

AWS D9.1M/D9.1:2000
An American National Standard



Sheet Metal Welding Code



American Welding Society



Key Words—Sheet metal, arc welding, braze welding, joint designs, qualification, workmanship, inspection, base metals, filler metals

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Sheet Metal Welding Code

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Prepared by
AWS D9 Committee on Welding,
Brazing, and Soldering of Sheet Metal

Under the Direction of
AWS Technical Activities Committee

Approved by
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Abstract

This code covers the arc and braze welding requirements for nonstructural sheet metal fabrications using the commonly welded metals available in sheet form. Requirements and limitations governing procedure and performance qualification are presented, and workmanship and inspection standards are supplied. The nonmandatory annexes provide useful information on materials and processes.



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Sheet Metal Welding Code

Note: Vertical lines adjacent to text indicate where changes (additions, modifications, corrections, deletions) from the 1990 edition were made. A single line represents a minor or editorial change. Double lines represent a major change or change in mandatory requirements. Changes in the annexes are not marked.

1. Scope, Purpose, and Applications

1.1 Scope. This code provides qualification, workmanship, and inspection requirements for both arc welding (Part A) and braze welding (Part B) as they apply to the fabrication, manufacture, and erection of nonstructural sheet metal components and systems.

1.2 Purpose. This code was developed to provide standardized requirements for the qualification, production, and acceptance of welding or braze welding of nonstructural sheet metal components.

1.3 Applications. This code has general applications in the following industrial areas:

- (1) Heating, ventilating, and air conditioning systems
- (2) Food processing equipment
- (3) Architectural sheet metal and similar applications
- (4) Other nonstructural sheet metal applications

This code covers sheet metal up to and including 3 gauge, or 6.35 mm [0.250 in.] (see Annex C). Also covered are the attachment of accessories and components of the system, and joining or attachment of any member, regardless of thickness, whose sole purpose is stiffening, supporting, or reinforcing the sheet metal.

Where negative pressure or positive pressure exceeds 30 kPa [5 psi] which is approximately 3 meters [120 in.] of standing water or where structural requirements are concerned, other codes or standards shall be used.

1.4 Required Information. This code requires values to be specified by the Engineer for 6.2 and 11.1.

1.5 Terms and Definitions

1.5.1 Terms and definitions shall be interpreted in accordance with the latest edition of AWS A3.0, *Standard Welding Terms and Definitions*.

1.5.2 Supplemental definitions and terms of significant importance to sheet metal welding are given in Annex B.

1.5.3 The Engineer referred to herein is the duly designated person who acts on behalf of the Owner in all matters within the scope of this code.

1.5.4 The term Contractor designates the party responsible for performing the welding under this code. The term is used collectively to mean Contractor, Fabricator, Erector, or Manufacturer.

1.5.5 The term independent third party designates an organization or agency qualified to perform testing required by this code.

1.6 Symbols. Symbols used in this code shall be in accordance with the latest edition of AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*.

1.7 Standard Units of Measurement. This standard 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. The standard with the designation D9.1M:2000 uses SI Units. The standard with the designation D9.1:2000 uses U.S. Customary Units. The latter are shown within brackets [] or in appropriate columns in tables and figures.

1.8 Safety and Health. These practices may involve hazardous materials, operations, and equipment. It is the responsibility of the user to establish appropriate safety and health practices in accordance with the safety precautions mandated by OSHA and recommended practices and procedures contained in the document ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, available from the American Welding Society. Additional information may be found in the *Safety and Health Fact Sheets*, a document of the AWS Safety and Health Committee. The equipment manufacturer's operating manual and safety instructions should always be carefully studied and complied with when operating welding or related equipment. Material Safety Data Sheets (MSDS) for materials used in these processes are available from the material supplier.

Part A **Arc Welding**

2. General Provisions for Arc Welding

2.1 Base Metal

2.1.1 Base metals to be joined under this code include coated and uncoated forms of carbon steel, low-alloy steel, chromium and chromium-nickel stainless steel alloys, aluminum and aluminum alloys, copper and copper alloys, nickel and nickel alloys, and titanium and titanium alloys.

2.1.2 Rust inhibitive coatings (including weldable primers), galvanized or aluminized coatings, or anti-spatter compounds may remain on the metal to be joined (see ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, for safety precautions).

2.2 Filler Metal

2.2.1 Filler metals shall be compatible with the base metal designated on the drawings or specified by the Engineer.

2.2.2 Suggested filler metals are listed in Annex A.

2.3 Processes. Joining processes under this code shall include shielded metal arc welding (SMAW), gas metal arc welding (GMAW), flux cored arc welding (FCAW), gas tungsten arc welding (GTAW), plasma arc welding (PAW), and carbon arc welding (CAW). Other processes may be used, provided they are qualified to the requirements of this code.

3. Arc Welding Procedure Qualification

3.1 Prior Procedure Qualification

3.1.1 Welding procedures qualified in accordance with AWS B2.1, *Standard for Welding Procedure and Performance Qualification*, latest edition, may be used, provided they meet the requirements of Section 3, Arc Welding Procedure Qualification, of this code. AWS Standard Welding Procedure Specifications published by AWS shall be accepted as qualified procedures.

