

AWS D9.1M/D9.1:2006
An American National Standard



Sheet Metal Welding Code



American Welding Society



**AWS D9.1M/D9.1:2006
An American National Standard**

**Approved by the
American National Standards Institute
July 25, 2006**

Sheet Metal Welding Code

5th Edition

Supersedes AWS D9.1M/D9.1:2000

Prepared by the
American Welding Society (AWS) D9 Committee on Welding, Brazing, and Soldering of Sheet Metal

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

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 informative annexes provide useful information on materials and processes.



American Welding Society

550 N.W. LeJeune Road, Miami, FL 33126

Table of Contents

	Page No.
<i>Personnel</i>	v
<i>Foreword</i>	vii
<i>Dedication</i>	ix
<i>List of Tables</i>	xiii
<i>List of Figures</i>	xiii
1. Scope, Purpose, and Applications	1
1.1 Scope.....	1
1.2 Purpose.....	1
1.3 Applications.....	1
1.4 Required Information.....	1
1.5 Symbols.....	1
1.6 Standard Units of Measurement.....	1
1.7 Safety and Health.....	1
2. Normative References	1
3. Terms and Definitions	2
Part A—Arc Welding	2
4. General Provisions for Arc Welding	2
4.1 Base Metal.....	2
4.2 Filler Metal.....	2
4.3 Processes.....	2
5. Arc Welding Procedure Qualification	2
5.1 Prior Procedure Qualification.....	2
5.2 Required Procedure Qualification Tests.....	2
5.3 Limitations of Procedure Qualification.....	4
5.4 Inspection of Procedure Qualification Test Welds.....	4
5.5 Responsibility for Qualification.....	7
5.6 Duration of Procedure Qualification.....	7
6. Qualification of Arc Welders and Arc Welding Operators	7
6.1 Prior Welder and Welding Operator Qualification.....	7
6.2 Required Welder and Welding Operator Qualification Tests.....	7
6.3 Limitations of Welder and Welding Operator Qualifications.....	7
6.4 Inspection of Welder and Welding Operator Qualification Test Welds.....	8
6.5 Responsibility for Qualification.....	9
6.6 Duration of Qualification.....	9
7. Arc Welding Workmanship	9
7.1 Uniformity.....	9
7.2 Joint Cleanliness.....	9
7.3 Position.....	9
7.4 Current and Polarity.....	9
7.5 Inspection of Workmanship.....	9
8. Inspection of Production Arc Welding Work	9
8.1 Fusion.....	9

8.2	Penetration	9
8.3	Reinforcement of Groove Welds	9
8.4	Throat and Convexity of Fillet Welds	9
8.5	Porosity or Inclusions	9
8.6	Undercut	9
8.7	Cracks	10
8.8	Conformance.....	10
	Part B—Braze Welding	10
9.	General Provisions for Braze Welding.....	10
9.1	Base Metal	10
9.2	Filler Metal	10
9.3	Processes.....	10
10.	Braze Welding Procedure Qualification	10
10.1	Prior Procedure Qualification	10
10.2	Required Procedure Qualification Tests	10
10.3	Limitations of Procedure Qualification	10
10.4	Inspection of Procedure Qualification Test Braze Welds.....	12
10.5	Responsibility for Qualification	12
10.6	Duration of Procedure Qualification	15
11.	Qualification of Braze Welders and Braze Welding Operators	15
11.1	Prior Braze Welder and Braze Welding Operator Qualification	15
11.2	Required Braze Welder and Braze Welding Operator Qualification Tests	15
11.3	Limitations of Braze Welder and Braze Welding Operator Qualifications.....	15
11.4	Inspection of Braze Welder and Braze Welding Operator Qualification Test Braze Welds.....	16
11.5	Responsibility for Qualification	16
11.6	Duration of Qualification.....	17
12.	Braze Welding Workmanship.....	17
12.1	Uniformity	17
12.2	Joint Cleanliness	17
12.3	Position	17
12.4	Current and Polarity.....	17
12.5	Inspection of Workmanship.....	17
13.	Inspection of Production Braze Welding Work	17
13.1	Bonding	17
13.2	Reinforcement of Groove Braze Welds.....	17
13.3	Throat and Convexity of Fillet Braze Welds	17
13.4	Porosity or Inclusions	17
13.5	Cracks	17
13.6	Conformance.....	17
	Annex A (Informative)—Recommended Filler Metals	19
	Annex B (Informative)—Supplemental Terms and Definitions	21
	Annex C (Informative)—Gage Numbers and Equivalent Thicknesses in SI Units and U.S. Customary Units	23
	Annex D (Informative)—Welding Procedure Specification (WPS) Form	25
	Annex E (Informative)—Procedure Qualification Record (PQR) Form	27
	Annex F (Informative)—Welder and Welding Operator Qualification Test Record Form	29
	Annex G (Informative)—Joint Design and Details.....	31
	Annex H (Informative)—Recommended Arc Welding Practices	39
	Annex I (Informative)—Recommended Braze Welding Practices	47
	Annex J (Informative)—General Knowledge Test	49
	Annex K (Informative)—Guidelines for the Preparation of Technical Inquiries	55

