

**AWS D15.1/D15.1M:2012-AMD1**  
**An American National Standard**



# **Railroad Welding Specification for Cars and Locomotives**



**American Welding Society®**



*second printing, October 2013*



**AWS D15.1/D15.1M:2012-AMD1  
An American National Standard**

**Approved by the  
American National Standards Institute  
April 18, 2012  
Amendment: August 30, 2013**

# **Railroad Welding Specification for Cars and Locomotives**

**5th Edition**

**Supersedes AWS D15.1/D15.1M:2007**

Prepared by the  
American Welding Society (AWS) D15 Committee on Railroad Welding

Under the Direction of the  
AWS Technical Activities Committee

Approved by the  
AWS Board of Directors

## **Abstract**

This specification establishes minimum standards for the manufacture and maintenance of railroad equipment. Clauses 4 through 17 cover the general requirements for welding in the railroad industry. Clauses 18 through 24 cover specific requirements for the welding of base metals thinner than 1/8 in [3 mm].



**American Welding Society®**

---

ISBN-13: 978-0-87171-813-6  
© 2012 by American Welding Society  
All rights reserved  
Printed in the United States of America  
Amendment: 2nd Printing, October 2013

**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 the AWS administers the process and establishes rules to promote fairness in the development of consensus, it does not independently test, evaluate, or verify the accuracy of any information or the soundness of any judgments contained in its standards.

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

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

This standard may be superseded by the issuance of new editions. This standard may also be corrected through publication of amendments or errata. It may also be supplemented by publication of addenda. Information on the latest editions of AWS standards including amendments, errata, and addenda are 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.

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

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

Official interpretations of any of the technical requirements of this standard may only be obtained by sending a request, in writing, to the appropriate technical committee. Such requests should be addressed to the American Welding Society, Attention: Managing Director, Technical Services Division, 8669 NW 36 St, # 130, Miami, FL 33166 (see Annex G). 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 D15 Committee on Railroad 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 D15 Committee on Railroad 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 D15 Committee on Railroad 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 (Amendment)

### AWS D15 Committee on Railroad Welding

M. R. Untermeyer, Chair	<i>Union Tank Car Company</i>
M. A. Forsstrom, 1st Vice Chair	<i>Greenbrier Rail Services</i>
T. M. Nelson, 2nd Vice Chair	<i>LTK Engineering Services</i>
S. N. Borrero, Secretary	<i>American Welding Society</i>
D. M. Allbritten	<i>General Electric—Rail</i>
R. C. Bly	<i>TTX Company—SRD</i>
C. Boulden	<i>Trinity Industries, Incorporated</i>
L. B. Broadway	<i>American Railcar Industries</i>
N. S. Brown	<i>Canadian Pacific Railway</i>
P. A. Burys	<i>Raul V. Bravo &amp; Associates</i>
R. A. Conrad	<i>Hobart Brothers</i>
D. S. Galda	<i>ITW Welding North America</i>
C. J. Gamblin	<i>Watco Companies</i>
J. Haacke	<i>Motive Power</i>
T. E. Hawkins	<i>NAVISTAR</i>
S. J. Hopper	<i>Union Tank Car Company</i>
D. S. Lassen	<i>Greenbrier Rail Services</i>
N. Lindell	<i>Oregon Iron Work</i>
S. J. McCullough	<i>Alltranstek, LLC</i>
C. L. Meeker	<i>GE Railcar Repair</i>
J. B. Pearson Jr.	<i>LTK Engineering Services</i>
T. Schmidt	<i>ECE Global</i>
B. E. Senior	<i>National Steel Car Limited NSC</i>
B. W. Siebold	<i>BNSF Railway Company</i>
D. M. Smook	<i>Midwest Railcar Repair, Incorporated</i>
T. D. Spry	<i>Electro Motive Diesel, Incorporated</i>
G. J. Stahle	<i>NAVISTAR</i>
L. H. Strouse	<i>U.S. Department of Transportation</i>
Z. Tanacs	<i>National Steel Car Limited NSC</i>
A. Willaredt	<i>American Railcar Industries</i>

### Advisors to the AWS D15 Committee on Railroad Welding

B. C. Blackwell	<i>Standard Car Truck Company</i>
W. Blamire	<i>Norfolk Southern Corporation</i>
J. L. Cooley	<i>J. C. &amp; Associates, Incorporated</i>
S. A. Coughlin	<i>Consultant</i>
W. Jaxa-Rozen	<i>Bombardier Transportation</i>
B. E. Lee	<i>Union Tank Car Company</i>
R. O. Thomure	<i>Sapa Extrusions</i>
D. A. Wright	<i>Wright Welding Technologies</i>

