alternative method of evaluation described in 10.3.1, the total cross-sectional area of the rounded indications (calculated from measurements taken from the radiograph) shall not exceed 0.015 in.² (9.7 mm²) in any 6 in. (150 mm) of weld.
4. The acceptance standard for slag inclusions in this test assembly is:
 - (a) Length of each individual slag indication: 3/16 in. (4.8 mm) maximum
 - (b) Total length of all slag indications: 1/4 in. (6.4 mm) maximum

Figure 5—Radiographic Standards for 1/4 in. (6.4 mm) Test Assembly

The indications may be of porosity or slag. The total area of the rounded indications for the alternative method shall not exceed the values given in Note 3 to the radiographic standards (Figures 4 through 8). Indications whose largest dimension does not exceed 1/64 in. (0.40 mm) shall be disregarded. Test assemblies with rounded indications larger than the largest indications permitted in the radiographic standards 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 2. The dimensions of the specimen shall be as shown in Figure 9.

11.2 The specimen shall be tested in the manner described in the tension test section of the latest edition of AWS B4.0, *Standard Methods for Mechanical Testing of Welds*.

11.3 The results of the tension test shall meet the requirements specified in Table 4.

12. Bend Test

12.1 Three transverse side-bend specimens [for electrodes larger than 5/64 in. (2 mm)] or two transverse

**(A) ASSORTED ROUNDED INDICATIONS**

SIZE PERMITTED IS 1/64 in. (0.4 mm) TO 0.075 in. (1.9 mm).

NUMBER PERMITTED IN ANY 6 in. (150 mm) OF WELD IS 17, WITH THE FOLLOWING RESTRICTIONS:

LARGE: OVER 0.049 in. (1.24 mm) TO 0.075 in. (1.90 mm) — 3 PERMITTED

MEDIUM: OVER 0.020 in. (0.51 mm) TO 0.049 in. (1.24 mm) — 3 PERMITTED

SMALL: OVER 0.015 in. (0.38 mm) TO 0.020 in. (0.51 mm) — 11 PERMITTED

**(B) LARGE ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.049 in. (1.24 mm) TO 0.075 in. (1.90 mm).

NUMBER PERMITTED IN ANY 6 in. (150 mm) OF WELD IS 5.

**(C) MEDIUM ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.020 in. (0.5 mm) TO 0.049 in. (1.3 mm).

NUMBER PERMITTED IN ANY 6 in. (150 mm) OF WELD IS 11.

**(D) SMALL ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.015 in. (0.38 mm) TO 0.020 in. (0.51 mm).

NUMBER PERMITTED IN ANY 6 in. (150 mm) OF WELD IS 72.

Notes:

1. The chart that is most representative of the size of the rounded indications in the radiograph of the test assembly shall be used to determine conformance with this specification. Rounded indications 1/64 in. (0.4 mm) and smaller shall be disregarded. The largest dimension of the indication (including any tail) is the size of the indication.
2. These radiographic requirements are for test welds made in the laboratory specifically for classification purposes. They are more restrictive than those usually encountered in general fabrication.
3. When using the alternative method of evaluation described in 10.3.1, the total cross-sectional area of the rounded indications (calculated from measurements taken from the radiograph) shall not exceed 0.023 in.² (14.8 mm²) in any 6 in. (150 mm) of weld.
4. The acceptance standard for slag inclusions in this test assembly is:
 - (a) Length of each individual slag indication: 7/32 in. (5.6 mm) maximum
 - (b) Total length of all slag indications: 3/8 in. (9.5 mm) maximum

Figure 6 — Radiographic Standards for 3/8 in. (9.5 mm) Test Assembly

**(A) ASSORTED ROUNDED INDICATIONS**

SIZE PERMITTED IS 1/64 in. (0.4 mm) TO 0.10 in. (2.5 mm).

NUMBER PERMITTED IN ANY 6 in. (150 mm) OF WELD IS 45, WITH THE FOLLOWING RESTRICTIONS:

LARGE: OVER 0.031 in. (0.79 mm) TO 0.10 in. (2.5 mm) — 1 PERMITTED

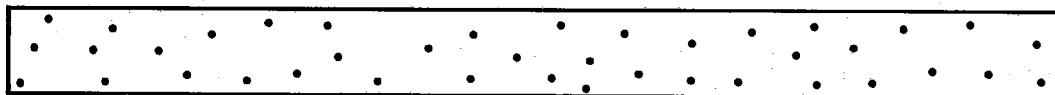
MEDIUM: OVER 0.019 in. (0.48 mm) TO 0.031 in. (0.79 mm) — 9 PERMITTED

SMALL: OVER 0.015 in. (0.38 mm) TO 0.019 in. (0.48 mm) — 35 PERMITTED

**(B) LARGE ROUNDED INDICATIONS**

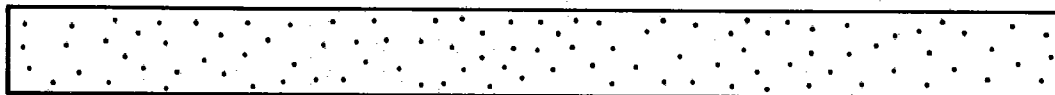
SIZE PERMITTED IS 0.031 in. (0.79 mm) TO 0.10 in. (2.5 mm).

NUMBER PERMITTED IN ANY 6 in. (150 mm) OF WELD IS 4.

**(C) MEDIUM ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.019 in. (0.48 mm) TO 0.031 in. (0.79 mm).

NUMBER PERMITTED IN ANY 6 in. (150 mm) OF WELD IS 40.

