

AWS D14.3/D14.3M:2019  
An American National Standard

**Specification  
for Welding  
Earthmoving,  
Construction,  
Agricultural, and  
Ground-Based  
Material Handling  
Equipment**



*Second printing, September 2020*

**AWS D14.3/D14.3M:2019**  
**An American National Standard**

**Approved by the**  
**American National Standards Institute**  
**February 28, 2018**

# **Specification for Welding Earthmoving, Construction, Agricultural, and Ground-Based Material Handling Equipment**

**7th Edition**

**Supersedes AWS D14.3/D14.3M:2010**

Prepared by the  
American Welding Society (AWS) D14 Committee on Machinery and Equipment

Under the Direction of the  
AWS Technical Activities Committee

Approved by the  
AWS Board of Directors

## **Abstract**

This specification provides standards for producing structural welds used in the manufacture and repair of earthmoving, construction, agricultural, and ground-based material handling equipment. Such equipment is defined as self-propelled, on- and off-highway machinery and associated implements. Manufacturer's responsibilities are presented as they relate to the welding practices that have been proven successful within the industry in the production of weldments on this equipment. Requirements for basic weld details, base material, filler material, processes, welding procedure qualification and documentation, welding personnel qualification, weld quality, inspection, and repair are included.



ISBN Print: 978-0-87171-954-6  
ISBN PDF: 978-1-64322-023-9  
© 2018 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](http://www.copyright.com)>.

## Statement on the Use of American Welding Society Standards

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

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

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

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

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

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

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

Official interpretations of any of the technical requirements of this standard may only be obtained by sending a request, in writing, to the appropriate technical committee. Such requests should be addressed to the American Welding Society, Attention: Managing Director, Standards Development, 8669 NW 36 St, # 130, Miami, FL 33166 (see Annex F). 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 D14 Committee on Machinery and Equipment. 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 D14 Committee on Machinery and Equipment 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 D14 Committee on Machinery and Equipment 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 D14 Committee on Machinery and Equipment

J. E. Campbell, Chair	<i>Machinery &amp; Welder Corp</i>
B. K. Banzhaf, 1st Vice Chair	<i>CNH Industrial America LLC</i>
R. Larsen, 2nd Vice Chair	<i>John Deere Des Moines Works</i>
J. R. Douglass, Secretary	<i>American Welding Society</i>
D. B. Ashley	<i>Hartford Steam Boiler</i>
J. S. Bailey	<i>Vermeer Corporation</i>
S. L. Blankman	<i>ESAB Welding and Cutting Products</i>
F. D. Borns	<i>Terex</i>
T. J. Bruno	<i>Link-Belt Construction Equipment Co</i>
T. F. Gary	<i>Worthington Industries</i>
R. K. Goyal	<i>John Deere India</i>
S. A. Harris	<i>Altec Industries Inc</i>
D. D. Jones	<i>Texas Hydraulics Inc</i>
D. J. Landon	<i>Vermeer Corporation</i>
R. Leemans	<i>John Deere &amp; Co</i>
M. C. Lewis	<i>Liebherr Mining Equip Newport News Co</i>
T. McMurtrey	<i>Trinity Meyer Utilities</i>
D. K. Miller	<i>The Lincoln Electric Co</i>
D. W. Moers	<i>Keppel LeTourneau</i>
C. L. Rasmussen	<i>Brigham Young University-Idaho</i>
L. L. Schweinegruber	<i>Consultant</i>
J. D. Slipke	<i>Rosenboom</i>
P. T. Snyder	<i>The Raymond Corporation</i>
M. A. Stevenson	<i>Stevenson Fabrication Services Inc</i>
*E. G. Yevick	<i>Weld-Met International Group</i>

### Advisors to the AWS D14 Committee on Machinery and Equipment

P. Collins	<i>WeldCon Engineering</i>
T. J. Landon	<i>Chicago Bridge &amp; Iron Co</i>
P. J. Palzkill	<i>Consultant</i>
J. L. Warren	<i>Chicago Bridge &amp; Iron Co</i>