### AWS D15A Subcommittee on Cars and Locomotives

D. M. Allbritten, Chair	<i>General Electric—Rail</i>
B. W. Siebold, 1st Vice Chair	<i>BNSF Railway Company</i>

**AWS D15A Subcommittee on Cars and Locomotives (Continued)**

R. A. Conrad, 2nd Vice Chair	<i>Hobart Brothers</i>
S. N. Borrero, Secretary	<i>American Welding Society</i>
B. C. Blackwell	<i>Standard Car Truck Company</i>
R. C. Bly	<i>TTX Company—SRD</i>
C. Boulden	<i>Trinity Industries, Incorporated</i>
L. B. Broadway	<i>American Railcar Industries</i>
N. S. Brown	<i>Canadian Pacific Railway</i>
P. A. Burys	<i>Raul V. Bravo &amp; Associates</i>
M. A. Forsstrom	<i>Greenbrier Rail Services</i>
D. S. Galda	<i>ITW Welding North America</i>
C. J. Gamblin	<i>Watco Companies</i>
J. Haacke	<i>Trinity Rail Group</i>
T. E. Hawkins	<i>NAVISTAR</i>
S. J. Hopper	<i>Union Tank Car Company</i>
D. Knife	<i>Select-Arc</i>
D. S. Lassen	<i>Greenbrier Rail Services</i>
N. Lindell	<i>Oregon Iron Work</i>
S. J. McCullough	<i>Alltranstek, LLC</i>
C. L. Meeker	<i>GE Railcar Repair</i>
T. M. Nelson	<i>LTK Engineering Services</i>
M. E. Oddie	<i>Electro Motive Diesel, Incorporated</i>
J. B. Pearson, Jr.	<i>LTK Engineering Services</i>
T. Schmidt	<i>ECE Global</i>
B. E. Senior	<i>National Steel Car Limited NSC</i>
D. M. Smook	<i>Midwest Railcar Repair, Incorporated</i>
T. D. Spry	<i>Electro Motive Diesel, Incorporated</i>
G. J. Stahle	<i>NAVISTAR</i>
L. H. Strouse	<i>U.S. Department of Transportation</i>
Z. Tanacs	<i>National Steel Car Limited NSC</i>
M. R. Untermeyer	<i>Union Tank Car Company</i>
J. W. Weaver	<i>American Railcar Industries</i>
A. Willaredt	<i>American Railcar Industries</i>

**Advisors to the AWS D15A Subcommittee on Cars and Locomotives**

S. A. Coughlin	<i>Consultant</i>
W. Jaxa-Rozen	<i>Bombardier Transportation</i>
R. O. Thomure	<i>Sapa Extrusions</i>
D. A. Wright	<i>Wright Welding Technologies</i>

## Personnel (Original)

### AWS D15 Committee on Railroad Welding

M. R. Untermeyer, Chair	<i>Union Tank Car Company</i>
R. A. Wolbert, 1st Vice Chair	<i>Progress Rail Services Corporation</i>
J. B. Pearson Jr., 2nd Vice Chair	<i>LTK Engineering Services</i>
S. N. Borrero, Secretary	<i>American Welding Society</i>
D. M. Allbritten	<i>General Electric—Rail</i>
R. C. Bly	<i>TTX Company—SRD</i>
C. Boulden	<i>Trinity Industries, Incorporated</i>
L. B. Broadway	<i>American Railcar Industries</i>
N. S. Brown	<i>Canadian Pacific Railway</i>
R. A. Conrad	<i>Hobart Brothers</i>
S. A. Coughlin	<i>Consultant</i>
M. R. Desjardins	<i>National Steel Car Limited</i>
J. Haacke	<i>Trinity Rail Group</i>
D. S. Lassen	<i>Greenbrier Rail Services</i>
T. M. Nelson	<i>LTK Engineering Services</i>
B. W. Siebold	<i>BNSF Railway Company</i>
T. D. Spry	<i>Electro Motive Diesel, Incorporated</i>
L. H. Strouse	<i>U.S. Department of Transportation</i>
A. Willaredt	<i>American Railcar Industries</i>

