

AWS D1.8/D1.8M:2021
An American National Standard

Structural Welding Code— Seismic Supplement



Documents

Document Sharing Hub

AWS D1.8/D1.8M:2021
An American National Standard

Approved by the
American National Standards Institute
August 16, 2021

Structural Welding Code— Seismic Supplement

4th Edition

Revises AWS D1.8/D1.8M:2016

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 supplements the requirements of AWS D1.1/D1.1M, *Structural Welding Code—Steel*. This code is intended to be applicable to welded joints in Seismic Force Resisting Systems designed in accordance with the AISC Seismic Provisions. Clauses 1–7 constitute a body of rules for the regulation of welding in Seismic Force Resisting Systems. There are seven mandatory annexes in this code. A commentary of the code is included with the document.



ISBN Print: 978-1-64322-206-6
ISBN PDF: 978-1-64322-207-3
© 2021 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 revised, 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: Director, Standards Development, 8669 NW 36 St, # 130, Miami, FL 33166 (see Annex I). 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) and any pertinent data that may be of use in improving this standard are requested and should be addressed to AWS Headquarters. 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.

Personnel

AWS D1 Committee on Structural Welding

T. L. Niemann, Chair	<i>Fickett Structural Solutions</i>
R. D. Medlock, Vice Chair	<i>High Steel Structures, LLC</i>
N. S. Lindell, Second Vice Chair	<i>Project & Quality Solutions</i>
J. A. Molin, Secretary	<i>American Welding Society</i>
U. W. Aschemeier	<i>Subsea Global Solutions</i>
E. L. Bickford	<i>International Inspection Services, Incorporated</i>
T. W. Burns	<i>Thom Burns Consulting, LLC</i>
H. H. Campbell, III	<i>Pazuzu Engineering</i>
R. D. Campbell	<i>Bechtel</i>
B. M. Connelly	<i>Eustis Engineering, LLC</i>
R. B. Corbit	<i>Retired</i>
M. E. Gase	<i>Midwest Steel</i>
T. P. Green	<i>Wiss, Janney, Elstner Associates</i>
M. A. Grieco	<i>MassDOT Research and Materials Laboratory</i>
J. J. Kenney	<i>Shell International E&P</i>
J. H. Kiefer	<i>ConocoPhillips (Retired)</i>
J. R. Kissell	<i>Trinity Consultants (Retired)</i>
B. R. Krueger	<i>Los Alamos National Laboratory</i>
V. Kuruvilla	<i>Lexicon</i>
J. Lawmon	<i>American Engineering and Manufacturing, Incorporated</i>
D. R. Luciani	<i>Canadian Welding Bureau</i>
M. J. Mayes	<i>Terracon Consultants</i>
D. L. McQuaid	<i>D. L. McQuaid & Associates, Incorporated</i>
J. K. Merrill	<i>TRC Companies</i>
D. K. Miller	<i>The Lincoln Electric Company</i>
J. B. Pearson, Jr.	<i>ALRV Consultant, LLC</i>
D. D. Rager	<i>Rager Consulting, Incorporated</i>
T. J. Schlafly	<i>American Steel Institute of Construction</i>
R. E. Shaw, Jr.	<i>Steel Structures Technology Center, Incorporated</i>
A. W. Sindel	<i>TRC Companies</i>
M. M. Tayarani	<i>Pennoni Associates, Incorporated</i>
P. Torchio, III	<i>Williams Enterprises of GA, Incorporated (Retired)</i>

Advisors to the D1 Main Committee on Structural Welding

N. J. Altebrando	<i>STV, Incorporated</i>
G. L. Fox	<i>Consultant</i>
H. E. Gilmer	<i>TUV Rheinland Industrial Solutions</i>
G. J. Hill	<i>GJ Hill & Associates</i>
M. L. Hoitomt	<i>Consultant</i>
C. W. Holmes	<i>Modjeski & Masters, Incorporated (Retired)</i>
W. S. Houston	<i>Nelson Stud Welding—Stanley Black & Decker</i>
M. D. Kerr	<i>McDermott</i>
P. G. Kinney	<i>Sandia National Laboratories</i>

Advisors to the D1 Main Committee on Structural Welding (Continued)

P. W. Marshall	<i>Moonshine Hill Proprietary</i>
G. S. Martin	<i>Consultant</i>
T. C. Myers	<i>Consultant</i>
D. C. Phillips	<i>Retired</i>
R. W. Stieve	<i>Parsons Corporation</i>
W. D. Wright	<i>Advantage Aviation Technologies</i>
D. G. Yantz	<i>Canadian Welding Bureau</i>

AWS D1L Subcommittee on Seismic Structures

R. E. Shaw, Jr., Chair	<i>Steel Structures Technology Center, Incorporated</i>
J. K. Merrill, Vice Chair	<i>TRC Companies</i>
J. A. Molin, Secretary	<i>American Welding Society</i>
S. E. Anderson	<i>Anderson Inspections</i>
C. Hanson Carbonneau	<i>Banker Steel Company</i>
R. Caroti	<i>Arcelor Mittal</i>
D. A. Koch	<i>Washington State University</i>
J. O. Malley	<i>Degenkolb Engineers</i>
B. R. Manning	<i>Schuff Steel</i>
M. J. Mayes	<i>Terracon Consultants</i>
D. W. Meyer	<i>ESAB Welding & Cutting Products</i>
D. K. Miller	<i>The Lincoln Electric Company</i>
P. R. Niewiarowski	<i>Sargent & Lundy</i>
T. J. Schlafly	<i>American Institute of Steel Construction</i>
R. H. R. Tide	<i>Wiss, Janney, Elstner Associates</i>

Advisors to the D1L Subcommittee on Seismic Structures

N. J. Altebrando	<i>STV, Incorporated</i>
T. P. Green	<i>Wiss, Janney, Elstner Associates</i>
R. Hamburger	<i>Simpson Gumpertz & Heger</i>
T. L. Niemann	<i>Fickett Structural Solutions</i>
D. K. Panda	<i>TMK IPSCO</i>
D. C. Phillips	<i>Retired</i>
D. D. Rager	<i>Rager Consulting, Incorporated</i>
D. Rees-Evans	<i>Steel Dynamics</i>

Foreword

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

Background. Damage sustained by welded steel moment-frame buildings in the 1994 Northridge earthquake, and extensive research conducted by the FEMA/SAC program following that earthquake, demonstrated that in order to obtain adequate performance of welded steel structures under conditions of severe earthquake-induced inelastic straining, additional controls on design, detailing, materials, workmanship, testing, and inspection are necessary. This research resulted in substantive changes to the AISC Seismic Provisions, which control the design of steel Seismic Force Resisting Systems (SFRS) designed to withstand severe inelastic straining as well as certain aspects of the materials and detailing of these systems. The provisions contained in this standard complement the AISC Seismic Provisions and are intended to ensure that welded joints that are designed to undergo significant repetitive inelastic strains as a result of earthquakes, or that are used to connect members designed to resist such inelastic strains, have adequate strength, notch toughness, and integrity to perform as intended. This code, together with AWS D1.1/D1.1M, *Structural Welding Code—Steel*, specifies the acceptable materials, procedures, and workmanship for constructing welded joints in SFRS designed in accordance with the AISC Seismic Provisions as well as the procedures and acceptance criteria for quality control and quality assurance inspection of welded joints in the SFRS. In some regions of the U.S., with low risk of intense earthquake shaking, building codes permit design of steel Seismic Force Resisting Systems that do not conform to the requirements of the AISC Seismic Provisions. The requirements of this code apply only to the SFRS in structures designed in accordance with the AISC Seismic Provisions and need not be applied to structures not designed to those provisions.

The first edition of D1.8 /D1.8M was published in 2005. The Supplement was revised in 2009 and again in 2016. This is the fourth edition of the AWS D1.8/D1.8M, *Structural Welding Code—Seismic Supplement*.

Editorial and technical revisions from the previous edition are indicated by underlining text. Changes in tables and figures have a single, vertical line in the margin. The following is a list of the most significant revisions from the 2016 edition:

Summary of Changes	
Clause/Table/ Figure/Annex	Modification
Clause 3	The definition of lowest anticipated service temperature (LAST) was revised, and a new definition was added; weld access hole.
Clause 4	Clause 4.3 was re-written to provide specific information about the mockup test. Figure 4.3 was revised and Figure 4.4, a new figure, was added for clarity. The macroetch specimen acceptance criteria was also revised for clarity.
Clause 6	Intermix of FCAW-S Filler Metal was revised to standardize the testing in accordance with Annex B. The Heat Input clause was modified to show the filler metals exempt from the heat input envelope testing in new Tables 6.4 and 6.5 rather than in the text. References to AWS A5.36 were removed as AWS A5.36 has been withdrawn. References to AWS A5.20 -D Designator were removed as they have been removed from AWS A5.20. Figure 6.2 was revised so that you can use it when working with small members and to prevent the slope of the access hole from being too large.
Annex B	Annex B was revised to describe an intermix test for FCAW-S over ESW welds. A new figure was also added to illustrate ESW, FCAW-S intermix test plate setup.

Commentary. The Commentary is nonmandatory and is intended only to provide insight, information, and provision rationale.

Normative Annexes. These annexes address specific subjects in the code and their requirements are mandatory requirements that supplement the code provisions.

Errata. All errata to a standard shall be published in the *Welding Journal* and posted on the AWS website (www.aws.org/standards/page/errata).

Suggestions. Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, D1L Subcommittee on Seismic Structures, American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.

