

Specification for Low-Alloy *and* *High Manganese* Steel Electrodes and Fluxes for Submerged Arc Welding



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American National Standards Institute
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Specification for **Low-Alloy *and High Manganese*** **Steel Electrodes and Fluxes** **for Submerged Arc Welding**

6th Edition

Revises AWS A5.23/A5.23M:2011

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 provides requirements for the classification of solid and composite carbon steel, low-alloy steel, *and high manganese steel* electrodes and fluxes for submerged arc welding. Electrode classification is based on chemical composition of the electrode for solid electrodes, and chemical composition of the weld metal for composite electrodes. Fluxes may be classified using a multiple-pass classification system or a two-run classification system, or both, under this specification. Multiple-pass classification is based on the mechanical properties and the deposit composition of weld metal produced with the flux and an electrode classified herein. Two-run classification is based upon mechanical properties only. Additional requirements are included for sizes, marking, manufacturing, and packaging. The form and usability of the flux are also included. A guide is appended to the specification as a source of information concerning the classification system employed and the intended use of submerged arc fluxes and 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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This standard is subject to revision at any time by the AWS A5 Committee on Filler Metals and Allied Materials. It must be reviewed every five years, and if not revised, it must be either reaffirmed or withdrawn. Comments (recommendations, additions, or deletions) and any pertinent data that may be of use in improving this standard are requested and should be addressed to AWS Headquarters. Such comments will receive careful consideration by the AWS A5 Committee on Filler Metals and Allied Materials and the author of the comments will be informed of the Committee's response to the comments. Guests are invited to attend all meetings of the AWS A5 Committee on Filler Metals and Allied Materials to express their comments verbally. Procedures for appeal of an adverse decision concerning all such comments are provided in the Rules of Operation of the Technical Activities Committee. A copy of these Rules can be obtained from the American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.

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Foreword

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

This document is the fourth of the A5.23/A5.23M specifications which 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 values in any way. In selecting rational metric units, AWS A1.1, *Metric Practice Guide for the Welding Industry*, is used where suitable. Tables and figures make use of both U.S. Customary and SI Units, which, with the application of the specified tolerances, provides for interchangeability of products in both the U.S. Customary and SI Units.

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.

Substantive changes in this edition are shown in italic font and include:

- (1) A new classification (Mn2) for an austenitic high manganese (nominal 19% Mn) weld deposit.*
- (2) New classifications (EB115 and B115) for an electrode and corresponding weld deposit with 10.5% Cr and 0.5% Mo modified with niobium and vanadium.*
- (3) New designators for low Mn + Ni B91 weld deposit.*
- (4) Requirements for reporting base and weld metal chemical composition for two-run classifications.*

The welding terms used in this specification shall be interpreted in accordance with the definitions given in the latest edition of AWS A3.0M/A3.0, *Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*.

The current document is the sixth revision of the initial joint ASTM/AWS document issued in 1976. The evolution of the AWS A5.23 specification took place as follows:

ANSI/AWS A5.23-76	<i>Specification for Bare Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding</i>
ANSI/AWS A5.23-80	<i>Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding</i>
ANSI/AWS A5.23-90	<i>Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding</i>
ANSI/AWS A5.23/A5.23M:1999	<i>Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding</i>
AWS A5.23/A5.23M:2007	<i>Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding</i>
AWS A5.23/A5.23M:2011	<i>Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding</i>

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.

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Specification for Low-Alloy *and High Manganese* Steel Electrodes and Fluxes for Submerged Arc Welding

1. Scope

1.1 This specification prescribes requirements for the classification of solid and composite carbon steel, low-alloy steel, *and high manganese* steel electrodes and flux-electrode combinations for submerged arc welding (SAW). This specification covers low-alloy *and high manganese* electrodes and low-alloy *and high manganese* multiple-pass flux-electrode classifications. This specification also addresses carbon steel, low-alloy steel, *and high manganese* steel two-run flux-electrode classifications. The multiple-pass classification of flux-electrode combinations for carbon steel SAW is not within the scope of this specification, but is covered in AWS A5.17/A5.17M.

