NOTICE OF
ADOPTION

AWS A5.15-90
NOTICE 1
8 April 1991
SUPERSEDING
AWS A5.15-82
15 April 1983

ADOPTION NOTICE

WELDING ELECTRODES AND RODS FOR CAST IRON

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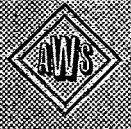
ANSI/AWS A5.15-90
An American National Standard

Specification for Welding Electrodes and Rods for Cast Iron



American Welding Society

Keywords — Welding electrodes, welding rods, cast iron, filler metal specifications, flux cored arc welding electrodes, shielded metal arc welding electrodes gas metal arc welding electrodes

ANSI/AWS A5.15-90
An American National Standard

Approved by
American National Standards Institute
March 14, 1990

Specification for Welding Electrodes and Rods for Cast Iron

Superseding
ANSI/AWS A5.15-82

Prepared by
AWS Committee on Filler Metal

Issued 1956: Revised, 1965, 1969, 1982

Under the Direction of
Technical Activities Committee

Approved by
AWS Board of Directors

Abstract

The chemical composition requirements for electrodes and rods for welding cast iron are specified. Copper-base rods used for braze welding of cast iron are not included. Major topics include general requirements, testing, packaging, and application guidelines.

American Welding Society
550 N.W. LeJeune Road, P. O. Box 351040, Miami, Florida 33135

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International Standard Book Number: 0-87171-328-4

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Foreword

(This Foreword is not a part of ANSI/AWS A5.15-90, *Specification for Welding Electrodes and Rods for Cast Iron*, but is intended for information purposes only.)

The first specification for electrodes and rods for welding cast iron was published more than thirty years ago as a joint ASTM/AWS document. The first revision that was exclusively an AWS specification was published in 1969 and revised in 1982.

Evolution of the document is as shown below:

ASTM A398-56T AWS A5.15-56T	Tentative Specification for Welding Rods and Covered Electrodes for Welding Cast Iron.
AWS A5.15-65T ASTM A398-65T	Tentative Specification for Welding Rods and Covered Electrodes for Cast Iron
AWS A5.15-69 ANSI W3.15-1973	Specification for Welding Rods and Covered Electrodes for Welding Cast Iron
ANSI/AWS A5.15-82	Specification for Welding Rods and Covered Electrodes for Cast Iron

Comments and suggestions for 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.

Table of Contents

List of Tables

List of Figures

Specification for Welding Electrodes and Rods for Cast Iron

1. Scope

This specification prescribes requirements for the classification of the following:

(1) Rods for oxyfuel gas welding
(2) Electrodes for gas metal arc welding
(3) Electrodes for flux cored arc welding
(4) Electrodes for shielded metal arc welding

These filler metals are suitable for welding gray cast iron, malleable cast iron, nodular cast iron, compacted graphite cast iron, and certain alloy cast irons.[1]

Part A
General Requirements

2. Classification

2.1 The electrodes and rods covered by this specification are classified according to chemical composition, as specified in Tables 1A, 1B, and 1C.

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

2.3 The electrodes and rods classified under this specification are intended for oxyfuel gas welding, shielded metal arc welding, gas metal arc welding, or flux cored arc welding, as applicable, but that is not to prohibit their use with any other process for which they are found suitable.

3. Acceptance

Acceptance[2] of the welding electrodes shall be in accordance with the provisions of ANSI/AWS A5.01, *Filler Metal Procurement Guidelines.*[3]

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,

1. Copper-base filler metals frequently used in the braze welding of cast iron are no longer included in this specification. For information pertaining to these materials see A7.6 in the Appendix.

2. See section A3 (in the Appendix) for further information concerning acceptance, testing of the material shipped, and *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. See section A4 (in the Appendix) for further information concerning certification and the testing called for to meet this requirement.

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 unit" in the last right-hand place of figures used in expressing the limiting value in accordance with the rounding off method given in ANSI/AWS A1.1, *Metric Practice Guide for the Welding Industry.*

Table 1A*
Chemical Composition Requirements for Undiluted Weld Metal for Shielded Metal Arc and Flux Cored Arc Welding Electrodes

		Weight Percent[a,b,c]										
AWS Classification[d]	UNS Number[e]	C	Mn	Si	P	S	Fe	Ni[f]	Mo	Cu[g]	Al	Other Elements, Total
Shielded Metal Arc Welding Electrodes												
ENi-CI	W82001	2.0	2.5	4.0	—	0.03	8.0	85 min.	—	2.5	1.0	1.0
ENi-CI-A	W82003	2.0	2.5	4.0	—	0.03	8.0	85 min.	—	2.5	1.0-3.0	1.0
ENiFe-CI	W82002	2.0	2.5	4.0	—	0.03	Rem.	45-60	—	2.5	1.0	1.0
ENiFe-CI-A	W82004	2.0	2.5	4.0	—	0.03	Rem.	45-60	—	2.5	1.0-3.0	1.0
ENiFeMn-CI	W82006	2.0	10-14	1.0	—	0.03	Rem.	35-45	—	2.5	1.0	1.0
ENiCu-A	W84001	0.35-0.55	2.3	0.75	—	0.025	3.0-6.0	50-60	—	35-45	—	1.0
ENiCu-B	W84002	0.35-0.55	2.3	0.75	—	0.025	3.0-6.0	60-70	—	25-35	—	1.0
Flux Cored Arc Welding Electrodes												
ENiFeT3-CI[h]	W82032	2.0	3.0-5.0	1.0	—	0.03	Rem.	45-60	—	2.5	1.0	1.0

*See notes on following page.

Table 1B*
Chemical Composition Requirements for Core Wire for Shielded Metal Arc Welding Electrodes

		Weight Percent[a,b,c]										
AWS Classification[d]	UNS Number[e]	C	Mn	Si	P	S	Fe	Ni	Mo	Cu	Al	Other Elements, Total
Shielded Metal Arc Welding Electrodes												
ESt	K01520	0.15	0.60	0.15	0.04	0.04	Rem.	—	—	—	—	—

*See notes on following page.

