

AWS D1.3/D1.3M:2008
An American National Standard



Structural Welding Code— Sheet Steel



American Welding Society



**AWS D1.3/D1.3M:2008
An American National Standard**

**Approved by the
American National Standards Institute
July 23, 2007**

Structural Welding Code— Sheet Steel

5th Edition

Supersedes ANSI/AWS D1.3-98

Prepared by the
American Welding Society (AWS) D1 Committee on Structural Welding

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This code covers the requirements associated with welding sheet steel having a minimum specified yield point no greater than 80 ksi [550 MPa]. The code requirements cover any welded joint made from the commonly used structural quality low-carbon hot rolled and cold rolled sheet and strip steel with or without zinc coating (galvanized). Clause 1 includes general provisions, Clause 2 design, Clause 3 prequalification, Clause 4 qualification, Clause 5 fabrication, Clause 6 inspection, and Clause 7 stud welding.



American Welding Society

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

Foreword

This foreword is not part of AWS D1.3/D1.3M:2008, *Structural Welding Code—Sheet Steel*, but is included for informational purposes only.

When the first edition of AWS D1.3, *Specification for Welding Sheet Steel in Structures*, was developed and issued in the 1978, it was anticipated that changes would be needed in the specification as further research was conducted on sheet steel welded joints. After users' experience with the specification and development of new sheet steel applications, it was revised in 1981, 1989, 1998, and 2008. Also, in the 1981 edition, the title of the standard was changed to AWS D1.3, *Structural Welding Code—Sheet Steel*, to conform with the uniform titles now being given to standards developed by the AWS D1 Committee on Structural Welding. The many changes in this document reflect both experience in using the code and the results of research, principally by the American Iron and Steel Institute's Subcommittee on Sheet Steel.

One of the primary objectives of this code is to define the allowable capacities used in sheet steel applications in which transfer of calculated load occurs. The foremost examples of such applications are steel decks, panels, storage racks, and stud and joist framing members. It is a concurrent objective of this code to impose workmanship, technique, and qualification requirements so as to effect consistently sound execution of welding of joints in these categories.

Certain shielded metal arc, gas metal arc, gas tungsten, gas metal arc, and flux cored arc welding procedure specifications (WPSs) when used with certain types of joints, have been tested by users and have a history of satisfaction performance. These WPSs are designated as prequalified, may be employed without further evidence, and include most of those that are commonly used. However, the purpose of defining prequalified WPSs is not to preclude the use of other WPSs as they are qualified.

Then other processes, WPSs, or joints are proposed, they are subject to the applicable provisions of this code and shall be qualified by tests. The obligation is placed on the contractor to prepare WPSs and qualify them before production use.

All WPSs (prequalified and qualified) must include the classification of the filler metal, its size, and for each type of weld, its melting rate or other suitable means of current control indicative of the melting rate, as applicable. The requirements for the qualification of welders and welding operators are also given. Welder qualification test requires each welder prove their ability to produce satisfactory weld using these prequalified or qualified WPSs.

Although this code is essentially directed at those joints that are used to transfer loads, the quality of welds where strength is not a governing consideration should meet quality standards that will maintain the integrity of the supporting structure. The allowable capacity provisions of Clause 2 could be disregarded when the welds are not used in a load-carrying capacity.

Underlined text in the subclauses, tables, or figures indicates an editorial or technical change from the 1998 edition. A vertical line in the margin next to a figure or table indicates a revision from the 1998 edition.

The following is a summary of the most significant technical revisions contained in D1.3/D1.3M:2008:

- (1) Addition of a new normative annex listing requirements when welding D1.3 sheet steels to other D1.1 steel product forms.
- (2) New Commentary for Clauses 2, 4, 5, and Annex A.
- (3) Extensive revisions in Tables 1.2, 4.1, and 4.2.
- (4) Addition of new essential variables within Table 4.3.
- (5) Addition of Tables 1.1, 3.1, and A.1.
- (6) Revisions throughout Figures 2.7, 3.1, 3.2, 3.3, 4.1, and C-2.1.

(7) New equation for SMAW melting rate.

(8) Deletion of Clause 7 Stud Welding.

(9) Weld/base-metal fusion restriction added in weld acceptance criteria.

(10) WPS temperature qualification changed from 60°F [16°C] or higher to 100°F [38°C] or lower.

Commentary. The commentary is nonmandatory and is intended only to provide insightful information into provision rationale.