### Advisors to the AWS D15 Committee on Railroad Welding

B. C. Blackwell	<i>Standard Car Truck Company</i>
W. Blamire	<i>Norfolk Southern Corporation</i>
J. L. Cooley	<i>J. C. &amp; Associates, Incorporated</i>
W. Jaxa-Rozen	<i>Bombardier Transportation</i>
M. MacGillivray	<i>Hobart Brothers of Canada Limited</i>
J. R. Murray	<i>TTX Company</i>
R. D. Stiffler	<i>United Industrial EMS</i>
D. A. Wright	<i>Wright Welding Technologies</i>

### AWS D15A Subcommittee on Cars and Locomotives

D. M. Allbritten, Chair	<i>General Electric—Rail</i>
B. W. Siebold, Vice Chair	<i>BNSF Railway Company</i>
S. N. Borrero, Secretary	<i>American Welding Society</i>
B. C. Blackwell	<i>Standard Car Truck Company</i>
R. C. Bly	<i>TTX Company—SRD</i>
C. Boulden	<i>Trinity Industries, Incorporated</i>
L. B. Broadway	<i>American Railcar Industries</i>
N. S. Brown	<i>Canadian Pacific Railway</i>
R. A. Conrad	<i>Hobart Brothers</i>
S. A. Coughlin	<i>Consultant</i>
M. R. Desjardins	<i>National Steel Car Limited</i>
M. A. Forsstrom	<i>Greenbrier Rail Services</i>
J. Haacke	<i>Trinity Rail Group</i>



**AWS D15A Subcommittee on Cars and Locomotives (Continued)**

D. Knife	<i>Select-Arc</i>
D S. Lassen	<i>Greenbrier Rail Services</i>
A. M. Lowe	<i>Trinity Rail Group</i>
T. M. Nelson	<i>LTK Engineering Services</i>
M. E. Oddie	<i>Electro Motive Diesel, Incorporated</i>
J. B. Pearson, Jr.	<i>LTK Engineering Services</i>
G. J. Stahle	<i>National Alabama Corporation</i>
T. D. Spry	<i>Electro Motive Diesel, Incorporated</i>
G. J. Stahle	<i>National Alabama Corporation</i>
L. H. Strouse	<i>U.S. Department of Transportation</i>
M. R. Untermeyer	<i>Union Tank Car Company</i>
J. W. Weaver	<i>American Railcar Industries</i>
A. Willaredt	<i>American Railcar Industries</i>
R. A. Wolbert	<i>Progress Rail Services Corporation</i>

**Advisors to the AWS D15A Subcommittee on Cars and Locomotives**

W. Jaxa-Rozen	<i>Bombardier Transportation</i>
K. R. Knarr	<i>FreightCar America, Incorporated</i>
M. A. Miller	<i>Norfolk Southern Corporation</i>
J. R. Murray	<i>TTX Company</i>
J. F. Sokolewicz	<i>Trinity Rail Group</i>
R. D. Stiffler	<i>United Industrial EMS</i>
D. A. Wright	<i>Wright Welding Technologies</i>

## Foreword

This foreword is not part of AWS D15.1/D15.1M:2012, *Railroad Welding Specification for Cars and Locomotives*, but is included for informational purposes only.

This specification establishes minimum standards for the manufacture and maintenance of railroad equipment. It was developed and is maintained by the D15 Committee on Railroad Welding of the American Welding Society.

Welding of railroad components is vital to the industry. An investigating committee was formed in 1982 which recommended a Railroad Welding Committee be formed to establish minimum welding standards for the industry. This recommendation was made because of confusion and incompleteness of the existing welding specifications and guides as applied to the railroad industry needs. The committee is made up of individuals from all segments of the railroad industry: both users and suppliers, the general public, and representatives of the Association of American Railroads.

The purpose of this specification is to provide a single comprehensive document of welding data that will be used throughout the railroad industry. Also, it should contribute to improvements in welding quality and performance. This document includes data from AWS D1.1/D1.1M, *Structural Welding Code—Steel*; AWS D1.2/D1.2M, *Structural Welding Code—Aluminum*; AWS D1.3/D1.3M, *Structural Welding Code—Sheet Steel*; and AWS D1.6/D1.6M, *Structural Welding Code—Stainless Steel*.

AWS D15.1-86 was titled simply *Railroad Welding Specification*. For the 1993 revision, the suffix *Cars and Locomotives* was added because the locomotive section had been introduced. A later revision was published in 2001, AWS D15.1:2001. The welding of rail is addressed in AWS D15.2, *Recommended Practice for the Welding of Rails and Related Rail Components for Use by Rail Vehicles*.