(Continued)

Table 1C
Chemical Composition Requirements
for Rods and Bare Electrodes

AWS Classification[d]	UNS Number[e]	Weight Percent[a,b,c] C	Mn	Si	P	S	Fe	Ni[f]	Mo	Cu[g]	Mg	Al	Ce	Other Elements, Total
Cast Iron Welding Rods for OFW														
RCI	F10090	3.2-3.5	0.60-0.75	2.7-3.0	0.50-0.75	0.10	Rem.	Trace	Trace	—	—	—	—	—
RCI-A	F10091	3.2-3.5	0.50-0.70	2.0-2.5	0.20-0.40	0.10	Rem.	1.2-1.6	0.25-0.45	—	—	—	—	—
RCI-B	F10092	3.2-4.0	0.10-0.40	3.2-3.8	0.05	0.015	Rem.	0.50	—	—	0.04-0.10	—	0.20	—
Electrodes for Gas Metal Arc Welding														
ERNi-CI	N02215	1.0	2.5	0.75	—	0.03	4.0	90 min.	—	4.0	—	—	—	1.0
ERNiFeMn-CI	N02216	0.50	10-14	1.0	—	0.03	Rem.	35-45	—	2.5	—	1.0	—	1.0

Notes:

a. The weld metal, core wire, or the filler metal, as specified, 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 this 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 shown are maximum, unless otherwise noted.

c. "Rem." stands for Remainder.

d. Copper-base filler metals frequently used in the braze welding of cast irons are no longer included in this specification. For information pertaining to these materials see A7.6.

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

f. Nickel plus incidental cobalt.

g. Copper plus incidental silver.

h. No shielding gas shall be used for classification ENiFeT3-CI.

Part B
Tests, Procedures, and Requirements

6. Summary of Tests

Chemical analysis, as specified in Table 2, of the filler metal or rod stock from which the filler metal is made, or the core wire, or the undiluted weld metal is the only test required for classification of a product under this specification.

7. Retest

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

8. Weld Test Assembly

8.1 One test assembly is required. It is the weld pad in Figure 1 for chemical analysis of undiluted weld metal from electrodes for shielded metal arc or flux cored arc welding electrodes, except for the ESt classification for which the core is analyzed.

Table 2
Required Tests

AWS Classification	Chemical Analysis of Undiluted Weld Metal from Weld Pad[1]	Chemical Analysis of Filler Metal[1]
ENi-CI	Required	N.R.
ENi-CI-A	Required	N.R.
ENiFe-CI	Required	N.R.
ENiFe-CI-A	Required	N.R.
ENiFeMn-CI	Required	N.R.
ENiCu-A	Required	N.R.
ENiCu-B	Required	N.R.
ENiFeT3-CI	Required	N.R.
RCI	N.R.	Required
RCI-A	N.R.	Required
RCI-B	N.R.	Required
ERNi-CI	N.R.	Required
ERNiFeMn-CI	N.R.	Required
ESt	N.R.	Required[2]

Notes:

1. "N.R." means that the test is not required.

2. Chemical requirements for the ESt classification are based on the composition of the core wire without any flux coatings.

8.2 Preparation of the weld test assembly shall be as prescribed in 8.3 and Figure 1. The base metal for the assembly shall be gray iron, nodular iron, or carbon steel. Testing of the assembly shall be as prescribed in 9.2 and 9.3

8.3 Weld Pad. When required by Table 2, a weld pad shall be prepared as specified in Figure 1. Base metal of any convenient size, of the type specified in 8.2, 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 multiple layers to obtain undiluted weld metal. The preheat temperature shall not be 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 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 9.2.

9. Chemical Analysis

9.1 For solid filler metal classified in Table 1A, and the core wire for electrodes classified in Table 1B, a sample of the filler metal, core wire, or the rod stock from which the filler metal or core wire is made, shall be prepared for chemical analysis. Solid filler metal, when analyzed for elements that are present in a coating (copper flashing, for example), shall be analyzed without removing the coating. When the filler metal is analyzed for elements other than those in the coating, the coating shall be removed if its presence affects the results of the analysis for other elements. Rod stock analyzed for elements not in the coating may be analyzed prior to applying the coating.

9.2 For electrodes classified in Table 1A, a sample shall be analyzed in the form of weld metal, not filler metal. The sample for analysis shall be taken from weld metal obtained with the filler metal. The sample shall come from a weld pad as shown in Figure 1. The top surface of the pad described in 8.3 and shown in Figure 1 shall be removed, discarded, and a sample for analysis shall be obtained from the underlying metal by any appropriate mechanical means. The sample shall be free of slag.

For covered electrodes 1/8 in. (3.2 mm) and smaller and flux cored electrodes .052 in. (1.3 mm) diameter and smaller, the sample shall be taken at least 7/16 in. (11 mm) from the nearest surface of the base metal. For covered electrodes larger than 1/8 in. (3.2 mm) diameter and flux cored electrodes larger than .052 in. (1.3 mm), the sample shall be taken at least 9/16 in. (14 mm) from that surface.

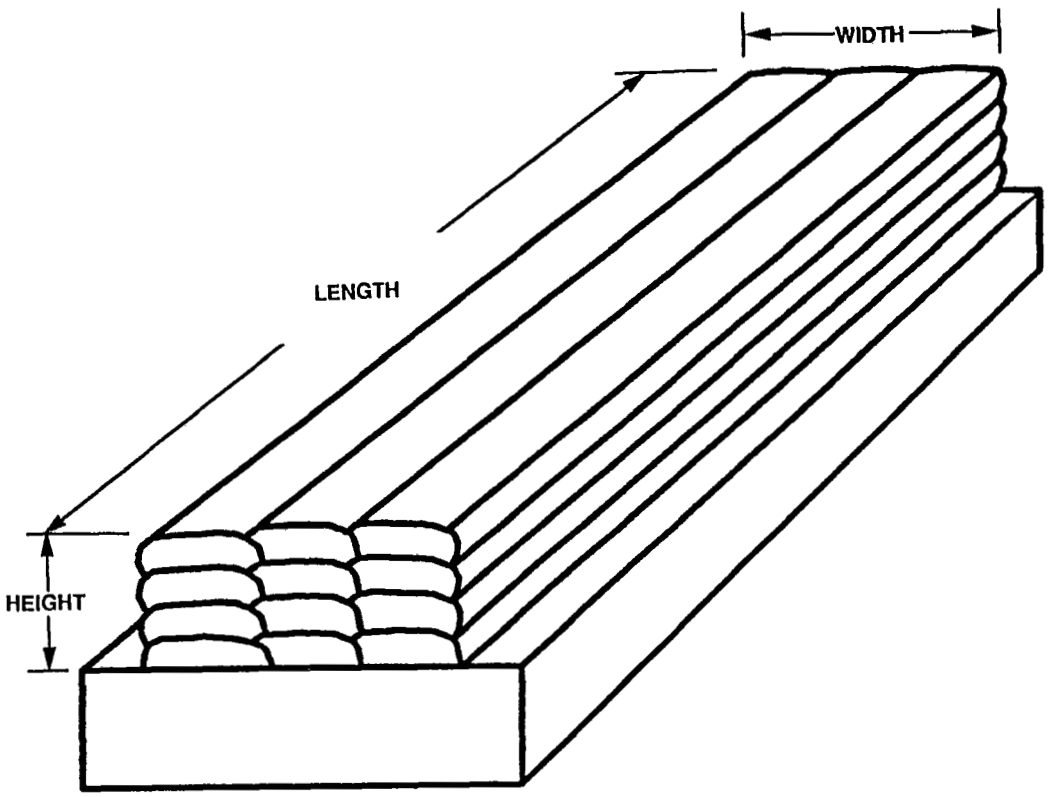
9.3 The sample shall be analyzed by accepted analytical methods. The referee method shall be the appropriate one of the following: [5]