**(D) SMALL ROUNDED INDICATIONS**

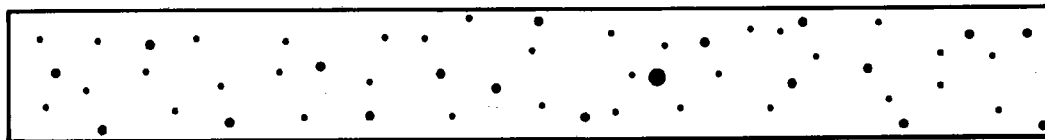
SIZE PERMITTED IS 0.015 in. (0.38 mm) TO 0.019 in. (0.48 mm).

NUMBER PERMITTED IN ANY 6 in. (150 mm) OF WELD IS 101.

Notes:

1. The chart that is most representative of the size of the rounded indications in the radiograph of the test assembly shall be used to determine conformance with this specification. Rounded indications 1/64 in. (0.40 mm) and smaller shall be disregarded. The largest dimension of the indication (including any tail) is the size of the indication.
2. These radiographic requirements are for test welds made in the laboratory specifically for classification purposes. They are more restrictive than those usually encountered in general fabrication.
3. When using the alternate method of evaluation described in 10.3.1, the total cross-sectional area of the rounded indications (calculated from measurements taken from the radiograph) shall not exceed 0.030 in.² (19.4 mm²) in any 6 in. (150 mm) of weld.
4. The acceptance standard for slag inclusions in this test assembly is:
 - (a) Length of each individual slag indication: 1/4 in. (6.4 mm) maximum
 - (b) Total length of all slag indications: 1/2 in. (13 mm) maximum

Figure 7 — Radiographic Standards for 1/2 in. (13 mm) Test Assembly

**(A) ASSORTED ROUNDED INDICATIONS**

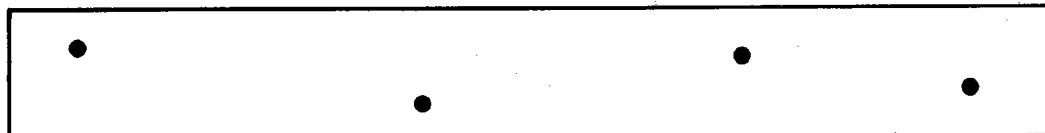
SIZE PERMITTED IS 1/64 in. (0.40 mm) TO 0.125 in. (3.2 mm).

NUMBER PERMITTED IN ANY 6 in. (150 mm) OF WELD IS 53, WITH THE FOLLOWING RESTRICTIONS:

LARGE: OVER 0.034 in. (0.86 mm) TO 0.125 in. (3.2 mm) — 1 PERMITTED

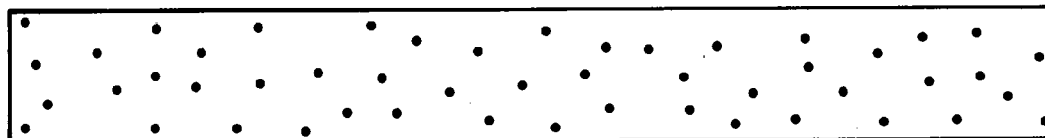
MEDIUM: OVER 0.024 in. (0.61 mm) TO 0.034 in. (0.86 mm) — 17 PERMITTED

SMALL: OVER 0.015 in. (0.38 mm) TO 0.024 in. (0.61 mm) — 35 PERMITTED

**(B) LARGE ROUNDED INDICATIONS**

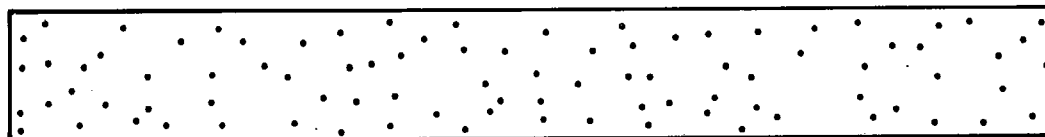
SIZE PERMITTED IS 0.034 in. (0.86 mm) TO 0.125 in. (3.2 mm).

NUMBER PERMITTED IN ANY 6 in. (150 mm) OF WELD IS 4.

**(C) MEDIUM ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.024 in. (0.61 mm) TO 0.034 in. (0.86 mm).

NUMBER PERMITTED IN ANY 6 in. (150 mm) OF WELD IS 50.

**(D) SMALL ROUNDED INDICATIONS**

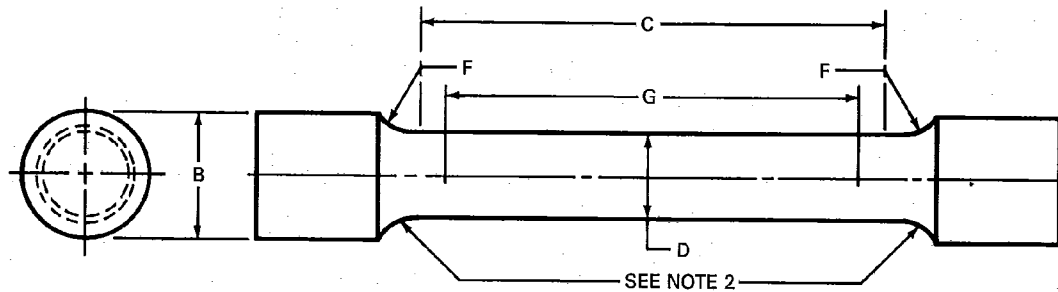
SIZE PERMITTED IS 0.015 in. (0.38 mm) TO 0.024 in. (0.61 mm).

NUMBER PERMITTED IN ANY 6 in. (150 mm) OF WELD IS 90.