Several significant modifications have been made in AWS D15.1/D15.1M:2012. A vertical line in the margin indicates a revision from the 2007 edition. Limitations of essential variables for welding procedure qualification and welder performance qualification have been set up in table format (Tables 10.1 and 11.1, respectively). Friction stir welding has been included in the list of approved welding processes. Additional prequalified joint details for FCAW and GMAW have been added (see Figures 7.1G and 7.2A). Table 17.1 (Weld Crater Limitations) has been added. Clause 18 (Welding of Sheet Metal) has been revised.

Comments and suggestions for the improvement of this standard are welcomed. They should be sent to the Secretary, AWS D15 Committee on Railroad Welding, American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.

# Table of Contents

	Page No.
<i>Personnel (Amendment)</i> .....	v
<i>Personnel (Original)</i> .....	vii
<i>Foreword</i> .....	ix
<i>List of Tables</i> .....	xxi
<i>List of Figures</i> .....	xxii
<b>1. General Requirements</b> .....	1
1.1 Scope.....	1
1.2 Units of Measurement.....	1
1.3 Safety .....	1
<b>2. Normative References</b> .....	1
<b>3. Terms and Definitions</b> .....	4
<b>4. General Information</b> .....	5
<b>5. Requirements for All Welding</b> .....	6
5.1 Processes .....	6
5.2 Welding Procedure Qualification .....	6
5.3 Qualification of Welders and Welding Operators.....	6
5.4 Design of Welded Joints.....	7
5.5 Consumables .....	10
<b>6. Technique and Workmanship</b> .....	22
6.1 General.....	22
6.2 Preparation of Base Metal.....	22
6.3 Steel and Aluminum Assembly Criteria.....	24
6.4 Weld Profiles .....	25
6.5 Repairs—After Welding.....	25
6.6 Arc Strikes.....	26
6.7 Cleaning and Protective Coatings .....	26
6.8 Weld Termination.....	27
6.9 Groove Weld Backing .....	27
6.10 Heat Input Control for Quenched and Tempered Steel.....	27
6.11 Stress Relief Heat Treatment.....	27
6.12 Peening.....	27
6.13 Workmanship for Stud Arc Welding (SW) .....	28
6.14 Workpiece Leads .....	28
6.15 Welding Air Brake Pipe .....	28
<b>7. Prequalified Welding Procedure Specifications—Joint Design Details</b> .....	32
7.1 Groove Weld Size (Effective Weld Size) .....	32
7.2 Joint Designs .....	32
7.3 Fillet Welds.....	32
7.4 Details of Plug and Slot Welds.....	32
7.5 Complete Joint Penetration Groove Welds.....	33
7.6 Partial Joint Penetration Groove Welds.....	33

<b>8. Technique for Prequalified Welding Procedure Specifications</b> .....	64
8.1 Base Metal, Filler Metal, and Related Metal Requirements .....	64
8.2 Preheat, Interpass, and Postweld Heat Treatment (PWHT) Requirements .....	64
8.3 Shielded Metal Arc Welding (SMAW) .....	64
8.4 Submerged Arc Welding (SAW) .....	65
8.5 Gas Metal Arc and Flux Cored Arc Welding (GMAW and FCAW).....	67
8.6 Plug and Slot Welds .....	68
8.7 Welding Wear Plates and Wear Liners .....	69
<b>9. General Requirements for Qualification</b> .....	80
9.1 Prequalified Procedures.....	80
9.2 Qualified Procedures .....	80
9.3 Welders, Welding Operators, and Tack Welders .....	80
9.4 Qualification Responsibility.....	80
<b>10. Procedure Qualification</b> .....	81
10.1 Limitation of Essential Variables .....	81
10.2 Types of Tests and Purposes.....	81
10.3 Base Metal and Its Preparation.....	81
10.4 Position of Test Welds .....	81
10.5 Joint Welding Procedure Specification .....	83
10.6 Test Specimens: Number, Type, and Preparation.....	83
10.7 Special Test Conditions .....	85
10.8 Method of Testing Specimens .....	85
10.9 Test Results Required.....	86
10.10 Records.....	87
10.11 Retests .....	87
<b>11. Welder Qualification</b> .....	114
11.1 General .....	114
11.2 Limitation of Variables.....	114
11.3 Qualification Tests Required .....	114
11.4 Groove Weld Plate Qualification Test for Plate .....	114
11.5 Groove Weld Qualification Test for Pipe or Square or Rectangular Tubing.....	114
11.6 Fillet Weld Qualification Test for Fillet Welds Only .....	114
11.7 Position of Test Welds.....	115
11.8 Base Metal.....	115
11.9 Joint Welding Procedure Specification .....	115
11.10 Test Specimens.....	115
11.11 Method of Testing Specimens .....	115
11.12 Test Results Required.....	116
11.13 Retests .....	117
11.14 Period of Effectiveness.....	117
11.15 Records.....	117
<b>12. Welding Operator Qualification</b> .....	132
12.1 General .....	132
12.2 Limitation of Variables.....	132
12.3 Qualification Tests Required for Welding Operators .....	132
12.4 Base Metal.....	132
12.5 Joint Welding Procedure Specification .....	132
12.6 Test Specimens: Number, Type, and Preparation.....	132
12.7 Method of Testing Specimens .....	132
12.8 Test Results Required.....	132
12.9 Retests .....	132