(1) ASTM E39, Standard Method for Chemical Analysis of Nickel

(2) ASTM E76, Standard Methods for Chemical Analysis of Nickel-Copper Alloys

(3) ASTM E350, Standard Method for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron and Wrought Iron

5. ASTM standards can be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19013.



Shielded Metal Arc Welding			Flux Cored Arc Welding			
Electrode Diameter	Minimum Height (H)	Minimum Length (L)	Electrode Diameter	Minimum Height (H)	Minimum Length (L)	Min. No. of Layers
1/8 in. (3.2 mm) and less	1/2 in. (13 mm)	1-1/2 in. (38 mm)	.052 in. (1.3 mm) and less	5/8 in. (16 mm)	3 in. (76 mm)	4
Greater than 1/8 in. (3.2 mm)	7/8 in. (22 mm)	2 in. (51 mm)	Greater than .052 in. (1.3 mm)	1 in. (25 mm)	4 in. (102 mm)	4

Notes: The width (W) of the weld metal shall be sufficient for the method of analysis. No shielding gas shall be used for classification ENiFeT3-CI.

Figure 1—Pad for Chemical Analysis of Undiluted Weld Metal

(4) ASTM E351, Standard Methods for Chemical Analysis of Cast Iron—All types

(5) ASTM E353, Standard Methods for Chemical Analysis of Stainless Heat Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys

(6) ASTM E354, Standard Method for Chemical Analysis of High Temperature Electric, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys

9.4 The results of the analysis shall meet the requirements of Table 1 for the classification of filler metal under test.

Part C
Manufacture, Identification, and Packaging

10. Welding Rods

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

10.2 Standard Sizes and Lengths. Standard sizes for welding rod shall be as shown in Table 3.

10.3 Finish and Uniformity. All rods shall a have smooth finish that is free from slivers, depressions, scratches, scale, seams, laps, and foreign matter that would adversely affect the welding characteristics or the properties of the weld metal.

10.4 Standard Package Forms. Standard package forms are straight lengths. Standard package dimensions are not specified. Welding rods shall be packed in containers of 5, 10, 25, 30, 50, 60, or 100 lb (2.3, 4.5, 11, 14, 23, 27 or 45 g) net weight. Other package weights shall be as agreed upon by supplier and purchaser.

10.5 Packaging. Welding rods shall be suitably packaged to ensure against damage shipment and storage under normal conditions.

10.6 Marking of Packages

10.6.1 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

10.6.2 Marking of any overpacking of unit packages with the items listed in 10.6.1 shall be optional with the manufacturer.

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

Table 3
Standard Sizes and Lengths of Welding Rods[a]

AWS Classification	Size, in.	Size Tolerance, in.	Length in.	Length Tolerance, in.
RCI	1/8 round	± 1/32	18	+1/2, -2
	1/8 square	± 1/32	20	+1/4, -2
	3/16, 1/4, 5/16, 3/8, 1/2, round or square	± 1/32	24	± 1/4, -2
RCI-A	1/8, 3/16, 1/4, 5/16, 3/8, 1/2, round or square	± 1/32	24	+1/4, -2
RCI-B	3/16, 1/4, 3/8, 1/2 round or square	± 1/32	24	+1/4, -2

Notes:
a. Sizes and lengths other than these shall be as agreed to by supplier and purchaser.

SI Equivalents

in.	mm
1/32 (0.031)	0.8
1/8 (0.125)	3.2
5/32 (0.156)	4.0
3/16 (0.188)	4.8
1/4 (0.250)	6.4
5/16 (0.313)	8.0
3/8 (0.375)	9.5
1/2 (0.500)	12.7
2	51
18	450
20	500
24	600

WARNING:

PROTECT yourself and others. Read and Understand this information.
FUMES AND GASES can be dangerous to health.
HEAT RAYS (INFRARED RADIATION from flame or hot metal) can injure eyes.

- Before use read and understand the manufacturer's instructions, the Manufacturers Safety Data Sheets (MSDSs), and your employer's safety practices.
- Keep your head out of the fumes.
- Use enough ventilation, exhaust at the flame, or both, to keep fumes and gases from your breathing zone and the general area.
- Wear correct eye, ear and body protection.
- 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, and OSHA Safety and Health Standards, 29 CFR 1910, available from the Government Printing Office, Washington, DC 20402

DO NOT REMOVE THIS INFORMATION

11. Shielded Metal Arc Welding Electrodes

11.1 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.

11.2 Standard Sizes and Lengths

11.2.1 Standard sizes (diameter of the core wire) and lengths for electrodes are shown in Table 4.

11.2.2 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 ± 1/4 in. (± 6.4 mm) from that specified.

11.3 Core Wire and Covering

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

11.3.2 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:

(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), and

(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.

Table 4
Standard Sizes and Lengths for Shielded Metal Arc Welding Electrodes

AWS Classification	Diameter in.	Size Tolerance in.	Length in.	Length Tolerance in.
ENi-CI ENi-CI-A	3/32	± 0.003	9, 12, and 14	± 1/4
ENiFe-CI ENiFe-CI-A ENiFeMn-CI ESt	1/8, 5/32, 3/16, 1/4	± 0.003	12 and 14	± 1/4
ENiCu-A ENiCu-B	3/32, 1/8, 5/32, 3/16	± 0.003	12 and 14	± 1/4

Notes:

Sizes and lengths other than these shall be available as agreed upon by the supplier and purchaser.

SI Equivalents	
in.	mm
0.003	0.08
3/32	2.4
1/8	3.2
5/32	4.0
3/16	4.8
1/4	6.4
9	230
12	300
14	350

11.3.3 The covering of electrodes shall be such that it is not readily damaged by ordinary handling.

11.4 Exposed Core

11.4.1 The grip end of each electrode shall be bare (free of covering) for a distance of not less than 1/2 in. (12 mm) nor more than 1-1/4 in. (32 mm) for electrodes 5/32 in. (4.0 mm) and smaller, and

not less than 3/4 in. (19 mm) nor more than 1-1/2 in. (38 mm) for electrodes 3/16 in. (4.8 mm) and larger, to provide for electrical contact with the electrode holder.

