

AWS D1.4/D1.4M:2005
An American National Standard



Structural Welding Code— Reinforcing Steel



American Welding Society



Key Words—Allowable stress, inspection,
qualification, reinforcing steel,
structural details, welded joint details

AWS D1.4/D1.4M:2005
An American National Standard

Approved by the
American National Standards Institute
July 8, 2005

Structural Welding Code— Reinforcing Steel

Including
Metal Inserts and Connections
in Reinforced Concrete
Construction

Sixth Edition

Supersedes ANSI/AWS D1.4-98

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

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This code covers the requirements for welding reinforcing steel in most reinforced concrete applications. It contains a body of rules for the regulations of welding reinforcing steel and provides suitable acceptance criteria for such welds.



American Welding Society

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

International Standard Book Number: 0-87171-004-8
American Welding Society
550 N.W. LeJeune Road, Miami, FL 33126
© 2005 by American Welding Society
All rights reserved
Printed in the United States of America
Reprinted: November 2005

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 Use of AWS American National 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 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 guaranty or warranty as to the accuracy or completeness of any information published herein.

In issuing and making this standard available, AWS is not 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.

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, 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 Managing Director, Technical Services Division, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126 (see Annex C). With regard to technical inquiries made concerning AWS standards, oral opinions on AWS standards may be rendered. However, 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 required 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, 550 N.W. LeJeune Road, Miami, FL 33126.

This page is intentionally blank.

Personnel

AWS D1 Committee on Structural Welding

D. D. Rager, Chair	<i>Rager Consulting, Incorporated</i>
D. K. Miller, 1st Vice Chair	<i>The Lincoln Electric Company</i>
A. W. Sindel, 2nd Vice Chair	<i>Sindel and Associates</i>
J. L. Gayler, Secretary	<i>American Welding Society</i>
*W. G. Alexander	<i>WGAPE</i>
N. J. Altebrando	<i>Hardesty and Hanover, LLP</i>
F. G. Armao	<i>The Lincoln Electric Company</i>
E. M. Beck	<i>MACTEC Engineering & Consulting</i>
E. L. Bickford	<i>J. Ray McDermott, Incorporated</i>
*O. W. Blodgett	<i>The Lincoln Electric Company</i>
F. C. Breismeister	<i>Strocal, Incorporated</i>
B. M. Butler	<i>Walt Disney World Company</i>
H. H. Campbell III	<i>Pazuzu Engineering</i>
L. E. Collins	<i>Team Industries, Incorporated</i>
R. B. Corbit	<i>Amer Gen</i>
M. V. Davis	<i>Consultant</i>
R. A. Dennis	<i>Consultant</i>
*A. R. Fronduti	<i>Rex Fronduti and Associates</i>
M. A. Grieco	<i>Massachusetts Highway Department</i>
C. R. Hess	<i>High Steel Structures, Incorporated</i>
*G. J. Hill	<i>G. J. Hill and Associates, Incorporated</i>
M. L. Hoitomt	<i>Hoitomt Consulting Services</i>
C. W. Holmes	<i>Modjeski and Masters, Incorporated</i>
*A. J. Julicher	<i>A. J. Julicher and Associates</i>
J. H. Kiefer	<i>ConocoPhillips, Incorporated</i>
D. R. Lawrence II	<i>Butler Manufacturing Company</i>
S. L. Luckowski	<i>Department of the Army</i>
P. W. Marshall	<i>MHP Systems Engineering</i>
M. J. Mayes	<i>Mayes Testing Engineers, Incorporated</i>
D. L. McQuaid	<i>D L McQuaid and Associates, Incorporated</i>
R. D. Medlock	<i>Texas Department of Transportation</i>
*W. A. Milek, Jr.	<i>Consultant</i>
J. L. Munnerylyn	<i>Consultant</i>
J. E. Myers	<i>Consultant</i>
T. Niemann	<i>Minnesota Department of Transportation</i>
D. C. Phillips	<i>ITW, Hobart Brothers Company</i>
J. W. Post	<i>J. W. Post and Associates, Incorporated</i>
T. Schlafly	<i>American Institute of Steel Construction</i>
*D. A. Shapira	<i>Washington Group International</i>
R. E. Shaw, Jr.	<i>Steel Structures Technology Center, Incorporated</i>
*D. L. Sprow	<i>Consultant</i>
R. W. Stieve	<i>Greenman-Pederson, Incorporated</i>
P. J. Sullivan	<i>Massachusetts Highway Department (Retired)</i>
M. M. Tayarani	<i>Massachusetts Turnpike Authority</i>
K. K. Verma	<i>Federal Highway Administration</i>
B. D. Wright	<i>Advantage Aviation Technologies</i>

