

AWS D1.6/D1.6M:2017
An American National Standard



Structural Welding Code— Stainless Steel



AWS D1.6/D1.6M:2017
An American National Standard

Approved by the
American National Standards Institute
January 9, 2017

Structural Welding Code— Stainless Steel

3rd Edition

Supersedes AWS D1.6/D1.6M:2007

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 for welding stainless steel structural assemblies.



ISBN: 978-0-87171-906-5
© 2017 by American Welding Society
All rights reserved
Printed in the United States of America

Photocopy Rights. No portion of this standard may be reproduced, stored in a retrieval system, or transmitted in any form, including mechanical, photocopying, recording, or otherwise, without the prior written permission of the copyright owner.

Authorization to photocopy items for internal, personal, or educational classroom use only or the internal, personal, or educational classroom use only of specific clients is granted by the American Welding Society provided that the appropriate fee is paid to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, tel: (978) 750-8400; Internet: <www.copyright.com>.

Statement on the Use of American Welding Society Standards

All standards (codes, specifications, recommended practices, methods, classifications, and guides) of the American Welding Society (AWS) are voluntary consensus standards that have been developed in accordance with the rules of the American National Standards Institute (ANSI). When AWS American National Standards are either incorporated in, or made part of, documents that are included in federal or state laws and regulations, or the regulations of other governmental bodies, their provisions carry the full legal authority of the statute. In such cases, any changes in those AWS standards must be approved by the governmental body having statutory jurisdiction before they can become a part of those laws and regulations. In all cases, these standards carry the full legal authority of the contract or other document that invokes the AWS standards. Where this contractual relationship exists, changes in or deviations from requirements of an AWS standard must be by agreement between the contracting parties.

AWS American National Standards are developed through a consensus standards development process that brings together volunteers representing varied viewpoints and interests to achieve consensus. While AWS administers the process and establishes rules to promote fairness in the development of consensus, it does not independently test, evaluate, or verify the accuracy of any information or the soundness of any judgments contained in its standards.

AWS disclaims liability for any injury to persons or to property, or other damages of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance on this standard. AWS also makes no guarantee or warranty as to the accuracy or completeness of any information published herein.

In issuing and making this standard available, AWS is neither undertaking to render professional or other services for or on behalf of any person or entity, nor is AWS undertaking to perform any duty owed by any person or entity to someone else. Anyone using these documents should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances. It is assumed that the use of this standard and its provisions is entrusted to appropriately qualified and competent personnel.

This standard may be superseded by new editions. This standard may also be corrected through publication of amendments or errata, or supplemented by publication of addenda. Information on the latest editions of AWS standards including amendments, errata, and addenda is posted on the AWS web page (www.aws.org). Users should ensure that they have the latest edition, amendments, errata, and addenda.

Publication of this standard does not authorize infringement of any patent or trade name. Users of this standard accept any and all liabilities for infringement of any patent or trade name items. AWS disclaims liability for the infringement of any patent or product trade name resulting from the use of this standard.

AWS does not monitor, police, or enforce compliance with this standard, nor does it have the power to do so.

Official interpretations of any of the technical requirements of this standard may only be obtained by sending a request, in writing, to the appropriate technical committee. Such requests should be addressed to the American Welding Society, Attention: Managing Director, Standards Development, 8669 NW 36 St, # 130, Miami, FL 33166 (see Annex K). With regard to technical inquiries made concerning AWS standards, oral opinions on AWS standards may be rendered. These opinions are offered solely as a convenience to users of this standard, and they do not constitute professional advice. Such opinions represent only the personal opinions of the particular individuals giving them. These individuals do not speak on behalf of AWS, nor do these oral opinions constitute official or unofficial opinions or interpretations of AWS. In addition, oral opinions are informal and should not be used as a substitute for an official interpretation.

Foreword

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

This is the third edition of the AWS D1.6, *Structural Welding Code—Stainless Steel*; the first edition was published in 1999. This code is the product of a pool of experts arriving at a consensus position, in keeping with the American National Standard Institute's requirements.

This code covers the requirements for welding stainless steel components other than pressure vessels or pressure piping. For many years, fabrications involving structural stainless steel welding used AWS D1.1/D1.1M, *Structural Welding Code—Steel*, to provide the requirements for quality construction. However, as the AWS D1.1 document is written for the carbon and low-alloy steels commonly encountered in structural fabrication, it does not explicitly address the unique requirements of stainless steels. The AWS Structural Welding Committee thus recognized the industry need for an AWS D1.1 analogue designed for the welding of stainless steel wrought and cast shapes and plates.

