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GUIDE FOR IDENTIFICATION AND DEVELOPMENT OF METRIC STANDARDS

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ACQUISITION, TECHNOLOGY, & LOGISTICS

SDMP

FOREWORD

This guide is intended to help organizations in the Department of Defense (DoD) determine when it is necessary to develop metric specifications and standards, and the best way to express metric units of measurement in those documents. The availability of metric documents is a prerequisite to the development of metric-based weapon systems and equipment. This document will help DoD program offices, standardization management activities, engineering offices, contractors, and others meet the requirements of Section 5164, Metric Usage, of the Public Law 100-418, the Omnibus Trade and Competitiveness Act of 1988.

If you have any questions or comments about this document or metric use in the DoD, please contact the Defense Standardization Program Office, 8725 John J. Kingman Road, ATTN: J-307, Stop 6233, Fort Belvoir, VA 22060-6221 or email DSPO@dla.mil.

GREGORY E. SAUNDERS
Director
Defense Standardization Program Office

GUIDE FOR IDENTIFICATION AND DEVELOPMENT OF METRIC[1] STANDARDS

1. Scope. This document provides guidance for the identification and development of standards and specifications using the International System of Units (SI), commonly known as the metric system. The guide does not cover metric practice, such as methods of converting and rounding, as addressed in IEEE/ASTM SI 10 (see 3.7.1).

2. Background. The Weights and Measures Law of the United States (15 U.S.C. § 205(b)(1)) states that it is the policy of the United States to designate the SI as the preferred system of measurements for trade and commerce. Another policy established under section (3) is that Federal agencies are to seek out ways to increase understanding of the SI through educational information and guidance and in their publications. 15 U.S.C. § 205(c)(4) defines the metric system of measurement as the International System of Units established by the General Conference of Weights and Measures[2] as interpreted or modified for the United States by the Secretary of Commerce.

3. Definitions.

3.1 Metric specification. Metric specifications have requirements given in rounded, rational, metric units, usually as a result of being originally developed in metric. The magnitudes are meaningful and practical (for example, 10 grams, not 0.35273 ounces). Documents containing only electrical units that are used in both the metric and inch-pound systems (for example, volts, amps, and ohms) are classified as metric documents. Documents also containing dimensional interfaces must have these interfaces in metric sizes to be classified as metric documents. Metric specifications are developed for items to interface or operate with other metric items.

3.2 Inch-pound specification. Inch-pound specifications have requirements given in rounded, rational, inch-pound units, usually as a result of being originally developed in inch-pound. The magnitudes are meaningful and practical (for example, 1 ounce, not 28.3495 grams). Inch-pound specifications should include those with rounded, rational, inch-pound units only. NOTE: There have been instances where magnitudes expressed in metric units as a result of mathematical conversion from rounded, rational inch-pound units are given first (preferred units) with the rounded, rational inch-pound units given in parenthesis or in a non-preferred position. These specifications are inch-pound documents. Inch-pound specifications are developed for items to interface or operate with other inch-pound items.

3.3 Hybrid specification. A hybrid specification is one in which some requirements are given in rounded, rational metric units, and other requirements are given in rounded, rational inch-pound units. Hybrid specifications are often required for use in new designs where existing usable components must interface in a metric system.

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[1] Since 1960, it has been known as The International System of Units (7th ed. Bureau International des Poids et Mesures 1998).

[2] For information on the General Conference of Weights and Measures, see http://www.bipm.fr/enus/2_Committees/cgpm.html.

3.4 Not measurement sensitive documents. A not measurement sensitive document is one in which application of the requirements does not depend substantially on some measured quantity. This type of document can be used with either a metric system or an inch-pound system.

3.5 Soft conversion. A soft conversion is the process of changing a measurement from inch-pound units to equivalent metric units within acceptable measurement tolerances without changing the physical configuration of the item.

3.6 Hard conversion. A hard conversion is the process of changing a measurement from inch-pound units to non-equivalent metric units which necessitates physical configuration changes of the item outside those permitted by established measurement tolerances. The term "hard conversion" is in general use in the United States, although it is technically incorrect when applied to specific items because no "conversion" takes place. Instead, a new metric item requiring a new part identification is created to eventually replace the inch-pound version of the item. The new item is often referred to as being in "hard metric."