Table of Contents

	Page No.
<i>Personnel</i>	v
<i>Foreword</i>	vii
<i>List of Tables</i>	xi
<i>List of Figures</i>	xi
1. General Requirements	1
1.1 Scope and General Provisions	1
1.2 Standard Units of Measurement	1
1.3 Safety Precautions	1
1.4 Responsibilities	2
1.5 Limitations	3
1.6 Welding Symbols	3
2. Normative References	5
3. Terms and Definitions	7
4. Welded Connection Details	9
4.1 Corner Clips of Continuity Plates and Stiffeners	9
4.2 Transitions in Thicknesses and Widths	9
4.3 Joint Details for Doublers	9
5. Welder Qualification	15
5.1 Supplemental Welder Qualification Testing	15
5.2 Welder Qualification Period	15
5.3 Welder Performance Qualification Record Information	16
6. Fabrication	17
<i>Part A—Filler Metal and Weld Metal</i>	17
6.1 Filler Metal and Weld Metal	17
<i>Part B—Additional Requirements for Demand Critical Filler Metal and Weld Metal</i>	18
6.2 Heat Input Envelope	18
6.3 Production Lot Control	18
6.4 FCAW Electrode Packaging, Storage, and Exposure	19
<i>Part C—Welding Procedure Specifications</i>	20
6.5 Welding Processes	20
6.6 Welding Procedure Specifications (WPSs)	20
6.7 Maximum Interpass Temperature	21
6.8 Heat Input	21
6.9 Bottom Flange Welding Sequence	21
6.10 Welder Identification	21
<i>Part D—Details</i>	21
6.11 Weld Access Holes	22
6.12 Tack Welding Requirements	22
6.13 Removal of Backing and Weld Root Treatment	23
6.14 Reinforcing Fillet Welds at Removed Weld Backing Locations	23
6.15 Fillet Welds at Left-In-Place Steel Backing	23

	Page No.
6.16 Weld Tabs	23
6.17 End Dams.....	24
<i>Part E—Protected Zone</i>	24
6.18 Protected Zone	24
7. Inspection	33
7.1 Inspection Task Assignment	33
7.2 Inspector Qualifications	33
7.3 Quality Assurance Agency Written Practice	34
7.4 Wide-Flange k-Area Inspection.....	34
7.5 Lamellar Tearing.....	34
7.6 Beam Copes and Weld Access Holes	34
7.7 Repaired Weld Access Holes in the Protected Zone.....	35
7.8 NDT of Repaired Tab Removal Sites	35
7.9 Magnetic Particle Testing Requirements	35
7.10 Ultrasonic Testing.....	35
Annex A (Normative)—WPS Heat Input Envelope Testing of Filler Metals for Demand Critical Welds	37
Annex B (Normative)—Intermix CVN Testing of Filler Metal Combinations (where one of the filler metals is FCAW-S).....	41
Annex D (Normative)—Supplemental Welder Qualification for Restricted Access Welding.....	51
Annex E (Normative)—Supplemental Testing for Extended Exposure Limits for FCAW Filler Metals.....	57
Annex F (Normative)—Supplemental Ultrasonic Technician Qualification	59
Annex G (Normative)—Supplemental Magnetic Particle Testing Procedures	63
Annex H (Normative)—Flaw Sizing by Ultrasonic Testing	67
Annex I (Informative)—Requesting an Official Interpretation on an AWS Standard	69
Annex J (Informative)—Informative Reference.....	71
<i>Commentary</i>	73
Foreword.....	75
Index	123
List of AWS Documents on Structural Welding.....	133

List of Tables

Table	Page No.
6.1 Filler Metal Mechanical Property Requirements	26
6.2 Diffusible Hydrogen Testing Requirements	26
6.3 Mechanical Property Requirements for Demand Critical Welds	27
6.4 Filler Metal Classifications Exempt From Heat Input Envelope Testing When $LAST \geq 50^{\circ}F [10^{\circ}C]$...	27
A.1 Heat Input Envelope Testing—Heat Input, Preheat, and Interpass Temperatures.....	39
A.2 All Weld Metal Mechanical Properties; Yield Strength, Tensile Strength, Elongation, and CVN Toughness Requirements	39
B.1 Filler Metal Essential Variables—FCAW-S Substrate/Root	44
B.2 Filler Metal Essential Variables—FCAW-S Fill.....	44
<i>Commentary</i>	
C-1.1 Removal of Tabs and Backing	81

List of Figures

Figure	Page No.
4.1 Transition of Butt Joints in Parts of Unequal Thicknesses.....	11
4.2 Transition of Butt Joints in Parts of Unequal Widths	12
4.3 Doubler to Column Flange Joint Detail.....	12
4.4 Doubler Weld Soundness Test	13
6.1 Reinforcing Fillet Weld Requirements	28
6.2 Alternate Geometry—Beam Flange Weld Access Hole Detail.....	29
6.3 Acceptable Tab Removal Conditions	30
6.4 Acceptable and Unacceptable Use of End Dams	31
A.1 Heat Input Envelope Test Plate.....	40
B.1 Intermix Test Plate.....	45
B.2 Interface Scribe Line Location	46
B.3 ESW, FCAW Intermix Test Plate	46
B.4 Intermix CVN Test Specimen Location	47
D.1 Test Plate Configuration for Option A	54
D.2 Test Plate Configuration for Option B.....	55
D.3 Test Plate Configuration Illustration.....	55
D.4 Location of Side Bend Specimens on Test Plates—Supplemental Welder Qualification	56
<i>Commentary</i>	
C-1.1 Example RBS/Column Strong Axis Connection.....	82
C-1.2 Example Eccentric Brace/Link/Column Connection	83
C-1.3 Example WUF-W/Column Strong Axis Connection	84
C-4.1 Curved Corner Clip	88
C-4.2 Straight Corner Clip	88
C-6.1 Measurement of Preheat and Interpass Temperature.....	101
C-6.2 Beam Flange to Column—Fillet Welds at Left-in-Place Steel Backing	101
C-6.3 Continuity Plate Copes without Weld Tabs	102
C-G.1 An Example of Effective Areas of Inspection Between Yoke Legs	120

This page is intentionally blank.

Structural Welding Code—Seismic Supplement

1. General Requirements

This clause addresses the general requirements to be applied for welded joints that are part of the Seismic Force Resisting System (SFRS).

This clause is organized as follows:

1.1 Scope and General Provisions

1.2 Standard Units of Measurement

1.3 Safety Precautions

1.4 Responsibilities

1.5 Limitations

1.6 Welding Symbols

1.1 Scope and General Provisions

The provisions of this code supplement the provisions of AWS D1.1/D1.1M, *Structural Welding Code—Steel*, and shall apply to the design, fabrication, quality control, and quality assurance of welded joints designed in accordance with the *AISC Seismic Provisions for Structural Steel Buildings*. All provisions of AWS D1.1/D1.1M for statically loaded structures shall apply to the designated welds, except as specifically modified herein.

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.

1.3 Safety Precautions

Safety and health issues and concerns are beyond the scope of this standard and therefore are not fully addressed herein. Safety and health information is available from 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 Responsibilities

1.4.1 Engineer's Responsibilities. In addition to the items listed in AWS D1.1/D1.1M, the Engineer shall provide the following information in the Contract Documents:

- (1) Connection configuration, material specifications, and part sizes required to provide the needed seismic performance (see 1.5)
- (2) Identification of members that comprise the Seismic Force Resisting System (SFRS) and that are subject to the provisions of this code (see Clause 3)
- (3) The location of the Protected Zone for members of the SFRS (see Clause 3)
- (4) Welds designated as "Demand Critical" and subject to specific provisions of this code (see Clause 3)
- (5) Locations where the removal of backing is required (see 6.13)
- (6) Locations where fillet welds are required when backing is permitted to remain (see 6.15)
- (7) Locations where the removal of weld tabs is required (see 6.16.3 and 6.16.4)
- (8) Locations where fillet welds are required to reinforce groove welds, or to improve connection geometry (see 6.14)
- (9) Locations of access holes and the required shape, whether standard AWS D1.1/D1.1M geometry (see 6.11.1.1), alternate geometry (see 6.11.1.2), or a special geometry designated by the Engineer (see 6.11.1.3)
- (10) The Lowest Anticipated Service Temperature (LAST) of the steel structure for structures that are not normally enclosed and maintained at a temperature of 50°F [10°C] or higher (see Clause 3 and 6.2.2)
- (11) Butt joints subject to tension where tapered transitions are required (see 4.2)
- (12) Those joints or groups of joints in which a specific assembly order, welding sequence, welding technique, or other special precautions are required (see AWS D1.1/D1.1M:2020 4.3.3 and 7.20)
- (13) Quality Assurance Plan (QAP) for the project (see Clause 3 and 7.1)
- (14) Any additional provisions applicable to the specific project not governed by AWS D1.1/D1.1M or this code.

1.4.2 Contractor's Responsibilities. When this code or the Quality Assurance Plan (QAP) requires the Contractor to retain documentation, the document(s) shall be retained for at least one year after substantial completion of construction. The documents shall be made available to the Engineer, Inspector, or both when requested. When the QAP requires submittal of document(s), submittals shall be made to the Engineer and copies of submittals shall be retained by the Contractor.

1.4.2.1 AWS A5 Specification Certification. Certificates of Conformance for electrodes, fluxes, and shielding gases shall satisfy the applicable AWS A5 specification requirements.

1.4.2.2 Certification of Heat Input Envelope Testing. Certifications that filler metals used to make Demand Critical welds meet the Heat Input Envelope Testing requirements of 6.2.1 and Annex A shall be provided by the filler metal manufacturer. Should the filler metal manufacturer not supply such certifications, the Contractor shall have the necessary testing performed and provide the test reports.

1.4.2.3 Product Data Sheets. For GMAW performed with composite (cored) electrodes and for all FCAW and SMAW electrodes, the filler metal manufacturer's data sheets or catalog data supplied with Welding Procedure Specifications (WPSs) shall show the recommended or typical welding parameter combinations. The manufacturer's recommendations for storage, exposure, and baking (if applicable) shall also be provided.

1.4.2.4 Diffusible Hydrogen Content. The Contractor shall retain documentation that the filler metals comply with the hydrogen requirements of 6.1.2, as applicable.