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 A5.23 uses U.S. Customary Units. The specification A5.23M uses SI Units. The latter are shown within brackets [], in appropriate columns in tables and figures and in paragraphs numbered with an “M” suffix. Standard dimensions based on either system may be used for the sizing of electrodes, packaging, or both under specification A5.23 or A5.23M.

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 Annex A. Clauses A5 and A11. Safety and health information is available from the following sources:

American Welding Society:

- (1) ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*
- (2) AWS Safety and Health Fact Sheets
- (3) Other safety and health information on the AWS website

Material or Equipment Manufacturers:

- (1) Safety Data Sheets supplied by materials manufacturers
- (2) 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 to or revisions of any of these publications do not apply.

American Welding Society (AWS) documents:

AWS A1.1, *Metric Practice Guide for the Welding Industry*

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 ADD1, *Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding*

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

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

AWS A5.17/A5.17M, *Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding*

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 documents:

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

ASTM A131/A131M, *Specification for Structural Steel for Ships*

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

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

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

ASTM A335/A335M *Standard Specification for Seamless Ferritic Alloy-Steel Pipe for High-Temperature Service*

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

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

ASTM A515/A515M, *Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service*

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

ASTM A517/A517M, *Specification for Pressure Vessel Plates, Alloy Steel, High-Strength, Quenched and Tempered*

ASTM A533/A533M, *Specification for Pressure Vessel Plates, Alloy Steel, Quenched and Tempered, Manganese-Molybdenum and Manganese-Molybdenum-Nickel*

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

ASTM A543/A543M, *Specification for Pressure Vessel Plates, Alloy Steel, Quenched and Tempered, Nickel-Chromium-Molybdenum*

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

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

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

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 Radiographic Examination Using Computed Radiography (Photostimulable Luminescence Method)*

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

International Organization for Standardization (ISO) document:

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

3. Classification

3.1 The SAW electrodes and fluxes covered by the A5.23 specification utilize a classification system based upon U.S. Customary Units and are classified according to the following:

(1) The mechanical properties of the weld metal obtained from a multiple-pass groove weld, a two-run butt weld, or both; made with a combination of a particular flux and a particular classification of electrode, as specified in Tables 1 and 2.

(2) The condition of heat treatment in which the properties are obtained, as specified in 9.4 or 9.5, as applicable (and as shown in Figure 1 or Figure 2, as applicable).

(3) For multiple-pass classifications, the chemical composition of the weld metal obtained with the combination of a particular flux and a particular classification of electrode as specified in Table 3. Weld metal chemical composition is not specified for two-run classifications under this specification (see Figure 1 or Figure 2, as applicable).

(4) The chemical composition of either the electrode (for solid electrodes) as specified in Table 4, or the weld metal produced with a particular flux (for composite electrodes) as specified in Table 3.

3.1M The SAW electrodes and fluxes covered by the A5.23M specification utilize a classification system based upon the International System of Units (SI) and are classified according to the following:

(1) The mechanical properties of the weld metal obtained from a multiple-pass groove weld, a two-run butt weld, or both; made with a combination of a particular flux and a particular classification of electrode, as specified in Tables 1M and 2.

(2) The condition of heat treatment in which the properties are obtained, as specified in 9.4 or 9.5, as applicable (and as shown in Figure 1M or Figure 2M, as applicable).

(3) For multiple-pass classifications, the chemical composition of the weld metal obtained with the combination of a particular flux and a particular classification of electrode as specified in Table 3. Weld metal chemical composition is not specified for two-run classifications under this specification (see Figure 1M or Figure 2M, as applicable).

(4) The chemical composition of either the electrode (for solid electrodes) as specified in Table 4, or the weld metal produced with a particular flux (for composite electrodes) as specified in Table 3.