Notes:

1. The chart that is most representative of the size of the rounded indications in the radiograph of the test assembly shall be used to determine conformance with this specification. Rounded indications 1/64 in. (0.4 mm) and smaller shall be disregarded. The largest dimension of the indication (including any tail) is the size of the indication.
2. These radiographic requirements are for test welds made in the laboratory specifically for classification purposes. They are more restrictive than those usually encountered in general fabrication.
3. When using the alternate method of evaluation described in 10.3.1, the total cross-sectional area of the rounded indications (calculated from measurements taken from the radiograph) shall not exceed 0.045 in.² (29.0 mm²) in any 6 in. (150 mm) of weld.
4. The acceptance standard for slag inclusions in this test assembly is:
 - (a) Length of each individual slag indication: 5/16 in. (7.9 mm) maximum.
 - (b) Total length of all slag indications: 3/4 in. (19 mm) maximum.

Figure 8 — Radiographic Standards for 3/4 in. (19 mm) Test Assembly



Dimensions of Specimen, in.

Test Assembly Thickness	D	G	C	B	F-min	Approximate Area, in. ²
3/4	0.500 ± 0.010	2.000 ± 0.005	2-1/4	3/4	0.38 (3/8)	0.2
1/2	0.250 ± 0.005	1.000 ± 0.005	1-1/4	3/8	0.18	0.05
3/8	0.160 ± 0.003	0.640 ± 0.005	3/4	5/16	0.15	0.02

Dimensions of Specimen, mm

Test Assembly Thickness	D	G	C	B	F-min	Approximate Area, mm ²
19	12.7 ± 0.25	50.8 ± 0.13	57	19	9.5	129
13	6.4 ± 0.13	25.4 ± 0.13	32	9.5	4.6	32
10	4.1 ± 0.08	16.3 ± 0.13	19	7.9	3.8	13

Notes:

1. Dimensions G and C shall be as shown, but the ends 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 gage length shall be slightly smaller at the center than at the ends. The difference shall not exceed 1% of the diameter.
3. The finish of the surface within the C dimension shall be no rougher than 63×10^{-6} in. (1.6 μ m).

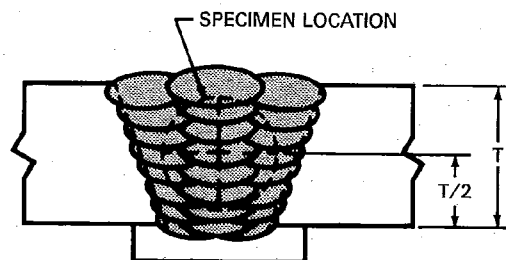


Figure 9 — Dimensions and Location of All-Weld-Metal Tension Test Specimen

Table 4
All-Weld-Metal Tension Test Requirements

AWS Classification	Tensile Strength, Min.		Elongation* Percent, Min.
	psi	MPa	
ENi-1	60 000	410	20
ENiCu-7	70 000	480	30
ENiCrFe-1 } ENiCrFe-2 } ENiCrFe-3 }	80 000	550	30
ENiCrFe-4	95 000	650	20
ENiMo-1 } ENiMo-3 }	100 000	690	25
ENiMo-7	110 000	760	25
ENiCrCoMo-1	90 000	620	25
ENiCrMo-1	90 000	620	20
ENiCrMo-2	95 000	650	20
ENiCrMo-3	110 000	760	30
ENiCrMo-4	100 000	690	25
ENiCrMo-5	100 000	690	25
ENiCrMo-6	90 000	620	35
ENiCrMo-7	100 000	690	25
ENiCrMo-9	90 000	620	25
ENiCrMo-10	100 000	690	25
ENiCrMo-11	85 000	585	25
ENiCrMo-12	95 000	650	35

*The elongation shall be determined from a gage length equal to 4 times the gage diameter.

face-bend specimens [for 5/64 in. (2 mm) electrodes], as required in Table 2, shall be taken from the assembly described in 8.4.1 and shown in Figure 2. The dimensions of the specimens shall be as shown in Table 5.

12.2 The specimens shall be bent uniformly through 180 degrees over a 3/4 in. (19 mm) radius in any suitable jig as specified in AWS B4.0, *Standard Methods for the Mechanical Testing of Welds*. Two standard jigs are shown in Figure 10. Positioning of the side-bend specimens shall be such that the side of the bend with the greater discontinuities, if any, is in tension. Positioning of the face-bend specimens shall be such that the face of the weld is in tension. For both types of transverse bend specimen, the weld shall be at the center of the bend.

12.3 Each 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 contain fissures in excess of those permitted in Table 6 when examined with the unaided eye.

Table 5
Dimensions of Bend Test Specimens

	Length ^a		Width ^a		Thickness ^a	
	in.	mm	in.	mm	in.	mm
Side	6	150	b	b	3/8	9.5
Face	6	150	1-1/2	38	3/8	9.5

Notes:

a. Minimum.

b. The width of the specimen is the thickness of the test assembly from which the specimen is taken (see Figure 2).

c. The radius of corners of the specimen shall be 1/8 in. (3.2 mm) maximum.

Part C

Manufacture, Identification, and Packaging

13. Method of Manufacture

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

14. Standard Sizes and Lengths

14.1 Standard sizes (diameter of the core wire) and lengths of electrodes are as shown in Table 7.

14.2 The diameter of the core wire shall not vary more than ± 0.003 in. (0.08 mm) from the diameter specified. The length shall not vary more than $\pm 3/8$ in. (± 10 mm) from that specified.

