

AWS D1.3/D1.3M:2018
An American National Standard

Structural Welding Code— Sheet Steel



Documents

Document Sharing Hub

AWS D1.3/D1.3M:2018
An American National Standard

Approved by the
American National Standards Institute
July 12, 2017

Structural Welding Code— Sheet Steel

6th Edition

Supersedes AWS D1.3/D1.3M:2008

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 4 design, Clause 5 prequalification, Clause 6 qualification, Clause 7 fabrication, and Clause 8 inspection.



ISBN: 978-0-87171-918-8

© 2017 by American Welding Society

All rights reserved

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 the 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 are entrusted to appropriately qualified and competent personnel.

This standard may be superseded by the issuance of new editions. Users should ensure that they have the latest edition.

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.

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

On occasion, text, tables, or figures are printed incorrectly, constituting errata. Such errata, when discovered, are posted on the AWS web page (www.aws.org).

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 C). 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.

This standard is subject to revision at any time by the AWS D1 Committee on Structural Welding. It must be reviewed every five years, and if not revised, it must be either reaffirmed or withdrawn. Comments (recommendations, additions, or deletions) that may be of use in improving this standard should be sent to AWS Headquarters. Any pertinent data supporting the comments are required. Such comments will receive careful consideration by the AWS D1 Committee on Structural Welding 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 D1 Committee on Structural Welding 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.

This page is intentionally blank.

Dedication

This 6th edition of **AWS D1.3/D1.3M**, *Structural Welding Code—Sheet Steel*, is dedicated by the D1H Subcommittee on Sheet Steel to John L. Uebele. The Subcommittee is gratefully indebted to John's 24 plus years of service on the subcommittee and his tireless efforts, devotion, and enthusiasm in making the last 3 revisions of D1.3/D1.3M possible. John's intelligence, mentorship, and warm good humor will be missed by all of us.

This page is intentionally blank.

Personnel

AWS D1 Committee on Structural Welding

A. W. Sindel, Chair	<i>TRC Solutions</i>
T. L. Niemann, Vice Chair	<i>Minnesota Department of Transportation</i>
R. D. Medlock, 2 nd Vice Chair	<i>High Steel Structures, LLC</i>
J. A. Molin (Secretary)	<i>American Welding Society</i>
F. G. Armao	<i>The Lincoln Electric Company</i>
U. W. Aschemeier	<i>Subsea Global Solutions</i>
G. L. Bickford	<i>Acute Technological Services</i>
T. M. Burns	<i>Thom Burns Consulting, LLC</i>
H. H. Campbell, III	<i>Pazuzu Engineering</i>
R. D. Campbell	<i>Bechtel</i>
R. B. Corbit	<i>CB&I</i>
M. A. Greico	<i>Massachusetts Department of Transportation</i>
J. J. Kenney	<i>Shell International E&P</i>
J. H. Kiefer	<i>Conoco Philips (Retired)</i>
S. W. Kopp	<i>High Steel Structures, LLC</i>
V. Kuruvilla	<i>Genesis Quality Systems</i>
J. Lawmon	<i>American Engineering and Manufacturing Incorporated</i>
N. S. Lindell	<i>Vigor</i>
D. R. Luciani	<i>Canadian Welding Bureau</i>
P. W. Marshall	<i>Moonshine Hill Proprietary</i>
M. J. Mayes	<i>Terracon Consultants</i>
D. L. McQuaid	<i>D. L. McQuaid & Associates Incorporated</i>
J. Merrill	<i>TRC Solutions</i>
D. K. Miller	<i>The Lincoln Electric Company</i>
J. B. Pearson, Jr.	<i>LTK Engineering Services</i>
D. D. Rager	<i>Rager Consulting, Incorporated</i>
T. J. Schlafly	<i>AISC</i>
R. E. Shaw, Jr.	<i>Steel Structures Technology Center Incorporated</i>
R. W. Stieve	<i>Parsons Corporation</i>
M. M. Tayarani	<i>Pennoni Associates, Incorporated</i>
P. Torchio, III	<i>Williams Enterprises of GA, Incorporated (Retired)</i>
D. G. Yantz	<i>Canadian Welding Bureau</i>

Advisors to the AWS D1 Committee on Structural Welding

W. G. Alexander	<i>WGAPE</i>
N. J. Altebrando	<i>STV, Incorporated</i>
E. M. Beck	<i>AMEC</i>
B. M. Butler	<i>Walt Disney World Company</i>
G. L. Fox	<i>Consultant</i>
H. E. Gilmer	<i>HRV Conformance Verification Association Incorporated</i>
G. J. Hill	<i>G. J. Hill & Associates</i>
M. L. Hoitomt	<i>Consultant</i>
C. W. Holmes	<i>Modjeski & Masters, Incorporated (Retired)</i>
G. S. Martin	<i>GE-Power & Water</i>

D. C. Phillips	<i>Retired</i>
J. W. Post	<i>JW Post & Associates, Incorporated</i>
K. K. Verma	<i>Consultant</i>
B. D. Wright	<i>Advantage Aviation Technologies</i>

AWS D1H Subcommittee on Sheet Steel

U. W. Aschemeier, Chair	<i>Subsea Global Solutions</i>
G. S. Martin, Vice Chair	<i>GE-Power Water</i>
J. A. Molin (Secretary)	<i>American Welding Society</i>
W. J. Bell	<i>Atlantic Testing Laboratories</i>
L. M. Bower	<i>NCI Building Systems</i>
R. D. Campbell	<i>Bechtel</i>
R. B. Corbit	<i>CB&I</i>
D. A. Fulton	<i>Consultant</i>
S. G. Kowats	<i>International Training Institute</i>
J. D. Niemann	<i>Kawasaki Motors Manufacturing Corp USA</i>
J. B. Pearson, Jr.	<i>LTK Engineering Services</i>
P. Rimmer	<i>Greenman and Pedersen, Incorporated</i>
T. Sputo	<i>Steel Deck Institute</i>
P. Torchio, III	<i>Williams Enterprises of GA, Incorporated (Retired)</i>
D. G. Yantz	<i>Canadian Welding Bureau</i>
C. Zanfiri	<i>CWB Group</i>

Advisors to the AWS D1H Subcommittee on Sheet Steel

O.W. Blodgett*	<i>The Lincoln Electric Company (Retired)</i>
J. D. Duncan	<i>Consultant</i>
M. D. Fender	<i>The McIntyre Company</i>
J. A. Grewe	<i>Omaha Public Power District</i>
A. L. Johnson	<i>Johnson Inspection</i>
D. R. Lawrence, II	<i>Consultant</i>
D. R. Luciani	<i>Canadian Welding Bureau</i>
T. Pekoz	<i>Cornell University</i>
D. D. Rager	<i>Rager Consulting, Incorporated</i>
B. D. Wright	<i>Advantage Aviation Technologies</i>

*deceased

Foreword

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

When the first edition of [AWS D1.3/D1.3M](#), *Specification for Welding Sheet Steel in Structures*, was developed and issued in 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, 2008, and now in 2017. Also, in the 1981 edition, the title of the standard was changed to [AWS D1.3/D1.3M](#), *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.

