METRIC STANDARDS FOR WORLDWIDE MANUFACTURING

2007 ELECTRONIC 7TH EDITION

Knut O. Kverneland

ARGENTINA
AUSTRALIA
AUSTRIA
BARBADOS
BELGIUM
BRAZIL
BULGARIA
CANADA
CHILE
CHINA
COLOMBIA
CROATIA
CUBA
CYPRUS
CZECH REPUBLIC
DENMARK
EGYPT
FINLAND
FRANCE
GERMANY
GREECE
HUNGARY
ICELAND
INDIA
INDONESIA
IRELAND
ISRAEL
ITALY
JAMAICA
JAPAN
REPUBLIC OF KOREA
MALAWI
MALAYSIA
MEXICO
MONGOLIA
NETHERLANDS
NEW ZEALAND
NORWAY
PAKISTAN
PAPUA NEW GUINEA
PERU
PHILIPPINES
POLAND
PORTUGAL
ROMANIA
RUSSIAN FEDERATIO
SINGAPORE
SLOVAKIA
SLOVENIA
SOUTH AFRICA
SPAIN
SRI LANKA
SWEDEN
SWITZERLAND
SYRIA
TANZANIA
THAILAND
TRINIDAD & TOBAGO
TUNISIA
TURKEY
UNITED KINGDOM
URUGUAY
USA
VENEZUELA
VIET NAM
YUGOSLAVIA
ZIMBABWE

METRIC STANDARDS FOR WORLDWIDE MANUFACTURING

By
Knut O. Kverneland

2007th edition

KOK metricUSA™.org, Inc., Statesville, North Carolina, USA 1978-2007

Library of Congress Cataloging-in-Publication Data

Kverneland Knut O., 1937-
METRIC STANDARDS for Worldwide Manufacturing / by Knut O. Kverneland.
Includes indexes.
ISBN 978-0-9744477-6-5 (e-book)
ISBN 978-0-7918-0261-8 (hardcover)

1. Manufacturers – Standards. 2. Metric System. 3. Standards, Engineering

ISO Metric Standards: A Key to World Trade

There is an old and wise saying, “No standards-no trade.” This is certainly true for standard quantities and units. Without consensus on these, trade, from shopping at the supermarket to exporting goods worldwide, would be very haphazard affair indeed.

Most industrialized countries have long recognized the necessity, and advantage, of adopting the metric system of measurement-or to give it its official title, the International System of Units (SI, for short-derived from its French title, Système international d’unités), which ISO (the International Organization for Standardization) is responsible for maintaining.

The SI is contained in the International Standard ISO 31, Quantities and Units, which consist of 14 separate parts. It is not only an important standard in itself, but it also serves as a basis and guideline for many other International Standards, ISO 31 is the work of ISO Technical Committee ISO/TC 12, Quantities, Units, Symbols, Conversion Factors, which has also produced the accompanying standard, ISO 1000, SI Units and Recommendations for the Use of Their Multiples and of Certain Other Units.

The reasons for aligning with the international consensus for worldwide use of the SI system become even more compelling as the relative importance of trade over production continues to grow. In nearly every year since the end of the Second World War, the volume of world trade has increased more rapidly than that of world production.

More than 20 years after most of the industrialized world has gone over to metric measurements, many in my own home country, the USA, are still dragging behind. Quite apart from the USA government’s pro-metric stance, the USA is being forced by market pressure to change.

The pressure is coming from American exporters who have to bear the expense of incorporating two systems of basic measurements into their offering: one for the home market, and one for the rest of the world. Pressure will also increase from American clients as the presence of incompatible systems denies them the possibility to mix and match products, deprives them of the greatest freedom of choice, or ties them to one supplier because they cannot integrate new equipment with what they already have.

There are, however certain sectors which have been completely metric, even in the USA For example, dimensions for film have always been metric: 8 mm, 16 mm, 35 mm, etc. In electrotechnology, the SI units such as ampere, volt, watt, ohm, etc., have been used since the beginning of this country.

In industry outside electrotechnology is also going metric step by step rather than inch by inch, even in the USA All specifications for the defense industry have long been in metric units. It has been decided that all Federal orders to industry from now on shall be given in metric units. All certificates from NIST, the National Institute for Standards and Technology, have also, for many years now, been given only in SI units. Thus, it is certain that the largest industrial nation will eventually become metric-maybe, I dare to hope, in my lifetime!