11.4.2 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 of the core wire to the location 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 covering near the arc end, baring the core wire no more than the lesser of 1/2 in. (13 mm) or twice the diameter of the core wire, meet the requirements of this specification, provided no chip uncovers more than 50 percent of the circumference of the core.

11.5 Electrode Identification. All electrodes shall be identified as follows:

11.5.1 At least one imprint of the electrode classification shall be applied to the electrode covering within 2-1/2 in. (65 mm) of the grip end of the electrode.

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

11.5.3 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.

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

11.6 Packaging

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

11.6.2 Standard package weights shall be as specified in 10.4 or as agreed upon by supplier and purchaser.

11.7 Marking of Packages

11.7.1 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

11.7.2 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 information.
FUMES AND GASES can be dangerous to 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 and Cutting*, published by the American Welding Society, 550 N.W. LeJeune Road, P. O. Box 351040, Miami, Florida 33135, and OSHA Safety and Health Standards, 29 CFR 1910, available from the Government Printing Office, Washington, DC 20402

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12. Gas Metal Arc and Flux Cored Arc Welding Electrodes

12.1 Method of Manufacture. The filler metals classified according to this specification may be manufactured by any method that will produce filler metals that meet the requirements of this specification.

12.2 Standard Sizes. Standard sizes for filler metal in different package forms (coils with support, coils without support, spools, and drums) shall be as shown in Table 5.

12.3 Finish and Uniformity

12.3.1 All filler metal shall have a smooth finish that is free from slivers, depressions, scratches,

Table 5
Standard Sizes and Tolerances for Gas Metal Arc and Flux Cored Arc Welding Electrodes

Standard Package Form	Standard Sizes Diameter in.	Standard Sizes Diameter mm	Tolerance in.	Tolerance mm
Coils With Support, Spools	— — — 1/16	.035 0.9 .045 1.1 .052 1.3 .063 1.6	±0.002	±0.051
Coils Without Support, Coils With Support, Spools, Drums	5/64 3/32 7/64 	0.078 2.0 0.094 2.4 0.109 2.8 .120 3.0	±0.003	±0.076
Coils With Support, Drums	1/8 5/32	0.125 3.2 0.156 4.0	±0.004	±0.10

Note:

Dimensions and tolernaces other than those shown shall be as agreed between the purchaser and supplier.

scale, seams, laps (exclusive of the longitudinal joint in flux cored electrodes), and foreign matter that would adversely affect the welding characteristics, the operation of the welding equipment, or the properties of the weld metal.

12.3.2 Each continuous length of filler metal shall be from a single lot of material, and welds, when present, shall have been made so as not to interfere with the uniform, uninterrupted feeding of the filler metal on automatic and semiautomatic equipment.

12.3.3 The core ingredients of flux cored arc welding electrodes 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.

12.4 Standard Package Forms

12.4.1 Standard package forms are coils with support, coils without support, spools, and drums. Standard package dimensions and weights for each form are given in Tables 6 and 7. Package forms, sizes, and weights other than these shall be as agreed between purchaser and manufacturer.

12.4.2 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 filler metal.

12.4.3 Spools shall be designed (see Figures 2 and 3) and constructed to prevent distortion of the filler metal during normal handling and use and shall be clean and dry enough to maintain the cleanliness of the filler metal.

12.5 Winding Requirements

Table 6
Standard Dimensions for Coils
With and Without Support and Drums

Coils Without Support		Coils With Support				Drums	
Inside Diameter of Coil,		Inside Diameter of Liner		Width of wound Electrode, max,		Outside Diameter	
in.	mm	in.	mm	in.	mm	in.	mm
12 22-1/2	300 570	12 ± 1/8	300 ± 3.2	4-5/8	120	15-1/2 20 23	390 510 580

Table 7
Standard Package Dimensions and Weights[a]

Type of Package	Package Size ID		Net Weight of Electrode,[b]	
	in.	mm	lb	kg
Coils Without Support	12	300	50	23
	22-1/2	570	100	45
Coils With Support	12	300	50	27
			60	23
Spools	12	300	25	11
	14	360	50	23
			60	27
	30	760	600	273
Drums	15-1/2	390	200	90
	20	510	500	230
	23	580	1100	500

Notes:

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

b. Net weights shall not vary more than ± 10% percent.

12.5.1 The filler metal shall be wound so that kinks, waves, sharp bends, overlapping, or wedging are not encountered, leaving the filler metal free to unwind without restriction. The outside end of the filler metal (the end welding is to begin with) shall be identified so it can be located readily and shall be fastened to avoid unwinding.

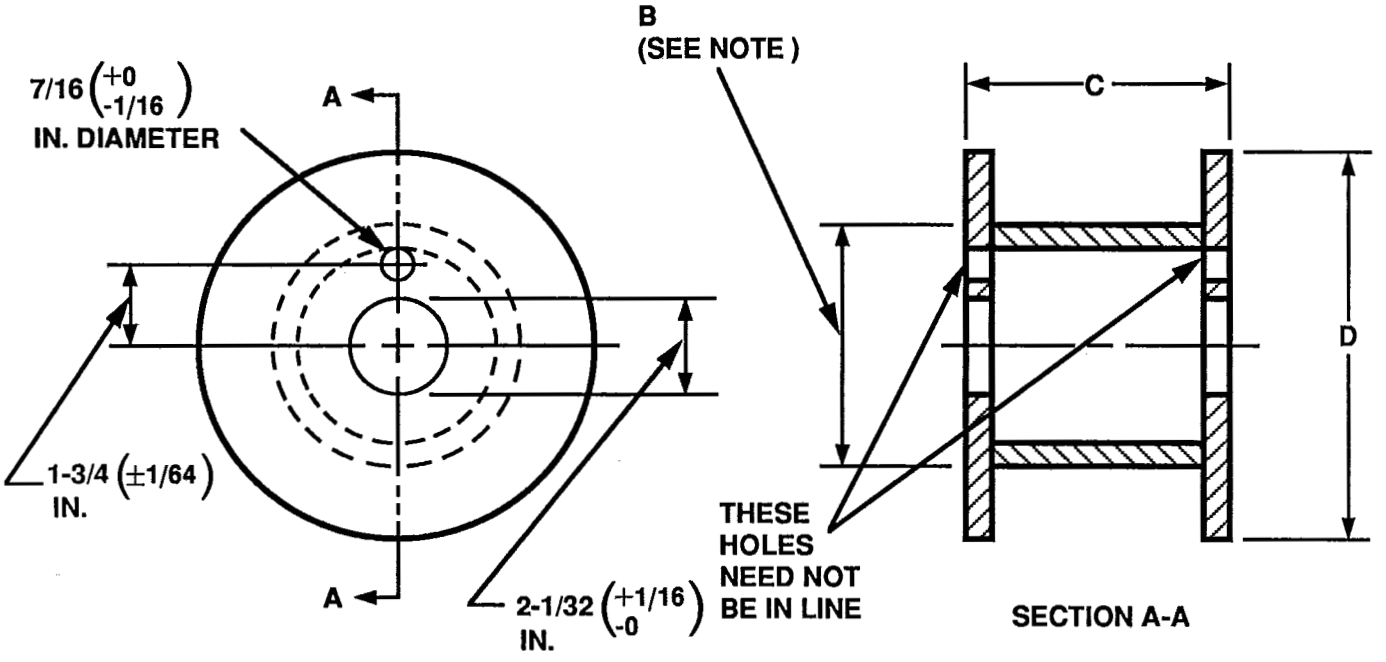
12.5.2 The cast and helix of filler metal in coils, spools, and drums shall be such that the filler metal will feed in an uninterrupted manner in semiautomatic and automatic equipment.

