

Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding



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Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding

5th Edition

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Prepared by the
American Welding Society (AWS) A5 Committee on Filler Metals and Allied Materials

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This specification prescribes the requirements for classification of low-alloy steel electrodes for flux cored arc welding. The requirements include chemical composition and mechanical properties of the weld metal and certain usability characteristics. Optional supplemental designators are also included for improved toughness and diffusible hydrogen. Additional requirements are included for standard sizes, marking, manufacturing, and packaging. A guide is appended to the specification as a source of information concerning the classification system employed and the intended use of low-alloy steel flux cored electrodes.

This specification makes use of both U.S. Customary Units and the International System of Units (SI). Since these are not equivalent, each system must be used independently of the other.



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Foreword

This foreword is not part of this standard but is included for informational purposes only.

This document is the third of the A5.29 specifications which uses both U.S. Customary Units and the International System of Units (SI) throughout. The measurements are not exact equivalents; therefore, each system must be used independently of the other, without combining values in any way. In selecting rational metric units, AWS A1.1, *Metric Practice Guide for the Welding Industry*, and ISO 544, *Welding Consumables — Technical Delivery Conditions for Welding Filler Materials and Fluxes—Type of Product, Dimensions, Tolerances, and Markings*, are used where suitable. Tables and figures make use of both U.S. Customary and SI Units which, with the application of the specified tolerances, provide for interchangeability of products in both the U.S. Customary and SI Units.

The current document is the fourth revision of the initial ANSI/AWS document issued in 1980. The evolution took place as follows:

ANSI/AWS A5.29-80	<i>Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding</i>
ANSI/AWS A5.29:1998	<i>Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding</i>
AWS A5.29/A5.29M:2005	<i>Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding</i>
AWS A5.29/A5.29M:2010	<i>Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding</i>

Substantive changes in this document are shown in *Italic font* and include:

(1) *A requirement is included to report the boron level of the weld deposit if intentionally added or known to be present at levels greater than 0.0010%.*

(2) *The maximum % Mn requirement for the Ni1 alloy type has been raised from 1.50% to 1.75%.*

(3) *Five new low-alloy types (B92, K10, K11, K12, and K13) have been added.*

(4) *The B9 alloy type has been renamed to B91 type to reflect current practice, and two supplemental designators are included for low Mn +Ni content. Refer to Figure 1, Clause 15.3, and A8.3 in Annex A.*

(5) *Two 20% Mn types (Mn1 and Mn2) have been included in this document.*

(6) *Added Computed Radiology and Digital Radiology methods.*

NOTE: The user's attention is called to the possibility that compliance with this standard may require use of an invention covered by patent rights.

By publication of this standard, no position is taken with respect to the validity of any such claim(s) or of any patent rights in connection therewith. If a patent holder has filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license, then details may be obtained from the standards developer.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS A5 Committee on Filler Metals and Allied Materials, American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.

All errata to a standard shall be published in the *Welding Journal* and posted on the AWS website.

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Table of Contents

	Page No.
<i>Personnel</i>	v
<i>Foreword</i>	vii
<i>List of Tables</i>	x
<i>List of Figures</i>	x
1. Scope	1
2. Normative References	1
3. Classification	3
4. Acceptance	3
5. Certification	4
6. Rounding Procedure	4
7. Summary of Tests	4
8. Retest	4
9. Test Assemblies	4
10. Chemical Analysis	6
11. Radiographic Test	6
12. Tension Test	7
13. Impact Test	7
14. Fillet Weld Test	8
15. Optional Supplemental Tests and Requirements	8
16. Method of Manufacture	9
17. Standard Sizes	9
18. Finish and Uniformity	9
19. Standard Package Forms	10
20. Winding Requirements	10
21. Filler Metal Identification	10
22. Packaging	10
23. Marking of Packages	10
Annex A (Normative)—Guide to AWS Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding	29
Annex B (Informative)—Requesting an Official Interpretation on an AWS Standard	43
AWS Filler Metal Specifications by Material and Welding Process	45
AWS Filler Metal Specifications and Related Documents	47