3.2 Fluxes may be classified under any number of classifications; for weld metal in either or both the as-welded and postweld heat treated conditions, for weld metal deposited using different electrode classifications, for multiple-pass or two-run classifications, or any combination thereof. Flux-electrode combinations may be classified under A5.23 with U.S. Customary Units, under A5.23M using the International System of Units (SI), or both. Flux-electrode combinations classified under both A5.23 and A5.23M must meet all of the requirements for classification under each system. The classification systems are shown in Figures 1 and 1M for multiple-pass classifications and in Figures 2 and 2M for two-run classifications.

3.3 The electrodes and fluxes classified under this specification are intended for SAW, but that is not to prohibit their use with any other process for which they are found suitable.

4. Acceptance

Acceptance of the electrodes and fluxes shall be in accordance with the provisions of AWS A5.01M/A5.01 and the tests and requirements of this specification. See 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 to the product, the manufacturer certifies that the product meets the requirements of this specification. See A4 (in Annex A) for further information concerning certification and the testing called for to meet this requirement.

6. Rounding Procedure

For the purpose 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 Rule A in Clause B.3 of ISO 80000-1 (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 an 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 (1 ksi) for tensile and yield strength for A5.23, to the nearest 10 MPa for tensile and yield strength for A5.23M 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 fulfil the requirements for the classification under test.

7. Summary of Tests

7.1 Chemical analysis of the electrode is the only test required for classification of a solid electrode under this specification. The chemical analysis of the rod stock from which the solid electrode is made may also be used provided the electrode manufacturing process does not alter the chemical composition. For composite electrodes, chemical analysis of the weld metal produced with the composite electrode and a particular flux is required.

7.2 The tests required for each flux-electrode classification are specified in Table 5. The purpose of these tests is to determine the mechanical properties and soundness of the weld metal. The base metal for test assemblies, preparation of the test samples, the welding and testing procedures to be employed, and the results required are given in Clauses 9 through 14.

7.3 Classification is based upon a 5/32 in [4.0 mm] electrode size as standard. If this size electrode is not manufactured, the closest size shall be used for classification tests. See Table 6, Note d and Table 7, Note e.

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. Material, specimens, or samples for retest may be taken from the original test assembly or sample or from 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 prescribed or proper procedures were not followed in preparing the weld test assembly or test specimen(s) 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 prescribed procedures. In this case, the requirement for doubling the number of test specimens does not apply.

9. Weld Test Assemblies

9.1 Requirements for Classification

9.1.1 Classification of Solid Electrodes. No weld test assembly is required for classification of solid electrodes.

9.1.2 Classification of Composite Electrodes. The chemical analysis of weld metal produced with the composite electrode and a particular flux is required for classification of a composite electrode under this specification. The weld pad shown in Figure 3 is used to meet this requirement for the classification of composite electrodes. The welding parameters for the multiple-pass groove weld, as specified in Table 6, shall be used. As an alternative to the weld pad, the sample for chemical analysis of composite electrode weld metal may be taken from the groove weld in Figure 4. Note g of Table 3 allows the sample for chemical analysis to be taken from the reduced section of the fractured tension test specimen or from a corresponding location (or any location above it) in the weld metal in the groove weld in Figure 4. In case of dispute, the weld pad shall be the referee method.

9.1.3 Classification of Flux-Electrode Combinations. One groove weld test assembly is required for each multiple-pass classification of a flux-solid electrode combination or a flux-composite electrode combination. This is the groove weld in Figure 4 for mechanical properties and soundness of weld metal. A second test assembly, the weld pad in Figure 3, is required for chemical analysis of the weld metal. However, Note g of Table 3 allows the sample for chemical analysis to be taken from the reduced section of the fractured tension test specimen or from a corresponding location (or any location above it) in the weld metal in the groove weld in Figure 4, thereby avoiding the need to make the weld pad. In case of dispute, the weld pad shall be the referee method.

One butt weld test assembly is required for each two-run classification of a flux-solid electrode combination or flux-composite electrode combination. This is the two-run weld test assembly in Figure 5 for mechanical properties and soundness of weld metal.