12.6 Filler Metal Identification

12.6.1 The product information and the precautionary information required in 12.8 for marking each package shall also appear on each coil, each spool, and each drum.

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

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



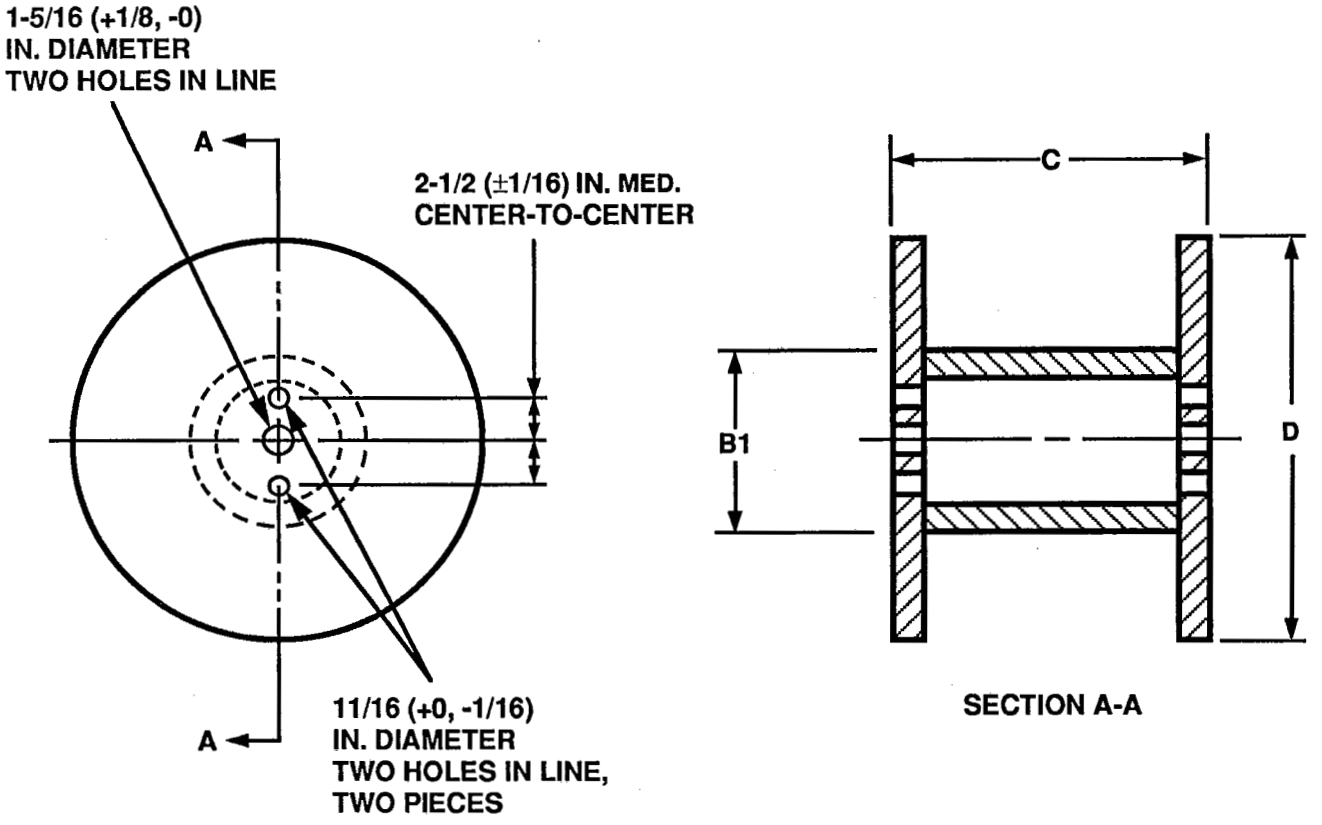
Note:

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

Dimensions		
Spool size	C	D, maximum
in.	in.	in.
12	4 ± 1/16	12
14	4 ± 1/16	14

Si Equivalents	
in.	mm
1/64 (.016)	0.4
1/32 (.031)	0.8
1/16 (.062)	1.6
7/16 (.438)	11.1
1/2 (.500)	13
3/4 (.750)	19.0
1	25.4
2	50.8
4	102
12	305
14	356

Figure 2—Dimensions of 12 and 14 in. (300 and 360 mm) Spools



Notes:

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

Dimensions		
Spool size	D	C, maximum
in.	in.	in.
30	30 ± 1/2	13 ± 1/2

Si Equivalents	
in.	mm
1/16 (.016)	0.4
1/8 (.125)	3.2
5/16 (.312)	7.9
1/2 (.500)	12.7
11/16 (.688)	17.5
1	25.4
2	50.8
13	330
30	762

Figure 3—Dimensions of 30 in. (760 mm) Spools

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

12.6.5 Drums shall have the information securely affixed in a prominent location on the side of the drum.

12.7 Packaging. Filler metal shall be suitably packaged to ensure against damage during shipment and storage under normal conditions.

12.8 Marking of Packages

12.8.1 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 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

12.8.2 The following precautionary information (as a minimum) shall be prominently displayed in legible print on all packages of welding 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 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 and Cutting*, published by the American Welding Society, 550 N.W. LeJeune Road, P. O. Box 351040, Miami, Florida 33135, and *OSHA Safety and Health Standards*, 29 CFR 1910, available from the U.S Printing Office, Washington, DC 20402

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Appendix

Guide to AWS A5.15-90, Specification For Welding Electrodes and Rods for Cast Iron

(This Appendix is not a part of ANSI/AWS A5.15-90, *Specification for Welding Electrodes and Rods for Cast Iron,* but is included for informational purposes only.[6])

A1. Introduction

The purpose of this Appendix is to correlate the 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 metal for which each filler metal is suitable.