Errata. It is the policy of the AWS D1 Committee on Structural Welding that all errata should be made available to users of this code. Therefore, in the Society News Section of the *AWS Welding Journal*, and errata (major editorial changes) that have been noted will be published in the July and November issues of the *Welding Journal* and posted on the AWS web site.

Suggestions. Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS D1 Committee on Structural Welding, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

Table of Contents

| | Page No. |
|--|-----------------|
| <i>Dedication</i> | v |
| <i>Personnel</i> | vii |
| <i>Foreword</i> | ix |
| <i>List of Tables</i> | xiii |
| <i>List of Figures</i> | xiii |
| <i>List of Forms</i> | xiv |
| 1. General Provisions | 1 |
| 1.1 Scope | 1 |
| 1.2 Sheet Steel Base Metal | 1 |
| 1.3 Welding Processes | 1 |
| 1.4 Weld Metal Requirements | 2 |
| 1.5 Weld Types | 2 |
| 1.6 <u>Terms and Definitions</u> | 3 |
| 1.7 Welding Symbols | 3 |
| 1.8 Safety Precautions | 3 |
| 1.9 Standard Units of Measurement | 3 |
| 2. Design of Welded Connections | 9 |
| Part A—Allowable Load Capacities | 9 |
| 2.1 Base-Metal Stresses | 9 |
| 2.2 Allowable Load Capacities in Weld Joints | 9 |
| Part B—Details of Welded Connections | 11 |
| 3. Prequalification of WPSs | 19 |
| 3.0 Scope | 19 |
| 3.1 <u>General</u> | 19 |
| 3.2 <u>Joint Details</u> | 19 |
| 4. Qualification | 25 |
| Part A—General Requirements | 25 |
| 4.1 Preparation of a WPS and PQR | 25 |
| 4.2 Engineer’s Approval | 25 |
| 4.3 Responsibility | 25 |
| 4.4 WPS Requirements | 25 |
| Part B—Welding Procedure Specification (WPS) | 25 |
| 4.5 Essential Variable Limitations | 25 |
| 4.6 Number of Tests, Testing Methods, and Acceptance Standards for WPS Qualification | 25 |
| Part C—Welder Performance Qualification | 29 |
| 4.7 Essential Variables | 29 |
| 4.8 Number of Tests and Methods for Welder Performance Qualification | 29 |
| 4.9 Duration of Qualification | 29 |
| 5. Fabrication | 45 |
| 5.1 General | 45 |
| 5.2 Preparation of Material | 45 |

| | Page No. |
|--|-----------------|
| 5.3 Assembly..... | 45 |
| 5.4 Allowable Deviation from WPS for Lower Temperatures <u>Using Annex A, Note 1</u> | 45 |
| 6. Inspection | 47 |
| Part A—Acceptance Criteria..... | 47 |
| 6.1 Production Weld Acceptance Criteria..... | 47 |
| Part B—Contractor’s Responsibility | 47 |
| 6.2 Inspection of WPS and Welder Qualifications | 47 |
| 6.3 Inspection of Work..... | 47 |
| <u>Annex A (Normative)—Applicable Provision Requirements When Welding D1.3 Sheet Steels to</u> | |
| <u>D1.1 Other Steel Product Forms</u> | 49 |
| Annex B (Informative)—Sample Welding Forms | 51 |
| Annex C (Informative)—Guidelines for the Preparation of Technical Inquiries for the Structural Welding Committee..... | 55 |
| Annex D (Informative)—Terms and Definitions | 57 |
| Annex E (Informative)—Gage Numbers and Equivalent Thicknesses..... | 61 |
| Annex F (Informative)—Safe Practices | 63 |
| <u>Annex G (Informative)—Reference Documents</u> | 67 |
| <i>Commentary on Structural Welding Code—Sheet Steel</i> | 69 |
| List of AWS Documents on Structural Welding..... | 83 |

List of Tables

| Table | Page No. |
|-------|---|
| 1.1 | Code Application Matrix of D1.3 and D1.1 Codes Based on Material Thickness Being Joined4 |
| 1.2 | Matching Filler Metal Requirements.5 |
| 1.3 | Welding Positions and Restrictions for WPS7 |
| 3.1 | <u>Prequalified WPS Requirements</u>20 |
| 4.1 | WPS Qualification Tests30 |
| 4.2 | PQR Essential Variable Changes Requiring WPS Requalification for SMAW, GMAW, FCAW, GTAW, and SAW32 |
| 4.3 | Electrode Classification Groups.....33 |
| 4.4 | Welder Performance Qualification Tests34 |
| A.1 | <u>Applicable Provision Requirements When Welding D1.3 Sheet Steels to D1.1 Other Steel Product Forms</u>49 |
| E.1 | Gage Numbers and Equivalent Thicknesses—Hot-Rolled and Cold-Rolled Sheet61 |
| E.2 | Gage Numbers and Equivalent Thicknesses—Galvanized Sheet.....61 |