9.2 Preparation. Preparation of each weld test assembly shall be as prescribed in 9.3, 9.4, and 9.5. The base metal for the weld pad, the multiple-pass groove weld, and the two-run weld assemblies shall be as required in Table 8 and shall meet the requirements of the ASTM specification shown there or a chemically equivalent steel. Testing of the assemblies shall be as prescribed in Clauses 10 through 13.

9.3 Weld Pad. For composite electrodes or for any flux-electrode multiple-pass classification, a weld pad shall be prepared as specified in Figure 3, except when either alternative in 9.1.2 or 9.1.3 is selected. Base metal of any convenient size and of the type specified in Table 8, shall be used as the base metal for the weld pad. The surface of the base metal on which the filler metal is deposited shall be clean and free from scale. The pad shall be welded in the flat position, three beads per layer, four layers high, using the flux for which classification is intended.

The welding parameters for the groove weld, as specified in Table 6, shall be used except that the preheat temperature shall not be less than 60°F [15°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 but shall be dry before the start of each pass. Testing of this assembly shall be as specified in Clause 10, Chemical Analysis.

9.4 Groove Weld for Multiple-Pass Classifications

9.4.1 For mechanical properties and soundness testing of a flux-electrode combination for multiple-pass classification, a test assembly shall be prepared and welded as specified in Figure 4 and Table 6 using base metal of the appropriate type specified in Table 8. Preheat and interpass temperatures shall be as specified in Table 9. The surfaces to be welded shall be clean and free of scale. Prior to welding, the assembly may be preset so that the welded joint will be sufficiently flat after welding to facilitate removal of the test specimens. As an alternative, restraint or a combination of restraint and presetting may be used to keep the welded joint within 5° of plane. A welded test assembly that is more than 5° out of plane shall be discarded. Straightening of the test assembly is prohibited. Testing of this assembly shall be as specified in Clauses 10 through 13, with the assembly in either the as-welded or the postweld heat treated condition, according to the classification of the weld metal (see Figures 1 and 1M). When tests are to be conducted in each condition (as-welded and postweld heat treated) two such assemblies, or one single assembly of sufficient length to provide the specimens required for both conditions, shall be prepared. In the latter case, the single assembly shall be cut transverse to the weld into two pieces. One of the pieces shall be tested in the as-welded condition and the other piece shall be heat treated prior to testing.

9.4.1.1 When postweld heat treatment 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.

9.4.1.2 Any multiple-pass groove weld test assembly to be heat treated shall be heat treated at the time and temperature specified in Table 9 for the applicable weld metal designation. The welded test assembly shall be put into a suitable furnace at a temperature not greater than 600°F [315°C]. The temperature shall be raised at a rate of 150°F [85°C] to 500°F [280°C] per hour until the holding temperature specified in Table 9 is attained. This temperature shall be maintained for 1 hour (–0, +15 minutes), except as indicated in note e of Table 9.

9.4.1.3 The test assembly shall then be allowed to cool in the furnace at a rate not greater than 350°F [200°C] per hour. After the test assembly has reached 600°F [315°C] it may be removed from the furnace and allowed to cool in still air.

9.5 Butt Weld for Two-Run Classifications

9.5.1 For mechanical properties and soundness testing of a flux-electrode combination for two-run classification, a test assembly shall be prepared and welded as specified in Figure 5 and Table 7 using base metal of the appropriate type specified in Table 8. The surfaces to be welded shall be clean and free of scale. Prior to welding, the assembly may be preset such that the welded joint will be sufficiently flat to facilitate removal of the test specimens. As an alternative, restraint or a combination of restraint and presetting may be used to keep the welded joint sufficiently flat after welding. Straightening of the test assembly is prohibited. Testing shall be as specified in Clauses 10 through 13, with the assembly in either the as-welded or postweld heat treated condition, according to the classification of the weld metal (see Figures 2 and 2M). When tests are to be conducted in each condition (as-welded and postweld heat treated) two such assemblies, or one single assembly of sufficient length to provide the specimens required for both conditions, shall be prepared. In the latter case, the single assembly shall be cut transverse to the weld into two pieces. One of the pieces shall be tested in the as-welded condition and the other piece shall be heat treated prior to testing.