1.4.2.5 Extended Exposure Capability of FCAW Filler Metals. When limits of filler metal exposure are extended in accordance with 6.4.3, documentation of testing in accordance with Annex E shall be retained by the Contractor.

1.4.2.6 Welding Procedure Specifications (WPSs). The Contractor shall be responsible for all WPSs.

1.4.2.7 Supplemental Welder Qualification Testing Documentation. The Contractor shall retain documentation that welders performing Demand Critical complete joint penetration groove welding of beam bottom flange to column T-joints have passed the Supplemental Welder Qualification for Restricted Access Welding test described in Annex D.

1.5 Limitations

This code is intended to apply to the following:

- (1) Structures made of steels with minimum specified yield strengths of 70 ksi [490 MPa] or less
- (2) Structures that utilize steel with a minimum specified yield strength of 55 ksi [380 MPa] or less for the beams or braces in which inelastic behavior is expected

1.6 Welding Symbols

Welding symbols shall be those shown in AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*. Special conditions shall be fully explained by added notes or details.

This page is intentionally blank.

2. Normative References

The documents listed below 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 except where a specific edition is included in the citation. For dated references, subsequent amendments or revisions of the publications may not apply since the relevant requirements may have changed.

American Welding Society (AWS) Standards:

- (1) AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*
- (2) AWS A3.0, *Standard Welding Terms and Definitions*
- (3) AWS A4.3, *Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding*
- (4) AWS A5.01M/A5.01, *Welding Consumables—Procurement of Filler Metals and Fluxes*
- (5) AWS A5.1/A5.1M, *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*
- (6) AWS A5.5/A5.5M, *Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding*
- (7) AWS A5.17/A5.17M, *Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding*
- (8) AWS A5.18/A5.18M, *Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding*
- (9) AWS A5.20/A5.20M, *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*
- (10) AWS A5.23/A5.23M, *Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding*
- (11) AWS A5.25/A5.25M, *Specification for Carbon and Low-Alloy Steel Electrodes and Fluxes for Electroslag Welding*
- (12) AWS A5.26/A5.26M, *Specification for Carbon and Low-Alloy Steel Electrodes for Electrogas Welding*
- (13) AWS A5.28/A5.28M, *Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding*
- (14) AWS A5.29/A5.29M, *Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*
- (15) AWS B4.0, *Standard Methods for Mechanical Testing of Welds*
- (16) AWS B5.1, *Specification for the Qualification of Welding Inspectors*
- (17) AWS C4.1, *Criteria for Describing Oxygen-Cut Surfaces, and Oxygen Cutting Surface Roughness Gauge*
- (18) AWS D1.1/D1.1M, *Structural Welding Code—Steel*
- (19) AWS QC1, *Standard for AWS Certification of Welding Inspectors*

American Institute of Steel Construction (AISC) Standards:

- (1) AISC 341, *Seismic Provisions for Structural Steel Buildings*
- (2) AISC 358, *Prequalified Connections for Special and Intermediate Moment Frames for Seismic Applications*

(3) AISC 360, *Specification for Structural Steel Buildings*

(4) AISC *Steel Construction Manual*

American Society for Nondestructive Testing (ASNT) Standards:

(1) ASNT SNT-TC-1A, *Recommended Practice for the Qualification and Certification of Nondestructive Testing Personnel*

(2) ASNT CP-189, *Standard for the Qualification and Certification of Nondestructive Testing Personnel*

Canadian Standards Association (CSA):

(1) CSA W178.2, *Certification of Welding Inspectors*

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.

demand critical welds. Welds designated by the Engineer in the contract documents, and required to meet specific requirements of this code.

doubler. Plate added to, and parallel with, a beam or column web to increase the strength at locations of concentrated forces.

k-area. The region of the web that extends from the tangent point of the web and the flange-web fillet (AISC k dimension) a distance 1-1/2 in [38 mm] into the web beyond the k detail dimension.¹

lowest anticipated service temperature (LAST). The lowest daily minimum temperature, or other suitable temperature, as established by the Engineer of record.

protected zone. That portion of a member of the SFRS, designated by the Engineer in Contract Documents in which inelastic straining is anticipated to occur and to which special limitations in these provisions apply with regard to attachments and fabrication.

quality assurance plan (QAP). The written description of qualifications, procedures, quality inspections, resources, and records to be used to provide assurance that the structure complies with the Engineer's quality requirements, specifications, jurisdictional requirements, and Contract Documents.

seismic force resisting system (SFRS). The assembly of structural elements in the building that resists seismic loads, as indicated by the Engineer in the Contract Documents. Included in the SFRS are the columns, beams, girders and braces, and the connections between these elements, specifically designed to resist seismic loads, either alone or in combination with other loads. The SFRS does not include other structural members not designed to resist seismic loads.

weld access hole. An opening that permits access for welding, backgouging, or for insertion of backing.

¹ See AISC *Specification for Structural Steel Buildings* for formal definition of k detail dimension.

This page is intentionally blank.

4. Welded Connection Details

This clause addresses the requirements and details for specific welded connections used in the Seismic Force Resisting System (SFRS).

This clause is organized as follows:

4.1 Corner Clips of Continuity Plates and Stiffeners

4.2 Transitions in Thicknesses and Widths

4.3 Joint Details for Doublers

4.1 Corner Clips of Continuity Plates and Stiffeners

Corners of continuity plates and stiffeners shall be clipped as follows (see Figures C-4.1 and C-4.2):

4.1.1 Along the Web. The corner clip along the web shall be detailed so that the clip extends a distance of at least 1-1/2 in [38 mm] beyond the published k detail dimension for the rolled shape.²

4.1.2 Along the Flange. The corner clip along the flange shall be detailed so that the clip does not exceed a distance of 1/2 in [12 mm] beyond the published k_1 dimension.³

4.1.3 Facilitating Suitable Weld Terminations. The corner clip shall be detailed to facilitate suitable weld terminations of both the flange weld and the web weld.

4.1.4 Curved Corner Clips. Curved corner clips, if used, shall have a minimum radius of 1/2 in [12 mm].

4.2 Transitions in Thicknesses and Widths

When butt joints subject to tension are required to be tapered, transitions shall be made in such manner that the slope in the transition does not exceed 1 in 2-1/2 (see Figure 4.1 for thickness transitions and Figure 4.2 for width transitions). The transition shall be accomplished by chamfering the thicker part, tapering the wider part, sloping the weld metal or by a combination of these.

4.3 Joint Details for Doublers

A prequalified WPS may be used for the welding of doublers to the webs, flanges, and fillets of hot rolled shapes using the details of Figure 4.3, provided all other requirements of Clause 5, Prequalification of WPSs, of the latest edition of AWS D1.1 are satisfied.

² See AISC 360 *Specification for Structural Steel Buildings* for formal definition of k detail dimension.

³ See the AISC *Steel Construction Manual* Part 1 for k_1 dimensions.

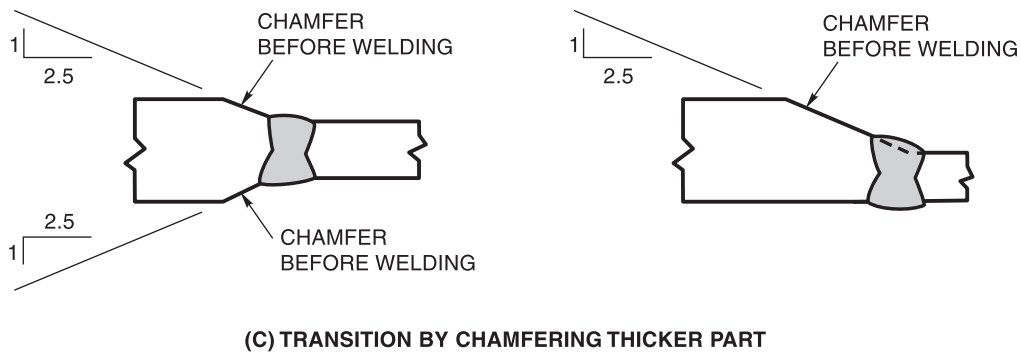
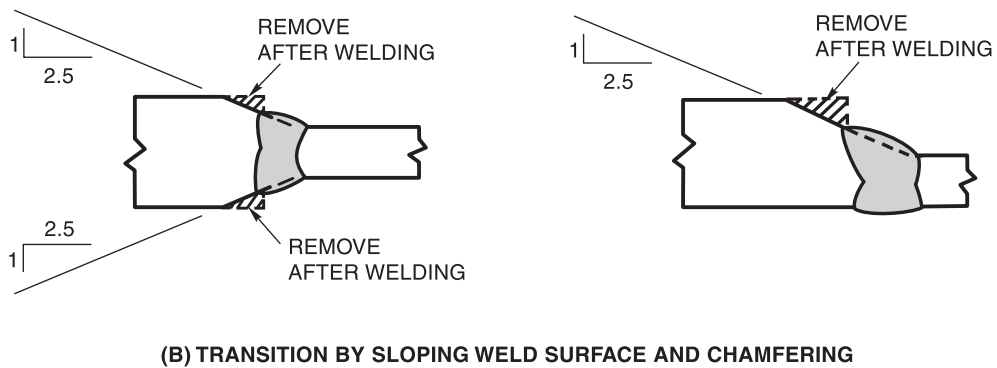
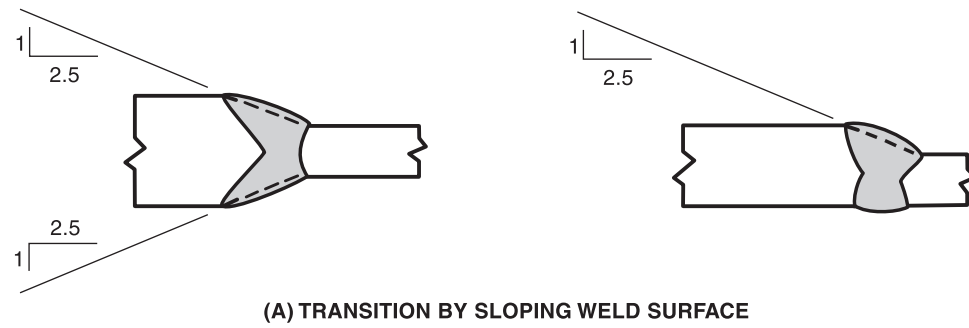
If either the production groove angle “ α ” or root opening “R” is less than permitted in Figure 4.3, the following shall be required:

- (1) Weld a mockup of the production joint with the doubler, web, and flange.
- (2) The mockup doubler weld test plate shall utilize the smallest root opening (“R”) and smallest included angle (“ α ”) to be used in production.
- (3) The thickness of the mockup doubler weld test plate shall be equal to or greater than the thickest doubler to be used in production, except that the mockup doubler thickness need not exceed 1 in [25 mm].
- (4) Prepare (3) macroetch tests approximately 4 in [100 mm] apart (see Figure 4.4). The test specimens shall be prepared with a finish suitable for macroetch examination. A suitable solution shall be used for etching to give a clear definition of the weld.