15. Core Wire and Covering

15.1 The core wire and covering shall be free of defects that would interfere with uniform deposition of the electrode.

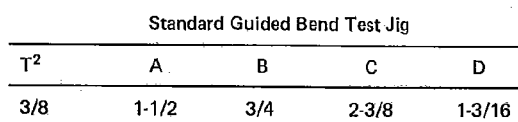
15.2 The core wire and covering shall be concentric to the extent that the maximum core-plus-one-covering dimension shall not exceed the minimum core-plus-one-covering dimension by more than the following:

(1) Seven percent of the mean dimension in sizes 3/32 in. (2.4 mm) and smaller

(2) Five percent of the mean dimension in sizes 1/8 in. (3.2 mm) and 5/32 in. (4.0 mm)

(3) Four percent of the mean dimension in sizes 3/16 in. (4.8 mm) and larger

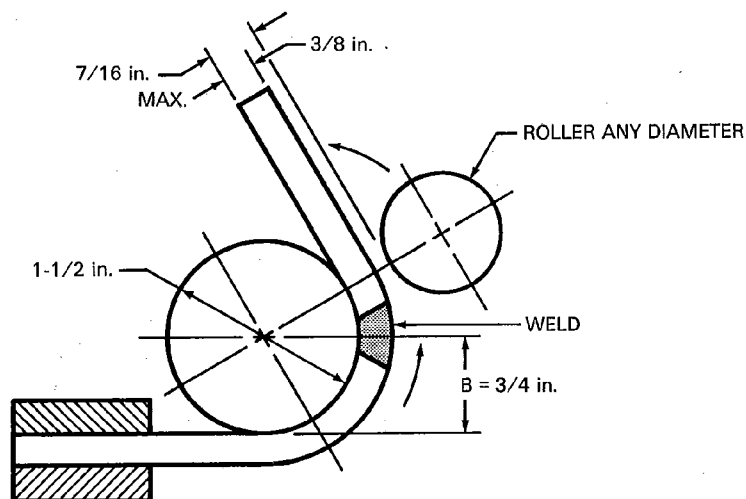
The concentricity may be measured by any suitable means.



1. Plunger and interior die surfaces shall be machine finished.
2. T = thickness of bend specimen.
3. All dimensions are in inches.

SI Equivalents			
in.	mm	in.	mm
1/8	3.2	2	51
1/4	6.4	2-3/8	60
5/16	7.9	3-7/8	98
3/8	9.5	4-1/2	110
1/2	13	5-1/4	130
5/8	16	6-3/4	170
3/4	19	7-1/2	190
1	25	9	230
1-1/8	29		
1-3/16	30		
1-1/2	38		

Figure 10 — Standard Bend Test Jigs



Wrap-around bend test jig

T	A	B
3/8	1-1/2	3/4

SI Equivalents	
in.	mm
1/16	1.6
1/4	6.4
3/8	9.5
7/16	11
3/4	19
1-1/2	38

Notes:

1. All dimensions are in inches.
2. Dimensions not shown are the option of the designer; it is essential for the jig to have adequate rigidity so the parts will not spring during the bending operation.
3. One end of the specimen shall be firmly clamped to the jig so the specimen does not slide during bending.

Figure 10 (continued)—Standard Bend Test Jigs

16. Exposed Core

16.1 The grip end of each electrode shall be bare (free of covering) for a distance of not less than 3/4 in. (19 mm), nor more than 1-1/4 in. (32 mm), to provide for electrical contact with the holder.

16.2 The arc end of each electrode shall be sufficiently bare and the covering sufficiently tapered to permit easy striking of the arc. The length of the bare portion (measured from the end to the point where the full cross section of the covering is obtained) shall not exceed 1/8 in. (3.2 mm) or the diameter of the core wire, whichever is less. Electrodes with chipped coverings near the arc end, baring the core wire no more than the lesser of 1/4 in. (6.4 mm) or twice the diameter of the core wire meet the requirements of this specification, provided no chip uncovers more than 50% of the circumference of the core.

17. Electrode Identification

All electrodes shall be identified as follows:

17.1 At least one legible imprint of the electrode classification shall be applied to the electrode covering within 2-1/2 in. (64 mm) of the grip end of the electrode.

17.2 The numbers and letters of the imprint shall be of bold block type of a size large enough to be legible.

17.3 The ink used for imprinting shall provide sufficient contrast with the electrode covering so that in normal use the numbers and letters are legible both before and after welding.

17.4 The prefix letter "E" in the electrode classification may be omitted from the imprint.

Table 6
Bend Test Requirements^a

AWS Classification	Electrode Size		Fissures Permitted						
			Maximum Number ^b	Maximum Length ^c					
	in.	mm		in.	mm				
ENi-1	{	5/64	2.0	3	1/8	3.2			
		3/32					2.4		
		1/8					3.2		
	{	5/32	4.0				4		
		3/16						4.8	
ENiCu-7	{	5/64	2.0	3					
		3/32			2.4				
		1/8			3.2				
	{	5/32	4.0		4				
		3/16				4.8			
		1/4				6.4			
ENiMo-1 ENiMo-3 ENiMo-7 ENiCrFe-1 ENiCrFe-2 ENiCrFe-4 ENiCrCoMo-1 ENiCrMo-1 ENiCrMo-2 ENiCrMo-3 ENiCrMo-4 ENiCrMo-5 ENiCrMo-6 ENiCrMo-7 ENiCrMo-9 ENiCrMo-10 ENiCrMo-11 ENiCrMo-12	{	5/64	2.0	3	3/32	2.4			
							3/32	2.4	
							1/8	3.2	
		{	5/32				4.0	3	
			3/16						4.8
		{	5/64				2.0	2	
			3/32						2.4
			1/8						3.2
			5/32						4.0
			3/16						4.8

Notes:

- a. These requirements apply to both side- and face-bend specimens.
b. The value shown is the maximum number of fissures permitted in the weld metal on the tension side of each bend specimen. The sizes of the fissures are defined in note c.
c. The number of fissures referred to in note b and shown in Table 6, is for fissures between 1/64 in. (0.4 mm) and the length shown in the last column of Table 6. Those less than 1/64 in. (0.4 mm) in length and those on the corners of the specimens shall be disregarded. Bend specimens with fissures longer than the length shown do not meet the requirements of this specification.