When 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. A Welder qualification test requires each welder to prove their ability to produce satisfactory welds using 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 4 could be disregarded when the welds are not used in a loadcarrying capacity.

Underlined text in the subclauses indicates an editorial or technical change from the 2008 edition. A vertical line in the margin next to a figure or table indicates a revision from the 2008 edition.

The following is a summary of the most significant technical revisions contained in D1.3/D1.3M:2018:

Summary of Changes

Clause/Table/Figure/Annex	Modification
Clause 1	Restructured the Clause, added new safety and health information, the addition of Hollow Structural Section (HSS) with wall thickness less than 1/8 in [3 mm] to the Code and the ability to use non low-hydrogen electrodes in a qualified WPS for arc spot, arc seam, and arc plug welds of sheet metal in the flat position to primary structural members thicker than ¼ in [6 mm]. Revised Tables 1.2 and 1.3 and added a new Figure.
Clause 2	This is a new clause listing normative references. It replaces 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 1.6 and Annex D from the previous edition.
Clause 4	Clause 4 was presented as Clause 2 in the previous edition. Provided clarification as to how to determine the load capacities in Clause 4.2. Revised Figures 4.2, 4.7, and 4.8. Added a new Figure for HSS Square Groove Weld in Butt Joint.
Clause 5	Clause 5 was presented as Clause 3 in the previous edition. Revised all the Figures in Clause 5 to indicate t = thickness.
Clause 6	Clause 6 was presented as Clause 4 in the previous edition. Added a scope to Clause 6, provided additional language to Clause 6.7.1.2 for clarification, provided conditions when weld assemblies shall be acceptable after testing, and added a provision for welder qualification regarding One and Two Sided Butt Joints. Revised Tables 6.1–6.4 and added new Figures 6.7–6.8.
Clause 7	Clause 7 was presented as Clause 5 in the previous edition. Substrate cleanliness requirements were significantly revised.
Clause 8	Clause 8 was presented as Clause 6 in the previous edition. Provided an additional requirement to Visual Inspection: Minimum Weld Throat and added language that permits welds exceeding the minimum length or size provided it is documented in the contract documents.
Annex B	The Annex B Forms were revised.

Errata: All errata to a standard shall be published in the *Welding Journal* and posted on the AWS website.

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, Miami, FL 33166.

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 Requirements	1
1.1 Scope	1
1.2 Standards of Measurement	1
1.3 Safety	1
1.4 Sheet Steel Base Metal	2
1.5 Welding Processes	2
1.6 Weld Metal Requirements	2
1.7 Weld Types	3
1.8 Welding Symbols	4
2. Normative References	11
3. Terms and Definitions	13
4. Design of Welded Connections	16
Part A—Allowable Load Capacities	16
4.1 Base Metal Stresses	16
4.2 Alternate Allowable Load Capacities in Weld Joints	16
Part B—Details of Welded Connections	19
5. Prequalification of WPSs	28
5.1 Scope	28
5.2 General	28
5.3 Joint Details	28
6. Qualification	34
6.1 Scope	34
Part A—General Requirements	34
6.2 Preparation of a WPS and PQR	34
6.3 Engineer's Approval	34
6.4 Responsibility	34
6.5 WPS Requirements	34
Part B—Welding Procedure Specification (WPS)	35
6.6 Essential Variable Limitations	35
6.7 Number of Tests, Testing Methods, and Acceptance Standards for WPS Qualification	35
Part C—Welder Performance Qualification	39
6.8 Essential Variables	39
6.9 Number of Tests and Methods for Welder Performance Qualification	40
6.10 Duration of Qualification	40

	Page No.
7. Fabrication	58
7.1 General	58
7.2 Preparation of Base Metal	58
7.3 Assembly	58
7.4 Allowable Deviation from WPS for Lower Temperatures Using Annex A, Note 1.	59
8. Inspection	60
Part A Acceptance Criteria	60
8.1 Production Weld Acceptance Criteria	60
Part B Contractor's Responsibility	60
8.2 Inspection of WPS and Welder Qualifications	60
8.3 Inspection of Work	60
<i>Annexes</i>	61
Annex A (Normative)—Applicable Provision Requirements when Welding D1.3 Sheet Steels to	
D1.1 Other Steel Product Forms	61
Annex B (Informative)—Sample Welding Forms	63
Annex C (Informative)—Requesting an Official Interpretation on an AWS Standard	67
Annex D (Informative)—Gage Numbers and Equivalent Thicknesses	69
Annex E (Informative)—Reference Documents	71
<i>Commentary on Structural Welding Code—Sheet Steel</i>	73
List of AWS Documents on Sheet Steel	89

List of Tables

Table	Page No.
1.1	Code Application Matrix of D1.3 and D1.1 Codes Based on Material Thickness Being Joined
1.2	Matching Filler Metal Requirements
1.3	Welding Positions and Restrictions for WPS
<u>5.1</u>	Prequalified WPS Requirements
<u>6.1</u>	WPS Qualification Tests
<u>6.2</u>	PQR Essential Variable Changes Requiring WPS Requalification for SMAW, GMAW, FCAW, GTAW, and SAW
<u>6.3</u>	Electrode Classification Groups
<u>6.4</u>	Welder Performance Qualification Tests
A.1	Applicable Provision Requirements when Welding D1.3 Sheet Steels to D1.1 Other Steel Product Forms
D.1	Gage Numbers and Equivalent Thicknesses Hot-Rolled and Cold-Rolled Sheet
D.2	Gage Numbers and Equivalent Thicknesses Galvanized Sheet

List of Figures

Figure	Page No.
<u>1.1</u>	Positions of Test for HSS Groove Welding
<u>4.1</u>	Square-Groove Welds in Butt Joints
<u>4.2</u>	Fillet Welds
<u>4.3A</u>	Single-Flare-Bevel-Groove Weld
<u>4.3B</u>	Single-Shear in Flare-Groove Welds
<u>4.3C</u>	Double-Shear in Flare-Groove Welds
<u>4.4</u>	Arc Spot Welds
<u>4.5</u>	Arc Seam Welds
<u>4.6</u>	Arc Plug Welds
<u>4.7</u>	Fillet Welds in Lap Joints
<u>4.8</u>	Fillet Welds in T-Joints
<u>4.9</u>	Single-Flare-Bevel-Groove Weld
<u>4.10</u>	Single-Flare-V-Groove Weld
<u>4.11A</u>	Edge Distances for Arc Spot Welds
<u>4.11B</u>	Arc Spot Weld Using Washer
<u>4.11C</u>	Typical Weld Washer
<u>4.12</u>	Arc Seam Welds Along Standing Rib
<u>4.13A</u>	Edge Distances for Arc Seam Welds
<u>4.13B</u>	Edge Distances for Arc Plug Welds
<u>4.14</u>	HSS Square Groove Weld in Butt Joint
<u>5.1A</u>	Square Groove Weld in Butt Joint with Steel Backing
<u>5.1B</u>	Square Groove Weld in Butt or Corner Joint without Backing
<u>5.2A</u>	Fillet Weld in Corner Joint
<u>5.2B</u>	Fillet Weld in Lap Joint