3.7 Metric units.

3.7.1 Metric units are a system of basic measures defined by the International System of Units based on "Le Systeme International d'Unites (SI)," of the International Bureau of Weights and Measures (IBWM)[3]. These units are described in IEEE/ASTM SI 10, *Use of the International System of Unites (SI): The Modern Metric System*.

3.7.2 In the United States, the authoritative SI source document is National Institute of Standards and Technology[4] NIST Special Publication 330, *The International System of Units (SI)*. For use in the United States, this is the official English language translation approved by the IBWM of its publication *Le System International d'Unites*. Guidance for use of Special Publication 330 is provided in NIST Special Publication 811, *Guide for the Use of the International System of Units (SI)*. Based on these two publications and on authority of 15 U.S.C. § 205(c)(4), the U.S. Department of Commerce issued *Metric System of Measurement: Interpretation of the International System of Units (SI)* in the Federal Register on July 28, 1998 (Vol. 63, No. 144) as the interpretation and modification of the SI for use in the United States.

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[3] For information about the International Bureau of Weights and Measures, see http://www.bipm.org.

[4] For additional information on these publications and the SI contact:

National Institute of Standards and Technology
Weights and Measures Division - Laws and Metric Group
100 Bureau Drive Stop 2600
Gaithersburg, Maryland 20899-2600
By email at: TheSI@nist.gov PH: 301-975-4004 FAX: 301-926-0647
You will find the Laws and Metric Group's Website at http://www.nist.gov/metric.
For NIST information on scientific units go to http://physics.nist.gov/cuu/Units/index.html.

4. When are Metric Standards and Specifications Needed? Normally, there are two situations when the development of a metric document is needed: (1) simply to put requirements in metric measurement units, and (2) development of physical modules for international harmonization. With regard to the first, this can often be accomplished by soft conversion. With regard to the second, there are pressures in areas of international product standardization for use of metric modules. Before one decides on the development of a metric document, the purpose of the document must be determined. Decisions must be reached on which requirements in the document are metric, which are soft converted, and which are inch-pound.

4.1 Where Soft Conversion Should Be Used. If the purpose is simply to put the requirements in metric language, a soft conversion is the only needed change. The soft conversion can be in the form of stating only the converted metric units in the requirements as substitutions for the inch-pound units; stating the metric units in parenthesis after the inch-pound units in the requirements or vice versa; or giving a table of conversions and/or conversion factors and giving the requirements in only one system. Soft conversion should be used in the following circumstances:

a. The technologies addressed in the document are based on the inch-pound system internationally. Examples are most areas of electronic packaging and grid spacing, hydraulics, and tire rim sizes. Since the purpose of metric is usually to achieve international standardization or interoperability, rather than metrication per se, there is no need to have a hard conversion in these areas. Rather, the purpose is to include metric language, since these documents describing these products or processes are expressed in metric units in the other countries and in the international standards.

b. Free standing, or stand alone, items where interoperability or interfacing is not needed, and there is no need for international standardization. Examples are pens and pencils, many types of furniture, etc.

c. Items or processes where rounded, rational numbers are not usual in either system. In these cases, economic and technical considerations are balanced to achieve an optimal situation. Examples of these are anti-corrosion coating thicknesses, electrical insulation thicknesses, locations of components in electronic assemblies, etc.

d. Capacities or volumes such as fuels, paints, and other coatings. Metric hardware or equipment can be painted using gallons of paint rather than liters, and can be powered by gallons of fuel as well as liters.

e. Many test method and process standards. Adding equivalent metric dimensions will permit the direct use of scales, micrometers, gauges, and other instruments calibrated in either system of units. However, if the existing standards and test methods affect final physical configuration or performance requirements, careful consideration is needed in preparing metric standards.

4.2 When Hard Conversion Is Needed. Hard conversion is often necessary when there is a need for international harmonization or to operate with metric hardware. New metric design standardization documents will generally be developed for:

a. Items which have universal application and which require standardization in order to provide metric components for designers of metric materiel.

b. Items such as wire sizes, screw thread forms, fasteners, tubing sizes, and dimension stock material used in new systems specified from the beginning in metric dimensions.

c. Those areas which specify existing system designs that are to be changed to permit the use of metric system standards, production machinery, raw materials, spare parts, and maintenance tools and for which the most cost effective set of such changes must be selected.

d. Items where a reduction in the ranges, types, styles, or classes or products will be facilitated by adoption of a family of metric items.

e. Items which are peculiar to the DoD and represent technological advances for operational application in new materiel.

f. Items which have a universal application of function and industry has now designed the items in the metric system of measurement.