List of Tables

Table	Page No.
1 A5.29 [A5.29M] Mechanical Property Requirements	11
2 Usability Designators and General Description of Electrode Types.....	15
3 Weld Metal Composition Requirements	16
4 Tests Required for Classification	18
5 Base Metal for Test Assemblies	19
6 Heat Input Requirements and Suggested Pass and Layer Sequence.....	20
7 Preheat, Interpass, and PWHT Temperatures	21
8 Dimensional Requirements for Fillet Weld Usability Test Specimens	22
9 Optional Diffusible Hydrogen Requirements	22
A.1 Comparison of Similar Classifications for ISO 17632	40
A.2 Comparison of Similar Classifications for ISO 17634	41
A.3 Comparison of Similar Classifications for ISO 18276	42

List of Figures

Figure	Page No.
1 A5.29/A5.29M Classification System.....	23
2 Test Assembly for Mechanical Properties and Soundness of Weld Metal.....	24
3 Pad for Chemical Analysis of Deposited Weld Metal.....	25
4 Fillet Weld Test Assembly and Positions	26
5 Radiographic Standards for Test Assembly in Figure 2.....	27

Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding

1. Scope

1.1 This specification prescribes requirements for the classification of low-alloy steel electrodes for flux cored arc welding (FCAW) either with or without shielding gas. *With two exceptions, the 20% manganese types “Mn1” and “Mn2,” iron is the only element whose content exceeds 10.5% in undiluted weld metal deposited by these electrodes.*

1.2 This specification makes use of both U.S. Customary Units and the International System of Units (SI). The measurements are not exact equivalents; therefore, each system must be used independently of the other without combining in any way when referring to weld metal properties. The specification with the designation A5.29 uses U.S. Customary Units. The specification A5.29M uses SI Units. The latter are shown within [brackets] or in appropriate columns in tables and figures. Standard dimensions based on either system may be used for the sizing of electrodes or packaging or both under the A5.29 and A5.29M specifications.

1.3 Safety and health issues and concerns are beyond the scope of this standard; some safety and health information is provided, but such issues are not fully addressed herein. Some safety and health information can be found in Clauses A5 and A11 in Annex A.

Safety and health information is available from the following sources:

American Welding Society:

ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*

AWS Safety and Health Fact Sheets

Other safety and health information on AWS website

Material or Equipment Manufacturers:

Safety Data Sheets supplied by material manufacturers

Operating Manuals supplied by equipment manufacturers

Applicable Regulatory Agencies

Work performed in accordance with this standard may involve the use of materials that have been deemed hazardous and may involve operations or equipment that may cause injury or death. This standard does not purport to address all safety and health risks that may be encountered. The user of this standard should establish an appropriate safety program to address such risks as well as to meet applicable regulatory requirements. ANSI Z49.1 should be considered when developing the safety program.

2. Normative References

The documents listed below are referenced within this publication and are mandatory to the extent specified herein. For undated references, the latest edition of the referenced standard shall apply. For dated references, subsequent amendments or revisions of the publications may not apply since the relevant requirements may have changed.

American Welding Society (AWS) documents:

AWS A3.0M/A3.0, *Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*

AWS A4.3, *Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding*

AWS A4.5M/A4.5 (ISO 15792-3 MOD), *Standard Methods for Classification Testing of Positional Capacity and Root Penetration of Welding Consumables in a Fillet Weld*

AWS A5.01M/A5.01 (ISO 14344 MOD), *Welding Consumables—Procurement of Filler Metals and Fluxes*

AWS A5.02/A5.02M, *Specification for Filler Metal Standard Sizes, Packaging, and Physical Attributes*

AWS A5.32M/A5.32 (ISO 14175 MOD), *Welding Consumables—Gases and Gas Mixtures for Fusion Welding and Allied Processes*

AWS B4.0, *Standard Methods for Mechanical Testing of Welds*

American National Standards Institute (ANSI) document:

ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*

ASTM International (ASTM) documents:

ASTM A36/A36M, *Standard Specification for Carbon Structural Steel*

ASTM A203/A203M, *Standard Specification for Pressure Vessel Plates, Alloy Steel, Nickel*

ASTM A204/A204M, *Standard Specification for Pressure Vessel Plates, Alloy Steel, Molybdenum*

ASTM A285/A285M, *Standard Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength*

ASTM A302/A302M, *Standard Specification for Pressure Vessel Plates, Alloy Steel, Manganese-Molybdenum and Manganese-Molybdenum-Nickel*

ASTM A387/A387M, *Standard Specification for Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum*