<u>5.2C</u>	Fillet Weld in T-Joint	31
<u>5.3A</u>	Flare-Bevel-Groove Weld in Butt Joint	32
<u>5.3B</u>	Flare-Bevel-Groove Weld in Corner Joint	32
<u>5.3C</u>	Flare-V-Groove Weld in Butt Joint	33
<u>5.3D</u>	Flare-Bevel-Groove Weld in Lap Joint	33
<u>6.1</u>	Test for Square-Groove Welds in Butt Joints.	49
<u>6.2A</u>	Test for Fillet Welds	50
<u>6.2B</u>	Extent of Validity of Fillet Weld Qualifications.	51
<u>6.3A</u>	Test for Sheet to Sheet Flare-Bevel-Groove Welds	51
<u>6.3B</u>	Test for Sheet to Supporting Structural Member Flare-Bevel-Groove Welds	52
<u>6.3C</u>	Test for Flare-V-Groove Welds	52
<u>6.3D</u>	Extent of Validity of Flare-Groove Weld Qualifications	53
<u>6.4</u>	Test for Arc Spot Welds	53
<u>6.5A</u>	Test for Sheet to Supporting Structural Member Arc Seam Welds	54
<u>6.5B</u>	Test for Sheet to Sheet Arc Seam Welds	54
<u>6.6</u>	Test for Arc Plug Welds	55
<u>6.7</u>	<u>Bend Test Coupon Location for HSS Weld Tests.</u>	57
<u>6.8</u>	<u>HSS Butt Weld Bend Test</u>	57
<u>C-4.1</u>	Allowable Stress for Fillet Welds.	79
<u>C-4.2</u>	Load Capacity of Fillet Welds	79
<u>C-4.3</u>	Arc Spot Welds.	80
<u>C-4.4</u>	Arc Seam Weld in a Supporting Plate	80
<u>C-6.1</u>	Melting Rate Measurement Illustrated.	82
<u>C-7.1</u>	Positions of Welding	85

List of Forms

Form		Page No.
B-1	Sample Form for Welding Procedure Qualification Record (PQR).	64
B-2	Sample Form for Welding Procedure Specification (WPS).	65
B-3	Sample Form for Welder and Welding Operator Performance Qualification Test Record (WPQR).	66

Structural Welding Code—Sheet Steel

1. General Requirements

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 [5 mm] in nominal thickness. In addition, welding hollow structural section (HSS) also called tubular members with wall thickness less than 1/8 in [3 mm] are included in the scope of this code. Design requirements for HSS member connections are not in the scope of this code. 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/D1.1M](#), conformance with the applicable provisions of Annex A of [AWS D1.3/D1.3M](#) 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 Requirements. The fundamental premise of the code is to provide general requirements 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 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 tables 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.

1.3 Safety

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.

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.

1.4 Sheet Steel Base Metal

1.4.1 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 1.4.2. 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/D1.1M](#), *Structural Welding Code—Steel*.

1.4.2 Other Base Metals. When a steel other than those covered in 1.4.1 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 6 and such other requirements as prescribed by the Engineer.

1.4.3 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].

1.5 Welding Processes

1.5.1 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.)*

1.5.2 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/D1.1M](#) code.

1.5.3 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.

1.6 Weld Metal Requirements

1.6.1 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. 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.

1.6.2 Other Base Metal/Filler Metal Combinations. Base metal/filler metal combinations other than those described in 1.6.1 shall be permitted when approved by the Engineer.

1.6.3 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.

1.6.4 Electrodes for Shielded Metal Arc Welding (SMAW)

1.6.4.1 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*.

1.6.4.2 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 mm], placing the jurisdiction of this control as specified in [AWS D1.1/D1.1M](#).

1.6.4.3 Nonlow-hydrogen Electrodes. Nonlow-hydrogen electrodes may be used in a qualified WPS for arc spot, arc seam, and arc plug welds of sheet metal in the flat position to primary structural members thicker than 1/4 in [6 mm], as limited by Annex A Table A.1 Note 1.

1.6.5 Submerged Arc Welding (SAW)

1.6.5.1 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*.

1.6.5.2 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.

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

1.6.6.1 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*, [AWS A5.29/A5.29M](#), *Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*, or [AWS A5.36/A5.36M](#), *Specification for Carbon and Low-Alloy Steel Flux Cored Electrodes for Flux Cored Arc Welding and Metal Cored Electrodes for Metal Arc Welding* as applicable.

1.6.6.2 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](#).

1.7 Weld Types

1.7.1 Square-Groove Welds in Butt Joints. These types of welds are restricted to the welding of sheet steel to sheet steel in all positions of welding.

1.7.2 Fillet Welds. These types of welds may be used in all positions of welding involving sheet steel to sheet steel or a sheet steel to a supporting structural member.

1.7.2.1 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.

1.7.3 Flare-Groove Welds. These types of welds 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)

1.7.4 Arc Spot Welds. These types of welds are spot welds made by an arc welding process in which the welds are 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].*

1.7.5 Arc Seam Welds. Arc seam welds are 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)

1.7.6 Arc Plug Welds. Arc plug welds are 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

1.8 Welding Symbols

The welding symbols used in this specification shall be those designated in [AWS A2.4:2007](#), *Standard Symbols for Welding, Brazing, and Nondestructive Examination*. Special conditions shall be fully explained by notes or details.

Table 1.1
Code Application Matrix of D1.3 and D1.1 Codes Based on Material Thickness
Being Joined (see 1.1)

Material Thickness	$t_2 < 1/8$ in [3 mm]	$1/8$ in $\leq t_2 \leq 3/16$ in [3 mm $\leq t_2 \leq 5$ mm]	$t_2 > 3/16$ in [5 mm]
$t_1 < 1/8$ in [3 mm]	D1.3	D1.3 or Annex A	Annex A
$1/8$ in $\leq t_1 \leq 3/16$ in [3 mm $\leq t_1 \leq 5$ mm]	D1.3 or Annex A	D1.3 or Annex A or D1.1	Annex A or D1.1
$t_1 > 3/16$ in [5 mm]	Annex A	Annex A or D1.1	D1.1

Note: Annex A, Note 1 applications may be used without removal of coating or galvanizing, provided the application meets the requirements of Note 1.