*Advisor

AWS D11 Subcommittee 9 on Reinforcing Steel

M. J. Mayes, Chair	<i>Mayes Testing Engineers, Incorporated</i>
J. K. Merrill, Vice Chair	<i>MACTEC Engineering & Consulting</i>
D. Gustafson	<i>Concrete Reinforcing Steel</i>
K. Landwehr	<i>Schuff Steel Company</i>
R. Miller	<i>State of Alaska DOT and PF</i>
J. Myers	<i>Consultant</i>
D. Scott	<i>PSI (retired)</i>

Foreword

This foreword is not a part of AWS D1.4/D1.4M:2005, *Structural Welding Code—Reinforcing Steel*, but is included for informational purposes only.

In 1961, the American Welding Society published its first reinforcing steel welding standard, AWS D12.1-61, *Recommended Practices for Welding Reinforcing Steel, Metal Inserts and Connections in Reinforced Concrete Construction*. The D12 Committee was disbanded some time after publication of the 1961 code and before publication of the 1975 edition.

The 1961 document was replaced with a greatly revised version, AWS D12.1-75, *Reinforcing Steel Welding Code*, with the format patterned after the AWS D1.1-72, *Structural Welding Code*. The 1975 code was produced by the AWS Structural Welding Committee but was not renumbered to reflect this committee change. As with ANSI/AWS D1.1, AWS D12.1-75 was designed as a self-contained code, including within it the qualification of welders and procedures, and requirements for workmanship, quality, and inspection.

The listings of materials and welding processes were revised in the D12.1-75 code. Items newly introduced were the carbon equivalent method for determining preheat, the parenthetical inclusion of metric (SI) conversions, and the two different methods of joint strength determination.

The AWS D12.1-75 document was revised and the title changed to ANSI/AWS D1.4-79, *Structural Welding Code—Reinforcing Steel*. Since the 1979 edition of ANSI/AWS D1.4, *Structural Welding Code—Reinforcing Steel*, was issued, further use by designers, engineers, and fabricators has necessitated a number of changes to the requirements; the 1992 and 1998 editions reflected these changes. This edition, AWS D1.4/D1.4M:2005, has additional revisions.

The following is a summary of the significant technical revisions in this edition:

Subsection 1.3.1—Deleted ASTM specifications from listed steels: ASTM A 184, A 185, A 497, A 616, and A6 17.

Table 5.2—Addresses bar sizes up to and including #6 [19] for C.E. over 0.75.

Section 5.4—New section added on weld cleaning.

Subsections to Section 6.3—Several subsections added to address welder qualification requirements and testing for fillet welds.

Subsection 7.7.3 and Section 7.9—Comprehensive approach for radiographic testing of reinforcing steel was added.

Annex A—Sample welding, testing, and inspection forms were updated.

Changes in Code Requirements. Technical and editorial changes in the text are indicated by underlining; changes to tables and figures are indicated by a single vertical line in the adjacent margin. Tables and figures have been revised, and two tables and one figure have been added.

