

AWS A1.1:2016
An American National Standard

Metric Practice Guide for the Welding Industry



AWS A1.1:2016
An American National Standard

Approved by
American National Standards Institute
August 30, 2016

Metric Practice Guide

for the Welding Industry

Supersedes AWS A1.1:2001

Prepared by the
American Welding Society (AWS) A1 Committee on Metric Practice

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This metric practice guide is based on the International System of Units (SI) as defined in the *U.S. Federal Register* notice of July 28, 1998, "Metric System of Measurement: Interpretation of the International System of Units for the United States." It includes the base units, derived units, and rules for their use. Also covered are conversion factors and rules for their use in converting U.S. customary units to SI units.

Recommendations are presented for style and usage in such areas as prefixes, punctuation, number grouping, etc. There are also suggestions to industry for managing the transition.



ISBN: 978-0-87171-896-9
©2016 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 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). 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, Technical Services Division, 8669 NW 36 St, # 130, Miami, FL 33166 (see Annex J). 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 A1 Committee on Metric Practice. 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 A1 Committee on Metric Practice 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 A1 Committee on Metric Practice 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 Committee on Metric Practice

G. D. Uttrachi, Chair	<i>WA Technology, LLC</i>
J. Letki, Vice Chair	<i>General Electric</i>
S. P. Hedrick, Secretary	<i>American Welding Society</i>
B. B. Barrow	<i>Defense Information Systems Agency, retired</i>
J. R. Frysinger	<i>Metric Methods; College of Charleston, retired</i>
E. A. Mechtly	<i>University of Illinois</i>

Advisors to the AWS Committee on Metric Practice

J. Liu	<i>Subsea Technology Inc</i>
A. Rabinkin	<i>Metglas Inc – Hitachi Metals</i>
S. K. Saha	<i>New York State Department of Transportation</i>

This page is intentionally blank.

Foreword

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

The AWS Metrication Policy states, in part, “The AWS supports a timely transition to the use of SI units.” At the present time, the U.S. stands alone as the only industrial country that still predominantly uses the inch-pound units of measurement. Since the signing of the Metric Act of 1975 and an initial flurry of transition, the voluntary feature of the Act allowed the impetus to stagnate. The U.S. industrial and commercial productivity, mathematics and science education, and the competitiveness of our products and services in world markets would be enhanced by the adoption of the metric system. Americans have, so far, only made ineffective attempts at public education and awareness of the metric system.

It is of historical interest that in the late 1700s Benjamin Franklin and Thomas Jefferson strongly supported decimal measurement and decimal currency. They were successful in having the US use a decimal currency but not the decimal measurement system they also promoted. In fact, in 1790 George Washington in his first annual message to Congress reminded the legislators “Uniformity in the currency, weights, and measures of the United States is an object of great importance, and will, I am persuaded, be duly attended to.” The metric system of measurement was part of the reforms Napoleon enacted and it was spread to all the lands under his control. This coherent method of measurement served to fuel the scientific progress of the coming decades. The USA, in fact, had a major influence on the measurement leaders in France, who were developing the decimal metric system to become the legal French measuring system. It should be noted that, by acts of Congress, the metric system has been legal for use in all commercial and legal dealings in the US since 1866 and it was declared to be the “preferred system of measurement” in 1988.

Simple conversation is not the answer. The use of two different unit systems was the cause of the loss of the Mars Climate Orbiter. NASA specified metric units for its design and construction but one subcontractor provided thruster performance data in pound force seconds instead of newton seconds. The spacecraft was intended to orbit Mars at 150 kilometers altitude, but incorrect data caused it to descend instead to about 57 kilometers burning the orbiter up in the Martian atmosphere. In addition to being a source of errors, simple mathematical conversion creates inconsistencies in allowable tolerances. It also causes extra cost when rounding causes tighter tolerances than specified in the original design.

Even the countries that were using metric measurement had to make compromises and changes to have a truly uniform system, which we now refer to as SI (International Standard.) A recent example was the value of a teaspoon, which was different in several countries. When dispensing medicine an accurate value is critical. There is now a unified SI value for this measure. The AWS Metric Practice Committee has tried to remain congruent with these unification changes, as have other Societies such as IEEE and ASME.

The American Welding Society has made significant progress in including SI units in our standards documents and in our published Welding Journal. This has helped make them accepted World Wide. This 6th edition reflects the current “state of the art” in SI practice for the U.S. welding industry and will assist the welding industry in converting to SI units and promote their voluntary use.