Changes in Code Requirements. Underlined text in the clauses, subclauses, tables, figures, or forms indicates a change from the 2007 edition. A vertical line in the margin of a table or figure also indicates a change from the 2007 edition.

The following is a list of the most significant revisions in the 2017 edition:

Summary of Changes	
Clause/Table/Figure/Annex	Modification
Clause 1	Restructured to identify a summary of the code clauses, new safety and health information, and code limitations.
Clause 2	This is a new clause listing normative references. It replaces subclause 1.9 and Annex G from the previous edition.
Clause 3	This is a new clause that provides terms and definitions specific to this standard. It replaces subclause 1.3 and Annex G from the previous edition.
Clause 4	Clause 4 was presented as Clause 2 in the previous edition. Reorganized and updated to better parallel AWS D1.1/D1.1M, <i>Structural Welding Code—Steel</i> , where appropriate, and now also references AISC/SCI <i>Design Guide 27: Structural Stainless Steel</i> .
Clauses 5 and 7	Clause 5 was presented as Clause 3 in the previous edition. Clause 7 was presented as Clause 5 in the previous edition. Both clauses had many misplaced subclauses and requirements (some fabrication requirements were in the prequalification clause and vice versa); content has been placed in the appropriate clause. Flare-V and flare-bevel-groove welded prequalified joint details have been included to address a need for these and some interpretations, and to parallel AWS D1.1/D1.1M, <i>Structural Welding Code—Steel</i> . These clauses are now restructured to follow the standard D1 code format and provide a more logical flow.
Clause 6	Clause 6 was presented as Clause 4 in the previous edition. This clause has been rewritten and now allows qualification directly to AWS B2.1/B2.1M, <i>Specification for Welding Procedure and Performance Qualification</i> , without approval from the Engineer, all while retaining D1.6 code qualification requirements if the Contractor decides to utilize these.
Clause 8	Clause 8 was presented as Clause 6 in the previous edition. Revisions include placing all visual Inspector and NDE personnel qualification requirements together for ease of use. Visual inspection acceptance criteria were removed from the text and placed in a new Table 8.1, similar to AWS D1.1/D1.1M, <i>Structural Welding Code—Steel</i> . Several errata items were incorporated and new commentary words were inserted that were taken directly from D1.1.

(Continued)

Summary of Changes (Continued)

Clause/Table/Figure/Annex	Modification
	Annex E from the previous edition was deleted as most of its content was moved to Clause 8. Some content from Annexes H and O of the previous edition was moved into Clause 8.
Clause 9	Clause 9 was presented as Clause 7 in the previous edition. Revised to identify numerous improvements already addressed by AWS D1.1/D1.1M, <i>Structural Welding Code—Steel</i> and AASHTO/AWS D1.5M/D1.5, <i>Bridge Welding Code</i> . The manufacturers' stud base qualification testing in Annex D from the previous edition was moved into Clause 9, similar to D1.1.
Annexes A and B	Revised to parallel AWS D1.1/D1.1M, <i>Structural Welding Code—Steel</i> , and to correct terms of fillet weld size to align with the correct usage in AWS A3.0M/A3.0, <i>Standard Terms and Definitions</i> , and A2.4, <i>Standard Symbols for Welding, Brazing, and Nondestructive Examination</i> .
Annex E	This is a new annex listing informative references.

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, 8669 NW 36 St, #130, Doral, FL 33166.

Table of Contents

	Page No.
<i>Personnel</i>	v
<i>Foreword</i>	vii
<i>List of Tables</i>	xiii
<i>List of Figures</i>	xiv
1. General Requirements	1
1.1 Scope	1
1.2 Units of Measurement	1
1.3 Safety	2
1.4 Limitations	2
1.5 Responsibilities	3
1.6 Approval	4
1.7 Welding Symbols	4
2. Normative References	5
3. Terms and Definitions	7
4. Design of Welded Connections	9
Part A—General Requirements	9
<u>4.0</u> General	9
<u>4.1</u> Contract Plans and Specifications	9
<u>4.2</u> Eccentricity of Connections	10
<u>4.3</u> Allowable Stresses	11
Part B—Weld Lengths and Areas	11
<u>4.4</u> Effective Areas	11
<u>4.5</u> Plug and Slot Welds	13
Part C—Miscellaneous Structural Details	14
<u>4.6</u> General	14
<u>4.7</u> Filler Plates	14
<u>4.8</u> Lap Joints	14
<u>4.9</u> Transitions of Butt Joints in Nontubular Connections	14
<u>4.10</u> Transitions in Tubular Connections	15
<u>4.11</u> Joint Configurations and Details	15
<u>4.12</u> Built-Up Members in Statically Loaded Structures	15
<u>4.13</u> Noncontinuous Beams	16
<u>4.14</u> Specific Requirements for Cyclically Loaded Structures	16
<u>4.15</u> Combinations of Different Types of Welds	16
<u>4.16</u> Skewed T-Joints	16
5. Prequalification	23
<u>5.1</u> Scope	23
<u>5.2</u> Welding Processes	23
<u>5.3</u> Base Metal/Filler Metal Combinations	24
<u>5.4</u> Engineer's Approval for Auxiliary Attachments	24