List of Tables

Table	Page No.
A.1	F Number Grouping of Welding Electrodes and Rods..... 19
C.1	Hot-Rolled and Cold-Rolled Steel Sheet..... 23
C.2	Galvanized Steel Sheet 23
C.3	Stainless Steel Sheet 24
C.4	Aluminum and Aluminum Alloy Sheet..... 24
C.5	Copper and Copper Alloy Sheet..... 24
H.1	Suggested Covered Electrode Size for Various Currents and Gages 40
H.2	Typical Storage and Drying Conditions for Covered Arc Welding Electrodes 41
H.3	Suggested Welding Conditions for Carbon Steel and Low Alloy Steel Sheet Metal..... 42
H.4	Suggested Welding Conditions for Aluminum Sheet Metal 44

List of Figures

Figure	Page No.
1	Procedure Qualification Test Assemblies..... 3
2	Butt Joint Groove Weld Test Positions 5
3	Fillet Weld Test Positions..... 6
4	Braze Weld Procedure Qualification Test Assemblies..... 11
5	Braze Groove Weld Test Positions..... 13
6	Braze Fillet Weld Test Positions 14
GA.1	Square-Groove Weld 31
GA.2	Square-Groove Weld with Backing..... 31
GA.3	Single-V-Groove Weld..... 31
GA.4	Edge Weld (in a Flanged Joint) 32
GA.5	Flare-Bevel-Groove Weld (in T-Joint or Inside Corner Joint) 32
GA.6	Flare-V-Groove Weld..... 32
GA.7	Square-Groove Corner Weld 32
GA.8	Flare-Bevel Weld (in an Offset Lap Joint) 33
GA.9	Flare-Bevel-Groove Weld 33
GA.10	Plain Lap Joint Fillet Weld..... 33
GA.11	Fillet Weld in T-Joint (One or Both Sides) 33
GA.12	Fillet Weld in Open (Offset) Corner Joint (Angle May Vary from 90°)..... 34
GA.13	Corner Weld with Backing 34
GB.1	Square-Groove Braze Weld..... 34
GB.2	Square-Groove Braze Weld with Backing 35
GB.3	Single-V-Groove Braze Weld..... 35
GB.4	Edge Braze Weld (in a Flanged Joint)..... 35
GB.5	Flare-Bevel-Groove Braze Weld (in T-Joint or Inside Corner Joint)..... 35
GB.6	Flare-V-Groove Braze Weld..... 36
GB.7	Square-Groove Corner Braze Weld..... 36
GB.8	Fillet Braze Weld T-Joint 36
GB.9	Fillet Braze Weld in Open (Offset) Corner Joint (Angle May Vary from 90°) 37
GB.10	Plain Lap Joint Braze Weld..... 37

Sheet Metal Welding Code

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. General applications of this code are 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 6.4 mm [0.250 in]. 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 paragraphs 8.2, 8.3, 13.1, and 13.3.

1.5 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*.

1.6 Standard Units of Measurement. This standard makes use of both the International System of Units (SI) and U.S. Customary Units. The latter are shown within brackets [] or in appropriate columns in tables and figures. The measurements are not exact equivalents; there-

fore, each system must be used independently of the other without combining in any way.

1.7 Safety and Health. Safety and health issues and concerns are beyond the scope of this standard and therefore are not fully addressed herein. Safety and health information is available from other sources, including, but not limited to, ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes* and applicable federal, state, and local regulations.

Additional information may be found in the *Safety and Health Fact Sheets*, a document of the AWS Safety and Health Committee.¹ 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 (MSDSs) for materials used in these processes are available from the material supplier.

2. Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this AWS standard. 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.

ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*;² and

AWS documents:³

1. AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*; and
2. AWS A3.0, *Standard Welding Terms and Definitions Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*.

¹ Safety and Health Fact Sheets are published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

² ANSI Z49.1 is published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

³ AWS standards are published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.