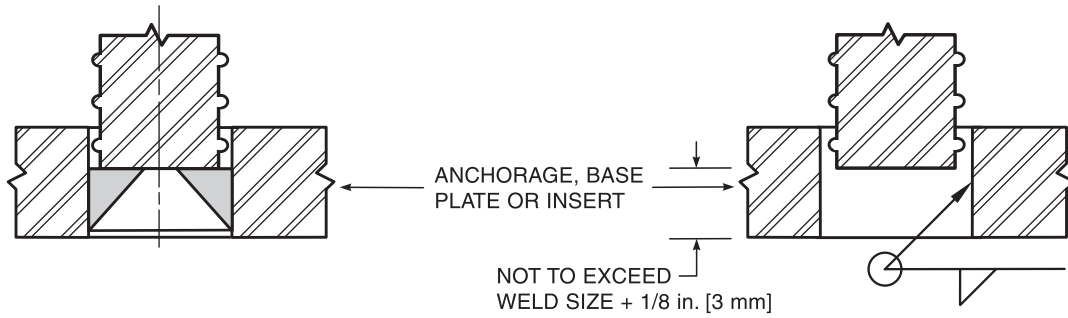
Errata. It is the Structural Welding Committee's Policy that all errata should be made available to users of the code. Therefore, in the Society News Section of the *AWS Welding Journal*, any errata (major changes) that have been noted will be published in the July and November issues of the *Welding Journal* and posted on the AWS website at: <http://www.aws.org/technical/d1/>.

Suggestions. Your comments for improving the *Structural Welding Code—Reinforcing Steel* are welcome. Submit comments to the Managing Director, Technical Services Division, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126; telephone (305) 443-9353; fax (305) 443-5951; e-mail info@aws.org; or via the AWS web site <<http://www.aws.org>>.

Errata

The following Errata have been identified and incorporated into the current reprint of this document.

Page 14—Figure 3.5, Detail C: figure on right side, upper dimension line for “NOT TO EXCEED WELD SIZE + 1/8 in. [3 mm]” moved down parallel to the bottom of the reinforcing bar.



(C) INTERNAL FILLET WELD

Table of Contents

	Page No.
<i>Personnel</i>	v
<i>Foreword</i>	vii
<i>Table of Contents</i>	ix
<i>List of Tables</i>	xi
<i>List of Figures</i>	xi
1. General Provisions	1
1.1 Scope.....	1
1.2 Application	1
1.3 Reinforcing Steel Base Metal	1
1.4 Welding Processes	2
1.5 Definitions	2
1.6 Welding Symbols	2
1.7 Safety Precautions	2
1.8 Standard Units of Measurement	2
1.9 <u>Reference Documents</u>	2
2. Allowable Stresses	5
2.1 Base-Metal Stresses	5
2.2 Allowable Stresses in Welds	5
2.3 Effective Weld Areas, Lengths, Throats, and Sizes	5
3. Structural Details	9
3.1 Transition in Bar Size	9
3.2 Eccentricity	9
3.3 Joint Types.....	9
3.4 Direct Butt Joints	9
3.5 Indirect Butt Joints.....	9
3.6 Lap Joints.....	9
3.7 Interconnection of Precast Members	9
4. Workmanship	17
4.1 Preparation of Base Metal	17
4.2 Assembly	17
4.3 Control of Distortion, Shrinkage, and Heat.....	17
4.4 Quality of Welds.....	17
5. Technique	21
5.1 Filler Metal Requirements	21
5.2 Minimum Preheat and Interpass Temperature Requirements	21
5.3 Arc Strikes	21
5.4 <u>Weld Cleaning</u>	21
5.5 Tack Welds	21
5.6 Progression of Welding	22
5.7 Welding of Coated Base Metal.....	22
5.8 SMAW Electrodes	22
5.9 Electrodes and Shielding Gas for Gas Metal Arc Welding (GMAW) and Flux Cored Arc Welding (FCAW)	23

List of Tables

Table	Page No.
2.1 Allowable Stresses in Welds	6
3.1 CJP Groove Weld Requirements for Direct Butt Joints	10
4.1 Radiographic Acceptance Criteria	18
5.1 Matching Filler Metal Requirements	24
5.2 Minimum Preheat and Interpass Temperatures	26
5.3 Permissible Atmospheric Exposure of Low-Hydrogen Electrodes	27
6.1 PQR Essential Variable Changes Requiring WPS Requalification for SMAW, GMAW, and FCAW	33
6.2 Number and Type of Tests for WPS Qualification	34
6.3 <u>Welder Qualification—Number, Type of Test, Production Welds, and Positions Qualified</u>	35
7.1 <u>Hole-Type Image Quality Indicator (IQI) Requirements</u>	48