Table 1.2
Matching Filler Metal Requirements (see 1.6.1)

Group No.	ASTM Steel Specifications	Yield Strength ^{a,b}		Tensile Strength ^{a,b}		AWS Filler Metal Specifications ^c	
		ksi	MPa	ksi	MPa		
I	ASTM A53/A53M	Gr A	30	205	48	330	SMAW AWS A5.1/A5.1M
		Gr B	35	240	60	415	E60XX, E70XX
	ASTM A109/A109M	Temper 4	—	—	48 ^d	330 ^d	SMAW AWS A5.5/A5.5M^e
		Temper 5	—	—	44 ^d	300 ^d	E70XX-XX
	ASTM A500 (Round structural tubing)	Gr A	33	230	45	310	SAW AWS A5.17/A5.17M
		Gr B	42	290	58	400	F6AX-EXXX, F7AX-EXXX
		Gr C	46	315	62	425	F6AX-ECXXX, F7AX-ECXXX
		Gr D	36	250	58	400	SAW AWS A5.23/A5.23M^e
	ASTM A500 (Shaped structural tubing)	Gr A	39	270	45	310	F7AX-EXXX-XX, F7AX-ECXX-XX
		Gr B	46	315	58	400	GMAW/GTAW AWS A5.18/A5.18M
		Gr C	50	345	62	425	ER70S-X, E70C-XC, E70C-XM
		Gr D	36	250	58	400	GMAW AWS A5.36/A5.36M
	ASTM A501/A501M	Gr A	36	250	58	400	Carbon Steel Fixed Classifications ^f
	ASTM A572/A572M	Gr 42	42	290	60	415	E70C-6M
	ASTM 606	Gr 45	45	310	65	450	Open Classifications ^g
		Gr 50 (as rolled)	50	340	70	480	E7XT15-C1A2-CS1
		Gr 50 (annealed/normalized)	45	310	65	450	E7XT15-M21-CS1,
	ASTM A653/A653M SS ^g	Gr 33	33	230	45	310	E7XTX-XAX-CS1, E7XTX-XAX-CS2
		Gr 37	37	255	52	360	GMAW/GTAW AWS A5.28/5.28M^e
		Gr 40	40	275	55	380	ER70S-XXX, E70C-XXX
	ASTM A653/A653M HSLAS	Gr 40	40	275	50	340	GMAW AWS A5.36/A5.36M^{e,g}
	ASTM A792/A792M ^h SS	Gr 33	33	230	45	310	Low Alloy Steel Open Classifications
		Gr 37	37	255	52	360	E7XTX-XAX-X
		Gr 40	40	275	55	380	FCAW AWS A5.20/A5.20M
	ASTM A1003/A1003M	Gr 33[230] Type H	33	230	45	310	E7XT-X, E7XT-XC, E7XT-XM
		Gr 37[255] Type H	37	255	52	360	FCAW AWS A5.36/A5.36M^e
		Gr 40[275] Type H	40	275	55	380	Carbon Steel Fixed Classifications ^f
	ASTM A1008/A1008M SS	Gr 25	25	170	42	290	E7XT-1C, E7XT-1M, E7XT-5C,
		Gr 30	30	205	45	310	E7XT-5M, E7XT-6, E7XT-8,
		Gr 33 Type 1 and 2	33	230	48	330	E7XT-9C, E7XT-9M, E7XT-12C,
Gr 40 Type 1 and 2		40	275	52	360	E7XT-12M, E70T-4, E7XT-7	
Gr 45		45	310	60	410	Open Classifications ^g	
ASTM A1008/A1008M HSLAS	Gr 45 Class 1	45	310	60	410	E7XTX-C1AX-CS1,	
	Gr 45 Class 2	45	310	55	380	E7XTX-M21-CS1 ^f ,	
	Gr 50 Class 2	50	340	60	410	E7XTX-CS1AX-CS2,	
ASTM A1008/A1008M HSLAS-F	Gr 50	50	340	60	410	E7XTX-M21- CS2 ^f ,	
ASTM A1011/A1011M ⁱ SS	Gr 30	30	205	49	340	E7XTX-AX-CS3	
	Gr 33	33	230	52	360	FCAW AWS A5.29/A5.29M^e	
	Gr 36 Type 1	36	250	53	365	E6XTX-X, E6XTX-XC, E7XTX-X,	
	Gr 36 Type 2	36	250	58–80	400–550	E7XTX-XC, E6XTX-XM, E7XTX-XM	
	Gr 40	40	275	55	380	FCAW AWS A5.36/A5.36M^{e,g}	
	Gr 45 Type 1	45	310	60	410	Low Alloy Steel Open Classifications	
	Gr 45 Type 2	45–60	310–410	60	410	E6XTX- C1AX-X,	
ASTM A1011/A1011M HSLAS	Gr 45 Class 1	45	310	60	410	E6XTX- M21-X ^f	
	Gr 45 Class 2	45	310	55	380	E7XTX- C1AX-X,	
	Gr 50 Class 2	50	340	60	410	E7XTX- M21X	
ASTM A1011/A1011M HSLAS-F	Gr 50	50	340	60	410	E6XTX-XAX-X, E7XTX-XAX-X,	
						E6XTX-AX-X, E7XTX-AX-X	

(Continued)

Table 1.2 (Continued)
Matching Filler Metal Requirements (see 1.6.1)