### AWS D14C Subcommittee on Earthmoving, Construction, and Agricultural Equipment

J. E. Campbell, Chair	<i>Machinery &amp; Welder Corp</i>
J. R. Douglass, Secretary	<i>American Welding Society</i>
J. S. Bailey	<i>Vermeer Corporation</i>
B. K. Banzhaf	<i>CNH Industrial America LLC</i>
S. L. Blankman	<i>ESAB Welding and Cutting Products</i>
F. D. Borns	<i>Terex</i>
T. J. Bruno	<i>Link-Belt Construction Equipment Co</i>
H. B. Craft	<i>Trinity Industries Inc</i>
G. D. Fairbanks	<i>Fairbanks Inspection &amp; Testing LLC</i>
S. A. Harris	<i>Altec Industries Inc</i>

D. J. Jones	<i>Texas Hydraulics Inc</i>
D. J. Landon	<i>Vermeer Corporation</i>
R. Larsen	<i>John Deere Des Moines Works</i>
R. Leemans	<i>John Deere &amp; Co</i>
T. McMurtrey	<i>Trinity Meyer Utilities</i>
C. L. Rasmussen	<i>Brigham Young University-Idaho</i>
J. D. Slipke	<i>Rosenboom</i>
P. T. Snyder	<i>The Raymond Corporation</i>
A. J. Thomas	<i>Caterpillar Inc</i>
*E. G. Yevick	<i>Weld-Met International Group</i>

**Advisors to the AWS D14C Subcommittee on Earthmoving and Construction Equipment**

R. M. Gneiting	<i>John Deere &amp; Co</i>
T. J. Landon	<i>Chicago Bridge &amp; Iron Co</i>
L. L. Schweinegruber	<i>Consultant</i>
R. T. Taylor	<i>Caterpillar Inc</i>
J. L. Warren	<i>Chicago Bridge &amp; Iron Co</i>

\*Deceased

## Foreword

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

AWS first published the Specification for Welding Earthmoving and Construction Equipment in 1977 to provide a welding specification where none previously existed. By definition, the types of equipment covered by the specification are numerous and varied. Every effort was made to reflect the best welding practices employed by manufacturers within the industry and to incorporate all the various methods which have proven successful by individual manufacturers. This edition builds on these foundations to improve interpretation and effect implementation. Text, tables, and figures have been updated or clarified to reflect more recent developments and promote standardization.

Underlined text or a vertical line in the margin indicates a revision of that item from the previous edition. Revisions to tables, figures, or annexes are marked with a vertical line in the margin.

Comments and inquiries concerning this standard are welcome. They should be sent to the Secretary, AWS D14 Committee on Machinery and Equipment, American Welding Society, 8669 NW 36 St, # 130 Miami, FL 33166.

This page is intentionally blank.

## Errata

The following Errata have been identified and are incorporated in this reprint.

Page 50, Figure 9.2 (D): replace “agngle” with “angle” in two places.

## Dedication

The AWS D14 Committee on Machinery and Equipment dedicates this edition of the D14.3/D14.3M, Specification for Welding Earthmoving, Construction, Agricultural, and Ground-Based Material Handling Equipment, to Edward G. Yevick for his significant contributions to the committee and his efforts to advance the science, technology and application of welding.

Ed joined AWS in 1963 and achieved the Life Membership Award with Gold Certificate for more than 51 years of service. He received the Samuel Wylie Miller Memorial Award in 2017 and the Honorary Membership Award in 2014. He served as technical representative for the AWS Pittsburgh Section for 15 years, and as chairman from 1980 to 1981. Ed was an active member of D14 Committee on Machinery and Equipment; D14B Subcommittee on Design of Welded Joints; D14C Subcommittee on Earthmoving, Construction, and Agricultural Equipment; D14E Subcommittee on Cranes and Presses; D14G Subcommittee on Rotating Equipment; D14I Subcommittee on Hydraulic Cylinders; and served as chairman of D14H Subcommittee on Surfacing of Industrial Mill Rolls. In addition to the Machinery and Equipment committee and subcommittees, Ed also served as chairman of the AWS D11 Committee on Welding Iron Castings and was serving his third term on the AWS Technical Activity Committee.