List of Figures

| Figure | Page No. |
|--------|---|
| 2.1 | Square-Groove Welds in Butt Joints 13 |
| 2.2 | Fillet Welds 13 |
| 2.3A | Single-Flare-Bevel-Groove Weld 13 |
| 2.3B | Single-Shear in Flare-Groove Welds 14 |
| 2.3C | Double-Shear in Flare-Groove Welds..... 14 |
| 2.4 | Arc Spot Welds 15 |
| 2.5 | Arc Seam Welds..... 15 |
| 2.6 | Arc Plug Welds 16 |
| 2.7 | Fillet Welds in Lap Joints 16 |
| 2.8 | Fillet Welds in T-Joints..... 16 |
| 2.9 | Single-Flare-Bevel-Groove Weld 17 |
| 2.10 | Single-Flare-V-Groove Weld..... 17 |
| 2.11A | Edge Distances for Arc Spot Welds..... 17 |
| 2.11B | Arc Spot Weld Using Washer..... 17 |
| 2.11C | Typical Weld Washer..... 17 |
| 2.12 | Arc Seam Welds Along Standing Rib..... 18 |
| 2.13A | Edge Distances for Arc Seam Welds 18 |
| 2.13B | Edge Distances for Arc Plug Welds..... 18 |
| 3.1A | Square Groove Weld in Butt Joint with Steel Backing..... 21 |
| 3.1B | Square Groove Weld in Butt or Corner Joint without Backing 21 |
| 3.2A | Fillet Weld in Corner Joint..... 21 |
| 3.2B | Fillet Weld in Lap Joint 22 |
| 3.2C | Fillet Weld in T-Joint..... 22 |
| 3.3A | Flare-Bevel-Groove Weld in Butt Joint 22 |

| Figure | Page No. |
|---|-----------------|
| 3.3B Flare-Bevel-Groove Weld in Corner Joint..... | 23 |
| 3.3C Flare-V-Groove Weld in Butt Joint | 23 |
| 3.3D Flare-Bevel-Groove Weld in Lap Joint..... | 24 |
| 4.1 Test for Square-Groove Welds in Butt Joints | 36 |
| 4.2A Test for Fillet Welds | 37 |
| 4.2B Extent of Validity of Fillet Weld Qualifications..... | 38 |
| 4.3A Test for Sheet to Sheet Flare-Bevel-Groove Welds | 38 |
| 4.3B Test for Sheet to Supporting Structural Member Flare-Bevel-Groove Welds..... | 39 |
| 4.3C Test for Flare-V-Groove Welds | 39 |
| 4.3D Extent of Validity of Flare-Groove Weld Qualifications..... | 40 |
| 4.4 Test for Arc Spot Welds..... | 40 |
| 4.5A Test for Sheet to Supporting Structural Member Arc Seam Welds | 41 |
| 4.5B Test for Sheet to Sheet Arc Seam Welds | 41 |
| 4.6 Test for Arc Plug Welds..... | 42 |
| <i>Commentary:</i> | |
| <u>C-2.1</u> Allowable Stress for Fillet Welds | 75 |
| <u>C-2.2</u> Load Capacity of Fillet Welds | 75 |
| <u>C-2.3</u> Arc Spot Welds | 75 |
| <u>C-2.4</u> Arc Seam Weld in a Supporting Plate | 76 |
| <u>C-4.1</u> Melting Rate Measurement Illustrated..... | 78 |
| <u>C-5.1</u> Positions of Welding | 80 |

List of Forms

| Form | Page No. |
|--|-----------------|
| <u>B-1</u> Sample Form for Welding Procedure Qualification Test Record (PQR) | 52 |
| <u>B-2</u> Sample Form for Welding Procedure Specification (WPS) | 53 |
| <u>B-3</u> Sample Form for Welder and Welding Operator Qualification Test Record | 54 |

Structural Welding Code—Sheet Steel

1. General Provisions

1.1 Scope

This code contains the requirements for arc welding of structural sheet/strip steels, including cold formed members, hereafter collectively referred to as “sheet steel,” which are equal to or less than 3/16 in (0.188 in) [4.8 mm] in nominal thickness. When this code is stipulated in contract documents, conformance with all its provisions shall be required, except for those provisions that the Engineer or contract documents specifically modifies or exempts.