Table 7
Standard Sizes and Lengths

Electrode Size (Core Wire Diameter)		Standard Lengths ^a							
		ENi-1		ENiCu-7		ENiCrFe-1, ENiCrFe-2, ENiCrFe-3, ENiCrFe-4, ENiCrMo-3		ENiMo-1, ENiMo-7, ENiCrMo-1, ENiCrMo-4, ENiCrMo-6, ENiCrMo-9, ENiCrMo-11	ENiMo-3 ENiCrCoMo-1 ENiCrMo-2, ENiCrMo-5, ENiCrMo-7, ENiCrMo-10, ENiCrMo-12 ^b
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
5/64 (0.078)	2.0	9	230	9	230	9	230	9	230
3/32 (0.094)	2.4	9 or 12	230 or 300	9 or 12	230 or 300	9 or 12	230 or 300	9 or 12	230 or 300
1/8 (0.125)	3.2	14	300	14	300	12 or 14	300 or 360	14	360
5/32 (0.156)	4.0	14	350	14	360	14	360	14	360
3/16 (0.188)	4.8 ^b	14	350	14	360	14	360	14	360
1/4 (0.250)	6.4	—	—	14	360	—	—	—	—

Notes:

a. Other lengths shall be as agreed by the purchaser and the supplier.

b. The 3/16 in. (4.8 mm) diameter is not standard for the ERNiCrMo-12 classification.

18. Packaging

18.1 Electrodes shall be suitably packaged to protect them from damage during shipment and storage under normal conditions.

18.2 Package weights shall be as agreed upon by supplier and purchaser.

19. Marking of Packages

19.1 The following product information (as a minimum) shall be legibly marked on the outside of each unit package:

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

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

WARNING:

- Protect yourself and others.
- Read and understand this label.
- 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 (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 and Cutting*, published by the American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, Florida, 33135; OSHA Safety and Health Standards, 29 CFR 1910, available from the U.S. Government Printing Office, Washington, DC 20402.

DO NOT REMOVE THIS INFORMATION

Appendix

Guide to AWS Specification for Nickel and Nickel Alloy Welding Electrodes for Shielded Metal Arc Welding

(This Appendix is not a part of ANSI/AWS A5.11-90, *Specification for Nickel and Nickel Alloy Welding Electrodes for Shielded Metal 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. Reference to appropriate base metal specifications is made whenever that can be done and when it would be helpful. Such references are intended only as examples rather than complete listings of the base metals for which each filler metal is suitable.

A2. Classification System

A2.1 The system for identifying the electrode classifications in this specification follows the standard pattern used in other AWS filler metal specifications. The letter "E" at the beginning of each classification designation stands for electrode.

A2.2 Since the electrodes are classified according to the chemical composition of the weld metal they deposit, the chemical symbol "Ni" appears right after the "E", as a means of identifying the electrodes as nickel-base alloys. The other symbols (Cr, Cu, Fe, Mo, and Co) in the designations are intended to group the electrodes according to their principal alloying elements. The individual designations are made up of these symbols and a number at the end of the designation (ENiMo-1 and ENiMo-3, for example). These numbers separate one composition from another, within a group, and are not repeated within that group.

A2.3 From an application point of view, the electrode classifications in this specification have corresponding classifications in ANSI/AWS A5.14, *Specification for Bare Nickel and Nickel Alloy Welding Electrodes and Rods*, for those cases in which there is a corresponding application for a bare electrode or rod (ER). Table A1 correlates the covered electrode classifications in this edition with those in the previous edition of this specification and the corresponding ER classification in ANSI/AWS A5.14. It also lists the current designation for each classification as it is given in a prominent and pertinent military specification, when such a designation exists.

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 that 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 the supplier normally conducts on material of that classification, as specified in Schedule F, Table I, of 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

Table A1
Comparison of Classifications

Classification in A5.11		Military Designation*	Corresponding Classification in A5.14
Present Classification	Previous Classification**		
ENi-1	ENi-1	4N11	ERNi-1
ENiCu-7	ENiCu-7	9N10	ERNiCu-7
ENiCrFe-1	ENiCrFe-1	3N12	—
ENiCrFe-2	ENiCrFe-2	4N1A	—
ENiCrFe-3	ENiCrFe-3	8N12	ERNiCr-3
ENiCrFe-4	ENiCrFe-4	—	—
ENiMo-1	ENiMo-1	3N1B	ERNiMo-1
ENiMo-3	ENiMo-3	4N1W	ERNiMo-3
ENiMo-7	ENiMo-7	—	ERNiMo-7
ENiCrCoMo-1	Not classified	—	ERNiCrCoMo-1
ENiCrMo-1	ENiCrMo-1	—	ERNiCrMo-1
ENiCrMo-2	ENiCrMo-2	—	ERNiCrMo-2
ENiCrMo-3	ENiCrMo-3	1N12	ERNiCrMo-3
ENiCrMo-4	ENiCrMo-4	—	ERNiCrMo-4
ENiCrMo-5	ENiCrMo-5	3N1C	—
ENiCrMo-6	ENiCrMo-6	—	—
ENiCrMo-7	ENiCrMo-7	—	ERNiCrMo-7
ENiCrMo-9	ENiCrMo-9	—	ERNiCrMo-9
ENiCrMo-10	Not Classified	—	ERNiCrMo-10
ENiCrMo-11	Not Classified	—	ERNiCrMo-11
ENiCrMo-12	Not Classified	—	—

* MIL-E-22200/3

** A5.11-83

Notes:

1. A5.11 is ANSI/AWS A5.11, *Specification for Nickel and Nickel Alloy Electrodes for Shielded Metal Arc Welding*.
2. Military Designation MIL-E-22200/3, is Nickel Base Alloy and Cobalt Base Alloy Covered Welding Electrodes.
3. A5.14 is ANSI/AWS A5.14, *Specification for Bare Nickel and Nickel Alloy Welding Electrodes and Rods*.