# Table of Contents

	<b>Page No.</b>
<i>Personnel</i> .....	v
<i>Foreword</i> .....	vii
<i>Dedication</i> .....	x
<i>List of Tables</i> .....	xiii
<i>List of Figures</i> .....	xiii
<b>1. General Requirements</b> .....	<b>1</b>
1.1 Scope .....	1
1.2 Units of Measure .....	2
1.3 Safety .....	2
1.4 Symbols .....	2
<b>2. Normative References</b> .....	<b>3</b>
<b>3. Terms and Definitions</b> .....	<b>3</b>
<b>4. Basic Weld Detail</b> .....	<b>4</b>
4.1 Groove Welds .....	4
4.2 Fillet Welds .....	4
4.3 Plug and Slot Welds .....	6
4.4 Combinations of Groove and Fillet Welds .....	6
4.5 Intermittent Welds .....	6
4.6 Weld Size Considerations .....	7
<b>5. Base Metals</b> .....	<b>7</b>
5.1 Structural Steels and Nonferrous Metals .....	7
5.2 Properties .....	8
5.3 Weldability and Welding Procedure Qualification .....	8
<b>6. Welding Processes and Consumables</b> .....	<b>8</b>
6.1 Processes .....	8
6.2 Consumables .....	8
<b>7. Welding Procedure Qualification</b> .....	<b>8</b>
7.1 Scope .....	8
7.2 General Requirements .....	11
7.3 Method I—Prototype Testing .....	17
7.4 Method II—Welding Procedure Qualification by Standard Testing Methods .....	18
7.5 Method III—Prequalified Welding Procedures .....	19
<b>8. Welding Personnel Qualification</b> .....	<b>40</b>
8.1 Scope .....	40
8.2 General .....	40
8.3 Welder <u>Performance</u> Qualification .....	41
8.4 Welding Operator Qualification .....	43
8.5 Operators of Automatic Welding Equipment .....	44
8.6 Qualification of Tack Welders .....	44
<b>9. Workmanship and Welding Quality Requirements</b> .....	<b>47</b>
9.1 Scope .....	47

9.2	General Requirements	47
9.3	Preparation of Materials	47
9.4	Assembly	47
9.5	Quality of Welds	49
9.6	Repair of Weld Defects	51
9.7	Cleaning	51
9.8	Dimensional Tolerance	52
<b>10.</b>	<b>Inspection</b>	<b>52</b>
10.1	Qualified Personnel	52
10.2	Nondestructive Examination	52
10.3	Weld Quality Levels	52
10.4	Conformance	52
10.5	Requalification	52
<b>11.</b>	<b>Field Repair and Modification</b>	<b>52</b>
11.1	General	52
11.2	Specific Instructions	52
11.3	Preheat	52
11.4	Qualified Personnel	52
11.5	Resources	52
	Annex A (Normative)—Prequalified Weld Joints	53
	Annex B (Informative)—Suggested Welding Procedure Specification and Qualification Test Record Forms	95
	Annex C (Informative)—Recommended Practices for Storage and Treatment of Electrodes and Fluxes	97
	Annex D (Informative)—Roadmap for Welding Procedure Specification (WPS) Development	101
	<u>Annex E (Informative)—Weld Break Test Samples</u>	103
	<u>Annex F (Informative)—Requesting an Official Interpretation on an AWS Standard</u>	107
	<u>Annex G (Informative)—Informative References</u>	109
	List of AWS Documents on Machinery and Equipment	111