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

This page is intentionally blank.

Table of Contents

	Page No.
<i>Personnel</i>	v
<i>Foreword</i>	vii
<i>List of Tables</i>	xi
1. Scope	1
2. The International System of Units (SI)	1
2.1 Completeness	1
2.2 Coherence	2
2.3 Uniqueness	2
2.4 Advantages of the SI	2
3. SI Units and Symbols	2
3.1 SI Base Units	2
3.2 SI Derived Units	2
3.3 Prefixes	2
4. Other Units Used with SI	2
5. Units Pertaining to Welding	5
6. Style and Usage	5
6.1 Application and Usage of Prefixes	5
6.2 Mass, Force, and Weight	6
6.3 Temperature	8
6.4 Time	8
6.5 Angles	8
6.6 Stress and Pressure	8
6.7 Capitalization	8
6.8 Plurals	8
6.9 Punctuation	8
6.10 Writing Numbers	9
6.11 Miscellaneous Styling	9
7. Conversions	10
7.1 Rules for Converting and Rounding	13
7.2 Inch to Millimeter Conversion	13
7.3 Other Conversions	15
7.4 Rounding Rules	16
8. Transition	16
8.1 Introduction	16
8.2 Considerations	16
9. Preferred Numbers	18
9.1 Definition	18
9.2 Application of Preferred Numbers	18
9.3 Value of Using Preferred Numbers	19

Annex A (Informative) — Inch to Millimeter Conversion 21

Annex B (Informative) — Pounds-Force per Square Inch to Kilopascal Conversion 23

Annex C (Informative) — Fahrenheit-Celsius Temperature Conversion 25

Annex D (Informative) — Other Documents 29

Annex E (Informative) — Other Organizations 31

Annex F (Informative) — Units for Newton’s Second Law 33

Annex G (Informative) — Intended Accuracy when Making Hard Conversions 35

Annex H (Informative) — Rational SI Plate Thickness for Consideration in Materials Specifications 37

Annex I (Informative) — Separating Digit Groups with Spaces 39

Annex J (Informative) — Requesting an Official Interpretation on an AWS Standard 45

List of Tables

Table	Page No.
1	SI Base Units 3
2	Examples of SI Derived Units 3
3	SI Prefixes 4
4	Other Units Which May be Used with SI Units. 5
5	Units Pertaining to Welding 6
6	Filler Metal Sizes 7
7	Fillet Sizes 7
8	General Conversions 11
9	Conversions for Common Welding Terms 12
10	Millimeter Value Rounding Using Inch Tolerance Span 14
11	Comparison of Rounding Methods A and B 14
12	Basic Preferred Numbers — Decimal Series 19
A.1	Inch to Millimeter Conversion 21
B.1	Pounds-Force per Square Inch to Kilopascal Conversion 23
C.1	Fahrenheit-Celsius Temperature Conversion 25
G.1	Intended Accuracy When Making Hard Conversions of Strength and Impact Properties 35
H.1	Rational SI Plate Thickness for Consideration in Materials Specifications 37

This page is intentionally blank.

Metric Practice Guide for the Welding Industry

1. Scope

1.1 This metric practice guide is based on the International System of Units (SI) as defined in the *U.S. Federal Register* notice of July 28, 1998, “Metric System of Measurement: Interpretation of the International System of Units for the United States”. (Other source documents and style guides are referenced in Annex D.) This guide contains specifications of the SI base units, derived units, prefixes, and rules for their use in AWS documents and by the welding industry. It also contains factors and rules for converting from U.S. customary units to SI units and recommendations to industry for managing the transition.

1.2 Safety

1.2.1 Safety and health issues and concerns are beyond the scope of this standard and therefore are not addressed herein.

1.2.2 Safety and health information is available from the following sources:

American Welding Society:

1. ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*¹
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

1.2.3 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.

2. The International System of Units (SI)

A system of units is any collection of related units. SI is the only system that has the properties outlined in 2.1 through 2.3.

2.1 Completeness. Completeness requires that a unit of measurement be defined for every quantity of interest in the physical sciences and technologies.

¹ Published by the American Welding Society, 8669 NW 36 Street, Miami, FL 33166; Telephone 800-443-9353; (website: www.aws.org).