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 representative 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 Program" in ANSI/AWS A5.01, *Filler Metal Procurement Guidelines*.

A5. Ventilation During Welding

A5.1 The following 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 involved

(4) The proximity of the welders or welding operators to the fumes as they issue from the welding zone, and to the gases and dust 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 and Cutting* (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 dealing with Health Protection and Ventilation.

A6. Welding Considerations

A6.1 Before welding or heating any nickel-base alloy, the material must be clean. Oil, grease, paint, lubricants, marking pencils, temperature-indicating materials, threading compounds, and other such materials frequently contain sulfur, lead, or silver, which may cause cracking (embrittlement) of the base metal or the weld metal if present during welding or heating.

A6.2 Electrodes of some of the classifications are used for dissimilar metal welds. When making such welds, it is important to obtain as little dilution as possible from the dissimilar metal member (steel, for example). This can be done by traveling slowly to deposit a thicker bead and to dissipate the energy of the arc against the molten weld metal or the nickel-base metal, rather than the steel member.

A6.3 Most of the electrodes in this specification are intended to be used with DCEP (Direct Current, Electrode Positive). Some of the new electrodes, however, are designed to operate also on alternating current. Electrodes of that type are so noted in the following discussion of each classification.

A7. Description and Intended Use of Electrodes

A7.1 ENi-1 Classification. Electrodes of this classification are used for welding wrought and cast forms of commercially pure nickel to themselves and to steel (i.e., joining nickel to steel and surfacing steel with nickel). Typical specifications for this nickel base metal are ASTM B160, B161, B162, and B163, all of which have UNS Numbers N02200 or N02201. Electrodes through the 1/8 in. (3.2 mm) size can be used in all positions. Electrodes larger than that are used only in the horizontal and flat positions.

A7.2 ENiCu-7 Classification. Electrodes of this classification are used for welding nickel-copper alloys to themselves and to steel, for welding the clad side of joints in steel clad with a nickel-copper alloy, and for surfacing steel with nickel-copper alloy weld metal. Typical specifications for the nickel-copper base metal are ASTM B127, B163, B164, B165, all of which have UNS Number N04400.

Electrodes through the 1/8 in. (3.2 mm) size can be used in all positions. Electrodes larger than that are used only in the flat and horizontal positions. The weld metal is suitable for service both in the as-welded condition and after an appropriate postweld heat treatment. Qualification tests should be conducted beforehand to make certain the necessary properties can be obtained after the particular heat treatment is employed.

A7.3 ENiCrFe Classifications

A7.3.1 ENiCrFe-1. Electrodes of this classification are used for welding nickel-chromium-iron alloys, for the clad side of joints in steel clad with nickel-chromium-iron alloy, and for surfacing steel with nickel-chromium-iron weld metal. The electrodes may be used for applications at temperatures ranging from cryogenic to around 1800°F (980°C). However, for temperatures above 1500°F (820°C), these electrodes do not exhibit optimum oxidation resistance and strength. The electrodes are also suitable for joining steel to nickel-base alloys. Typical specifications for the nickel-chromium-iron base metal are ASTM B163, B166, B167, and B168, all of which have UNS Number N06600. Electrodes through the 1/8 in. (3.2 mm) size can be used in all positions. Electrodes larger than that are used only in the horizontal and flat positions.

A7.3.2 ENiCrFe-2. Electrodes of this classification are used for welding nickel-chromium-iron alloys, 9% nickel steel and a variety of dissimilar metal joints (involving carbon steel, stainless steel, nickel, and nickel base alloys). The base metals can be wrought or cast (welding grade), or both. The electrodes may be used for applications at temperatures ranging from cryogenic to around 1800°F (980°C). However, for temperatures above 1500°F (820°C), ENiCrFe-2 does not exhibit optimum oxidation resistance and strength. Typical specifications for the nickel-chromium-iron base metal are ASTM B163, B166, B167, and B168, all of which have UNS Number N06600. Electrodes through the 1/8 in. (3.2 mm) size can be used in all positions. Electrodes larger than that are used only in the horizontal and flat positions.

A7.3.3 ENiCrFe-3. Electrodes of this classification are used for welding nickel-chromium-iron alloys, for welding the clad side of joints on steel clad with nickel-chromium-iron alloy, and for surfacing steel with nickel-chromium-iron weld metal, when comparatively high

manganese contents are not detrimental. The electrode may be used for applications at temperatures ranging from cryogenic to about 900°F (480°C). Typical specifications for the nickel-chromium-iron base metal are ASTM B163, B166, B167, and B168, all of which have UNS Number N06600.

These electrodes can also be used for welding steel to other nickel-base alloys. Fewer fissures are permitted on the bend test for this weld metal than for weld metal of the ENiCrFe-1 and ENiCrFe-2 classifications. Electrodes through the 1/8 in. (3.2 mm) size can be used for welding in all positions. Electrodes larger than that are used only in the horizontal and flat positions.