## List of Tables

Table		Page No.
<u>4.1</u>	Z-Loss Dimensions (Nontubular) . . . . .	6
<u>4.2</u>	Z-Loss Dimensions for Calculating Prequalified PJP T-, Y-, and K-Tubular Connection Minimum Weld Sizes . . . . .	7
<u>7.1</u>	Weldability Classification—Typical Steel Products . . . . .	24
<u>7.2</u>	Base Metal/Filler Metal Strength Relationships . . . . .	24
<u>7.3</u>	Weldability Classification . . . . .	25
<u>7.4</u>	Minimum Preheat and Interpass Temperatures . . . . .	26
<u>7.5</u>	Filler Metal Requirements for Prequalified Complete Joint Penetration Groove Welds . . . . .	27
<u>7.5M</u>	Filler Metal Requirements for Prequalified Complete Joint Penetration Groove Welds . . . . .	32
<u>7.6</u>	Prequalified Joint Dimensions and Groove Angles for CJP Groove Welds in Tubular T-, Y-, and K-Connections Made by SMAW, GMAW-S, and FCAW . . . . .	37
<u>7.7</u>	Prequalified WPS Requirements . . . . .	38
<u>7.8</u>	Prequalified WPS Variables . . . . .	39
<u>7.9</u>	Minimum Single Pass Fillet Weld Size for Heat Input . . . . .	40
<u>7.10</u>	Minimum Weld Size for Partial Joint Penetration Groove Welds . . . . .	40
<u>8.1</u>	Welding Personnel Qualification—Type and Position Limitations . . . . .	41
C.1	Electrodes Covered by AWS A5.1/A5.1M, <i>Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding</i> . . . . .	98
C.2	Electrodes Covered by AWS A5.5/A5.5M, <i>Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding</i> . . . . .	98
D.1	Roadmap for Development of Welding Procedure Specifications (WPSs) . . . . .	101

## List of Figures

Figure		Page No.
<u>4.1</u>	Skewed Groove Weld . . . . .	5
<u>4.2</u>	Concave Fillet Weld Profiles . . . . .	5
<u>4.3</u>	Convex Fillet Weld Profiles . . . . .	5
<u>4.4</u>	Skewed T-Joint . . . . .	6
<u>4.5</u>	Combination of Bevel-Groove and Fillet Weld Profile . . . . .	7
<u>7.1</u>	Positions of Groove Welds . . . . .	13
<u>7.2</u>	Positions of Fillet Welds . . . . .	14
<u>7.3</u>	Positions of Test Plates for Groove Welds . . . . .	15
<u>7.4</u>	Positions of Test Plates for Fillet Welds . . . . .	16
<u>7.5</u>	Typical Micro Hardness Locations . . . . .	17
<u>7.6</u>	Weld Bead in which Depth and Width Exceed the Width of the Weld Face . . . . .	21
<u>8.1</u>	Examples of Workmanship Samples . . . . .	42
<u>8.2</u>	Fillet Weld Break Specimen—Tack Welder Qualification . . . . .	45
<u>8.3</u>	Groove Weld Break Specimen—Tack Welder . . . . .	45
<u>8.4</u>	Method of Rupturing Specimen—Tack Welder Qualification . . . . .	45
<u>8.5</u>	Method of Evaluating Tack Welder Qualification for Grooves . . . . .	46