12.10	Period of Effectiveness.....	133
12.11	Records.....	133
<b>13.</b>	<b>Tack Welder Qualification.....</b>	<b>135</b>
13.1	General.....	135
13.2	Limitation of Variables.....	135
13.3	Qualification Tests Required.....	135
13.4	Base Metal.....	135
13.5	Test Specimens: Number, Type, and Preparation.....	135
13.6	Method of Testing Specimens.....	135
13.7	Test Results Required.....	135
13.8	Retests.....	135
13.9	Period of Effectiveness.....	135
13.10	Records.....	135
<b>14.</b>	<b>Inspection—General Requirements.....</b>	<b>137</b>
14.1	Manufacturer’s Responsibility.....	137
14.2	Designated Inspector (Fabrication Inspector).....	137
14.3	Inspection of Welding.....	137
14.4	Weld Size and Location.....	137
14.5	Visual Inspection of Completed Welds.....	137
14.6	Documentation.....	137
14.7	Verification Inspection.....	137
14.8	Personnel Qualifications.....	138
<b>15.</b>	<b>NDE General Requirements.....</b>	<b>138</b>
15.1	Nondestructive Testing.....	138
<b>16.</b>	<b>NDE Methods.....</b>	<b>139</b>
16.1	Radiographic Testing of Groove Welds.....	139
16.2	Ultrasonic Testing of Groove Welds.....	139
16.3	Liquid Penetrant Testing of Welds.....	141
16.4	Magnetic Particle Testing of Welds.....	141
<b>17.</b>	<b>Acceptance Criteria.....</b>	<b>151</b>
17.1	Temporary Welds.....	151
17.2	Visual Inspection Acceptance Criteria.....	151
17.3	Radiographic Inspection Acceptance Criteria.....	151
17.4	Ultrasonic Inspection Acceptance Criteria.....	151
17.5	Liquid Penetrant Acceptance Criteria.....	151
17.6	Magnetic Particle Acceptance Criteria.....	151
<b>18.</b>	<b>Requirements for Welding Sheet Metal.....</b>	<b>154</b>
18.1	Design of Welded Joints.....	154
18.2	Joint and Procedure Qualification for Welding Sheet Metal.....	154
<b>19.</b>	<b>Welder, Welding Operator, and Tack Welder Qualification—Carbon, Low Alloy, and Stainless Steel Sheet Metals.....</b>	<b>165</b>
19.1	General.....	165
19.2	Limitation of Variables.....	165
19.3	Retests.....	165
19.4	Period of Effectiveness.....	165
<b>20.</b>	<b>Technique and Workmanship for Welding Sheet Metal.....</b>	<b>168</b>
<b>21.</b>	<b>Inspection of Welding Procedure Qualification and Equipment for Welding Sheet Metal.....</b>	<b>168</b>

	<b>Page No.</b>
<b>22. Weld Details—Sheet Metal</b> .....	168
22.1 Groove Welds (Butt Joints) .....	168
22.2 Fillet Welds.....	168
<b>23. Sheet Metal Weld Quality—Visual Inspection Acceptance Criteria</b> .....	168
Annex A (Normative)—Alternate Base Material Specifications (Steel).....	169
Annex B (Informative)—Filler Metal Classifications .....	171
Annex C (Informative)—Effective Weld Size—Special Cases.....	175
Annex D (Informative)—Sample Report Forms .....	179
Annex E (Informative)—Gage Thickness of Sheet Metal and Aluminum Filler Alloy Selection Guide.....	205
Annex F (Informative)—Macroetch Procedures .....	209
Annex G (Informative)—Guidelines for the Preparation of Technical Inquiries .....	213
List of AWS Documents on Railroad Welding.....	215