ASTM A514/A514M, *Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding*

ASTM A516/A516M, *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service*

ASTM A537/A537M, *Standard Specification for Pressure Vessel Plates, Heat-Treated, Carbon-Manganese-Silicon Steel*

ASTM A572/A572M, *Standard Specification for High-Strength Low-Alloy Columbium Structural Steel*

ASTM A588/A588M, *Standard Specification for High-Strength Low-Alloy Structural Steel, up to 50 ksi [345 MPa] Minimum Yield Point with Atmospheric Corrosion Protection*

ASTM A913/A913M, *Standard Specification for High-Strength Low-Alloy Steel Shapes of Structural Quality, Produced by Quenching and Self-Tempering Process (QST)*

ASTM A992/A992M, *Standard Specification for Structural Steel Shapes*

ASTM A1106/A1106M, *Standard Specification for Pressure Vessel Plate, Alloy Steel, Austenitic High Manganese for Cryogenic Application*

ASTM DS-56 (SAE HS-1086), *Metals & Alloys in the Unified Numbering System*

ASTM E23, *Standard Test Methods for Notched Bar Impact Testing of Metallic Materials*

ASTM E29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*

ASTM E350, *Standard Test Methods for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron*

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

ASTM E1032, *Standard Test Method for Radiographic Examination of Weldments*.

ASTM E2033, *Standard Practice for Computed Radiology (Photostimulable Luminescence Method)*

ASTM E2698, *Standard Practice for Radiological Examination Using Digital Detector Arrays*

International Organization for Standardization (ISO) documents:

ISO 15792-1-Amendment 1 (2011), *Welding Consumables — Test Methods — Part 1: Test Methods for All Weld-Metal Test Specimens in Steel, Nickel and Nickel Alloys (Amendment 1)*

ISO 80000-1, *Quantities and Units, Part 1: General*

United States Department of Defense (DODSSP) publications:

MIL-S-16216, *Specification for Steel Plate, Alloy, Structural, High Yield Strength (HY-80 and HY-100)*

MIL-S-24645, *Specification for Steel Plate, Sheet, or Coil, Age-Hardening Alloy, Structural, High Yield Strength (HSLA-80 and HSLA-100)*

NAVSEA Technical Publication T9074-BD-GIB-010/0300, *Base Materials for Critical Applications: Requirements for Low Alloy Steel Plate, Forgings, Castings, Shapes, Bars, and Heads of HY-80/100/130 and HSLA-80/100*.

3. Classification

3.1 The flux cored electrodes covered by the A5.29 specification utilize a classification system based upon U.S. Customary Units. The flux cored electrodes covered by the A5.29M specification utilize a classification system based upon the International System of Units (SI).

Both are classified according to:

- (1) The mechanical properties of the weld metal, as specified in Table 1.
- (2) The positions of welding for which the electrodes are suitable, as shown in Figure 1 and Table 2.
- (3) Certain usability characteristics of the electrode (including the presence or absence of a shielding gas), as specified in Figure 1 and Table 2.
- (4) Chemical composition of the weld metal, as specified in Table 3.

3.2 Electrodes classified under one classification shall not be classified under any other classification in this specification with the exception of the following: Gas-shielded electrodes may be classified with 100% CO₂ shielding gas (“C” designator) and with a 75% to 80% Ar/balance CO₂ shielding gas (“M” designator).

Electrodes may be classified under A5.29 using U.S. Customary Units, and/or under A5.29M using the International System of Units (SI). Electrodes classified under either classification system must meet all requirements for classification under that system. The classification system is shown in Figure 1.

3.3 The electrodes classified under this specification are intended for flux cored arc welding either with or without an external shielding gas. Electrodes intended for use without external shielding gas or with the shielding gases specified in Figure 1 are not prohibited from use with any other process or shielding gas for which they are found suitable.

4. Acceptance

Acceptance of the welding electrodes shall be in accordance with the provisions of AWS A5.01M/A5.01. See Clause A3 in Annex A for further information concerning acceptance, testing of the material shipped, and AWS A5.01M/A5.01.

5. Certification

By affixing the AWS specification and classification designations to the packaging or the classification designations to the product, the manufacturer certifies that the product meets the requirements of this specification. See Clause A4 in Annex A for further information concerning certification and the testing called for to meet this requirement.