A2. Classification System

A2.1 The system for identifying welding rod and electrode classifications used 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, the letters "ER" at the beginning of each classification designation stands for a filler metal which is suitable for use as either an electrode or rod, and the letter "R" at the beginning of each classification designation stands for a welding rod. The next letters in the filler metal designation are based on the chemical composition of the filler metal or undiluted weld metal. Thus, NiFe is a nickel-iron alloy, NiCu is a nickel-copper alloy, etc. Where different compositional limits in filler metals of the same alloy family result in more than one classification, the individual classifications are differentiated by the designators "A" or "B", as in ENiCu-A and ENiCu-B.

6. For additional information, refer to AWS D11.2, Guide for Welding Iron Castings

A2.2 For flux cored electrodes the designator "T" indicates a tubular electrode. The number "3" indicates that the electrode is used primarily without an external shielding gas.

A2.3 Most of the classifications within this specification contain the usage designator "CI" after the hyphen which indicates that these filler metals are intended for cast iron applications. The usage designator is included to eliminate confusion with other filler metal classifications from other specifications which are designed for alloys other than cast irons. The two exceptions, ENiCu-A and ENiCu-B, preceded the introduction of the usage designator and have never had the "CI" added.

A2.4 The chemical symbols have been used in all the filler metals except the cast iron and mild steel groups. Since there are no chemical symbols for cast iron and mild steel, the letters "CI" and "St" have been assigned to this group to designate cast iron and mild steel filler metals, respectively. The suffixes "A" and "B" are used to differentiate two alloys of the cast iron filler metals from other cast iron rod classifications.

A3. Acceptance

A3.1 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 normally conducted on material of that classification, as specified in Schedule F, Table 1, of ANSI/AWS A5.01. Testing in accordance with any other Schedule in that Table shall be specifically required by the purchase order. In such cases, acceptance of the material shipped shall be in accordance with those requirements.

A4. Certification

A4.1 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.

A4.2 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 made. 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 to which welders and welding operators can be 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 dusts, according to the materials and processes used

(4) The proximity of the welder and 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 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 entitled Health Protection and Ventilation.

A6. Welding Considerations

A6.1 Welding Considerations for Electrodes

A6.1.1 The casting skin should be removed from the weld area by machining, grinding, chipping or other suitable means. When repairing casting defects, care should be exercised to ensure removal of any defective metal to sound base metal before welding. Also, all oil, grease, dirt, or other foreign material should be eliminated by the use of suitable solvents. If oil, grease, or solvents have impregnated the casting, heat should be applied to the area to be welded until volatilization is no longer observed. A temperature of 750°F (400°C) generally is sufficient for this operation. If the casting is too greasy, flash heating the welding surfaces to about 1000°F (540°C) should drive off the grease in a gaseous state.

A6.1.2 For V-groove welds, the edges should be beveled to form a 60 to 80 degree groove angle. For very thick base metal, a U-groove weld with a 20-25 degree groove angle and a groove radius of at least 3/16 to 1/2 in. (4.8 to 13 mm) should be used.

A6.1.3 Welding currents should be within the range recommended by the supplier of the electrode, and as low as possible, consistent with smooth operation, good bead contour, and securing good fusion of the groove face. If welding is in other than the flat and horizontal positions, the recommended currents should be reduced to some extent for vertical position and overhead position welding.

A6.1.4 The electrode should be manipulated so that the width of the weld bead is no greater than three times the nominal diameter of the electrode being used. If a large cavity must be filled, the sides may be surfaced, and the cavity gradually filled toward the center of the repaired area.

A6.1.5 When continuous welding is employed, heat input from the previous passes serves as moderate preheating or to maintain the preheat temperature. Use of preheating is not

always necessary, but it is often used. In large castings, it may occasionally be found desirable to use intermittent welding to provide a more even temperature distribution, keeping the casting warm to the touch, but not permitting it to get too hot.

A6.1.6 The hardness of the heat-affected zone is a function of the composition and cooling rate of the base metal. An increase in the cooling rate for a given composition will increase the hardness of the heat-affected zone. Thus, any steps taken to retard the cooling rate such as preheating or the use of insulating material combined with preheating will be beneficial in lowering the hardness of the heat-affected zone. The hardness of the weld metal depends to a great extent upon the amount of dilution, and can be controlled within reasonable limits during welding. Single layer weld metal which has high dilution may have a hardness as high as 350 Brinell for ENiFe-CI, ENiFe-CI-A, and ESt electrodes, and around 210 Brinell for the ENi-CI, ENi-CI-A, and ENiCu-B weld metal.

Moderately thick weld beads, where the dilution is reduced by directing the arc onto the weld pool, or the later layers of multiple-layer welds, may give lower hardness ranges. Typical ranges for mechanical properties of undiluted filler metal are listed in Table A1.

A6.1.7 Preheating is especially helpful in overcoming the differential mass effect encountered when welding a thick to a thin base metal. The use of preheat in conjunction with welding for pressure tightness also increases the resistance to cracking at the weld interface. Judicious use of preheating when welding cast iron will permit the weld and surrounding area to cool at a more uniform rate.

A6.1.8 Peening often is used to reduce stresses and decrease distortion. Peening should be done with repeated moderate blows of a round-nose or needle tool with sufficient force to move the metal, but not enough to rupture it. Peening should be done while the metal is still above 1000°F (540°C). Peening is not recommended for root beads or weld beads at the weld face.

A6.1.9 The possibility of cracking makes it generally advisable in welding any sizable casting to employ studs that fasten the weld to the unaffected base metal below the weld interface. Studs are usually 1/4 to 5/8 in. (6.4 to 16 mm) in diameter, projecting 3/16 to 1/4 in. (4.8 to 6.4 mm) above the surface to be welded, and screwed or pressed in to a depth at least equal to their diameter. The cross-sectional area of the studs should be 25 to 35% of the area of the weld surface.

A6.2 Welding Considerations for Rods Classified as RCI and RCI-A

A6.2.1 The casting should be prepared as described in A6.1.1.

A6.2.2 Castings to be welded with a V-groove should have the edges beveled to form a 60 to 90 degree include angle. The groove should have a root face greater than zero, so that there is less difficulty in aligning the joint members and there is no melting through of the entire thickness.

A6.2.3 Next, the casting should be preheated as a whole, or locally in critical sections, if a closed or rigid construction is involved. Ideally, this involves preheating the entire casting to 800 to 1050°F (430 to 566°C), or in the case of alloy castings, as high as 1250°F (677°F). The preheating not only tends to equalize expansion and contraction stresses and ensure the machinability of the final weld, but also enables the weld to be made more rapidly. Such preheating preferably should be done in a charcoal fire or a furnace. In the case of small castings, however, preheating with a welding torch may be employed.