New metric standardization documents will often supplement specifications and standards and will not necessarily supersede them. As the use of the metric system grows, use of metric standardization documents will increase, while use of customary standardization documents will decrease.

4.3 When No Conversion Is Needed.

a. Items which are becoming obsolete and the change to metric is not practical.

b. Items which will continue in use without modifications. No useful purpose will be served in translating inches to millimeters for such items, its spare parts, or the tools required to maintain them since production and maintenance will continue to use inch-pound system facilities and standards.

c. Items of very limited applications where costs of metric modules outweigh benefits.

d. Not measurement sensitive documents (see 3.4).

4.4 Metric Approaches. The following approaches should be considered when developing specifications and standards to support metric usage:

a. New parallel document. For very complex documents filled with many conversion-susceptible measurements, the logical method is to issue a new SI metric standardization

document. Great care should be used to ensure that the new document is hard metric, and that equivalents are carefully selected. After that, the basic document and the metric document would be revised concurrently, until such time as the inch-pound document is no longer required and is cancelled.

b. Metric appendix. For less complex documents, or for very complex documents where retention of the original document number is considered necessary, a hard metric appendix could be prepared. The basic document would remain in inch-pound units and refer to the appendix for metric information. The appendix would refer to the basic document for technical features and cite only the metric equivalents, exercising care to ensure that equivalents are carefully selected.

c. Metric notes. For relatively simple documents with only a few measurement units, metrication may be handled by appropriate notes or by one or more footnotes.

d. Contract wording. Metric requirements can be inserted in contracts in lieu of development of metric specifications or standards.

4.5 Metric Values. As far as the individual quantity requirements contained in the document, there are two basic ways of arriving at practical and meaningful metric values in hard conversion:

a. Size substitution - simple replacement of standard inch-pound size with existing accepted metric size. This is often used to conform to internationally recognized metric modules. Use of preferred types and sizes and parts and materials, especially those of ISO and IEC should be encouraged. Alteration of international or foreign standards to fit domestic needs before adoption is sometimes necessary.

b. Adaptive conversion - a change from a rounded, rational inch-pound quantity to a rounded, rational metric quantity which is reasonably equivalent (as, for example, speed limits).

The decision on which to use must be based on knowledge, experience, and common sense. There is a need for addressing rationalization and variety reduction, and consideration of arithmetic or geometric series of sizes. It is desirable to use metric dimensions for physical interface in hybrid systems, except between inch-pound items.

5. Dual Dimensions. The use of both metric and inch-pound measurements on drawings or other pictorial illustrations to be used in a specification or standard should be avoided. The use of tables to translate the specific inch-pound units to metric units is acceptable. For text material, when preference is given to inch-pound units, acceptable metric units may be shown in parentheses. When preference is given to metric units, inch-pound units may be omitted or included in parentheses. In general, where it has long been standard practice to cite metric units alone (such as citing temperatures only in degrees Celsius), inch-pound equivalents may be omitted. A specific repetitive equivalent (for example, 1 inch (25.4 mm)), need be inserted only the first time it appears in a paragraph of a standardization document.

6. Other Guidance Publications. The following organizations have developed publications to provide additional guidance on metric use and practices.

Aerospace Industries Association – NAS 10000 "NA Documents Preparation and Maintenance in SI (Metric) Units." Available from http://aia-aerospace.org/

Aerospace Industries Association – NAS 10001 "Preferred Metric Units for Aerospace." Available from http://aia-aerospace.org/

American Petroleum Institute – "Guidelines for Use of the International System of Units (SI) in the Petroleum and Allied Industries, Third Edition" API MPMS Chapter 15-01. Available from http://api-ec.api.org/newsplashpage/index.cfm

American Society of Agricultural Engineers – EP285.7, "Use of SI (Metric) Units." Available from http://www.asae.org/

American Society of Heating, Refrigerating, and Air Conditioning Engineers – 2001 ASHRAE Fundamentals Handbook: Chapter 37, "Units and Conversions." Available from http://www.ashrae.org/