6. Rounding Procedure

For purposes of determining compliance with the requirements of this standard, the actual test values obtained shall be subjected to the rounding rules of ASTM E29 or ISO 80000-1 Rule A in Clause B, (the results are the same). If the measured values are obtained by equipment calibrated in units other than those of the specified limit, the measured values shall be converted to the units of the specified limit before rounding. If the average value is to be compared to the specified limit, rounding shall be done only after calculating the average. An observed or calculated value shall be rounded to the nearest 1000 psi for tensile and yield strength for A5.29 [to the nearest 10 MPa for tensile and yield strength for A5.29M] and to the nearest unit in the last right-hand place of figures used in expressing the limiting values for other quantities. The rounded results shall fulfill the requirements for the classification under test.

7. Summary of Tests

7.1 The tests required for each classification are specified in Table 4. The purpose of these tests is to determine the mechanical properties, soundness, and chemical composition of the weld metal and 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 Clauses 9 through 14.

7.2 This document provides for three optional supplemental tests and designations which are not required for classification but which are included to provide additional information which may be useful to the user. See Figure 1 and Clause 15.

8. 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 sample or from one or two new test assemblies or samples. For chemical analysis, retest need be only for those specific elements that failed to meet the test requirement. If the results of one or both retests fail to meet the requirement, the material under test shall be considered as not meeting the requirements of this specification for that classification.

In the event that during preparation or after completion of any test, it is clearly determined that specified or proper procedures were not followed in preparing the weld test assembly or test specimens, or in conducting the test, the test shall be considered invalid, without regard to whether the test was actually completed or whether test results met, or failed to meet, the requirement. That test shall be repeated, following proper specified procedures. In this case, the requirement for doubling the number of test specimens does not apply.

9. Test Assemblies

9.1 Various weld test assemblies are required, depending on the classification of the electrode and the manner in which the tests are conducted. They are:

- (1) The groove weld in Figure 2 for mechanical properties, soundness of the weld metal, and weld deposit chemical composition.
- (2) The weld pad in Figure 3 for chemical analysis of the weld metal.
- (3) The fillet weld or welds in Figure 4 for usability of the electrode.

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

9.2 Preparation of each weld test assembly shall be as specified in 9.3, 9.4, and 9.5, as applicable. The base metal for each assembly shall be as required in Table 5 and shall meet the requirements of any one of the appropriate ASTM or military specifications shown there, or a chemically equivalent specification. Testing of the assemblies shall be as prescribed in Clauses 10 through 14.

9.3 Groove Weld Test Assembly. One or two weld test assemblies shall be prepared and welded as specified in Figure 2 and Table 6, using base metal of the appropriate type as specified in Table 5. Testing of this assembly shall be as specified in Table 4. Preheat and interpass temperatures shall be as specified in Table 7.

The electrode diameter for one test assembly shall be 3/32 in [2.4 mm] or the largest diameter manufactured. The electrode diameter for the other test assembly shall be 0.045 in [1.2 mm] or the smallest diameter manufactured. If the maximum diameter manufactured is 1/16 in [1.6 mm] or less, only the largest diameter need be tested. The electrode polarity shall be as specified in Table 2. Testing of the assemblies shall be as required in Table 4, in either the as-welded or postweld heat treatment (PWHT) condition specified in Table 1. Prior to welding, the test assembly shall be heated to the preheat temperature specified in Table 7, measured by temperature indicating crayons or surface thermometers at the location shown in Figure 2. This interpass temperature shall be maintained for the remainder of the weld. Should it be necessary to interrupt welding, the assembly shall be allowed to cool in still air. The assembly shall be heated to a temperature within the specified interpass temperature range before welding is resumed.

Welding shall be in the flat position unless otherwise indicated in Table 4. The assembly shall be restrained during welding or preset to prevent warpage in excess of 5°. An assembly that is warped more than 5° from plane shall be discarded. It shall not be straightened.

When PWHT is required, the heat treatment shall be applied to the test assembly before the specimens for mechanical testing are removed. This heat treatment may be applied either before or after the radiographic examination. The temperature of the test assembly shall be raised in a suitable furnace at the rate of 150°F to 500°F [85°C to 280°C] per hour until the postweld heat treatment temperature specified in Table 7, for the electrode classification, is attained. This temperature shall be maintained for one hour (–0, +15 minutes), unless otherwise noted in Table 7. The test assembly shall then be allowed to cool in the furnace at a rate not greater than 350°F [200°C] per hour. It may be removed from the furnace when the temperature of the furnace has reached 600°F [315°C] and allowed to cool in still air.