A6.2.4 A neutral oxyfuel gas flame is preferred for welding cast iron. Some authorities, however, recommended the occasional use of a reducing flame where decarburization is to be avoided. A flux is required. The purpose of the flux is to increase the fluidity of the iron silicate slag that forms on the weld pool.

A6.2.5 After the groove has been beveled and cleaned, and the casting preheated, the welding torch is directed over an area extending 1 in. (25 mm) around the weld until the entire area is a dull red. Then the flame is directed at the bottom of the groove, keeping the tip of the cone 1/8 to 1/4 in. (3.2 to 6.4 mm) from the metal, until a weld pool approximately 1 in. (25 mm) long has been formed. The flame is then gradually moved from side to side until the groove faces begin to melt into the weld pool. The flame is directed on the rod, and filler metal is added to the weld pool. The groove faces are melted ahead of the advancing pool. The thickness of each layer of weld metal should not exceed 3/8 in. (9.5 mm).

Table A1
Typical Mechanical Properties of Undiluted Weld Metal

Electrode	Tensile Strength ksi	Tensile Strength MPa	Yield Strength 0/2% offset ksi	Yield Strength 0/2% offset MPa	Elongation % in 2 in.	Hardness BHN
RCI	20-25	138-172	—	—	—	150-210
RCI-A	35-40	241-276	—	—	—	225-290
RCI-B (As-welded)	80-90	552-621	70-75	483-517	3-5	220-310
RCI-B (Annealed)	50-60	345-414	40-45	276-310	5-15	150-200
ESt	—	—	—	—	—	250-400
ENi-CI	40-65	276-448	38-60	262-414	3-6	135-218
ENi-CI-A	40-65	276-448	38-60	262-414	3-6	135-218
ENiFe-CI	58-84	400-579	43-63	296-434	6-18	165-218
ENiFe-CI-A	58-84	400-579	43-63	296-434	4-12	165-218
ENiFeMn-CI	75-95	517-655	60-70	414-483	10-18	165-210
ENiFeT3-CI	65-80	448-552	40-55	276-379	12-20	150-165
ERNiFeMn-CI	75-100	517-689	65-80	448-552	15-35	165-210

A6.2.6 In the case of rigid structures requiring extensive machining, it is advisable to stress relieve at the preheat temperature after welding. In any case, the casting should be allowed to cool slowly by furnace cooling, or by covering with, or immersion in, an insulating material such as dry sand.

A6.3 Welding Considerations for RCi-B Rods

A6.3.1 Preparation of castings for welding is similar to that called for in A6.2.1 and A6.2.2. Preheating should be uniform.

A6.3.2 The application of RCI-B welding rods is the same as that described for the other RCI filler metals. The weld zone can withstand higher residual stresses without cracking. However, it is advisable to apply slow cooling to prevent stress cracks in the base metal. It is recommended that residual stress be reduced by preheating castings uniformly to 1600°F (870°C), and providing slow furnace cooling by covering with, or immersion in, an insulating material such as dry sand. After such treatment, the castings will withstand exposure to considerable thermal expansion and will permit heavy machining.

A7. Description and Intended Use of Electrodes and Rods for Welding Cast Iron.

The following are guidelines for the application of welding rods and welding electrodes in conjunction with various types of cast iron. These guidelines are general and are subject to modification based on the experience of the welder and information supplied by the filler metal manufacturer. Only rods employed in conjunction with an oxyfuel gas heat source, and electrodes intended for the SMAW, GMAW, or FCAW processes are discussed. This limitation, defined in the scope, is not intended to deter a prospective user from considering other welding processes for which these filler metals might prove satisfactory.

A7.1 Cast Iron Welding Rods

A7.1.1 RCI (Cast Iron) Classification

A7.1.1.1 Ordinary machinable gray iron castings may vary from 20 to 40 ksi (140 to 280 MPa) tensile strength, and 150 to 250 Brinell hardness. The use of a gray iron welding rod for oxyfuel gas welding can produce a machinable weld metal of the same color, composition and structure as the base metal. The weld, if properly made, may be as strong as the original casting. See Table A1.

A7.1.1.2 RCI welding rods are used for filling in or building up new or worn castings, and for general fabrication, salvage and repair.

A7.1.2 RCI-A (Cast Iron) Classification

A7.1.2.1 This cast iron welding rod contains small amounts of molybdenum and nickel, which give it a slightly higher melting point than the ordinary cast iron welding rod, RCI. The molten weld metal is more fluid. Welding can be done more rapidly.

A7.1.2.2 The RCI-A welding rod (with a weld metal hardness of approximately 230 Brinell) may be used if an alloy cast iron is being welded, and when greater tensile strength and finer grain structure are desired. The weld metal is generally considered machinable.

A7.1.3 RCI-B (Nodular Cast Iron) Classification. These nodular (ductile) cast iron welding rods are capable of producing sound weld metal when used to weld higher-strength gray iron, malleable, and nodular iron castings with the oxyfuel gas process. Under optimum conditions, the welds produced have mechanical properties of 60 000 psi (410 MPa) minimum ultimate tensile strength; 45 000 psi (310 MPa) minimum yield strength; 5 to 15 percent elongation; and a maximum Brinell hardness of 200. These mechanical properties are due to the fact that most of the graphite content in the weld metal is in nodular form, which results in good ductility and machining properties for the weld. Color match to the base metal generally is good.

A7.2 Nickel-Base Electrodes for SMAW of Cast Irons. Arc welding with nickel-base covered electrodes is widely employed for welding cast iron. Weld metal made with these electrodes, even without preheating, usually can be machined (the heat affected zone may not be machinable). Welding is fairly rapid when compared to processes such as oxyfuel gas welding. Although welding in the flat position only is required in this specification, some electrodes may be capable of use in other positions. Tensile properties are not specified for the nickel base SMAW electrodes classified in this specification. The tensile and yield strengths may vary widely among manufacturers as shown in Table A1. The filler metal supplier or manufacturer should be contacted for product recommendations.

A7.2.1 ENi-CI (Nickel) Classification. This electrode can be used to join ordinary gray irons to themselves, or to other ferrous and nonferrous materials, and to reclaim or repair castings. Satisfactory welds can be produced on small and medium size castings where the welding stresses are not overly severe, or where the phosphorus content of the iron is not high. Because of lower strength than the ENiFe-CI and lower ductility of the weld metal, these electrodes should be used only in applications where maximum machinability of highly diluted filler metal is necessary. Otherwise, the ENiFe-CI classification is preferred. The ENi-CI classification may also be used on malleable or ductile iron.

A7.2.2 ENi-CI-A (Nickel) Classification. ENi-CI-A electrodes frequently are used interchangeably with ENi-CI electrodes. The covering of ENi-CI-A electrodes contains more aluminum to improve operating characteristics such as slag coverage and flowability. However, the aluminum becomes an alloy of the weld metal and may affect ductility.