American Society of Mechanical Engineers – "ASME Orientation and Guide for Use of SI-(Metric) Units—Ninth Edition." Available from http://www.asme.org/

American Society of Mechanical Engineers – ASME B4.2, "Preferred Metric Limits and Fits." Available from http://www.asme.org/

American Society of Mechanical Engineers – ASME B4.3, "General Tolerances for Metric Dimensioned Products." Available from http://www.asme.org/

American Welding Society – "Metric Practice Guide for the Welding Industry; 2001." Available from http://www.aws.org/

American Welding Society – "Everyday Pocket Handbook on Metric Practices for the Welding Industry." Available from http://www.aws.org/

Association for Information and Image Management – ANSI/AIIM TR01, "Guidelines for Metrics – With 1992 Addendum." Available from http://www.aiim.org/

ASTM International – IEEE/ASTM SI 10, "Use of the International System of Units (SI): The Modern Metric System." Available from http://www.astm.org

ASTM International – E621, "Standard Practice for the Use of Metric (SI) Units in Building Design and Construction." Available from http://www.astm.org

ASTM International – E 713, "Standard Guide for Selection of Scales for Metric Building Drawings." Available from http://www.astm.org

ASTM International – F 1332, "Standard Practice for Use of SI (Metric) Units in Maritime Applications" (Supplement to IEEE/ASTM SI 10). Available from http://www.astm.org

Department of Commerce/National Institute of Standards and Technology – NIST Special Publication 330, "International System of Units (SI)." Available from http://www.nist.gov/metric

Department of Commerce/National Institute of Standards and Technology – NIST Special Publication 811, "Guide for the Use of the International System of Units (SI)." Available from http://www.nist.gov/metric

Department of Commerce/National Institute of Standards and Technology – NIST Special Publication 814, "Interpretation of the SI for the United States and Federal Government Metric Conversion Policy." Available from http://www.nist.gov/metric

Department of Commerce/National Institute of Standards and Technology – Federal Register/Vol. 63, No. 144/Tuesday, July 28, 1998/Notices "Metric System of Measurement: Interpretation of the International System of Units for the United States." Included in NIST Special Publication 814. Available from http://www.nist.gov/metric

Department of Commerce/National Institute of Standards and Technology – "The NIST Reference on Constants, Units and Uncertainty." Available from http://physics.nist.gov/cuu/index.html

Electronic Industries Alliance – JEDEC JEP86-A-76, "Recommended Practice for Dual Dimensioning." Available from http://www.eia.org

Institute of Electrical and Electronic Engineers – IEEE 260.1, "American National Standard Letter Symbols for Units of Measurement (SI Units, Customary Inch-Pound Units, and Certain Other Units)." Available from http://www.ieee.org

Institute of Electrical and Electronics Engineers – IEEE 945, "IEEE Recommended Practice for Preferred Metric Units for Use in Electrical and Electronics Science and Technology." Available from http://www.ieee.org

Institute of Electrical and Electronics Engineers – IEEE/ASTM SI 10, "Use of the International System of Units (SI): The Modern Metric System." Available from http://www.ieee.org

Interagency Committee on Metric Policy – FED-STD-376, "Preferred Metric Units for General Use by the Federal Government." Available from http://assist.daps.dla.mil/quicksearch/

International Bureau of Weights and Measures – "The International System of Units (SI)" 7th Edition 1998 with 2000 Supplement." Available from http://www.bipm.org/enus/6_Publications/si/si-brochure.html

International Organization for Standardization – ISO 1000, "SI Units and Recommendations for the Use of Their Multiples and Certain Other Units." Available from http://www.iso.ch/iso/en/ISOOnline.frontpage

National Fluid Power Association – NFPA T2.10.2, "Survey on Metric Language Usage by the US Fluid Power Industry." Available from http://www.nfpa.com/

Society of Automotive Engineers – SAE AIR 1657, "Handbook of Hydraulic Metric Calculations." Available from http://www.sae.org

Society of Automotive Engineers – SAE AIR 1758, "Limits and Fits, International Metric Tolerance System." Available from http://www.sae.org

Society of Automotive Engineers – SAE J390, "Dual Dimensioning Engineering Drawings." Available from http://www.sae.org

Society of Automotive Engineers – SAE TSB003, "Rules for SAE Use of SI (Metric) Units." Available from http://www.sae.org