9.4 Weld Pad. A weld pad shall be prepared as specified in Figure 3, except when one of the alternatives in 9.1 (taking the sample from the broken tension test specimen or from a corresponding location or any location above it along the weld centerline in the weld metal in the groove weld in Figure 2) is selected.

Base metal of any convenient size of the type specified in Table 5 shall be used as the base for the weld pad. The surface of the base metal on which the filler metal is to be deposited shall be clean. The pad shall be welded in the flat position with multiple layers, to obtain undiluted weld metal. The preheat temperature shall not be less than 60°F [15°C] and the interpass temperature shall not exceed 325°F [165°C].

The welding procedure used for the weld pad shall satisfy the heat input requirements specified in Table 6. The slag shall be removed after each pass. The pad may be quenched in water between passes, but shall be dry before the start of each pass. The dimensions of the completed pad shall be as shown in Figure 3. Testing of this assembly shall be as specified in 10.2.

9.5 Fillet Weld. When specified in Table 4, test assemblies shall be welded using the appropriate base metal as specified in Table 5. Refer to Note b of Table 4 and Figure 4 for requirements, including welding position, for the Fillet Weld test. Testing of the assembly shall be as specified in Clause 14.

Before assembly, the standing member (web) shall have one edge prepared throughout its length and the base member (flange) side shall be straight, smooth and clean. The test plates shall be assembled as shown in Figure 4. When assembled, the faying surfaces shall be in intimate contact along the entire length of the joint. The test assembly shall be secured with tack welds deposited at each end of the weld joint.

The welding procedure and the size of the electrode to be tested shall be as selected by the manufacturer. The fillet weld shall be a single pass weld deposited either semiautomatically or automatically as selected by the manufacturer. Both pieces to form the test assembly shall have cross sections of 3/8 in [10 mm] to 1/2 in [12 mm] thickness by 3 in [75 mm] minimum width. The length of the weld shall be 12 in [300 mm] minimum.

The fillet weld shall be deposited only on one side of the joint as shown in Figure 4. Weld cleaning shall be limited to chipping, brushing, and needle scaling. Grinding, filing, or other metal cutting of the fillet weld face is prohibited. The testing of the assembly shall be as specified in Clause 14.

10. Chemical Analysis

10.1 The sample for analysis shall be taken from weld metal produced with the flux cored electrode and the shielding gas (if any) with which it is classified. The sample shall be taken from the reduced section of the fractured tension test specimen or from a corresponding location, or any location above it along the weld centerline, in the groove weld in Figure 2, unless the option for the weld pad described in 9.4 is used. The sample for chemical analysis shall be prepared for analysis by any means that will not affect the chemical composition.

10.2 The weld pad described in 9.4 can also be used to produce the weld metal sample for chemical analysis. The top surface of the pad described in 9.4 and shown in Figure 3 shall be removed and discarded and a sample for analysis shall be obtained from the underlying metal by any means that will not affect the chemical composition. The sample shall be free of slag. The sample shall be taken at least 3/8 in [10 mm] from the nearest surface of the base metal. In case of dispute, the analysis of the sample taken from the groove weld shall be the referee method.

10.3 The sample shall be analyzed by accepted analytical methods. The referee method shall be ASTM E350, except for the Mn1 and Mn2 classifications. For the Mn1 and Mn2 classifications, ASTM E353 shall be the referee method.

10.4 The results of the analysis shall meet the requirements of Table 3 for the classification of electrode under test.

11. Radiographic Test

11.1 The welded test assembly described in 9.3 and shown in Figure 2 shall be radiographed to evaluate the soundness of the weld metal. In preparation for radiography, the backing shall be removed and both surfaces of the weld shall be machined or ground smooth and flush with the original surfaces of the base metal or with a uniform reinforcement not exceeding 3/32 in [2.5 mm].

It is permitted on both sides of the test assembly to remove base metal to a depth of 1/16 in [1.5 mm] nominal below the original base metal surface in order to facilitate backing and/or buildup removal. Thickness of the weld metal shall not be reduced by more than 1/16 in [1.5 mm] less than the nominal base metal thickness, so that the thickness of the prepared radiographic test specimen equals at least the thickness of the base metal minus 1/16 in [1.5 mm].