A7.3.4 ENiCrFe-4. Electrodes of this classification are used for welding 9% nickel steel. Typical specifications for the 9% nickel steel base metal are ASTM A333, A334, A353, A522, and A553, all of which have UNS Number K81340. The strength of the weld metal is higher than that of the ENiCrFe-2 classification and the electrodes are ac-dc electrodes. Because of the latter, they are especially useful where ac is desired to combat arc blow.

A7.4 ENiMo Classifications

A7.4.1 ENiMo-1. Electrodes of the ENiMo-1 classification are used for welding nickel-molybdenum alloys as well as the clad side of joints in steel clad with a nickel-molybdenum alloy and for welding nickel-molybdenum alloys to steel and to other nickel base alloys. Typical specifications for the nickel-molybdenum base metal are ASTM B333, B335, B619, B622, and B626, all of which have UNS Number N10001. ENiMo-1 electrodes normally are used only in the flat position.

A7.4.2 ENiMo-3. Electrodes of the ENiMo-3 classification are used for welding dissimilar metal combinations of nickel-base, cobalt-base, and iron-base alloys. These electrodes normally are used only in the flat position.

A7.4.3 ENiMo-7. Electrodes of the ENiMo-7 classification have controlled low levels of carbon, iron, and cobalt and are used for welding nickel-molybdenum alloys, for welding the clad side of joints in steel clad with a nickel-molybdenum alloy, and for welding nickel-molybdenum alloys to steel and to other nickel base alloys. Typical specifications for the nickel-molybdenum base metals are ASTM B333, B335, B619, B622, and B626, all of which have UNS Number N10665. These electrodes normally are used only in the flat position.

A7.5 ENiCrCoMo-1 Classification. Electrodes of the ENiCrCoMo-1 classification are used for welding nickel-chromium-cobalt-molybdenum alloys (UNS No. N06617) to themselves and to steel and for surfacing steel with nickel-chromium-cobalt-molybdenum weld metal. The electrodes are also used for applications where

optimum strength and oxidation resistance is required above 1500°F (820°C) up to 2100°F (1150°C), especially when welding on base metals of nickel-iron-chromium alloys. Electrodes 3/32 in. (2.4 mm) and 1/8 in. (3.2 mm) in diameter can be used for welding in all positions. Larger electrodes are used for welding in the flat or horizontal positions.

A7.6 ENiCrMo Classifications

A7.6.1 ENiCrMo-1. Electrodes of this classification are used for welding nickel-chromium-molybdenum alloys, for welding the clad side of joints in steel clad with nickel-chromium-molybdenum alloy, and for welding nickel-chromium-molybdenum alloy to steel and to other nickel base alloys. Typical specifications for the nickel-chromium-molybdenum base metals are ASTM B581, B582, B619, and B622, all of which have UNS Number N06007. These electrodes normally are used only in the flat position.

A7.6.2 ENiCrMo-2. Electrodes of this classification are used for welding nickel-chromium-molybdenum alloys, for welding the clad side of joints in steel clad with nickel-chromium-molybdenum alloy, and for welding nickel-chromium-molybdenum alloys to steel and to other nickel base alloys. Typical specifications for the nickel-chromium-molybdenum base metals are ASTM B435, B572, B619, B622, and B626, all of which have UNS Number N06002. These electrodes normally are used only in the flat position.

A7.6.3 ENiCrMo-3. Electrodes of the ENiCrMo-3 classification are used for welding nickel-chromium-molybdenum alloys to themselves and to steel, and for surfacing steel with nickel-chromium-molybdenum weld metal. These electrodes also can be used for welding nickel base alloys to steel. The electrodes are used in applications where the temperature ranges from cryogenic to 1800°F (980°C). For optimum strength and oxidation resistance above 1500°F (820°C), the ENiCrCoMo-1 electrode should be used. Typical specifications for the nickel-chromium-molybdenum base metals are ASTM B443, B444, and B446, all of which have UNS Number N06625. Electrodes through the 1/8 in. (3.2 mm) size can be used for welding in all positions. Electrodes larger than that are used only in the flat and horizontal positions.

A7.6.4 ENiCrMo-4. Electrodes of this classification are used for welding low carbon nickel-chromium-molybdenum alloy, for welding the clad side of joints in steel clad with low carbon nickel-chromium-molybdenum alloy, and for welding low carbon nickel-chromium-molybdenum alloy to steel and to other nickel base alloys. Typical specifications for the nickel-chromium-molybdenum base metals are ASTM B574, B575, B619, B622, and B626, all of which have UNS Number N10276.

These electrodes normally are used only in the flat position.

A7.6.5 ENiCrMo-5. Electrodes of this classification are used for welding of joints in steel clad with a nickel-chromium-molybdenum alloy and for the joining of nickel-chromium-molybdenum alloys to steel or to other nickel base alloys. Typical specification for the nickel-chromium-molybdenum base metals are ASTM B334, B336, and B366, all of which have UNS Number N10002. These electrodes normally are used only in the flat position.

A7.6.6 ENiCrMo-6. Electrodes of this classification are used for welding 9% nickel steel, but they can be used in other applications as well. Typical specifications for the 9% nickel steel base metal are ASTM A333, A334, A353, A522, and A553, all of which have UNS Number K81340. These electrodes are ac-dc electrodes, which makes them especially useful for combating magnetic arc blow. Electrodes through the 1/8 in. (3.2 mm) size can be used for welding in all positions. Electrodes larger than that are used only in the flat and horizontal positions.

A7.6.7 ENiCrMo-7. Electrodes of this classification are used for welding nickel-chromium-molybdenum alloy, for the welding of the clad side of joints in steel clad with nickel-chromium-molybdenum alloy, and for joining nickel-chromium-molybdenum alloys to steel and to other nickel-base alloys. Typical specifications for the nickel-chromium-molybdenum base metals are ASTM B574, B575, B619, B622, and B626, all of which have UNS Number N06455. These electrodes normally are used only in the flat position.