Group No.	ASTM Steel Specifications	Yield Strength ^{a,b}		Tensile Strength ^{a,b}		AWS Filler Metal Specifications ^c	
		ksi	MPa	ksi	MPa		
II	ASTM A109/A109M	Temper 3	—	—	55 ^d	380 ^d	SAW AWS A5.1/A5.1M
	ASTM A501/A501M	Gr B	50	345	70	480	E70XX
	ASTM A529/A529M	Gr 50	50	345	65–100	450–690	SAW AWS A5.5/A5.5M^e
		Gr 55	55	380	70–100	485–690	E70XX
	ASTM A572/A572M	Gr 50	50	345	65	450	SAW AWS A5.17/A5.17M
		Gr 55	55	380	70	485	F7AX-EXXX, F7AX-ECXX
	ASTM A606		45–50	310–340	65–70	450–480	SAW AWS A5.23/A5.23M^e
	ASTM A653 SS	Gr 50 Class 1	50	340	65	450	F7AX-EXXX-XX, F7AX-ECXXX-XX
		Gr 50 Class 2	50	340	—	—	GMAW/GTAW AWS A5.18/A5.18M
		Gr 50 Class 3	50	340	70	480	ER70S-X, E70C-XC, E70C-XM
		Gr 50 Class 4	50	340	60	410	GMAW/GTAW AWS A5.28/A5.28M^e
		Gr 55	55	380	70	480	ER70S-XXX, E70C-XXX
		Gr 60	60	410	70	480	GMAW AWS A5.36/A5.36M^{e,g}
		Gr 50	50	340	60	410	Low Alloy Steel Open Classifications
	ASTM A653/A653M^h HSLAS	Gr 55 Class 1	55	380	70	480	E7XTX-XAX-X
		Gr 55 Class 2	55	380	65	450	FCAW AWS A5.20/A5.20M
		Gr 60	60	410	70	480	E7XT-X, E7XT-XC, E7XT-XM
	ASTM A653/A653M^h HSLAS-F	Gr 55 Class 1	55	380	70	480	FCAW AWS A5.36/A5.36M
		Gr 55 Class 2	55	380	65	450	Carbon Steel Fixed Classifications ^f
		Gr 60	60	410	70	480	E7XT-1C, E7XT-1M,
	ATM A792	Gr 50 Class 1	50	340	65	450	E7XT-5C, E7XT-5M,
		Gr 50 Class 2	50	340	—	—	E7XT-6, E7XT-8,
		Gr 50 Class 4	50	340	60	410	E7XT-9C, E7XT-9M,
		Gr 60	60	410	70	480	E7XT-12C, EX7T-12M,
	ASTM A1003/A1003M	Gr 50 Type H	50	340	65 ^j	450	E70T-4, E7XT-7
		Gr 55 Type H	55	380	70 ^j	480	Open Classifications ^g
		Gr 57 Type H	57	395	70 ^j	480	E7XTX-C1AX-CS1,
		Gr 60 Type H	60	410	70 ^j	480	E7XTX-M21-CS1 ^f ,
	ASTMA1008/A1008M SS	Gr 50	50	340	65	450	E7XTX-C1AX-CS2,
	ASTM A1008/A1008M HSLAS	Gr 50 Class 1	50	340	65	450	E7XTX-XAX-CS1,
		Gr 55 Class 1	55	380	70	480	E7XTX-XAX-CS2,
		Gr 55 Class 2	55	380	65	450	E7XTX-AX-CS3
		Gr 60 Class 2	60	410	70	480	FCAW AWS A5.29/A5.29M^e
	ASTM A1008/A1008M HSLAS-F	Gr 60	60	410	70	480	E7XTX-X, E7XTX-XC,
	ASTM A1011/A1011M SS	Gr 50	50	340	65	450	E7XTX-XM
		Gr 55	55	380	70	480	FCAW AWS A5.36/A5.36M^{e,g}
	ASTM A1011/A1011M HSLAS	Gr 50 Class 1	50	340	65	450	Low Alloy Steel Open Classifications
		Gr 55 Class 1	55	380	70	480	E7XTX-C1AX-X,
		Gr 55 Class 2	55	380	65	450	E7XTX-M21X ^f ,
		Gr 60 Class 2	60	410	70	480	E7XTX-XAX-X
	ASTM A1011/A1011M HSLAS-F	Gr 60	60	410	70	480	E7XTX-AX-X
	ASTM A1039/A1039M SS	Gr 50	50	340	65	450	
		Gr 55	55	380	70	480	
		Gr 50 Class 1	50	340	65	450	
		Gr 50 Class 2	50	340	60	410	
	ASTM A1039/A1039M HSLAS	Gr 55 Class 1	55	380	70	480	
		Gr 55 Class 2	55	380	65	450	
		Gr 60 Class 2	60	410	70	480	
	ASTM A1063/A1063M SS	Gr 50	50	340	65	450	
		Gr 55	55	380	70	480	
	ASTM A1063/A1063M HSLAS	Gr 50 Class 1	50	340	65	450	
		Gr 50 Class 2	50	340	60	410	
		Gr 55 Class 1	55	380	70	480	
		Gr 55 Class 2	55	380	65	450	

(Continued)

Table 1.2 (Continued)
Matching Filler Metal Requirements (see 1.6.1)

Group No.	ASTM Steel Specifications		Yield Strength ^{a,b}		Tensile Strength ^{a,b}		AWS Filler Metal Specifications ^c
			ksi	MPa	ksi	MPa	
III	ASTM A572/A572M	Gr 60	60	415	75	520	SMAW AWS A5.5/A5.5M^e E80XX-X
		Gr 65	65	450	80	550	
	ASTM A653/A653M SS	Gr 70	70	480	80	550	SAW AWS A5.23/A5.23M^e F8AX-EXXX-XX, F8AX-ECXXX-XX
	ASTM A653/A653M HSLAS	Gr 70	70	480	80	550	GMAW/GTAW AWS A5.28/A5.28M^e ER80S-XXX, E80C-XXX
	ASTM A653/A653M HSLAS-F	Gr 70	70	480	80	550	
	ASTM A1003/A1003M	Gr 70 Type H	70	480	80 ^j	550	GMAW AWS A5.36/A5.36M^{e,g} Low Alloy Steel Open Classifications
	ASTM A1008 SS	Gr 60	60	410	75	520	E8XTX-XAX-X
		Gr 60 Class 1	60	410	75	520	
	ASTM A1008/A1008M HSLAS	Gr 65 Class 1	65	450	80	585	FCAW AWS A5.29/A5.29M^e E8XTX-X, E8XTX-XC, E8XTX-XM
		Gr 65 Class 2	65	450	75	550	FCAW AWS A5.36/A5.36M^{e,g} Low Alloy Steel Open Classifications
		Gr 70 Class 2	70	480	80	550	E8XTX-C1AX-X, E8XTX-M21X ^f , E8XTX-XAX-X, E8XTX-AX-X
	ASTM A1008/A1008M HSLAS-F	Gr 70	70	480	80	550	
		Gr 70	70	480	80	550	
	ASTM A1011/A1011M SS	Gr 60	60	410	75	520	
		Gr 60 Class 1	60	410	75	520	
	ASTM A1011/A1011M HSLAS	Gr 65 Class 1	65	450	80	550	
		Gr 65 Class 2	65	450	75	520	
		70 Class 2	70	480	80	550	
	ASTM A1011/A1011M HSLAS-F	Gr 70	70	480	80	550	
IV	ASTM A653 SS	Gr 80	80	550	82	570	SAW AWS A5.23/A5.23M^e F9AX-EXXX-XX
	ASTM A653/A653M HSLAS	Gr 80	80	550	90	620	F9AX-ECXXX-XX
	ASTM A792/A792M (Al-Zn coated) ^h	Gr 80	80	550	82	570	GMAW/GTAW AWS A5.28/A5.28M^e ER90S-X, E90C-XXX
	ASTM A1008/A1008M SS	Gr 70	70	480	85	585	GMAW AWS A5.36/A5.36M^{e,g} Low Alloy Steel Open Classifications
		Gr 80	80	550	82	565	E9XTX-XAX-X
	ASTM A1008/A1008M HSLAS	Gr 70 Class 1	70	480	85	585	
	ASTM A1008/A1008M HSLAS-F	Gr 80	80	550	90	620	FCAW AWS A5.29/A5.29M^e E9XTX-X, E9XTX-XC, E9XTX-XM
		Gr 80	80	550	90	620	FCAW AWS A5.36/A5.36M^{e,g} Low Alloy Steel Open Classifications
	ASTM A1011/A1011M SS	Gr 70	70	480	85	585	E9XTX-C1AX-X
	ASTM A1011/A1011M HSLAS	Gr 70 Class 1	70	480	85	585	E9XTX-M21-X ^f E9XTX-XAX-X, E9XTX-AX-X

^a Yield and tensile properties are those specified in the material standard.

^b Properties are minimum specified values unless noted otherwise.

^c See AWS D1.1/D1.1M for mandatory use of low-hydrogen electrodes and section 1.6.4.3 for nonlow-hydrogen electrodes for arc spot, seam and plug welds on metal decking.

^d Approximate values; mechanical properties are not listed in the ASTM Specification. Design values shall be determined by the Engineer.