5.5	<u>Preheat and Interpass Temperature Requirements</u>	24
5.6	<u>Limitations of Variables for PWPSs</u>	24
5.7	<u>General PWPS Requirements</u>	25
5.8	<u>Fillet Weld Requirements</u>	25
5.9	<u>Plug and Slot Weld Requirements</u>	25
5.10	<u>Partial Joint Penetration (PJP) Groove Weld Requirements</u>	25
5.11	<u>Complete Joint Penetration (CJP) Groove Weld Requirements</u>	26
5.12	<u>Flare-Bevel-and Flare-V-Groove Weld Requirements</u>	26
5.13	<u>Tubular Connection Requirements</u>	26
6.	Qualification	78
6.1	<u>Scope</u>	78
	<u>Part A—General Requirements</u>	78
6.2	<u>Common Requirements for Procedure and Performance Qualification</u>	78
	<u>Part B—Welding Procedure Qualification</u>	78
6.3	<u>Welding Procedure Qualification</u>	78
6.4	<u>Essential Variables</u>	79
6.5	<u>Base Metal Qualification</u>	79
6.6	<u>Qualification Thickness Limitations</u>	79
6.7	<u>Groove Weld Qualification</u>	80
6.8	<u>Fillet Weld Qualification</u>	80
6.9	<u>Mechanical Testing and Visual Examination</u>	80
6.10	<u>Alternate Fillet Weld WPS Qualification</u>	83
6.11	<u>Retests</u>	83
6.12	<u>Weld Cladding Requirements</u>	83
	<u>Part C—Performance Qualification</u>	84
6.13	<u>General</u>	84
6.14	<u>Limitation of Variables for Performance Qualifications</u>	85
6.15	<u>Types, Purposes, and Acceptance Criteria of Tests and Examinations for Performance Qualification</u>	85
6.16	<u>Welder and Welding Operator Cladding Requirements</u>	86
7.	Fabrication	126
7.1	<u>Scope</u>	126
7.2	<u>Base Metals</u>	126
7.3	<u>Welding Consumable and Electrode Requirements</u>	126
7.4	<u>Preparation of Base Metal (Including Mill-Induced Discontinuities, Cleaning, and Surface Preparation)</u>	128
7.5	<u>Base Metal Repairs by Welding</u>	129
7.6	<u>Mislocated Holes</u>	129
7.7	<u>Assembly</u>	129
7.8	<u>Tolerances of Joint Dimensions and Root Passes</u>	130
7.9	<u>Weld Backing</u>	131
7.10	<u>Preheat and Interpass Temperatures</u>	131
7.11	<u>Welding Environment</u>	131
7.12	<u>WPSs and Welders</u>	131
7.13	<u>Tack Welds and Temporary Welds</u>	131
7.14	<u>Distortion of Members</u>	132
7.15	<u>Sizes, Lengths, and Locations of Welds</u>	132
7.16	<u>Techniques for Plug and Slot Welds</u>	132
7.17	<u>Weld Terminations</u>	133
7.18	<u>Peening</u>	133
7.19	<u>Arc Strikes</u>	133
7.20	<u>Weld Cleaning</u>	133