A7.6.8 ENiCrMo-9. Electrodes of this classification are used for welding nickel-chromium-molybdenum alloy, for the welding of the clad side of joints in steel clad with nickel-chromium-molybdenum alloy, and for joining nickel-chromium-molybdenum alloys to steel and to other nickel base alloys. Typical specifications for the nickel-chromium-molybdenum base metal are ASTM B581, B582, B619, B622, and B626, all of which have UNS Number N06985. These electrodes normally are used only in the flat position.

A7.6.9 ENiCrMo-10. Electrodes of this classification are used for welding nickel-chromium-molybdenum alloy, for the welding of the clad side of joints in steel clad with nickel-chromium-molybdenum alloy, and for joining nickel-chromium-molybdenum alloys. Typical specifications for the nickel-chromium-molybdenum base metals are ASTM B574, B575, B619, B622, and B626, all of which have UNS Number N06022. Electrodes through the 1/8 in. (3.2 mm) size can be used for welding in all positions. Electrodes larger than that are used only in the flat position.

A7.6.10 ENiCrMo-11. Electrodes of this classification are used for welding nickel-chromium-molybdenum alloy, for the welding of the clad side of joints in steel clad with nickel-chromium-molybdenum alloy, and for joining nickel-chromium-molybdenum alloys to steel and to other nickel-base alloys. Typical specifications for the nickel-chromium-molybdenum base metal are ASTM B581, B582, B619, B622, and B626, all of which have UNS Number N06030. These electrodes normally are used only in the flat position.

A7.6.11 ENiCrMo-12. Electrodes of this classification are used for welding chromium-nickel-molybdenum austenitic stainless steels to themselves, to duplex (austenitic-ferritic) stainless steels, to nickel-chromium-molybdenum alloys, and to steel. The ENiCrMo-12 composition is balanced to provide corrosion resistant welds for use at temperatures below the creep range of highly alloyed austenitic stainless steels. Typical specifications for the chromium-nickel-molybdenum stainless steel base metals are A240, A167, A182, A249, A276, A312, A358, A473, and A479, most particularly the grade UNS S31254 contained in those specifications. Electrodes through the 1/8 in. (3.2 mm) size can be used for welding in all positions. Electrodes larger than that can be used only for welding in the flat and horizontal positions.

A8. Special Tests

It is recognized that supplementary tests may be required for certain applications. In such cases, tests to determine specific properties such as corrosion resistance, scaling resistance, or strength at elevated or cryogenic temperatures may be required.

ANSI/AWS A5.01, *Filler Metal Procurement Guidelines*, contains provisions for ordering such tests. This section is included for the guidance of those who desire to specify such special tests. Those tests may be conducted as agreed upon between supplier and purchaser.

A8.1 Corrosion or Scaling Tests

A8.1.1 Although welds with electrodes in this specification are commonly used in corrosion and heat-resisting applications, tests for those properties are not included in the specification. When required for a particular application, tests can be conducted on specimens taken from either a weld pad or a welded joint. Specimens from a joint are suitable for qualifying the welding procedure (for a specific application involving corrosion or oxidation resistance), but not for qualifying the electrode.

Tests on specimens from a joint have the disadvantage of being a combined test of the properties of the weld metal, the heat-affected zone, and the unaffected base

metal. With them, it is more difficult to obtain reproducible data (when a difference exists in the properties of the metal in the various parts of the specimen). Specimens taken from a joint have the advantage of being able to duplicate the joint design and the welding sequence planned for fabrication.

A8.1.2 Specimens for testing corrosion or oxidation resistance of the weld metal alone are prepared by following the procedure outlined in 8.3 of the specification. The pad size should be at least $3/4$ in. (19 mm) in height by $2\text{-}1/2$ in. (65 mm) by $[1 + 5n/8 \text{ in. } (25 + 16n \text{ mm})]$ where, "n" represents the number of specimens required

from the pad. Specimens measuring $1/2 \times 2 \times 1/4$ in. ($13 \times 50 \times 6.4$ mm) are machined from the top of the pad in a manner such that the 2 in. (50 mm) dimension of the specimen is parallel to the $2\text{-}1/2$ in. (64 mm) dimension of the pad and the $1/2$ in. (13 mm) dimension is parallel with the length of the pad.

A8.1.3 The heat treatment, surface finish, and marking of the specimens prior to testing should be in accordance with standard practices for tests of similar alloys in the wrought or cast forms. The testing procedures should correspond to ASTM, *Recommended Practice G4 for Conducting Plant Corrosion Tests*.

AWS Filler Metal 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 Stainless Steel Weld Metal
A4.3	Standard Procedures for Determination of 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 Covered Carbon Steel Arc Welding Electrodes
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 Covered Corrosion-Resisting Chromium and Chromium-Nickel Steel Welding Electrodes
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
A5.9	Specification for Corrosion-Resisting Chromium and Chromium-Nickel Steel Bare and Composite Metal Cored and Stranded Welding Electrodes and Welding 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 Arc Welding Electrodes
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 Filler Metals for Gas Shielded Arc Welding
A5.19	Specification for Magnesium Alloy Welding Rods and Bare Electrodes
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 Electrodes
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 Consumables Used for Electroslag Welding of Carbon and High Strength Low Alloy Steels
A5.26	Specification for Consumables Used for Electrode Gas Welding of Carbon and High Strength Low Alloy Steels
A5.27	Specification for Copper and Copper Alloy Rods for Oxyfuel Gas 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

For additional information, contact the Order Department, American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, Florida 33135.