9.1	<u>Workmanship Tolerances in Assembly of Groove Welded Joints</u> . . . . .	48
9.2	<u>Acceptable and Unacceptable Weld Profiles</u> . . . . .	50
A.1	<u>Prequalified Complete Joint Penetration Groove Welded Joints Details</u> . . . . .	54
A.2	<u>Prequalified Partial Joint Penetration Groove Welded Joints Details</u> . . . . .	75
A.3	<u>Details for Prequalified Fillet Welds of Shielded Metal Arc Welding (SMAW), Gas Metal Arc Welding (GMAW), Submerged Arc Welding (SAW), and Flux Cored Arc Welding (FCAW)</u> . . . . .	85
A.4	<u>Prequalified Joint Details for PJP T-, Y-, and K-Tubular Connections</u> . . . . .	86
A.5	<u>Fillet Welded Prequalified Tubular Joints Connections Made by SMAW, GMAW, and FCAW</u> . . . . .	87
A.6	<u>Prequalified Joint Details for CJP T-, Y-, and K-Tubular Connections</u> . . . . .	88
A.7	<u>Definitions and Detailed Selections for Prequalified CJP, T-, Y-, and K-Tubular Connections</u> . . . . .	89
A.8	<u>Prequalified Joint Details for CJP Groove Welds in Tubular T-, Y- and K-Connections-Standard Flat Profiles for Limited Thickness</u> . . . . .	90
A.9	<u>Prequalified Joint Details for CJP Groove Welds in Tubular T-, Y- and K-Connections-Profile with Toe Fillet for Intermediate Thickness</u> . . . . .	91
A.10	<u>Prequalified Joint Details for CJP Groove Welds in Tubular T-, Y-, and K-Connections-Concave Improved Profile for Heavy Sections or Fatigue</u> . . . . .	92
A.11	<u>Prequalified Skewed T-Joint Details (Nontubular)</u> . . . . .	93
E.1	<u>Fillet Weld Break Test Specimen</u> . . . . .	103
E.2	<u>PJP Flare Groove Weld Break Test Specimen</u> . . . . .	104
E.3	<u>Weld Break Test Specimen Welding Steps</u> . . . . .	104
E.4	<u>Weld Break Test Specimen Macro-Section</u> . . . . .	104
E.5	<u>Method for Testing Fillet Weld Break Test Specimen</u> . . . . .	104
E.6	<u>Method for Testing Flare Groove Weld Break Test Specimen</u> . . . . .	105
E.7	<u>Method for Testing Flare Bevel Weld Break Test Specimen</u> . . . . .	105

# Specification for Welding Earthmoving, Construction, Agricultural, and Ground-Based Material Handling Equipment

## 1. General Requirements

**1.1 Scope.** This specification applies to all structural welds used in the manufacture and repair of earthmoving, construction, agricultural, and ground-based material handling equipment.<sup>1</sup> It reflects the welding practices employed by manufacturers within the industry and incorporates various methods which have been proven successful by individual manufacturers. No restrictions are placed on the use of any welding process or procedure, provided the weld produced meets the qualification requirements of this specification. No attempt is made to limit or restrict the progression of welding technology for earthmoving, construction, agricultural, and/or ground-based material handling equipment manufacturing and repair, nor should any such limitation be inferred. Design criteria for allowable stresses for the base and weld metal and the fatigue analysis for welded joints are not published in the specification. The user shall utilize AWS D14.4/D14.4M, *Specification for the Design of Welded Joints in Machinery and Equipment*, or appropriate engineering practices and principles for design criteria.

**1.1.1** The Manufacturer's adherence to this specification shall include responsibility for the following:

- (1) welding, as defined in 1.1.1, in accordance with this specification;
- (2) producing welds as designated on drawings by appropriate symbols and notes, with sufficient detail to show joint preparation compatible with applied processes;
- (3) providing and using written Welding Procedure Specifications (WPSs);
- (4) ensuring that qualified welders are used to make welds;
- (5) recording and maintaining results of all welder performance and procedure qualification tests;
- (6) controlling use of designated base metals and consumables;
- (7) inspecting the welds to the requirements of this specification;
- (8) having a quality system in place. The requirements of AWS B5.17, *Specification for the Qualification of Welding Fabricators* may be used as a guide in establishing this quality program. Accreditation of quality systems of welding fabricators may be obtained through the AWS Certified Welding Fabricator (CWF) or equivalent programs.
- (9) determining the responsible technical authority when the term "Engineer" is used. If the Owner wants to assume engineering responsibility, it shall be specified in the contract documents.

<sup>1</sup> For purposes of this specification, earthmoving, construction, agricultural, and ground-based material handling equipment are described as on- and off-highway machinery and associated implements, as well as support equipment such as conveyors. Products that this specification covers include, but are not limited to, crawlers, tractors, graders, loaders, off-highway trucks, power shovels, backhoes, mobile cranes, draglines, forklifts, power trucks, and similar equipment. Products such as gantry and jib cranes are not within the scope of this specification.