When used in conjunction with AWS D1.1, conformance with the applicable provisions of Annex A of AWS D1.3 shall apply (see also Table 1.1). Two weld types unique to sheet steel, arc spot, and arc seam are included in this code.

1.1.1 Applicable Materials. This code is applicable to the welding of structural sheet steels to other structural sheet steels or to supporting structural steel members.

1.1.2 General Stipulations. The fundamental premise of the code is to provide general stipulations applicable to any situation. Acceptance criteria for production welds different from those specified in the code shall be permitted for a particular application, provided they are suitably documented by the proposer and approved by the Engineer. These alternate acceptance criteria shall be based upon evaluation of suitability for service using past experience, experimental evidence, or engineering analysis considering material type, service load effects, and environmental factors.

1.1.3 Approval. All references to the need for approval shall be interpreted to mean approval by the Engineer, defined as the duly designated person who acts for and in behalf of the owner on all matters within the scope of this code. Deviations from code requirements shall require the Engineer’s approval.

1.2 Sheet Steel Base Metal

1.2.1 Specified Base Metals. Sheet steel base metals to be welded under this code shall conform to the requirements of the latest edition of one of the specifications listed in Table 1.2, or any sheet steel qualified in conformance with 1.2.2. Any combination of these steels may be welded together. These steels may also be welded to any of the steels listed in the latest edition of AWS D1.1, *Structural Welding Code—Steel*.

1.2.2 Other Base Metals. When a steel other than those covered in 1.2.1 is approved under the provisions of the project or product specification, and such a steel is proposed for welded construction, the weldability of the steel and the WPS for welding it shall be established by qualification in conformance with the requirements of Clause 4 and such other requirements as prescribed by the Engineer.

1.2.3 Minimum Yield Point. The provisions of this code are intended for use with sheet steel having a minimum specified yield point equal to or less than 80 ksi [550 MPa].

1.3 Welding Processes

1.3.1 Approved Processes. This code provides for welding with the shielded metal arc welding (SMAW), gas metal arc welding (GMAW), flux cored arc welding (FCAW), gas tungsten arc welding (GTAW), or submerged arc welding (SAW) welding processes. (*NOTE: Any variation of gas metal arc welding (GMAW), including short-circuiting transfer, is acceptable.*)

1.3.2 Stud Welding. When stud welding through the flat portion of sheet steel decking or roofing onto other product forms, the WPS, the studs, and the quality control requirements shall conform with the applicable provisions in the AWS D1.1 code.

1.3.3 Other Processes. Other welding processes may be used when approved by the Engineer. In such case, the Engineer shall specify any additional qualification requirements necessary to assure satisfactory joints for the intended service.

1.4 Weld Metal Requirements

1.4.1 Matching Filler Metals. When using the indicated weld process, the filler metals listed in Table 1.2 provide a weld joint with strengths matching that of the base metal.

1.4.2 Other Base Metal-Filler Metal Combinations. Base metal-filler metal combinations other than those described in 1.4.1 shall be permitted when evaluated and approved by the Engineer. When base metals of dissimilar strengths are welded, the filler metal tensile strength shall be equal to or greater than that of the lowest tensile strength base metal.

1.4.3 Manufacturer's Certification. When requested by the Engineer, the contractor shall furnish an electrode manufacturer's certification stating that the electrode will meet the requirements of the classification.

1.4.4 Electrodes for Shielded Metal Arc Welding (SMAW)

1.4.4.1 AWS Specification. Electrodes for SMAW shall conform to the requirements of the latest edition of AWS A5.1/A5.1M, *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*, or to the requirements of AWS A5.5/A5.5M, *Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding*.

1.4.4.2 Low-Hydrogen Electrode Control. This control shall be for sheet steel that is welded to a primary structural member which is thicker than 1/4 in [6.4 mm], placing the jurisdiction of this control as specified in AWS D1.1.

1.4.5 Submerged Arc Welding (SAW)

1.4.5.1 AWS Specification. The bare electrodes and fluxes used in combination for SAW shall conform to the requirements of the latest edition of AWS A5.17/A5.17M, *Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding*, or to the requirements of the latest edition of AWS A5.23/A5.23M, *Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding*.

