AWS A1.1:2026
An American National Standard

Metric Practice Guide for the Welding Industry



American Welding Society®



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Metric Practice Guide for the Welding Industry

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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.

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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 It must be reviewed every five years, and if not revised, it must be either reaffirmed or withdrawn.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.

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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 U.S. 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 worldwide.

This is the 7th edition of AWS A1.1. The following are some of the significant changes from the 2016 edition: the numbering and formatting were updated to conform to the latest AWS Style and Methods Guide. Underlined text in the standard indicates a change from the previous edition.

All errata to a standard shall be published in the *Welding Journal* and posted on the AWS website.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS A1 Committee on Metric Practice, American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.

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Metric Practice Guide for the Welding Industry

1. General Requirements

1.1 Scope. 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.

Although this guide is not written with mandatory requirements, mandatory language, such as the use of "shall", will be found in those portions of the document where failure to follow the instructions or procedures could produce inferior, misleading or unsafe results.

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

Safety and health information is available from the following sources:

American Welding Society:

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

(2) AWS Safety and Health Fact Sheets

(3) Other safety and health information on the AWS website

Material or Equipment Manufacturers:

(1) Safety Data Sheets supplied by materials manufacturers

(2) Operating Manuals supplied by equipment manufacturers

Applicable Regulatory Agencies

Work performed in accordance with this standard may involve the use of materials that have been deemed hazardous, and may involve operations or equipment that may cause injury or death. This standard does not purport to address all safety and health risks that may be encountered. The user of this standard should establish an appropriate safety program to address such risks as well as to meet applicable regulatory requirements. ANSI Z49.1 should be considered when developing the safety program.

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.

2.2 Coherence. Coherence requires that all derived units in the system be obtained from the base units by the rules of multiplication and division with no numerical factor other than the number one (1) ever occurring in the expressions for derived units in terms of the base units. The system of units must also be coherent with its corresponding system of quantities and equations. A system of units is coherent with respect to a system of quantities and equations if the system of units is chosen in such a way that the equations between numerical values have exactly the same form (including numerical factors) as the corresponding equations between quantities.

Quantity	Derived Unit	Unit Equation
Energy (force times distance) $E = F \cdot l$	joule	1 J = 1 N · m
Power (rate of energy transfer) $P = E/t$	watt	1 W = 1 J/s
Pressure (force divided by area) $p = F/A$	pascal	1 Pa = 1 N/m^2

2.3 Uniqueness. Uniqueness requires that there be one, and only one, unit defined for each quantity. For example, the SI units for force (newton), energy (joule), and power (watt) are the same, respectively, whether the process is mechanical, electrical, or thermal.

2.4 Advantages of the SI. The International System of Units (SI) is the metric system of units in its latest form. SI is the only system of units which fully satisfies all the above three requirements for completeness, coherence, and uniqueness. Within SI, a set of base-ten prefixes is defined to form decimal multiples and submultiples of SI units. SI Units and their base-ten multiples and submultiples are in harmony with our decimal system of arithmetic, facilitating easy numerical calculations. Awkward manipulations of common fractions such as 1/16, 1/32, and 1/64 are completely unnecessary. All industrial nations, including the United States by the Omnibus Trade and Competitiveness Act of 1988 (Public Law 100-418), have chosen the SI as the preferred system of units for all applications in science, engineering, technology, commerce, and trade.

3. SI Units and Symbols

SI consists of seven base units, derived units, and a set of prefixes for the formation of multiples of the various units.

3.1 SI Base Units. Names of SI base quantities, names of corresponding SI base units, their symbols, and definitions are given in Table 3.1.

3.2 SI Derived Units. SI derived units are formed as described in 2.2. Some of them have been given special names and symbols. Examples are listed in Table 3.2.

3.3 Prefixes. SI prefixes may be used to indicate multiples of SI units, thus simplifying numeric terms and providing a convenient substitute for writing powers of ten as generally preferred in computation. For example, 16 800 meters or 16.8×10^3 meters becomes 16.8 kilometers. See Table 3.3 for the list of prefixes and 6.1 for examples of their use. The kilogram is the only SI base or derived unit whose name, for historical reasons, contains a prefix. In this case, the appropriate prefix is attached to gram.