The as fit-up tolerances given for the Figure 4.3 details shall apply to the mockup dimensions when assembling the production joints.

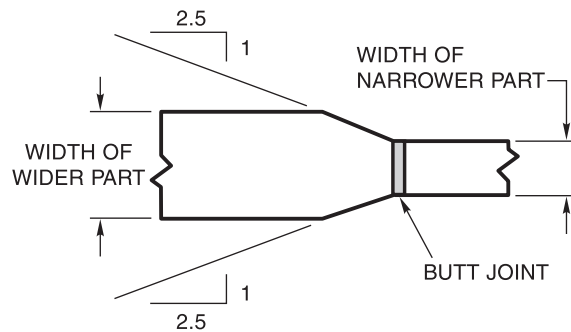
4.3.1 Macroetch Specimen Acceptance Criteria. The macroetch specimens, when inspected visually, shall conform to the following requirements:

- (1) no cracks
- (2) thorough fusion between adjacent layers of weld metal and between weld metal and base metal
- (3) thorough fusion to the root of the joint, but not necessarily beyond.



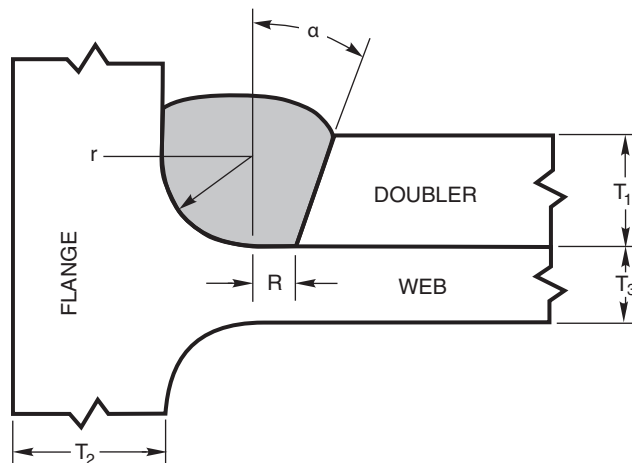
Source: Reproduced from AWS D1.1/D1.1M:2006, *Structural Welding Code—Steel*, Figure 2.2, Miami: American Welding Society.

Figure 4.1—Transition of Butt Joints in Parts of Unequal Thicknesses



Source: Reproduced from AWS D1.1/D1.1M:2006, *Structural Welding Code—Steel*, Figure 2.3, Miami: American Welding Society.

Figure 4.2—Transition of Butt Joints in Parts of Unequal Widths



Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)			Groove Preparation			Permitted Welding Position
		T ₁	T ₂	T ₃	Root Opening Fillet Radius Groove Angle	Tolerances		
						As Detailed in [mm]	As Fit-Up in [mm]	
SMAW	Dblr	U	U	U	R = 0*	+1/16, −0 [+1.5, −0]	±1/4 [±6]	F
					r = As Rolled	N/A	As-Rolled	
					α = 20°	+10°, −0°	+10°, −5°	
GMAW FCAW	Dblr—GF	U	U	U	R = 0*	+1/16, −0 [+1.5, −0]	±1/4 [±6]	F
					r = As Rolled	N/A	As-Rolled	
					α = 30°	+10°, −0°	+10°, −5°	
SAW	Dblr—S	U	U	U	R = 0*	+1/16, −0 [+1.5, −0]	±1/4 [±6]	F
					r = As Rolled	N/A	As-Rolled	
					α = 30°	+10°, −0°	+10°, −5°	

*Root, R is the distance from the tangent of the rolled fillet to the nearest point on the doubler.

Figure 4.3—Doubler to Column Flange Joint Detail

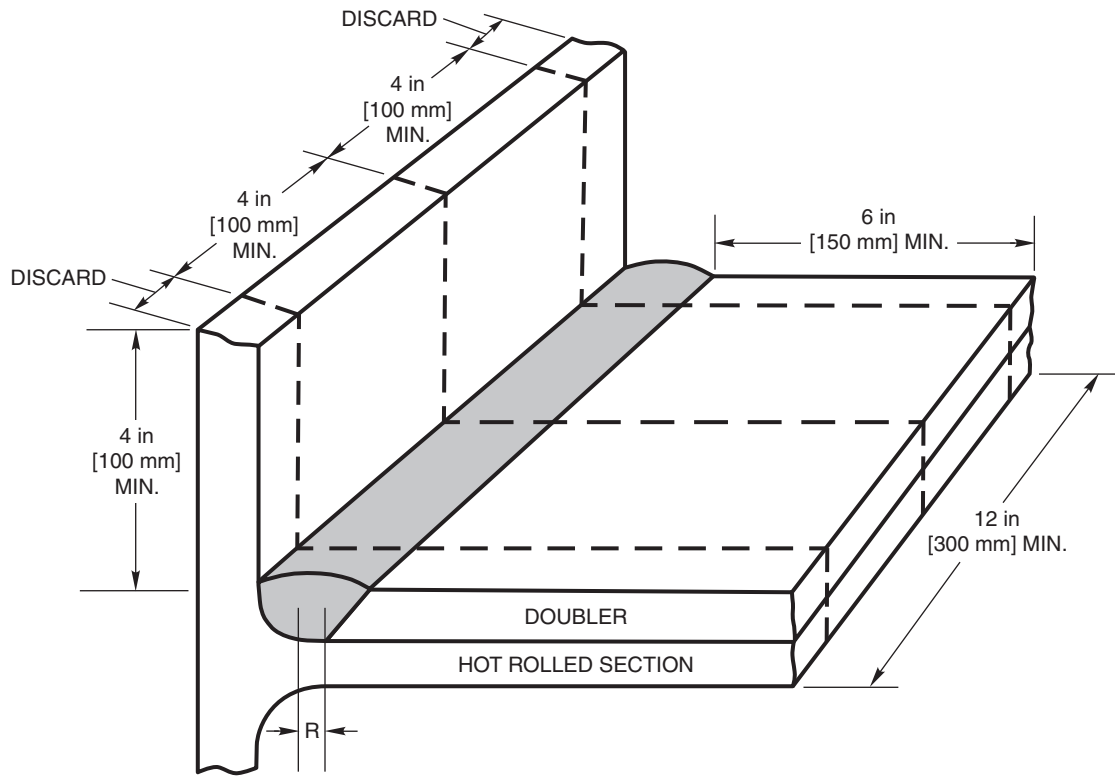


Figure 4.4—Doubler Weld Soundness Test (See 4.3)

This page is intentionally blank.

5. Welder Qualification

This clause addresses the requirements for the qualifications for welders that will weld Demand Critical complete joint penetration groove welds through the weld access hole in specific connections used in the Seismic Force Resisting System (SFRS).

This clause is organized as follows:

5.1 Supplemental Welder Qualification Testing

5.2 Welder Qualification Period

5.3 Welder Performance Qualification Record Information

5.1 Supplemental Welder Qualification Testing

5.1.1 Required Tests. In addition to the requirements of AWS D1.1/D1.1M:2020 Clause 6, welders shall pass the Supplemental Welder Qualification for Restricted Access Welding test as prescribed in Annex D, when the welder is required to make welds subject to all of the following requirements:

- (1) The weld is a Demand Critical complete joint penetration groove weld.
- (2) The weld joins the bottom beam flange to the column flange.
- (3) The weld in the groove must be made by welding through a beam web weld access hole.

5.1.2 Testing Parameters. The Supplemental Welder Qualification for Restricted Access Welding test shall be performed in the flat position using the welding process that will be used in the work. The test shall be performed using a deposition rate equal to or greater than that to be used in production.

5.1.3 Backing. The Supplemental Welder Qualification for Restricted Access Welding test shall use the type of backing to be used on the project, except that, tests performed with no backing shall qualify the welder to use steel backing in production, but the reverse shall not be permitted.

If backing other than steel is used, or if no backing is used, the welder shall be qualified using the maximum root opening that will be permitted in production. If the project will use no backing, no backing shall be permitted on the qualification test.

5.1.4 Tack Welders. Tack welders are not required to perform the Supplemental Welder Qualification for Restricted Access Welding test described in Annex D.

5.2 Welder Qualification Period

The qualification for welding personnel using the Supplemental Welder Qualification for Restricted Access Welding test prescribed in Annex D shall remain valid for 36 months, providing the continuity requirements for process use of AWS D1.1/D1.1M:2020 6.2.3 are met. Should the 36-month period elapse while welding on the project, the Supplemental Welder Qualification for Restricted Access Welding qualification shall remain valid unless there is a specific reason to question the welder's ability.

5.3 Welder Performance Qualification Record Information

Welder Performance Qualification Records for the Supplemental Welder Qualification for Restricted Access Welding test described in Annex D shall, as a minimum, provide all applicable essential variables contained in Table 6.12 of AWS D1.1/D1.1M:2020, and the following:

- (1) Type of backing, if used
- (2) Maximum root opening (if steel backing is not used)
- (3) Minimum groove angle (if steel backing is not used)
- (4) Maximum deposition rate

6. Fabrication

This clause addresses the requirements for the filler metals; weld metal; welding procedure specifications (WPSs); fabrication details, welding, and repair of specific welded joints; and specific prohibitions and repairs in the Protected Zone; as used in the Seismic Force Resisting System (SFRS).