1.4.5.2 Flux. Flux used for submerged arc welding shall be dry and free of contamination from dirt, mill scale, oils, or other foreign material. All flux shall be purchased in packages that can be stored, under normal

conditions, for at least six months without such storage affecting its welding characteristics or weld properties. Flux from damaged packages shall be discarded or shall be dried at a minimum temperature of 250°F [120°C] for one hour before use. Flux shall be placed in the dispensing system immediately upon the opening of a package, or if used from an opened package, the top 1 in [25 mm] shall be discarded. Flux that has been wet shall not be used.

1.4.6 Gas Metal Arc Welding, Flux Cored Arc Welding (FCAW), and Gas Tungsten Arc Welding (GTAW) Filler Metals

1.4.6.1 AWS Specification. The filler metals and shielding for GMAW, FCAW, or GTAW shall conform to the requirements of the latest edition of AWS A5.18/A5.18M, *Specification for Carbon Steel Electrodes and Rods for Gas Metal Arc Welding*, or AWS A5.28/A5.28M, *Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding*, AWS A5.20/A5.20M, *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*, or AWS A5.29/A5.29M, *Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*, as applicable.

1.4.6.2 Shielding Media. A gas or gas mixture used for shielding in GMAW, FCAW when required, or GTAW, shall meet the requirements of AWS A5.32/A5.32M, Specification for Welding Shielding Gases. When requested by the Engineer, the gas manufacturer shall furnish certification that the gas or gas mixture meets the requirements of AWS A5.32/A5.32M.

1.5 Weld Types

1.5.1 Square-Groove Welds in Butt Joints. This type of weld is restricted to the welding of sheet steel to sheet steel in all positions of welding.

1.5.2 Fillet Welds. This type of weld may be used in all positions of welding involving sheet steel to sheet steel or a sheet steel to a supporting structural member.

1.5.2.1 Fillet Welds in Lap and T-Joints. Fillet welds in lap and T-joints may be used in all positions (see Table 1.3) involving a sheet steel to sheet steel or a sheet steel to a supporting structural member.

NOTE: When fillet welding sheet steel to a supporting structural member, measures shall be taken to prevent underbead cracking.

1.5.3 Flare-Groove Welds. This type of weld may be used in all positions involving the following:

- (1) Two sheet steels for flare-V and flare-bevel grooves

(2) A sheet and a supporting structural member for flare-bevel groove (see Table 1.3)

1.5.4 Arc Spot Welds. This type of weld is a spot weld made by an arc welding process in which the weld is made without preparing a hole in either member. These welds are restricted to the welding of sheet steel to supporting structural member in the flat position (see Table 1.3). *NOTE: Neither the thickness of a single sheet nor the combined thickness of two sheets welded to the thicker supporting structural members shall exceed 0.15 in [3.7 mm].*

1.5.5 Arc Seam Welds. An arc seam weld is made without preparing a slot in either member.

These welds are restricted to the welding of joints involving:

- (1) Sheet to sheet in the flat or horizontal position
- (2) Sheet to thicker supporting structural member in the flat position (see Table 1.3)

1.5.6 Arc Plug Welds. An arc plug weld is made by filling a circular hole in an outer member or members.

These welds may be used in all positions involving the following:

- (1) Multiple layers of sheet steels
- (2) Multiple layers of sheet steels and a thicker supporting structural member

1.6 Terms and Definitions

The welding terms used in this specification shall be interpreted in accordance with definitions given in the latest edition of AWS A3.0, *Standard Welding Terms and Definitions*, supplemented by Annex D of this specification.

1.7 Welding Symbols

The welding symbols used in this specification shall be those designated in the latest edition of AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*. Special conditions shall be fully explained by notes or details.

1.8 Safety Precautions

The safety precautions shall conform to the latest edition of ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, published by the American Welding Society.

NOTE: Work performed to this code may involve hazardous operations and materials, such as fumes and solid particles originating from welding consumables, the base metal, and coatings present on the base metal. The code does not purport to address all safety concerns associated with its use. It is the responsibility of the user to establish appropriate safety and health practices. The user should determine the applicability of any regulatory limitations prior to use.

See Annex F for additional information relating to the basic elements of safety general to arc welding processes.

1.9 Standard Units of Measurement

This standard makes use of both U.S. Customary Units and the International System of Units (SI). The latter are shown within brackets [] or in appropriate columns in table and figures. The measurements may not be exact equivalents; therefore, each system must be used independently. Equivalents for gages or fractions are noted within parenthesis throughout the standard.