^e Only the as-welded condition is applicable, therefore only the following filler metals specification electrode classifications meet the criteria for this table:

^f SMAW: AWS A5.1/A5.1M; AWS A5.5/A5.5M Electrodes with the following suffixes: -C3, -C3L, -C4, -P1, -NM1, -W1, -W2, -G, -M (when Purchaser and Supplier agree the alloy is to be used in the "as-welded" condition).

^g Only SAW AWS A5.17/A5.17M; AWS A5.23/A5.23M Flux/Electrode combinations classified to be used in the "as-welded" condition.

^h GMAW: AWS A5.18/A5.18M; AWS A5.28/A5.28M Electrodes with the following classification suffixes: -Ni1, -D2, -G (when Purchaser and Supplier agree the alloy is to be used in the "as-welded" condition).

ⁱ FCAW: AWS A5.20/A5.20M; AWS A5.29/A5.29M Electrodes with the following classification suffixes: -Ni1 (except EXXT5-Ni1), -Ni1M (except EXXT5-Ni1M), -Ni1C (except EXXT5-Ni1C), -Ni2 (except EXXT5-Ni2), -Ni2M (except EXXT5-Ni2M), -Ni2C (except EXXT5-Ni2C), -Ni3 (except EXXT5-Ni3), -D1C, -D1M, -D3C, -D3M, -K1C, -K1M, -K2, -K2C, -K2M, -K6, -K6C, -K6M, -K8, -W2C, -W2M, -G (when Purchaser and Supplier agree the alloy is to be used in the "as-welded" condition).

^j FCAW: Any AWS A5.36/A5.36M FCAW or GMAW-Metal Core filler metal may be used in "PREQUALIFIED" WPS if classified in the "AS-WELDED" condition and meets all of the required mechanical properties for the sheet steel, regardless of alloy.

^k The prequalified Argon based shielding gases for carbon and low alloy steel FCAW, and carbon steel GMAW-Metal Core Fixed Classifications shall be M21-ArC-20-25(SG-AC-20/25), see 1.4.6.2(2).

^l For Open classifications for carbon and low alloy steel FCAW and GMAW-metal core electrodes, the electrodes classified with the previous shielding gas requirements of AWS A5.18/A5.18M, AWS A5.20/A5.20M, AWS A5.28/A5.28M, and AWS A5.29/A5.29M shall be considered for use with prequalified WPS and other shielding gases listed in Table 5 of AWS A5.36/A5.36M used for classification of an electrode, but only the specific shielding gas used for classification and not the range of the shielding gas designator, see 1.4.6.2(3).

^m For galvanized material see ASTM Specifications for coating details.

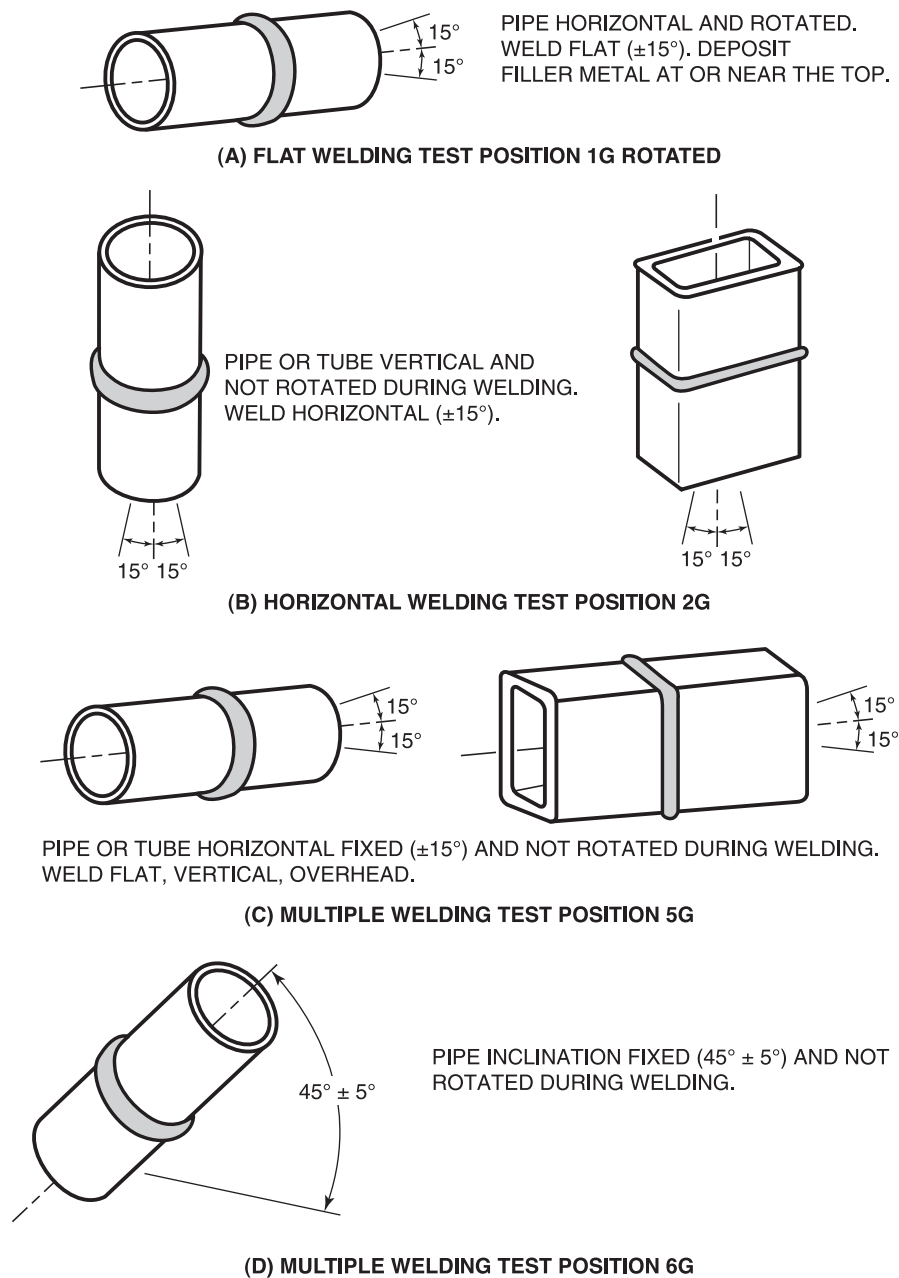
ⁿ For material used for floor plate see ASTM A786 clause 7

^o Specified for Type H only

Table 1.3
Welding Positions^a and Restrictions for WPS (see 1.7.3)

	Square-Groove Weld in Butt Joint	Fillet Weld	Flare-Bevel- Groove Weld	Flare-V- Groove Weld	Arc Spot Weld	Arc Seam Weld	Arc Plug Weld
Sheet to Sheet	F H V OH	F H V OH	F H V OH	F H V OH	— — — —	F H — —	F H V OH
Sheet to Supporting Member	— — — —	F H V OH	F H V OH	— — — —	F — — —	F — — —	F H V OH
HSS to HSS or HSS to Sheet or Supporting Member	F H V OH	F H V OH	F H V OH	F H V OH	— — — —	— — — —	— — — —

^a Positions of welding: F = flat, H = horizontal, V = vertical, OH = overhead



Source: Adapted from [AWS D1.1/D1.1M:2015](#), *Structural Welding Code—Steel*, Figure 9.17, Miami: American Welding Society.