This part contains one clause:

Part A—Filler Metal and Weld Metal

Part B—Additional Requirements for Demand Critical Filler Metal and Weld Metal

Part C—Welding Procedure Specifications

Part D—Details

Part E—Protected Zone

Part A *Filler Metal and Weld Metal*

This part addresses the requirements for the filler metals and weld metal used in the Seismic Force Resisting System (SFRS). Additional requirements for Demand Critical filler metal and weld metal are addressed in Part B.

This part contains one clause:

6.1 Filler Metal and Weld Metal

6.1 Filler Metal and Weld Metal

All welds governed by this code shall comply with all the requirements of 6.1. The requirements of 6.2.1, 6.2.2, 6.2.3, and 6.3.1 shall apply only to Demand Critical welds.

6.1.1 AWS A5 Specification Properties. Filler metals shall meet the requirements of Table 6.1 as determined from testing in accordance with the applicable AWS A5 specification.

6.1.2 Diffusible Hydrogen Level. All welding electrodes and electrode-flux combinations shall meet the requirements of Table 6.2.

6.1.3 Certification of AWS A5 Specification Properties and Diffusible Hydrogen. The manufacturer's typical Certificate of Conformance shall be considered adequate proof that the supplied electrode or electrode-flux combination meets the requirements of 6.1.1 and 6.1.2. Testing of filler metal samples or of production welds shall not be required.

6.1.4 Intermix of FCAW-S Filler Metal. When FCAW-S filler metals are used in combination with filler metals for other processes, including FCAW-G, supplemental notch toughness testing shall be conducted in accordance with Annex B.

Part B

Additional Requirements for Demand Critical Filler Metal and Weld Metal

This part addresses the additional requirements for the filler metals and weld metal used for welds designated as Demand Critical welds in the Seismic Force Resisting System (SFRS). Requirements for all filler metals and weld metal used on the SFRS are addressed in Part A.

This part is organized as follows:

6.2 Heat Input Envelope

6.3 Production Lot Control

6.4 FCAW Electrode Packaging, Storage, and Exposure

6.2 Heat Input Envelope

6.2.1 WPS Heat Input Envelope Testing Properties. Filler metals for Demand Critical welds shall provide the mechanical properties in Table 6.3, based upon the WPS Heat Input Envelope Testing prescribed in Annex A, except the filler metals shown in Table 6.4 shall be exempt from the testing prescribed in Annex A when LAST is equal to or greater than 50°F [10°C].

6.2.2 Lowest Anticipated Service Temperature Applications. For Demand Critical welds in applications where the Seismic Force Resisting System is subjected to service temperatures below 50°F [10°C] following completion of the structure, the minimum CVN of 40 ft·lbf [54 J] as prescribed by 6.2.1 shall be provided:

- (1) at a test temperature not more than 20°F [11°C] above the Lowest Anticipated Service Temperature for 70 ksi [490 MPa] and 80 ksi [550 MPa] filler metals, and
- (2) at LAST for 90 ksi [620 MPa] filler metals.

The exemptions in 6.2.1 and 6.3.4 shall not apply when LAST is less than 50°F [10°C].

6.2.3 Testing Source. The WPS Heat Input Envelope Testing of Filler Metals, required for Demand Critical welds and described in Annex A, shall be performed by the filler metal manufacturer, by the Contractor, or by a third party acceptable to the Engineer. The Contractor shall be responsible to ensure that this testing has been performed for the filler metals to be used, regardless of the testing source.

6.3 Production Lot Control

6.3.1 Production Lots

- (1) Production lots shall be as defined in AWS A5.01M/A5.01.
- (2) Production lots shall meet the following requirements:
 - (a) Class C3 or C4 for SMAW electrodes
 - (b) Class S3 or S4 for solid electrodes for GMAW and SAW
 - (c) Class T3 or T4 for FCAW and composite electrodes for GMAW and SAW
 - (d) Class F2 for SAW fluxes

6.3.2 Filler Metal Production Lot Testing. Each production lot of filler metal used to make Demand Critical welds shall be tested in conformance with

- (1) the applicable AWS A5 specification filler metal classification tests, and
- (2) Annex A.

6.3.3 Alternative to Filler Metal Production Lot Testing. Filler metals used to make Demand Critical welds shall be exempted from production lot testing, provided:

(1) a minimum of three different lots of material, as defined in 6.3.1, for each trade name and diameter to be used in production, are first tested in accordance with Annex A, and

(2) the filler metals have been produced by manufacturers audited and approved by one or more of the following agencies:

- (a) American Bureau of Shipping (ABS)
- (b) Lloyd's Register of Shipping
- (c) American Society of Mechanical Engineers (ASME)
- (d) U.S. Department of Defense
- (e) A quality assurance program acceptable to the Engineer

To remain exempt from production lot testing, the manufacturer shall perform the tests as described in Annex A on at least one production lot of material at a frequency not to exceed three years, for each trade name and diameter of electrode to be used in production.

6.3.4 Testing for Exemptions to Production Lot Testing

(1) For LAST greater than or equal to 50°F [10°C], filler metals listed in Table 6.4 shall be exempted from production lot testing when the CVN toughness of the weld metal deposited with the electrode equals or exceeds 20 ft-lbf [27 J] at a temperature not exceeding 0°F [−18°C], when tested in accordance with the applicable AWS A5 filler metal specification. The manufacturer's Certificate of Conformance shall be considered sufficient evidence of meeting this requirement.

(2) For LAST less than 50°F [10°C], the tests to support exemption from production lot testing for filler metals listed in Table 6.4 shall be conducted at a temperature not more than 20°F [11°C] above LAST for 70 ksi [490 MPa] and 80 ksi [550 MPa] filler metals, and at a temperature not more than LAST for 90 ksi [620 MPa] filler metals.

6.4 FCAW Electrode Packaging, Storage, and Exposure

The following provisions shall be applicable for Demand Critical welds:

6.4.1 Packaging Condition. Electrodes shall be provided in protective packaging that limits the ability of the electrode to absorb moisture. When removed from the packaging, the electrode shall be capable of depositing weld metal with a maximum diffusible hydrogen content not to exceed the limits of 6.1.2. Electrode from packaging that has been punctured or torn shall be dried in accordance with the electrode manufacturer's recommendations, or shall not be used for Demand Critical welds.

6.4.2 Modification of Electrodes. Modification or lubrication of the electrode after manufacture is prohibited, except that drying as recommended by the manufacturer is permitted.

6.4.3 Exposure Time Limits for FCAW Electrodes. After removal from protective packaging, the permissible atmospheric exposure time of FCAW electrodes shall be limited as follows:

(1) Exposure shall not exceed the electrode manufacturer's guidelines, when the guidelines are based upon electrode exposure tests conducted in accordance with Annex E.

(2) In the absence of test data required in (1), the electrode may be tested in accordance with Annex E, and the results of such tests used as the basis for the exposure limits.

(3) In the absence of test data prescribed by (1) or (2), the total accumulated exposure time for FCAW electrodes shall not exceed 72 hours. Storage time in a protective package or cabinet shall not be included in the accumulated exposure time.

6.4.4 Overexposed FCAW Electrode. Electrodes that have been exposed to the atmosphere for periods that exceed the limits of 6.4.3 shall be dried in accordance with the electrode manufacturer's recommendations, or shall not be used for Demand Critical welds. The electrode manufacturer's recommendations shall include time, temperature, and number of drying cycles permitted.

Part C

Welding Procedure Specifications

This part addresses the requirements for the welding procedure specifications used to make welds in the Seismic Force Resisting System (SFRS).

This part is organized as follows:

6.5 Welding Processes

6.6 Welding Procedures Specifications (WPSs)

6.7 Maximum Interpass Temperature

6.8 Heat Input

6.9 Bottom Flange Welding Sequence

6.10 Welder Identification

6.5 Welding Processes

6.5.1 Approved Processes for Demand Critical Welds. SMAW, GMAW (except short circuit transfer), FCAW, and SAW may be used to make Demand Critical welds governed by this code.

6.5.2 Other Processes for Demand Critical Welds. Other processes may be used, provided that one or more of the following criteria is met:

- (1) The process is part of the prequalified connection details, as described in AISC 341;
- (2) The process is permitted for the connection in AISC 358;
- (3) The process was used to perform a satisfactory connection qualification test in accordance with AISC 341;
- (4) The process is approved by the Engineer.

6.6 Welding Procedure Specifications (WPSs)

6.6.1 General. WPSs shall be prequalified, or shall be qualified by test, in accordance with applicable AWS D1.1/D1.1M requirements and this code.

6.6.2 WPS Content. The WPS shall specify all applicable essential variables of AWS D1.1/D1.1M. For Demand Critical welds, the WPS shall additionally list the following essential variables:

- (1) Electrode manufacturer and trade name;
- (2) One or more combinations of variables that produce heat input limits listed in 6.8.1.

6.6.3 Air Velocity Limits

6.6.3.1 Gas-Shielded Processes. Welding with the GMAW and FCAW-G processes shall not be performed in winds exceeding 3 mph [5 kph]. Windscreens or shelters may be used to shield the welding operation from excessive wind.

6.6.3.2 Non Gas-Shielded Processes. SMAW, FCAW-S, and SAW may be performed without limitation to air velocity, provided the welds meet the visual acceptance criteria.

6.7 Maximum Interpass Temperature

6.7.1 Standard Maximum Interpass Temperature. The maximum interpass temperature shall not exceed 550°F [288°C], unless an alternate value is qualified in accordance with 6.7.2. The maximum interpass temperature shall be measured at a distance of 1 in to 3 in [25 mm to 75 mm] from the joint.