List of Figures

Figure	Page No.
2.1 Effective Weld Sizes for Flare-Groove Welds	7
3.1 Direct Butt Joints Showing Transition Between Bars of Different Sizes	10
3.2 Direct Butt Joints	11
3.3 Indirect Butt Joints	12
3.4 Lap Joints	13
3.5 Details of Joints of Anchorages, Base Plates, and Inserts	14
4.1 Acceptable and Unacceptable Weld Profiles	19
4.2 Minimum Distance to Cold Bending Radius Tangent Points	20
6.1 Direct Butt Joint Test Positions for Groove Welds.....	36
6.2 Indirect Butt Joint Test Positions for Flare-Groove Welds or Fillet Welds.....	37
6.3 Positions of Groove Welds	38
6.4 Positions of Fillet Welds	39
6.5 Full Section Tension Test Specimens for WPS Qualification Tests.....	40
6.6 Full Section Tension Test and Macroetch Test Specimens for Welder Qualification Tests	42
7.1 <u>Source Position</u>	49
7.2 <u>Film Placement</u>	50
E.1 Temperature-Moisture Content Chart to be Used in Conjunction with Testing Program to Determine Extended Atmospheric Exposure Time of Low-Hydrogen Electrodes.....	66
E.2 Application of Temperature-Moisture Content Chart in Determining Atmospheric Exposure Time of Low-Hydrogen Electrodes	67

This page is intentionally blank.

Structural Welding Code— Reinforcing Steel

1. General Provisions

1.1 Scope

The code shall apply to the welding of:

1. Reinforcing steel to reinforcing steel, and
2. Reinforcing steel to carbon or low-alloy structural steel.

When the code is stipulated in contract documents, conformance with all provisions shall be required, except for those provisions that the Engineer or contract documents specifically modifies or exempts.

1.2 Application

1.2.1 This code shall be used in conjunction with the prescribed general building code requirements and is applicable to all welding of reinforcing steel, using the processes listed in 1.4, and performed as a part of reinforced concrete construction.

1.2.2 The weldments specified in this code shall not be used where impact properties are a requirement of the general specification. Impact testing requirements of welded reinforcing bars are not included in this code.

1.2.3 All references to the need for approval shall be interpreted to mean approval by the Engineer.

1.3 Reinforcing Steel Base Metal

1.3.1 Reinforcing steel base metal in this code shall conform to the requirements of the latest edition of one of the ASTM specifications listed within this paragraph. Combinations of any of these reinforcing steel base metals, when welded, shall use a WPS (welding procedure specification) qualified in conformance with Section 6.

1. ASTM A 82/A 82M
2. ASTM A 496/A 496M
3. ASTM A 615/A 615M
4. ASTM A 706/A 706M
5. ASTM A 767/A 767M
6. ASTM A 775/A 775M
7. ASTM A 934/A 934M

Manufacturing and testing requirements for mats and fabric are covered by the respective ASTM specification. For joining the ASTM A 82/A 82M and A 496/A 496M to other reinforcing wires, reinforcing bars, or structural steels, the Engineer shall specify filler metal and the provisions of this code shall apply.

1.3.2 When a reinforcing steel not listed in 1.3.1 is approved under the provisions of the general building code or by the Engineer, its chemical composition and carbon equivalent shall be provided and its weldability established by qualification in accordance with the requirements of 6.2 and all other requirements prescribed by the Engineer.

1.3.3 Base metal, other than those previously listed, shall be one of the structural steels listed in the latest edition of AWS D1.1, *Structural Welding Code—Steel*, or any steel stipulated in the contract documents or approved by the Engineer.

1.3.4 The carbon equivalent of reinforcing steel bars shall be calculated as shown in 1.3.4.1 or 1.3.4.2, as applicable.

1.3.4.1 For all steel bars, except those designated as ASTM A 706, the carbon equivalent shall be calculated using the chemical composition, as shown in the mill test report, by the following formula:

$$C.E. = \%C + \%Mn/6 \quad (\text{Eq. 1})$$