Figure 1.1—Positions of Test for HSS Groove Welding (see Table 1.3)

2. Normative References

The following documents 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) Standards:

- (1) [AWS A2.4:2007](#), *Standard Symbols for Welding, Brazing, and Nondestructive Examination*
- (2) [AWS A3.0](#), *Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*
- (3) [AWS A5.1/A5.1M](#), *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*
- (4) [AWS A5.5/A5.5M](#), *Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding*
- (5) [AWS A5.17/A5.17M](#), *Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding*
- (6) [AWS A5.18/A5.18M](#), *Specification for Carbon Steel Electrodes and Rods for Gas Metal Arc Welding*
- (7) [AWS A5.20/A5.20M](#), *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*
- (8) [AWS A5.23/A5.23M](#), *Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding*
- (9) [AWS A5.28/A5.28M](#), *Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding*
- (10) [AWS A5.29/A5.29M](#), *Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*
- (11) [AWS A5.32/A5.32M](#), *Specification for Welding Shielding Gases*
- (12) [AWS A5.36/A5.36M](#), *Specification for Carbon and Low-Alloy Steel Flux Cored Electrodes for Flux Cored Arc Welding and Metal Cored Electrodes for Metal Arc Welding*
- (13) [AWS D1.1/D1.1M](#), *Structural Welding Code—Steel*

American Iron and Steel Institute (AISI) Standards:

- (1) AISI S100 *North American Specification for the Design of Cold-Formed Steel Structural Members*

ASTM International Standards:

- (1) [ASTM A53/A53M-12](#), *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless*
- (2) [ASTM A109/A109M-15](#), *Standard Specification for Steel, Strip, Carbon (0.25 Maximum Percent), Cold-Rolled*
- (3) [ASTM A501/A501M-14](#), *Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing*
- (4) [ASTM A529/A529M-14](#), *Standard Specification for High-Strength Carbon-Manganese Steel of Structural Quality*
- (5) [ASTM A572/A572M-15](#), *Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel*
- (6) [ASTM A606/606M-15](#), *Standard Specification for Steel, Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, with Improved Atmospheric Corrosion Resistance*

- (7) ASTM A611-73(1979), Standard Specification for Steel, Cold-Rolled Sheet, Carbon, Structural
- (8) ASTM A653/A653M-15e1, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
- (9) ASTM A715-81e1, Standard Specification for Steel Sheet and Strip, Hot-Rolled, High-Strength, Low-Alloy, with Improved Formability
- (10) ASTM A792/A792M-10(2015), Standard Specification for Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process
- (11) ASTM A1003/A1003M-15, Standard Specification for Steel, Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, with Improved Atmospheric Corrosion Resistance
- (12) ASTM A1008/A1008M-15, Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
- (13) ASTM A1011/A1011M-15, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
- (14) ASTM A1039/A1039M-13, Standard Specification for Steel, Sheet, Hot Rolled, Carbon, Commercial, Structural, and High-Strength Low-Alloy, Produced by Twin-Roll Casting Process
- (15) ASTM A1063/A1063M-11a, Standard Specification for Steel Sheet, Twin-Roll Cast, Zin-Coated (Galvanized) by the Hot-Dip Process

3. Terms and Definitions

AWS A3.0M/A3.0, Standard Welding Terms and Definitions, provides the basis for terms and definitions used herein. However, the following terms and definitions are included below to accommodate usage specific to this document.

A

arc seam weld. A seam weld made by an arc welding process (see Figure 4.5).

arc spot weld. A spot weld made by an arc welding process (see Figure 4.4).

automatic welding. Welding with equipment that performs the welding operation without adjustment of the controls by a welding operator. The equipment may or may not load and unload the workpieces. See also **mechanized welding**.

B

burn back. This condition occurs where the sheet steel melts back and does not become a part of the weld, leaving a void between the weld metal and the sheet steel.

butt joint. A joint between two members aligned approximately in the same plane (see Figure 4.1).

C

coating. A thin layer, equal to or less than 0.004 in [0.1 mm] of material applied by surfacing for the purpose of corrosion prevention, resistance to high temperature scaling, wear resistance, lubrication or other purposes.

complete fusion. Fusion which has occurred over the entire base metal surface intended for welding and between all adjoining weld beads.

complete joint penetration. A penetration by weld metal for the full thickness of the base metal in a joint with a groove weld.

Contractor. Any company, or that individual representing a company, responsible for the fabrication, erection, manufacturing, or welding, in conformance with the provisions of this code.

corner joint. A joint between two members located approximately at right angles to each other.

D

double-square-groove weld. A type of groove weld.

E

edge joint. A joint between the edges of two or more parallel or nearly parallel members.

effective length of weld. The length throughout which the correctly proportioned cross section of the weld exists. In a curved weld, it shall be measured along the weld axis.

effective throat. The minimum distance minus any convexity between the weld root and the face of a fillet weld.

Engineer. The duly designated individual who acts for, and in behalf of, the Owner on all matters within the scope of the code.

G

groove weld size. For sheet steel welding, this is assumed to be the thickness of the sheet steel.

I

Inspector.

(1) Contractor's Inspector. The duly designated person who acts for, and in behalf of, the Contractor on all inspection and quality matters within the scope of the code and of the contract documents.

(2) Verification Inspector. The duly designated person who acts for, and in behalf of, the Owner or Engineer on all inspection and quality matters specified by the Engineer.

(3) Inspector(s) (unmodified). When the term "Inspector" is used without further qualification as the specific Inspector category described above, it applies equally to the Contractor's Inspector and the Verification Inspector.

J

joint welding procedure. The materials, detailed methods, and practices employed in the welding of a particular joint.

M

manual welding. A welding operation performed and controlled completely by hand. See also **automatic welding**.

mechanized welding. Welding with equipment that requires manual adjustment of the equipment controls in response to visual observation of the welding, with the torch, gun, or electrode holder held by a mechanized device.

melting rate. The length of electrode melted in one minute.

N

nugget size (arc welding). The diameter or width of the nugget measured in the plane of the interface between the pieces joined.

O

overhead position. The position in which welding is performed from the underside of the joint (see Figure C-7.1).

Owner. The individual or company that exercises legal ownership of the product or structural assembly produced under this code.

P

partial joint penetration. Joint penetration that is intentionally less than complete.

positioned weld. A weld made in a joint that has been placed as to facilitate making the weld.

procedure qualification. The demonstration that welds made by a specific procedure can meet prescribed standards.

R

reinforcement of weld. See **weld reinforcement**.

root of weld. See **weld root**.

S

Code Terms “Shall,” “Should,” and “May.” “Shall,” “should,” and “may” have the following significance:

(1) Shall. Code provisions that use “shall” are mandatory unless specifically modified in contract documents by the Engineer.

(2) Should. The word “should” is used to recommend practices that are considered beneficial, but are not mandatory.