## List of Tables

Table	Page No.	
5.1	Minimum Weld Size for Partial Joint Penetration Groove Welds.....	12
5.2	Allowable Weld Stresses (Steel) .....	12
5.3	Allowable Weld Stresses (Aluminum).....	13
5.4	Minimum Mechanical Properties for Welded Aluminum Alloys (Gas Tungsten Arc or Gas Metal Arc Welding with No Postweld Heat Treatment).....	14
5.5	Minimum Mechanical Properties for Before Welding.....	15
5.6	Allowable Atmospheric Exposure of Low Hydrogen Electrodes .....	17
6.1	Limits on Acceptability and Repair of Cut Edge Discontinuities.....	29
6.2	Joint Dimension Tolerances .....	29
6.3	Maximum Exposure Time at Temperature Preparatory to Forming or Welding Aluminum Alloys .....	30
7.1	Minimum and Maximum Plug Diameter and Slot Width .....	34
7.2	Effective Size of Flare-Groove Welds Filled Flush.....	34
7.3	Minimum Fillet Weld Size .....	34
7.4	Legend for Figures 7.1A–7.1L and 7.2A–7.2K .....	35
8.1	Prequalified Base Metal—Filler Metal Combinations for Matching Strength .....	70
8.2	Prequalified Minimum Preheat and Interpass Temperature (Steel) .....	76
10.1	PQR Essential Variable Changes Requiring WPS Requalification for SMAW, SAW, GMAW, FCAW, and GTAW .....	88
10.2	Procedure Qualification—Number and Type of Specimens and Range of Thickness Qualified—Complete Joint Penetration Groove Weld.....	93
10.3	Procedure Qualification—Number and Type of Specimens and Range of Thickness Qualified—Partial Joint Penetration Groove Weld .....	94
10.4	Procedure Qualification—Number and Type of Specimens and Range of Thickness Qualified—Fillet Weld.....	94
10.5	Procedure Qualification Type and Position Limitations .....	95
10.6	As-Welded Strength of Aluminum Alloys (GTAW or GMAW).....	96
11.1	Performance Qualification—Limitation of Essential Variables.....	118
11.2	Electrode Classification Groups for Welder and Tack Welder Qualification.....	118
11.3	Number and Type of Specimens and Range of Thickness Qualified—Welder and Welding Operator Qualification .....	119
11.4	Welder and Welding Operator Qualification—Type and Position Limitation .....	120
11.5	Maximum Reinforcement—Pipe Welds .....	120
17.1	Weld Crater Limitations .....	152
17.2	Undercut and Porosity Limitations .....	152
17.3	Ultrasonic Testing Acceptance—Rejection Criteria .....	153
18.1	Essential and Non-Essential Variables for Inclusion in WPS—FCAW, GMAW, GTAW, and SMAW .....	156
18.2	Procedure Qualification Tests .....	158
19.1	Limitation of Variables for Welder Qualification—FCAW, GMAW, GTAW, and SMAW .....	166
19.2	Welder Qualification Tests .....	167
A.1	Numerical Indexing of Base Material Specifications (Steel).....	171
B.1	Grouping of Welding Electrodes and Rods for Qualification .....	173
C.1	Equivalent Fillet Weld Leg Size Factors for Skewed T-Joints .....	178
E.1	Hot-Rolled and Cold-Rolled Sheet Metal.....	207
E.2	Galvanized Sheet Metal .....	207
E.3	Guide to the Choice of Filler Metal for General Purpose Welding of Aluminum .....	208