3.1.2 The Engineer, exercising proper discretion, may accept evidence of previous qualification of specific procedures to be used on work being performed under this code. All required information shall be recorded on a Procedure Qualification Record (PQR) form similar to that shown in Annex E.

3.2 Required Procedure Qualification Tests

3.2.1 Welding Procedure Specification. The qualification of a WPS shall be the responsibility of the Contractor. Each welding procedure to be used in conjunction with this code shall be prepared as a Welding Procedure Specification (WPS) to be used in fabrication and installation. An independent third party may perform the actual procedure qualification tests and prepare the forms, however, the Contractor shall be responsible for certifying acceptance in accordance with the requirements of this code (see 3.5.1). All required information for the WPS shall be recorded on a form similar to that shown in Annex D.

3.2.2 Typical Joints. Qualification of any groove weld shown in Annex G provides qualification for any groove or fillet weld. Qualification of any fillet weld shown in Annex G provides qualification for any fillet weld. Qualification of a fillet weld does NOT provide qualification for a groove weld.

3.2.3 Preparing Joint Chosen for Testing. The chosen joint design shall be prepared as a longitudinal joint between two 75 mm [3 in.] by 150 mm [6 in.] sheets, assembled as one of the designs sketched in Figure 1 or as the actual joint to be used. Qualification testing using the butt joint in Figure 1 shall qualify all groove and fillet weld joint designs.

3.2.4 Welding the Test Joint. The joint shall be welded using the process specified in the WPS (see 3.2.1).

3.3 Limitations of Procedure Qualification. A qualified welding procedure shall be used only within the range of operating variables tested during qualification. These limits of essential variables are described in the

5. Arc Welding Workmanship

Work performed under this code shall exhibit qualities of workmanship described below.

5.1 Uniformity. Surfaces to be joined shall be uniform and free of defects.

5.2 Joint Cleanliness

5.2.1 Joint surfaces, as well as surfaces adjacent to a joint, shall be free of loose scale, oxides, rust, grease, and foreign matter.

5.2.2 Tightly adherent spatter is not a cause for rejection.

5.3 Position. If a welding position is not specified explicitly by the Engineer or dictated by a job condition, joints shall be welded in the most favored position for which both the procedure and the welder or welding operator are qualified.

5.4 Current and Polarity. Welding current and polarity shall be in accordance with the qualified welding procedure.

5.5 Inspection of Workmanship. Welds shall be visually inspected and shall meet the acceptance criteria of Section 6, Inspection of Arc Welding Work.

6. Inspection of Arc Welding Work

Inspection of all production welds shall be visual, without aid of magnification. (Prescription eyeglasses for vision correction are acceptable.)

Acceptance criteria for production welds different from those specified in this code may be used for a particular application, provided they are suitably documented and approved by the Engineer.

The Contractor shall conduct inspections to ensure conformance to the acceptance criteria. The Engineer, with mutual agreement between the Owner and Contractor, may also conduct inspections of the work to ensure conformance to the acceptance criteria. The specified acceptance criteria for the work shall be as follows:

6.1 Fusion. Complete fusion shall be obtained.

6.2 Penetration. Required joint penetration as specified for the application shall be present.

6.3 Reinforcement of Groove Welds. A maximum of 3.2 mm [1/8 in.] face reinforcement and 3.2 mm [1/8 in.] root reinforcement shall be acceptable.

6.4 Throat and Convexity of Fillet Welds. The minimum throat shall be as specified for the application with maximum convexity not to exceed 3.2 mm [1/8 in.].

6.5 Porosity or Inclusions. Some limited porosity or inclusion is acceptable, consistent with 6.1 and limited to the following:

(1) One visible pore or inclusion no larger than 0.5t is permitted in any 25 mm [1 in.] of weld, where t is the thickness of the thinner member.

(2) Three visible pores or inclusions no larger than 0.25t also are permitted in any 25 mm [1 in.] of weld, where t is the thickness of the thinner member.

6.6 Undercut

6.6.1 Groove Welds. Undercut may not exceed 0.15t.

6.6.2 Fillet Welds. Undercut may not exceed 0.15t when the base-metal thickness being welded is 4.8 mm [0.187 in.] or thinner, or exceed 0.25t when the base-metal thickness being welded is greater than 4.8 mm [0.187 in.].

6.7 Cracks. There shall be no cracks.

6.8 Conformance. Completed welds shall be visually inspected for location, size, and length in accordance with the engineering drawing and specification requirements.

Part B *Braze Welding*

7. General Provisions for Braze Welding

7.1 Base Metal

7.1.1 Base metals to be joined under this code include coated and uncoated forms of carbon steel, low-alloy steel, chromium and chromium-nickel stainless steel alloys, aluminum and aluminum alloys, copper and copper alloys, nickel and nickel alloys, and titanium and titanium alloys.

7.1.2 Rust inhibitive coatings (including weldable primers), galvanized or aluminized coatings, or anti-spatter compounds may remain on the metal to be joined (see ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, for safety precautions).

7.2 Filler Metal

7.2.1 Filler metals shall be compatible with the base metal designated on the drawings or specified by the Engineer.

7.2.2 Suggested filler metals are shown in Annex A, Table A1. Only those filler metals with a melting