(3) May. The word “may” in a provision allows the use of optional procedures or practices that can be used as an alternative or supplement to code requirements. Those optional procedures that require the Engineer’s approval shall either be specified in the contract documents, or require the Engineer’s approval. The Contractor may use any option without the Engineer’s approval when the code does not specify that the Engineer’s approval shall be required.

single-flare-bevel-groove weld. A weld in a groove formed by a member with a curved surface in contact with a planar member (see Figure 4.3A).

single-flare-V-groove weld. A weld in a groove formed by two members with curved surfaces (see Figure 4.10).

square-groove weld. A type of groove weld (see Figure 4.1).

stud arc welding (SW). An arc welding process that uses an arc between a metal stud, or similar part, and the other workpiece. When the surfaces to be joined are properly heated, they are brought together under pressure. Partial shielding may be obtained by the use of a ceramic ferrule surrounding the stud. Shielding gas or flux may or may not be used.

T

T-joint. A joint between two members located approximately at right angles to each other in the form of a T (see Figure 4.8).

throat of a fillet weld. See **effective throat**. (See **actual throat and theoretical throat** in AWS A3.0)

throat of a fillet weld. For sheet steel welding, this is assumed to be the thickness of the sheet steel.

W

weld. As applied here to sheet metal welding, a localized coalescence of metal produced by heating to suitable temperatures with or without the use of filler metal. The filler metal has a melting point approximately the same as the base metals.

weld washer. A washer used for containing arc spot welds on sheet metal thinner than 0.028 in [0.7 mm].

welding operator. One who operates machine or automatic welding equipment.

weld reinforcement. Weld metal in excess of the quantity required to fill a joint. See also **face reinforcement** and **root reinforcement** in AWS A3.0.

weld root. The points, as shown in cross section, at which the back of the weld intersects the base metal surfaces.

weld toe. The junction of the weld face and the base metal.

4. Design of Welded Connections

Part A *Allowable Load Capacities*

NOTE: For welds not designed to resist external loads, the Engineer may disregard the requirements of this subclause.

Components to be Used in Design Formulae

- P = Allowable load capacity (kips)
- F_u = Specified minimum ultimate tensile strength of sheet steel (ksi)
- F_y = Specified minimum yield strength of sheet steel (ksi)
- F_{xx} = Specified minimum tensile strength of AWS electrode classification (ksi)
- F_w = Allowable weld shear stress $0.3 F_{xx}$ (ksi)
- t = Thickness of sheet steel thinner member exclusive of coatings (single sheet or combined multiple thicknesses of sheet steels) (in) [mm]
- t_w = Weld throat or size (see Figures 4.2, 4.3B, 4.3C, [Clause 3](#) for the definition of actual throat of a fillet weld, and AWS A3.0 for definitions of groove weld size, actual, and theoretical throat) (in) [mm].
- L = Length of weld—for fillet, flare-groove, or arc seam welds (in) [mm]
- NOTE: For arc seam welds the L dimension does not include the circular ends (see Figure 4.5)*
- h = Lip height—for flare-groove welds (see Figures 4.3B and 4.3C) (in) [mm]
- d = Visible diameter of the weld face of arc spot welds or arc plug welds (see Figures 4.4 and 4.6) or the visible width of arc seam welds (see Figure 4.5) (in) [mm]
- d_a = Resultant average diameter of an arc spot weld or arc plug weld (see Figures 4.4 and 4.6) or an average width of an arc seam weld (see Figure 4.5) (in) [mm]
- d_e = Effective diameter of an arc spot weld or arc plug weld or an effective width of an arc seam weld at the faying surface (see Figures 4.4, 4.5, and 4.6) (in) [mm]

NOTE: If it can be shown by sectioning and measuring that a WPS will consistently give a larger effective diameter (d_e) at the faying surface, this value may be used providing this particular WPS is used

4.1 Base Metal Stresses

The allowable base metal stresses shall be those specified in the latest edition of the *Specification for the Design of Cold-Formed Steel Structural Members* of the American Iron and Steel Institute or as otherwise specified in the applicable contract specifications.

4.2 Alternate Allowable Load Capacities in Weld Joints

Load capacities shall be determined by the applicable section of AISI S100 *Specification for the Design of Cold-Formed Steel Structural Members*, or as described in clauses 4.2.2 to 4.2.6.

4.2.1 Square-Groove Welds in Butt Joints. The allowable unit load capacities for matching electrode and base metal combinations (see Table 1.2) for a groove weld in a butt joint, welded from one side or both sides, shall be that of the lower strength base metal in the joint, provided that the weld size is equal to the thickness of the base metal (see Figure 4.1).

4.2.2 Fillet Welds. The allowable load capacity, P , of a fillet weld in lap and T-joints, made in any welding position [see Figure 4.2(a) and Figure 4.2(b)] for matching base metal/filler metal combinations (see Table 1.2), shall be as follows:

4.2.2.1 When t_w is equal to or greater than the thickness of the sheet steel t , for fillet welds transverse to direction of loading:

$$P = 0.4(t)L(F_u) \quad (1)$$

When t_w is equal to or greater than the thickness of the sheet steel t , for fillet welds longitudinal to direction of loading, the allowable load capacity is:

$$P = 0.4 \left(1 - 0.01 \frac{L}{t} \right) t(L)F_u \text{ for } \frac{L}{t} < 25 \quad (2)$$

$$P = 0.3(t)L(F_u), \text{ for } \frac{L}{t} \geq 25 \quad (3)$$

4.2.2.2 When t_w is less than the thickness of the sheet steel t :

$$P = 0.3(t_w)L(F_{xx}) \quad (4)$$

where

t_w = Theoretical throat

= $0.707 w_1$ or $0.707 w_2$, whichever is smaller.

w_1, w_2 = leg of weld and $w_1 < t_1$ in lap joints [see Figure 4.2(a) and Figure 4.2(b)].

4.2.3 Flare-Groove Welds. For matching base metal/filler metal combinations (see Table 1.2), the allowable load capacity, P , of flare-groove welds made in any welding position is considered to be governed by the thickness of the sheet steel adjacent to the welds, provided that a weld size at least equal to the thickness of the sheet steel as was obtained with the WPS qualification. This capacity shall be determined by one of the applicable equations that follow:

(1) Loads applied transversely to weld axis

(a) Flare-bevel-groove welds (see Figure 4.3A)

The capacity of the welded joint is given by:

$$P = \frac{t(L)F_u}{3} \quad (5)$$

(b) Flare-V-groove welds. Loads applied transversely to the weld axis have not been considered.

(2) Loads applied longitudinally with weld axis (see Figure 4.3B and Figure 4.3C)

If the weld size (t_w) is equal to or greater than (t) but less than ($2t$), or if the lip height (h) is less than weld length (L), then

$$P = 0.3(t)L(F_u) \quad \frac{\text{single shear}}{\text{see Figure 4.3B}} \quad (6)$$

If (t_w) is equal to or greater than ($2t$) and the lip height (h) is equal to or greater than (L), then

$$P = 0.6(t)L(F_u) \quad \frac{\text{double shear}}{\text{see Figure 4.3C}} \quad (7)$$