## List of Figures

Figure	Page No.
5.1	Fillers Less than 1/4 in [6 mm] Thick..... 18
5.2	Lap Width and Member Axial Load ..... 18
5.3	Fillers 1/4 in [6 mm] or Thicker..... 19
5.4	Details for Fillet Welds ..... 20
5.5	Distribution of Mechanical Properties in the Vicinity of an Aluminum Weld..... 21
6.1	Cut Edge Discontinuity ..... 30
6.2	Acceptable and Unacceptable Weld Profiles ..... 31
7.1A	Prequalified Complete Joint Penetration (CJP) Groove Welded Joint Details ..... 36
7.1B	Prequalified Complete Joint Penetration (CJP) Groove Welded Joint Details ..... 37
7.1C	Prequalified Complete Joint Penetration (CJP) Groove Welded Joint Details ..... 38
7.1D	Prequalified Complete Joint Penetration (CJP) Groove Welded Joint Details ..... 40
7.1E	Prequalified Complete Joint Penetration (CJP) Groove Welded Joint Details ..... 43
7.1F	Prequalified Complete Joint Penetration (CJP) Groove Welded Joint Details ..... 44
7.1G	Prequalified Complete Joint Penetration (CJP) Groove Welded Joint Details ..... 46
7.1H	Prequalified Complete Joint Penetration (CJP) Groove Welded Joint Details ..... 47
7.1I	Prequalified Complete Joint Penetration (CJP) Groove Welded Joint Details ..... 48
7.1J	Prequalified Complete Joint Penetration (CJP) Groove Welded Joint Details ..... 49
7.1K	Prequalified Complete Joint Penetration (CJP) Groove Welded Joint Details ..... 49
7.1L	Prequalified Complete Joint Penetration (CJP) Groove Welded Joint Details ..... 50
7.2A	Prequalified Partial Joint Penetration (PJP) Groove Welded Joint Details ..... 52
7.2B	Prequalified Partial Joint Penetration (PJP) Groove Welded Joint Details ..... 53
7.2C	Prequalified Partial Joint Penetration (PJP) Groove Welded Joint Details ..... 54
7.2D	Prequalified Partial Joint Penetration (PJP) Groove Welded Joint Details ..... 55
7.2E	Prequalified Partial Joint Penetration (PJP) Groove Welded Joint Details ..... 56
7.2F	Prequalified Partial Joint Penetration (PJP) Groove Welded Joint Details ..... 57
7.2G	Prequalified Partial Joint Penetration (PJP) Groove Welded Joint Details ..... 58
7.2H	Prequalified Partial Joint Penetration (PJP) Groove Welded Joint Details ..... 59
7.2I	Prequalified Partial Joint Penetration (PJP) Groove Welded Joint Details ..... 60
7.2J	Prequalified Partial Joint Penetration (PJP) Groove Welded Joint Details ..... 61
7.2K	Prequalified Partial Joint Penetration (PJP) Groove Welded Joint Details ..... 62
8.1	Weld Pass in Which Depth and Width Exceed the Width of the Weld Face..... 79
10.1	Positions of Groove Welds ..... 98
10.2	Positions of Fillet Welds ..... 99
10.3	Positions of Test Plates for Groove Welds ..... 100
10.4	Positions of Test Pipe or Tubing for Groove Welds ..... 101
10.5	Test Positions for Fillet Welds (for Plate) ..... 102
10.6	Test Positions for Fillet Welds (for Pipe and Tubing)..... 103
10.7	Location of Test Specimens on Welded Test Pipe ..... 104
10.8	Location of Test Specimens for Welded Square and Rectangular Tubing..... 104
10.9	Location of Test Specimens on Welded Test Plate for 1/8 in to 3/8 in [3 mm to 10 mm] (inclusive) Thick Procedure Qualification ..... 105
10.10	Location of Test Specimens on Welded Test Plate 3/8 in [10 mm] Thick and Over Procedure Qualification..... 106
10.11	Reduced-Section Tension Specimen ..... 107
10.12	All-Weld-Metal Tension Specimen ..... 108
10.13	Side-Bend Specimens ..... 109