A7.2.3 ENiFe-CI (Nickel-Iron) Classification. This electrode may be used for making repair welds on, as well as for joining, work pieces of various types of cast iron, including nodular iron, and for welding them to steel and some nonferrous base metals. Castings containing phosphorus levels higher than normal (approximately 0.20% phosphorus) are more readily welded using these electrodes than with an electrode of the ENi-CI classification. Experience has shown that satisfactory welds can be made on thick and highly restrained weldments, and on high-strength and engineering grades of cast iron.

A7.2.4 ENiFe-CI-A (Nickel-Iron) Classification. ENiFe-CI-A electrodes frequently are used interchangeably with ENiFe-CI electrodes. The covering of ENiFe-CI-A electrodes contains more aluminum to improve operating characteristics such as slag coverage and flowability. However, the aluminum becomes an alloy of the weld metal and may affect ductility.

A7.2.5 ENiFeMn-CI (Nickel-Iron-Manganese) Classification. This electrode has a nominal addition of 12% manganese to the nickel-iron system which improves the flow of the molten metal and somewhat increases the crack resistance of the weld metal. The manganese also increases the tensile strength and improves ductility, which provides properties closer to those of the higher strength grades of nodular cast iron base metals than can be achieved with the ENiFe-CI. ENiFeMn-CI electrodes are also used for surfacing to improve wear resistance or for buildup.

A7.2.6 ENiCu-A and ENiCu-B (Nickel-Copper) Classification. These electrodes have been used in many of the same applications as the ENiFe-CI, ENiFe-CI-A, and ENiFeMn-CI electrodes. They are used to produce a low depth of fusion weld, since high dilution by the base metal may cause weld cracking.

A7.3 ESt (Steel) Classification for SMAW of Cast Iron

A7.3.1 This covered electrode for all welding positions is designed specifically for the welding of cast iron. It has a low-melting-point covering and differs from the ordinary mild steel electrodes included in ANSI/AWS A5.1, *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding.* Weld metal from this electrode is not readily machinable.

A7.3.2 Since it is virtually impossible to prevent the formation of a hard zone or layer in the weld metal because of dilution from the base metal, this type of electrode is largely confined to the repair of small pits and cracks, with some application in the repair of castings that require no postweld machining. Since the shrinkage of steel is greater than that of cast iron, high stresses develop as the weld cools. Residual stresses may be severe enough to cause cracking.

A7.3.3 Preheating is employed only when necessary to prevent excessive stresses in other parts of the casting. ESt electrodes generally are used at low amperage to minimize the dilution effect in the fusion zone and consequent weld and base metal cracking. The usual recommended amperages are 60 to 95 amps for 3/32 in. (2.4 mm), 80 to 110 amps for 1/8 in. (3.2 mm), and 110 to 150 amps for 5/32 in. (4.0 mm) electrodes using dcep (electrode positive) or ac. The beads should be short and widely separated, to distribute the heat, and each bead should be peened lightly. The slag volume is low but very alkaline. Residual slag should be removed completely if the weld area is to be painted.

A7.4 Nickel-Base Filler Metal for GMAW of Cast Iron. Only gas metal arc welding of classifications ERNiFeMn-CI and ERNi-CI are addressed by this specification. The requirements for rods for gas tungsten arc welding and other welding methods have not been included. Since these filler metals could be manufactured as rods, they have been assigned the "ER" designation.

A7.4.1 ERNiFeMn-CI (Nickel-Iron-Manganese) Classification. This solid continuous bare electrode can be used for the same applications as the ENiFeMn-CI covered SMAW electrode. The strength and ductility of this classification makes it suitable for welding the higher strength grades of nodular iron castings.

A7.4.2 ERNi-CI (Nickel) Classification. This solid continuous bare electrode is composed of essentially pure nickel (99%) and contains no deoxidizers. The electrode is used to weld iron castings when weld metal with highly diluted filler metal is to be machined.

A7.4.3 Shielding Gases. Shielding gases should be used as recommended by the manufacturer.

A7.5 Nickel-Base Electrode for FCAW of Cast Iron. The ENiFeT3-CI (nickel-iron electrode) is a continuous flux cored electrode that has been designed to operate without an external shielding gas. For this reason, it is commonly referred to as a self-shielded flux-cored electrode, but it may also be used with an external shielding gas if recommended by the manufacturer. The composition of this classification is similar to that of an ENiFe-CI except for a higher manganese content. It can be used in the same types of applications as the ENiFe-CI electrode. It is generally used for thick base metal or where processes can be automated. This electrode contains 3-5% manganese to aid in resisting weld metal hot cracking and to improve strength and ductility of the weld metal.

A7.6 In addition to the electrodes and rods classified in this specification, a number of copper-base welding rods frequently are used for braze welding cast iron. The lower temperatures associated with depositing these filler metals and their generally low strength and high ductility frequently offers advantages when welding cast iron. Copper-base welding electrodes and rods have been classified in other specifications and are listed in Table A2 for reference purposes.

Table A2
Copper-Base Welding Electrodes and Rods from AWS Specifications Suitable for Welding Cast Irons

Classification	Type	Specification
	Cast Filler Metals (OFW)	
RBCuZn-A	Naval brass	A5.27
RCuZn-B	Low fuming brass [Ni]	A5.27
RCuZn-C	Low fuming brass	A5.27
RBCuZn-D	Nickel brass	A5.27
	Covered Electrodes (SMAW)	
ECuSn-A	Phosphor bronze	A5.6
ECuSn-C	Copper-tin	A5.6
ECuAl-A2	Copper-aluminum	A5.6

Note:

ANSI/AWS A5.6, Specification for Covered Copper and Copper Alloy Arc Welding Electrodes.

ANSI/AWS A5.27, Specification for Copper and Copper Alloy Rods for Oxyfuel Gas Welding.

A8. Postweld Heat Treatment

Postweld heat treatment may also be used to improve the machineability of the heat-affected zone adjacent to the weld metal. Tempering beads sometimes are employed to achieve the desired improvement. These beads, consisting entirely of filler metal and a previous bead, are made in such a manner that the heat input tempers any martensite present from a previous bead.

AWS Filler Metal Related Documents

AWS Designation	Title*
FMC	Filler Metal Comparison Charts
A4.2	Standard Procedures for Calibrating Magnetic Instruments to Measure 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
A5.10	Specification for Aluminum and Aluminum Alloy Bare Welding Rods and Electrodes
A5.11	Specification for Nickel and Nickel Alloy Covered Welding Electrodes
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 Electrogas 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, Phone: (305) 443-9353.