6.7.2 Alternative Maximum Interpass Temperature. The temperature limit of 6.7.1 may be increased by qualification testing. The qualification testing shall be performed in accordance with AWS D1.1/D1.1M. The maximum heat input to be used in production shall be used in the qualification testing. The qualified maximum interpass temperature shall be the lowest interpass temperature used for any pass during qualification testing. The weld metal and HAZ shall be tested. The weld metal shall meet all the mechanical properties required by 6.1.1 and 6.2.1, as applicable. The HAZ CVN toughness shall be tested in accordance with AWS D1.1/D1.1M:2020 Clause 6, Qualification, and shall meet the minimum requirement shown in Table 6.1 of this code with specimens taken at both 1 mm and 5 mm from the fusion line. The steel used for the qualification testing shall be of the same type and grade as will be used in production.

6.8 Heat Input

6.8.1 Heat Input Limits. Heat input limits on WPSs for Demand Critical welds shall be within the heat input range qualified by testing in accordance with Annex A.

6.9 Bottom Flange Welding Sequence

Complete joint penetration groove welds of beam bottom flanges to column flanges, or of beam bottom flanges to continuity plates, using weld access holes shall be sequenced as follows:

- (1) As far as is practicable, starts and stops shall not be directly under the beam web.
- (2) Each layer shall be completed across the full width of the flange before beginning the next layer.
- (3) For each layer, the weld starts and stops shall be on the opposite side of the beam web, as compared to the previous layer.

6.10 Welder Identification

The Contractor shall establish and implement a means by which the welder(s) welding on each joint can be identified and associated with the specific joint. Stamps, if used, shall be the low-stress type.

Part D Details

This part addresses the requirements for the fabrication details, welding, and repair of specific welded joints, as used in the Seismic Force Resisting System (SFRS).

This part is organized as follows:

6.11 Weld Access Holes

6.12 Tack Welding Requirements

6.13 Removal of Backing and Weld Root Treatment

6.14 Reinforcing Fillet Welds at Removed Weld Backing Locations

6.15 Fillet Welds at Left-in-Place Steel Backing

6.16 Weld Tabs

6.17 End Dams

6.11 Weld Access Holes

Weld access holes for all Demand Critical welds shall conform to the following:

6.11.1 Shape

6.11.1.1 Standard AWS D1.1/D1.1M Geometry. Unless otherwise specified in Contract Documents, all weld access holes shall meet the dimensions and tolerances of AWS D1.1/D1.1M or AISC 360. At the option of the Contractor, Figure 6.2 may be used.

6.11.1.2 Alternate Geometry. When alternate geometry is required by Contract Documents for beam-to-column moment connections, the weld access hole shall comply with Figure 6.2.

6.11.1.3 Special Geometry. When a special geometry is required by Contract Documents, the weld access hole geometry shall comply with the dimensions and tolerances specified.

6.11.2 Quality Requirements for Weld Access Holes

6.11.2.1 Surface Roughness. Except for access holes using AWS D1.1/D1.1M standard geometry, or when otherwise specified by the Engineer, the weld access hole finish shall have a surface roughness of not more than 500 μin [13 μm]. AWS C4.1, *Criteria for Describing Oxygen-Cut Surfaces, and Oxygen Cutting Surface Roughness Gauge*, Sample 4, may be used as a guide for evaluating surface roughness of these surfaces.

6.11.2.2 Notches and Gouges. Notches or gouges in the weld access hole, including those from thermal cutting and misaligned saw cuts, shall be removed by grinding, faired to a slope of not more than 1:5 against a straight cut surface, or to a radius of not less than 3/8 in [10 mm] if in the curved portion of the cut surface. The depth of notches and gouges that may be repaired by grinding is not limited, provided the final shape of the weld access hole meets the required dimensions, tolerances, and profiles.

6.11.2.3 Repair of Notches by Welding. Notches deeper than those that can be repaired by grinding (as defined in 6.11.2.2) may be repaired by welding. Prior to welding, the notch or gouge shall be ground to provide a smooth contour with a radius not less than 1/4 in [6 mm]. The repair area shall be preheated to a temperature of not less than 150°F [66°C]. A written repair WPS for this application shall be followed. Following completion of welding, the area shall be ground, and the overall area made smooth and flush to meet the contour and finish requirements for the access hole, with fairing of the welded surface to adjoining surfaces.

6.12 Tack Welding Requirements

6.12.1 Preheat. Preheat for all tack welds shall be as required by the WPS.

6.12.2 Placement of Tack Welds. In the Protected Zone, unless specifically required or permitted by the Engineer and shown on detail drawings, tack welds shall be prohibited outside the weld joint.

6.12.3 Tack Welds to Steel Backing in the Protected Zone. Tack welds between backing and the beam flange outside the weld joint shall be prohibited. Tack welds that attach steel backing to groove welds in the Protected Zone shall be placed within the weld joint, when practicable, with the following exception: steel backing may be tack welded to columns for beam flange to column flange welds.

6.12.4 Removal of Improperly Placed Tack Welds. Improperly placed tack welds shall be removed by grinding. Gouges or notches shall be repaired in accordance with 6.18.5.2.

6.13 Removal of Backing and Weld Root Treatment

When fusible (steel) backing is required to be removed, removal shall be by air carbon arc gouging (CAG), plasma arc gouging (PAG), grinding, chipping, or other thermal cutting processes. The process shall be controlled to minimize errant gouging. After backing removal (both for steel and nonfusible backing), the weld root shall be backgouged to sound metal. Backgouged joints shall be filled with weld metal, as necessary, to achieve at least a flush condition. The weld shall be deposited in accordance with an applicable WPS. Gouges that remain after any back welding or fillet welding is performed shall be repaired. Notches and gouges not greater than 1/16 in [1.5 mm] deep shall be faired to a slope not greater than 1:5. Deeper notches shall be repaired by welding in accordance with an applicable WPS.

6.14 Reinforcing Fillet Welds at Removed Weld Backing Locations

When reinforcing fillet welds are required at locations where steel backing has been removed, the minimum size shall be 5/16 in [8 mm]. The leg of the fillet adjacent to the beam flange shall be such that the fillet toe is located on base metal, except that if the back weld and base metal is ground smooth after removal of backing, the fillet need not extend to the base metal. See Figure 6.1.

6.15 Fillet Welds at Left-in-Place Steel Backing

6.15.1 Minimum Fillet Weld Size. When a fillet weld is required between the left-in-place steel backing and the column, the minimum size shall be 5/16 in [8 mm].

6.15.2 Prohibited Welds on Left-in-Place Steel Backing. Steel backing at beam flange to column flange joints shall not be welded to the underside of the beam flange. Tack welds shall not be permitted in this area.

6.16 Weld Tabs

6.16.1 Minimum Weld Tab Length. Where practicable, weld tabs shall extend a minimum of 1 in [25 mm] or the thickness of the part, whichever is greater, beyond the edge of the joint. Weld tab length need not exceed 2 in [50 mm]. Where there is inadequate access for weld tabs, such as with closely spaced pieces or pieces intersecting at acute angles, weld ends may be cascaded for approximately one weld size.

6.16.2 Tack Welds Attaching Weld Tabs. Tack welds attaching weld tabs in the Protected Zone shall be made within the joint, and shall meet the requirements of 6.12.

6.16.3 Weld Tab Removal—General. When weld tabs are required by Contract Documents to be removed, weld tabs shall be removed and the end of the weld finished. Removal shall be by air carbon arc gouging (CAG), grinding, chipping, or thermal cutting. The process shall be controlled to minimize errant gouging. The edges where weld tabs have been removed shall have a surface roughness of not more than 500 μin [13 μm]. AWS C4.1, *Criteria for Describing Oxygen-Cut Surfaces, and Oxygen Cutting Surface Roughness Gauge*, Sample 4, may be used as a guide for evaluating surface roughness of these surfaces. Grinding to a flush condition is not required. The contour of the weld shall provide a smooth transition, free of notches and sharp corners. At T-joints, a minimum radius in the corner need not be provided. The weld end shall be free of defects. Defects not greater than 1/16 in [1.5 mm] deep shall be removed by grinding and faired to a slope not greater than 1:5. Other defects shall be excavated and repaired by welding in accordance with an applicable WPS. See Figure 6.3.

6.16.4 Weld Tabs for Continuity Plates. Weld tabs for continuity plates shall not be used at the end of the weld adjacent to the column web-to-flange juncture, except when permitted or required by the Engineer. Unless specified to be removed by the Engineer, weld tabs shall not be removed when used in this location.

6.17 End Dams

6.17.1 Material. End dams may be metallic or nonmetallic.

6.17.2 Placement. End dams shall not be placed at either end of the weld joint, except as follows: end dams may be placed at the outboard ends of the weld tabs, provided the weld tabs are removed upon completion of the weld (see Figure 6.4).

Part E *Protected Zone*

This part addresses the requirements for specific prohibitions of attachments and erection aids, and for repairs in the Protected Zone; as used in the Seismic Force Resisting System (SFRS).

This part contains one clause:

6.18 Protected Zone

6.18 Protected Zone

6.18.1 Attachments and Welds. Welded attachments, including stud welds and fasteners for the connection of other materials, shall be prohibited within the Protected Zone. Arc spot welds (puddle welds) for the attachment of metal decking shall be permitted in the Protected Zone.

6.18.2 Erection Aids. If erection aids are required to be attached within the Protected Zone, the Contractor shall obtain the Engineer's approval for the use of such attachments.

6.18.3 Removal of Welds in Protected Zone. When welds in the Protected Zone are required to be removed, removal shall be by air carbon arc cutting (CAC-A), grinding, chipping, or other thermal cutting processes. The process shall be controlled to minimize errant gouging. After removal, the area shall be ground smooth and shall be free of defects.