7.21	Weld Metal Removal and Repair	134
7.22	Postweld Heat Treatment	134
8.	Inspection	138
8.1	Scope	138
	Part A—General Requirements	138
8.2	Inspection of Materials	139
8.3	Inspection of Welding Procedure Specifications (WPSs)	139
8.4	Inspection of Welder and Welding Operator Performance Qualifications	139
8.5	Inspection of Work and Records	140
	Part B—Contractor’s Responsibilities	140
8.6	Obligations of the Contractor	140
	Part C—Acceptance Criteria	141
8.7	Scope	141
8.8	Engineer’s Approval for Alternate Acceptance Criteria	141
8.9	Visual Inspection	141
8.10	Penetrant Testing (PT) and Magnetic Particle Testing (MT)	141
8.11	Nondestructive Testing (NDT)	141
8.12	Radiographic Testing (RT)	142
8.13	Ultrasonic Testing (UT)	143
	Part D—NDT Procedures	143
8.14	Procedures	143
8.15	Extent of Testing	143
	Part E—Radiographic Testing (RT)	144
8.16	RT of Welds	144
8.17	RT Procedures	144
8.18	Supplementary RT Requirements for Tubular Connections	146
8.19	Examination, Report, and Disposition of Radiographs	147
	Part F—Ultrasonic Testing (UT) of Groove Welds	147
8.20	General	147
8.21	Qualification Requirements	147
8.22	UT Equipment	148
8.23	Reference Standards	149
8.24	Equipment Qualification	149
8.25	Calibration Methods	149
8.26	Scanning Patterns and Methods	150
8.27	Weld Discontinuity Characterization Methods	151
8.28	Weld Discontinuity Sizing and Location Methods	151
8.29	Interpretation Problems With Discontinuities	152
8.30	Equipment Qualification Procedures	153
8.31	Weld Classes and Amplitude Level	155
8.32	Acceptance-Rejection Criteria	155
8.33	Preparation and Disposition of Reports	156
8.34	Testing Procedures	156
8.35	Examples of dB Accuracy Certification	158
	Part G—Other NDT Methods	158
8.36	General Requirements	158
8.37	Radiation Imaging Systems Including Real-Time Imaging	158
8.38	Advanced Ultrasonic Systems	159
8.39	Additional Requirements	159
9.	Stud Welding	207
9.1	Scope	207

9.2	General Requirements	207
9.3	Mechanical Requirements of Studs	208
9.4	Stud Welding Procedure Qualification	208
9.5	Stud Welding Operator Performance Qualification	209
9.6	Production Welding Control	210
9.7	Inspection and Testing	212
9.8	Manufacturers' Stud Base Qualification Requirements	212
Annex A	(Normative)—Effective Throat (S)	221
Annex B	(Normative)—Effective Throats of Fillet Welds in Skewed T-Joints	225
Annex D	(Informative)—Suggested Filler Metals for Various Combinations of Stainless Steels and Other Ferrous Base Metals	229
Annex E	(Informative)—Informative References	261
Annex F	(Informative)—Recommended Inspection Practices	263
Annex G	(Informative)—Nonprequalified Stainless Steels—Guidelines for WPS Qualification and Use	267
Annex H	(Informative)—Sample Welding Forms	273
Annex I	(Informative)—Macroetchants for Austenitic Stainless Steel Welds	279
Annex J	(Informative)—Ultrasonic Unit Certification	281
Annex K	(Informative)—Requesting an Official Interpretation on an AWS Standard	289
Commentary		291
Foreword		293
Index		309
List of AWS Documents on Structural Welding		317

Structural Welding Code—Stainless Steel

1. General Requirements

1.1 Scope

This code contains welding requirements for the fabrication, assembly, and erection of welded structures and weldments subject to design stress where at least one of the materials being joined is stainless steel. The code is intended to be used for base metals with a minimum thickness of 1/16 in [1.5 mm] or 16 gage. It shall be used in conjunction with any complementary code or specification for the design or construction of stainless steel structures and weldments. When this code is stipulated in contract documents, conformance with all provisions of the code shall be required, except for those provisions that the Engineer (see 1.5.1) or contract documents specifically modify or exempt.

The following is a summary of the code clauses:

(1) **General Requirements.** This clause contains basic information on the scope and limitations of the code, key definitions, and the major responsibilities of the parties involved with stainless steel fabrication.

(2) **Normative References.** This clause contains a list of reference documents that assist the user in implementation of this code or are required for implementation.

(3) **Terms and Definitions.** This clause contains terms and definitions as they relate to this code.

(4) **Design of Welded Connections.** This clause contains requirements for the design of welded connections.

(5) **Prequalification.** This clause contains the requirements for exempting a Welding Procedure Specification (WPS) from qualification by testing.

(6) **Qualification.** This clause contains the requirements for qualification of WPSs and welding personnel (welders and welding operators) by testing, including the tests required and the ranges qualified.

(7) **Fabrication.** This clause contains welding requirements for fabrication, assembly, and erection of welded stainless steel structures governed by this code, including the requirements for base metals, welding consumables, welding technique, weld details, material preparation and assembly, workmanship, weld repair, and other requirements.

(8) **Inspection.** This clause contains the requirements for the Inspector's qualifications and responsibilities, acceptance criteria for discontinuities, and procedures for nondestructive testing (NDT).

(9) **Stud Welding.** This clause contains the requirements for welding of studs to structures where at least one of the materials being joined is stainless steel.

1.2 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 tables and figures. The measurements may not be exact equivalents; therefore, each system must be used independently.