Both surfaces of the test assembly in the area of the weld shall be smooth enough to avoid difficulty in interpreting the radiograph.

11.2 The weld shall be radiographed in accordance with one of the following. The quality level of inspection shall be 2-2T.

(1) **Film Radiology.** ASTM E1032.

(2) **Computed Radiology (CR).** ASTM E2033 and the requirements of ASTM E1032 except where CR differs from film. The term film, as used within ASTM E1032, applicable to performing radiography in accordance with ASTM E2033, refers to phosphor imaging plate.

(3) **Digital Radiology (DR).** ASTM E2698 and the requirements of ASTM E1032 except where DR differs from film. The term film, as used within ASTM E1032, applicable to performing radiography in accordance with ASTM E2698, refers to digital detector array (DDA).

11.3 The soundness of the weld metal 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 longer than 1/4 in [6 mm] or 1/3 of the thickness of the weld, whichever is greater, or no groups of slag inclusions in line that have an aggregate length greater than the thickness of the weld in a length 12 times the thickness of the weld, except when the distance between the successive inclusions exceeds 6 times the length of the longest inclusion in the group, and

(3) No rounded indications in excess of those permitted by the radiographic standards in Figure 5.

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

11.3.1 A rounded indication is an indication on the radiograph whose length is no more than three times its width. Rounded indications may be circular or irregular in shape and may have tails. The size of a rounded indication is the largest dimension of the indication, including any tail that may be present. The indication may be of porosity or slag. Assemblies with indications larger than the large indications permitted in the radiographic standard (Figure 5) do not meet the requirements of this specification.

12. Tension Test

12.1 One all-weld-metal tension test specimen, as specified in the Tension Test Clause of AWS B4.0, shall be machined from the welded test assembly described in 9.3 and shown in Figure 2. The tension test specimen shall have a nominal diameter of 0.500 in [12.5 mm], (0.250 in [6.5 mm] for some electrodes, as indicated in Note 2 of Figure 2), and a nominal gage length to diameter ratio of 4:1.

12.1.1 For classifications to be tested in the as-welded condition as specified in Table 1, the weld test assembly or tension test specimen may be aged at a temperature not to exceed 220°F [105°C] for up to 48 hours then allowed to cool to room temperature. No aging shall be performed prior to radiographic examination. Refer to A8.4 for a discussion of the purpose of aging.

12.1.2 The specimen shall be tested in the manner described in the Tension Test Section of AWS B4.0.

12.1.3 The results of the all-weld-metal tension test shall meet the requirements specified in Table 1 for that classification.

13. Impact Test

13.1 Five full-size Charpy V-Notch impact specimens, as specified in the Fracture Toughness Test Section of AWS B4.0, shall be machined from the test assembly shown in Figure 2, for those classifications for which impact testing is required in Table 4.

The Charpy V-Notch specimens shall have the notched and the struck surfaces parallel within 0.002 in [0.05 mm]. The other two surfaces of the specimen shall be square with the notched or struck surfaces within 10 minutes of a degree. The notch shall be smoothly machined and shall be square with the longitudinal edge of the specimen within one degree.

The geometry of the notch shall be measured on at least one specimen in a set of five specimens. Measurement shall be done at a minimum 10X magnification on either a shadowgraph or metallograph. The correct location of the notch shall be verified by etching before or after machining.

13.1.1 The five specimens shall be tested in accordance with the Fracture Toughness Test Section of AWS B4.0. The test temperature shall be at or below the temperature specified in Table 1 for the classification under test. For those electrodes to be identified by the optional supplemental impact designator “J,” the test temperature shall be as specified in Note e of Table 1. See also 15.2. The actual temperature used shall be listed on the certification document.

13.1.2 In evaluating the test results (except the K9 classifications), the lowest and the highest values obtained shall be disregarded. Two of the remaining three values shall equal or exceed the specified 20 ft·lbf [27 J] energy level. One of the three may be lower, but not lower than 15 ft·lbf [20 J], and the average of the three shall be not less than the required 20 ft·lbf [27 J] energy level.

13.1.3 For the K9 classification, the average of all five values must meet the minimum requirement. One of the five may be 10 ft·lbf [14 J] lower than the minimum requirement.