6.18.4 Correction of Errors. If fillet welds or tack welds are placed between the backing and the beam flange in error, they shall be repaired as follows:

- (1) The weld shall be removed such that the fillet weld or tack weld no longer attaches the backing to the beam flange.
- (2) The surface of the beam flange shall be ground flush and shall be free of defects.
- (3) Any gouges or notches shall be repaired in accordance with 6.18.5.

6.18.5 Repair of Gouges and Notches. Gouges and notches in the Protected Zone shall be repaired as follows:

6.18.5.1 Grinding. When gouges and notches are repaired by grinding, the ground area shall provide a gradual taper to the surface of the base metal. In the direction parallel to the member axis, the taper shall not be greater than 1:5. In the direction transverse to the member axis, the taper shall not be greater than 1:2.5.

6.18.5.2 Repair Welding of Gouges and Notches. When repairs require welding, the notch or gouge shall be removed and ground to provide a smooth radius of not less than 1/4 in [6 mm] in preparation for welding. Welding shall be done in accordance with an applicable WPS. Preheat shall be in accordance with AWS D1.1/D1.1M, but shall not be less than 150°F [66°C]. Electrodes shall comply with 6.1. Following welding, the repair weld shall be ground to a smooth contour with a surface roughness not to exceed 500 µin [13 µm]. AWS C4.1, *Criteria for Describing Oxygen-Cut Surfaces, and Oxygen Cutting Surface Roughness Gauge*, Sample 4, may be used as a guide for evaluating surface roughness of these surfaces. After repair, the area shall be inspected using magnetic particle testing (MT). The resultant thickness of the repaired area shall be at least the base metal thickness less 1/16 in [1.5 mm].

6.18.6 Repair of Mislocated Holes. Where the Engineer requires welded restoration of holes in the Protected Zone, a procedure shall be developed by the Contractor and approved by the Engineer. The procedure shall include an appropriate WPS with a minimum preheat of 150°F [66°C], a requirement to grind the weld reinforcement surface flush as defined in AWS D1.1/D1.1M:2020 Clause 7, and verification of the soundness of the weld using both magnetic particle testing and ultrasonic testing.

6.18.7 Repair of Mislocated Stud Welds. Mislocated studs in the Protected Zone shall be cut off and ground flush.

6.18.8 Repair of Mislocated Screws and Shot Pins. Where mislocated pins or screws are required by the Engineer to be repaired by welding, a procedure shall be developed by the Contractor and approved by the Engineer. The procedure shall include an appropriate WPS with a minimum preheat of 150°F [66°C], and shall include the shape of the excavation to be restored by welding. Grinding or gouging shall be performed to the depth of the pin or screw. The welded surface shall be ground flush. The weld soundness shall be verified by both magnetic particle testing and ultrasonic testing.

Table 6.1
Filler Metal Mechanical Property Requirements (see 6.1.1)

Property	Classification Strength Levels		
	70 ksi [490 MPa]	80 ksi [550 MPa]	90 ksi [620 MPa]
Yield Strength, ksi [MPa] ^a	58 [400] min.	68 [470] min.	78 [540] min.
Tensile Strength, ksi [MPa]	70 [490] min.	80 [550] min.	90 [620] min.
Elongation (%)	22 min.	19 min.	17 min.
CVN Toughness, ft-lbf [J] ^b	20 [27] min. @ 0°F [−18°C]	20 [27] min. @ 0°F [−18°C]	25 [34] min. @ −20°F [−29°C]

^a 0.2% offset method.

^b Filler metals classified as meeting the required absorbed energy at a temperature lower than the required test temperature also meet this requirement.

Table 6.2
Diffusible Hydrogen Testing Requirements (see 6.1.2)

Process	Filler Metal Specification	Filler Metal Type	Standard Test	Optional Test
SMAW	A5.1/A5.1M	Carbon Steel	Moisture Content per AWS A5.1	H16 per AWS A4.3 ^a
	A5.5/A5.5M	Low Alloy	Moisture Content per AWS A5.5	
GMAW—solid electrode	A5.18/A5.18M	Carbon Steel	Exempt ^b	
	A5.28/A5.28M	Low Alloy	Exempt ^b	
GMAW— composite (metal cored) electrode	A5.18/A5.18M	Carbon Steel	H16 per AWS A4.3	None
	A5.28/A5.28M	Low Alloy	H16 per AWS A4.3	None
FCAW	A5.20/A5.20M	Carbon Steel	H16 per AWS A5.20	None
	A5.29/A5.29M	Low Alloy	H16 per AWS A5.29	None
SAW	A5.17/A5.17M	Carbon Steel	H16 per AWS A4.3	None
	A5.23/A5.23M	Low Alloy	H16 per AWS A4.3	None
EGW with solid electrodes	A5.26/A5.26M	Carbon Steel and Low Alloy	Exempt ^b	
EGW with composite electrodes	A5.26/A5.26M	Carbon Steel and Low Alloy	N/A	As agreed upon between the Contractor and the Engineer. ^c
ESW	A5.25/A5.25M	Carbon Steel and Low Alloy	N/A	As agreed upon between the Contractor and the Engineer. ^c

^a These optional tests may be used in lieu of the standard tests, at the option of the Contractor.

^b These filler metals are exempt from any measurement to determine hydrogen content.

^c There is no standard test for measuring diffusible hydrogen for these filler metals.

Table 6.3
Mechanical Property Requirements for Demand Critical Welds (see 6.2.1)

Property	Classification Strength Levels		
	70 ksi [490 MPa]	80 ksi [550 MPa]	90 ksi [620 MPa]
Yield Strength, ksi [MPa] ^a	58 [400] min.	68 [470] min.	78 [540] min.
Tensile Strength, ksi [MPa]	70 [490] min.	80 [550] min.	90 [620] min.
Elongation (%)	22 min.	19 min.	17 min.
CVN Toughness, ft-lbf [J] ^{b,c}	40 [54] min. @ 70°F [21°C]	40 [54] min. @ 70°F [21°C]	40 [54] min. @ 50°F [10°C]

^a 0.2% offset method.

^b For LAST of 50°F [10°C]. For LAST less than 50°F [10°C], see 6.2.2.

^c Tests conducted in accordance with Annex A meeting 40 ft-lbf [54 J] min. at a temperature lower than the required test temperature also meet this requirement.

Table 6.4
Filler Metal Classifications Exempt From Heat Input Envelope Testing
When LAST ≥ 50°F [10°C] (see 6.2.1)

AWS Filler Metal Specification		Process	Classification Strength		Electrode Classification	
U.S. Customary Units	SI Units		ksi	MPa	U.S. Customary Units	SI Units
A5.1	A5.1M	SMAW	70	490	E7018 E7018-1	E4918 E4918-1
A5.5	A5.5M	SMAW	70 80	490 550	E7018-C3L E8018-C3	E4918-C3L E5518-C3
A5.18	A5.18M	GMAW	70	490	ER70S-X	ER49S-X
A5.28	A5.28M	GMAW	80	550	ER80S-NiX	ER55S-NiX