9.5.1.1 When postweld heat treatment 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.

9.5.1.2 Any two-run butt weld test assembly to be heat treated shall be put into a suitable furnace at a temperature not greater than 600°F [315°C]. The temperature shall be raised at the rate of 150°F [85°C] to 500°F [280°C] per hour until the postweld heat treatment temperature of 1150°F ± 25°F [620°C ± 15°C] is attained. This temperature shall be maintained for 30 minutes (–0, +7 minutes). The above postweld heat treat procedure also applies to FXTPIXG-EXX flux-electrode classifications unless otherwise specified by the purchaser.

9.5.1.3 The test assembly shall then be allowed to cool in the furnace at a rate not greater than 350°F [200°C] per hour. After the test assembly has reached 600°F [315°C] it may be removed from the furnace and allowed to cool in still air.

9.6 Diffusible Hydrogen. In those cases in which an optional supplemental diffusible hydrogen designator is to be added to the flux-electrode classification designation, diffusible hydrogen test assemblies shall be prepared, welded, and tested as specified in Clause 14, Diffusible Hydrogen Test.

10. Chemical Analysis

10.1 For solid electrodes, a sample of the electrode or the rod stock from which it is made shall be prepared for chemical analysis. Solid electrodes, when analyzed for elements that are present in a coating (copper flashing, for example), shall be analyzed without removing the coating. When the electrode 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 reducing the rod to the finished electrode diameter and applying the coating.

10.2 For composite electrodes and for the multiple-pass classification of flux-electrode combinations, the sample for analysis shall be taken from the weld pad in Figure 3, from the reduced section of the fractured tension test specimen in Figure 4, or from a corresponding location (or any location above it) in the weld metal in the butt weld in Figure 4. Weld

metal from the butt weld used for two-run classification (Figure 5) may not be used for the purpose of classifying composite electrodes. In case of dispute, the weld pad in Figure 3 shall be used as the referee method.

The top surface of the pad described in 9.3 and shown in Figure 3 shall be removed and discarded and a sample for analysis shall be obtained from the underlying metal of the fourth layer of the weld pad by any means that will not change 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. The sample from the reduced section of the fractured tension test specimen or from a corresponding location (or any location above it) in the groove weld in Figure 4 shall be prepared for analysis by any suitable means that will not change the chemical composition.

10.3 The sample shall be analyzed by accepted analytical methods. The referee method shall be the procedure in the latest edition of ASTM E350 or ASTM E353, as appropriate for the metal type.

10.4 For composite electrodes and for the multiple-pass classification of flux-electrode combinations, the results of the weld metal analysis shall meet the requirements of Table 3 for the applicable weld metal designation. For solid electrodes, the results of the electrode analysis shall meet the requirements of Table 4 for the classification of electrode being tested.

10.5 *For two-run classifications, the chemical composition of the weld metal is not specified, but reporting of the chemical composition of the base and weld metal are required and shall include C, Mn, Si, S, P, Cu, Cr, Ni, Mo, V, Nb, Ti, and B. The base metal chemical composition may be obtained from the specific steel used for the certification test assembly or metal from the heat of steel used for the certification test assembly. A certified material test report from the base metal supplier traceable to the specific heat of steel used for the certification test assembly may be used. Weld metal chemical analysis shall be obtained from the weld deposit of the second pass.*

11. Radiographic Test

11.1 The groove weld for multiple-pass classifications described in 9.4 and shown in Figure 4 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] in order to facilitate backing and/or buildup removal. The thickness of the weld metal shall not be reduced by more than 1/16 in [1.5 mm], 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.

The butt weld for two-run classifications described in 9.5 and shown in Figure 5 shall be radiographed to evaluate the soundness of the weld metal. In preparation for radiography, both ends of the test joint may be trimmed off to remove run-on and run-off tabs, if any, and any excess weld joint material. The surfaces of both weld beads may 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 buildup removal. The thickness of the weld metal shall not be reduced by more than 1/16 in [1.5 mm] 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).