<b>Figure</b>	<b>Page No.</b>
10.14 Face- and Root-Bend Specimens .....	110
10.15 Fillet Weld Soundness Test for Procedure Qualification .....	111
10.16 Location of Test Specimens on Welded Test Plate 1 in [25 mm] Thick—Consumables Verification for Fillet Weld Procedure Qualification .....	112
10.17 Pipe Fillet Weld Soundness Test Procedure Qualification .....	113
11.1 Test Plate for Unlimited Thickness Welder Qualification .....	121
11.2 Test Plate for Unlimited Thickness Horizontal Position—Welder Qualification .....	122
11.3 Test Plate for Limited Thickness—Welder Qualification .....	123
11.4 Test Plate for Limited Thickness Horizontal Position—Welder Qualification .....	124
11.5 Tubular Butt Joint—Welder Qualification without Backing .....	124
11.6 Tubular Butt Joint—Welder Qualification with Backing .....	124
11.7 Fillet-Weld-Break and Macroetch Test Plate Welder and Welding Operator Qualification— Option 1 .....	125
11.8 Fillet Weld Root-Bend Test Plate Welder and Welding Operator Qualification—Option 2 .....	126
11.9 Fillet Weld on Pipe—Welder and Welding Operator Qualification—Option 3 .....	127
11.10 Location of Test Specimens on Welded Test Pipe and Square or Rectangular Tubing— Welder Qualification .....	128
11.11 Guided-Bend Jig .....	129
11.12 Guided-Bend Wraparound Jig .....	130
11.13 Guided-Bend Roller Jig .....	131
12.1 Test Plate for Unlimited Thickness—Welding Operator Qualification .....	134
13.1 Fillet-Weld-Break Specimen—Tack Welder Qualification .....	136
13.2 Method of Rupturing Specimen—Tack Welder Qualification .....	136
16.1 Weld Quality Requirements for Discontinuities Occurring in Cyclically Loaded Nontubular Tension Welds (Limitations of Porosity and Fusion Discontinuities) .....	142
16.2 Weld Quality Requirements for Discontinuities Occurring in Cyclically Loaded Nontubular Compression Welds (Limitations of Porosity or Fusion-Type Discontinuities) .....	143
16.3 Weld Quality Requirements for Elongated Discontinuities as Determined by RT of Tubular Joints .....	144
16.4 Maximum Acceptable RT Images .....	149
16.5 For RT of Tubular Joints 1-1/8 in [30 mm] and Greater, Typical of Random Acceptable Discontinuities .....	150
18.1 Square-Groove Weld in Butt Joint .....	159
18.2 Arc Spot Welds .....	159
18.3 Arc Spot Weld Using Washer .....	159
18.4 Edge Distances for Arc Spot Welds .....	159
18.5 Lap-Fillet Welds .....	160
18.6 Fillet Welds in T-Joints .....	160
18.7 Single-Flare-Bevel-Groove Weld—Horizontal .....	160
18.8 Single-Flare-V-Groove Weld—Flat .....	160
18.9 Square-Groove Butt Joints .....	161
18.10 Test for Arc Spot Weld .....	161
18.11 Fillet Weld Test Assembly .....	162
18.12 Standard Test Assembly for Flare-Bevel-Groove Welds; Test C—Sheet-to-Sheet .....	163
18.13 Standard Test Assembly for Flare-Bevel-Groove Weld; Test D—Sheet-to-Supporting Plate .....	163
18.14 Standard Test Assembly for Flare-V-Groove Welds .....	164

# Railroad Welding Specification for Cars and Locomotives

## 1. General Requirements

**1.1 Scope.** This specification covers the minimum welding requirements applicable to welded structures and cast components used in the railroad industry. It is not intended to apply to tank car tanks nor to the welding of rails. Recommended practices for welding railroad rails and related components are included in D15.2, *Recommended Practice for the Welding of Rails and Related Rail Components for Use by Rail Vehicles*. Specifications for welding tank car tanks and components welded directly thereto are outlined in the *AAR Manual of Standards and Specifications for Welding*, Section C—Part III, Specification M-1002 (AAR M-1002 C-III).

Welding symbols shall be those shown in the latest edition of AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*.

**1.2 Units of Measurement.** This standard makes use of both U.S. Customary Units and the International System of Units (SI). The latter are shown within brackets ([ ]), or in appropriate columns in tables and figures. The measurements may not be exact equivalents; therefore, each system must be used independently.

**1.3 Safety.** Safety and health issues and concerns are beyond the scope of this standard; some safety and health information is provided, but such issues are not fully addressed herein.

Safety and health information is available from the following sources:

American Welding Society

- (1) ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*
- (2) AWS Safety and Health Fact Sheets
- (3) Other safety and health information on the AWS website

Material or Equipment Manufacturers:

- (1) Material Safety Data Sheets supplied by materials manufacturers
- (2) Operating Manuals supplied by equipment manufacturers

Applicable Regulatory Agencies

## 2. Normative References

The standards listed below contain provisions that, through reference in this text, constitute mandatory provisions of this AWS standard. For undated references, the latest edition of the referenced standard shall apply. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply.

American Welding Society (AWS) standards:<sup>1</sup>

AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*;

AWS A3.0M/A3.0, *Standard Welding Terms and Definitions Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*;

<sup>1</sup> AWS standards are published by the American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.