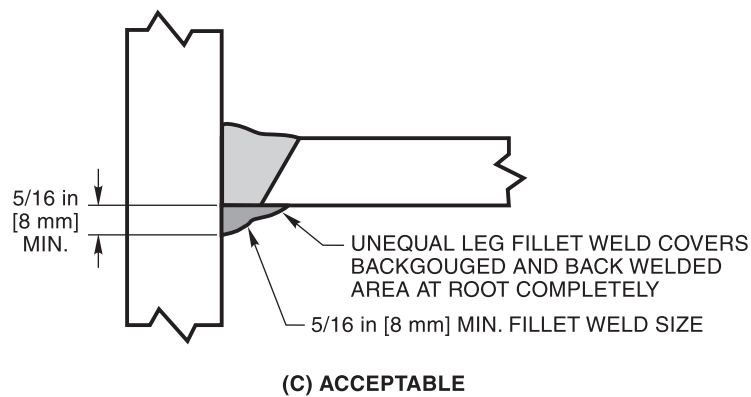
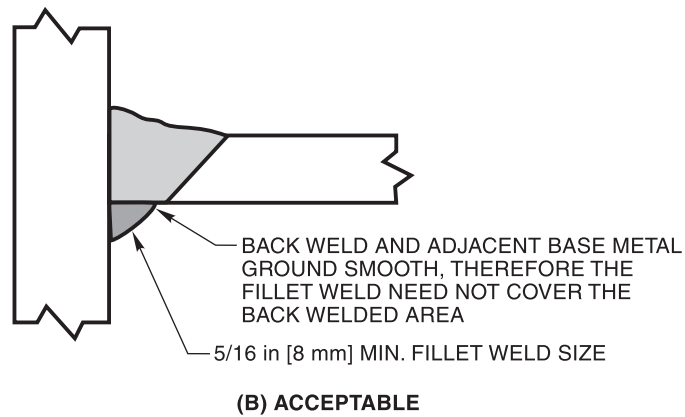
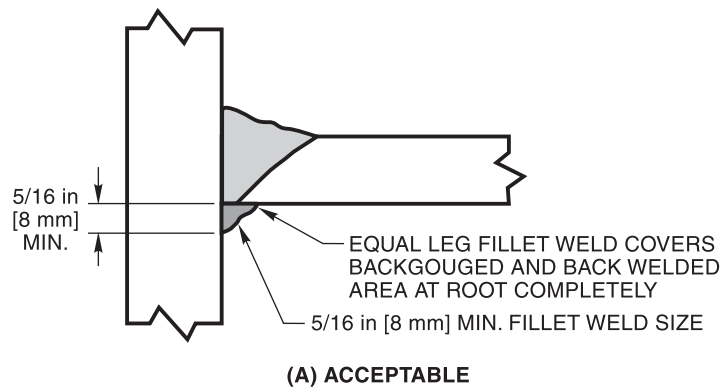
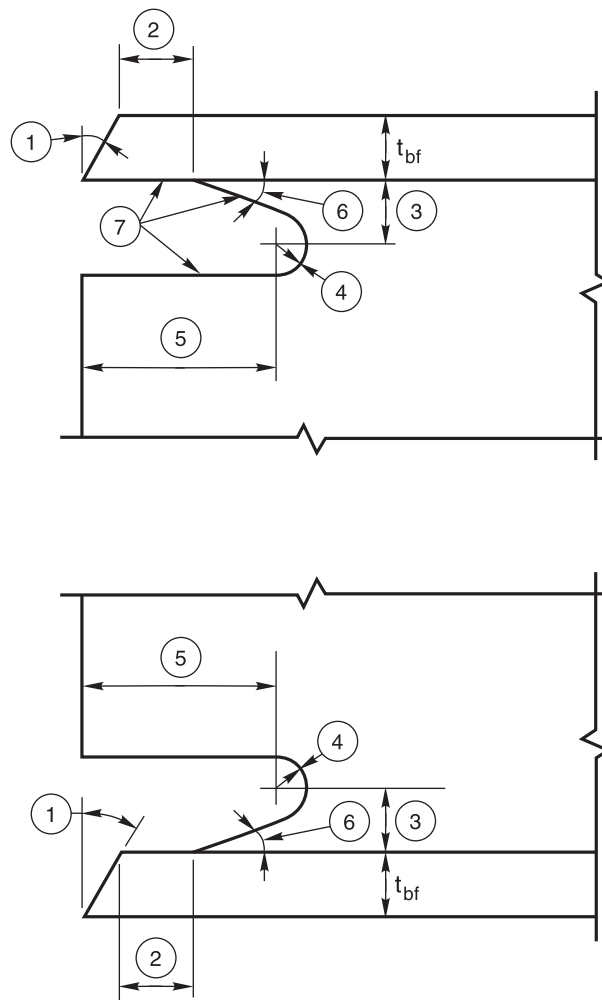
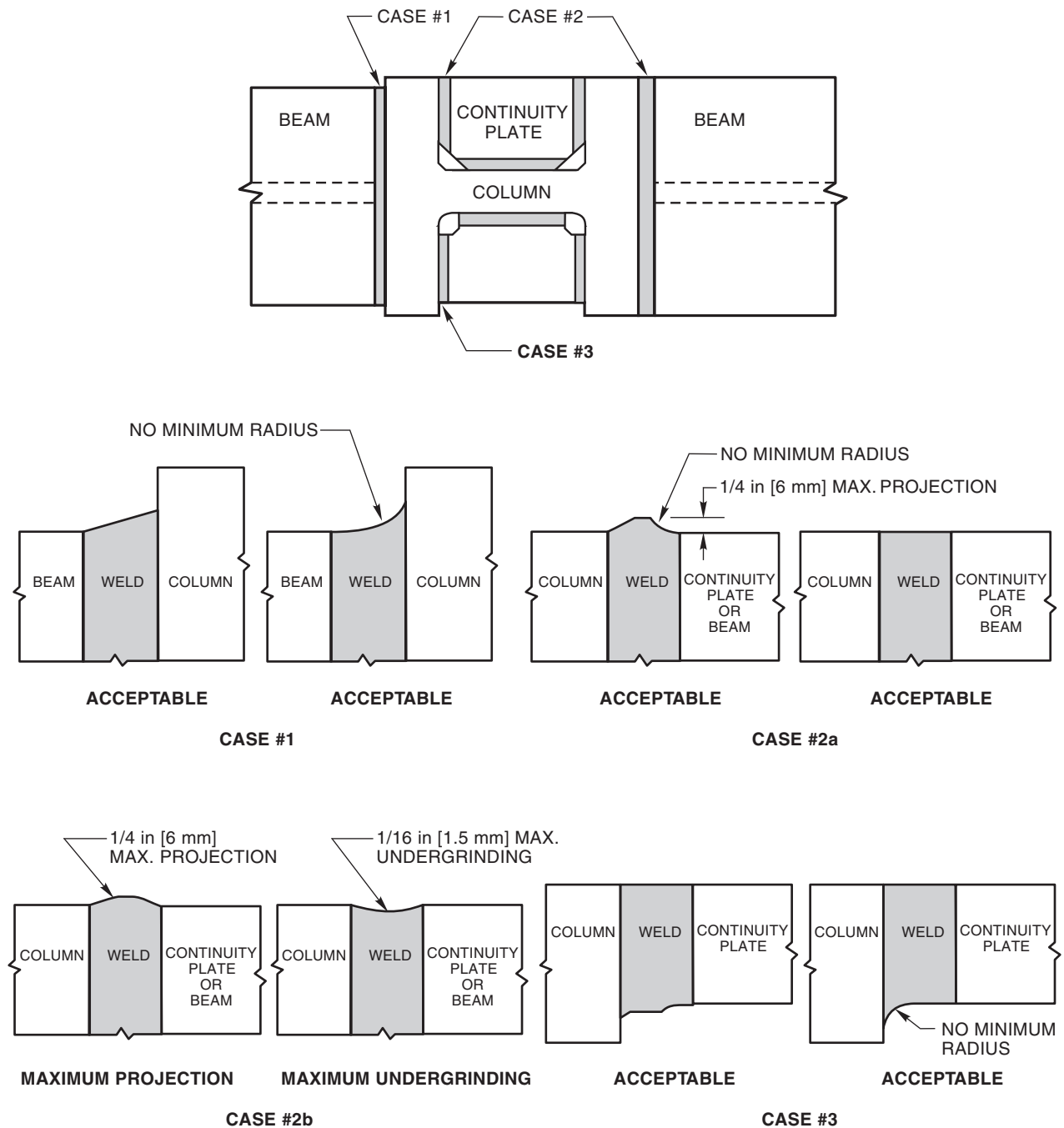


Figure 6.1—Reinforcing Fillet Weld Requirements (see 6.14)



Item	Description	As Detailed	As Fabricated
1	Groove Angle	As required for WPS	
2	Distance from as-detailed weld toe to intersection of weld access hole and beam flange	t_{bf} or 1/2 in [12 mm], whichever is greater	$+0.5 t_{bf}$ $-0.25 t_{bf}$
3	Distance from inner surface of beam flange to working point of weld access hole radius	For $t_{bf} \leq 1$ in [25 mm], 3/4 in [20 mm]	$+1/4$ in [6 mm] -0
		For $t_{bf} > 1$ in [25 mm], 0.75 t_{bf} minimum, t_{bf} maximum	
4	Radius of curve	3/8 in [10 mm], minimum	+unlimited not less than 3/8 in [10 mm]
5	Distance from end of web member to working point of weld access hole radius	3 t_{bf} minimum	$\pm 1/2$ in [12 mm]
6	Angle at intersection of weld access hole and beam flange	25° maximum	+5° -unlimited
7	Surface roughness	see 6.11.2.1	

Figure 6.2—Alternate Geometry—Beam Flange Weld Access Hole Detail (see 6.11.1.2)



Note: All contours, thermal cuts exceeding 500 μin [13 μm] roughness shall be ground to 500 μin [13 μm] finish or smoother.

Figure 6.3—Acceptable Tab Removal Conditions (see 6.16.3)

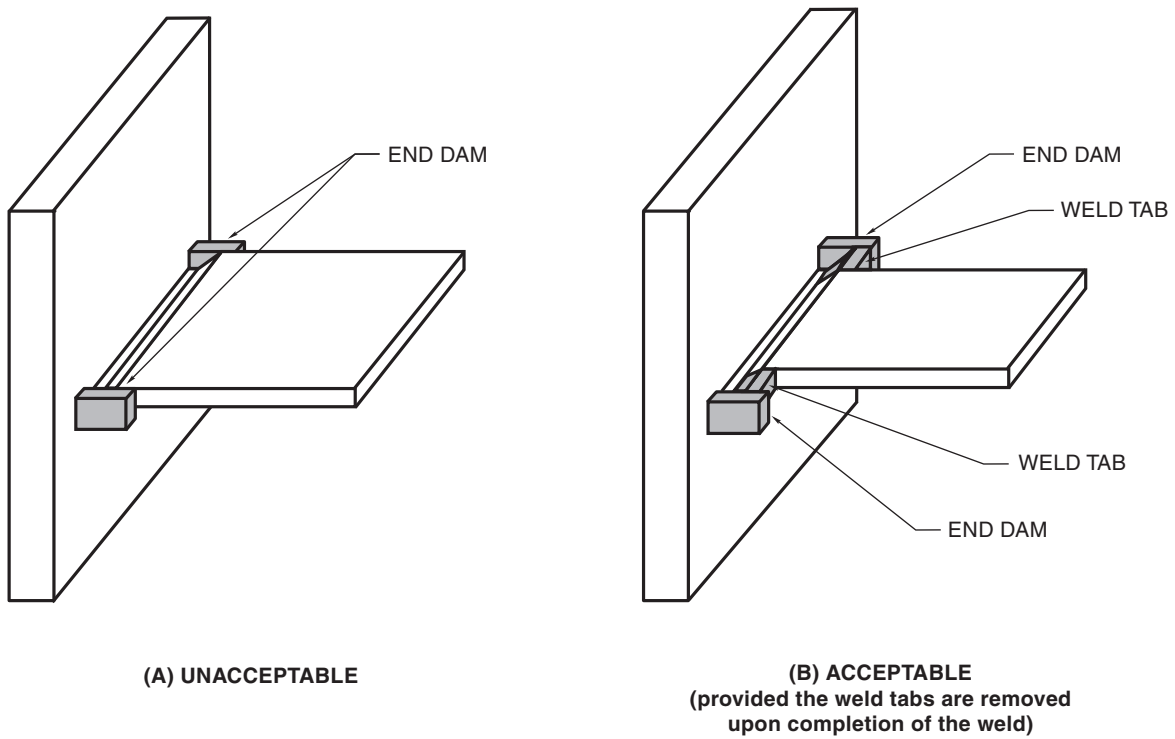


Figure 6.4—Acceptable and Unacceptable Use of End Dams (see 6.17.2)

This page is intentionally blank.