It is a particular pleasure for me, as ISO Secretary-General, and as an American, to be invited to provide the Foreword for this second edition of Knut O. Kverneland’s book. Like ISO’s International Standards, it contributes to a common basis for the international exchange of goods, services, and technological know-how, as well as promoting common understanding in the scientific and engineering communities worldwide.

Dr. Lawrence D. Eicher
Former ISO Secretary-General

The publication of Knut O. Kverneland's book is most timely for the USA and Canada. It should prove to be a valuable reference volume as well in other English speaking countries which are in the midst of or are completing the transition to the metric system.

National standards having a metric base have been virtually unknown in the USA. Although many standards-developing groups use dual measurement notation, the standard sizing and rating practices are still based on the conventional inch-pound-gallon, USA customary system. USA technical committees are now coming to grips with the problem of developing metric-based standards. As references in their work, they will be using the standards of ISO and IEC, as well as those of industrialized nations which are already on the metric system.

Knut O. Kverneland's *METRIC STANDARDS for Worldwide Manufacturing* will provide a very useful bridge for those engineers who are required to develop components to metric specifications in advance of availability of applicable American National Standards. The book will also be a valuable tool in guiding the many technical committees and subcommittees which will be working on the new metric American National Standards.

A native of Norway, Mr. Kverneland received his early education in that country and graduated with a Masters of Science in Mechanical Engineering from the Technical University of Hannover, Germany. He has been fully conversant with the metric measurement units since childhood and is completely familiar with their use in engineering.

The author joined Massey Ferguson in 1966 as a design engineer, and has risen through consecutive positions as Engineering Analyst and Standards Engineer until being appointed to the position of Supervisor of Standards. In this capacity, Mr. Kverneland was responsible for Massey Ferguson's North American standards.

Mr. Kverneland also maintains a heavy outside professional commitment. He was a member of the Society of Automotive Engineers, Director of the Detroit Section of the Standards Engineering Society, and Chairman of the American National Standards Committee B4 on Standards for Limits and Fits.

In 1972 and 1973, Mr. Kverneland participated as a member of an ad hoc metric study committee of the SAE Off-Road Vehicle Council. He also served on the engineering standards evaluation and promotion subcommittee of the group. Because of its international manufacturing operations, Massey Ferguson's need for world metric standards information was apparent. Mr. Kverneland was thus aided in his SAE committee work by the high degree of interest of his company's management, which provided him with ready access to the computer and to standards data accumulated in its many manufacturing operations around the world. It was this work which prompted him to undertake writing of this book.

Mr. Kverneland is to be commended for his dedication to this project, and a well-deserved vote of thanks must be given to Massey Ferguson for the management support it provided the author in this undertaking,

Roy P. Trowbridge
Past Director, Engineering Standards
General Motors Corporation
Past President, American National Standards Institute

The change to the metric system offers North American manufacturing unique opportunities to introduce new thinking to the old ways products were made. The metric system requires new fastener sizes, new material stock sizes, new cutting tools, new gages, etc., to be used in production. This is where tremendously rewarding opportunities come into play. For example, 11 or less threaded fastener sizes may be selected to replace more than 50 sizes used in the old systems (see Table 8-1). Multiply the number of unique fastener sizes that can be eliminated by several thousand dollars each (automotive actual savings), and the total dollar savings for your company can very well become quite impressive.

The selection of metric material and components must be based on existing international and national metric standards. Therefore, in providing a foundation for this volume, the author has compared standards in the eight largest industrial countries of the world, which together produce the majority of the worlds products.

The preferred numbering system, coupled with the preferred metric sizes, preferred metric tolerances for holes (4) and shafts (4), and the preferred fits (10) (see Table 6-1), is another powerful tool available to you.

This highly integrated ISO tolerancing system has been in use in the European continent for 60 years, where it has saved industry there millions, if not billions, of dollars in reduced costs in manufacturing, engineering, purchasing, and inspection.

Among other things, this volume is also one of the most powerful rationalization tools available (see Table 4-1). It is now up to the reader to make the rationalized selection of standard parts and components listed in this book that will return the most benefits. The motto the author supports is "**SELL AMERICAN**" rather than the negative promotion we frequently hear. "**BUY AMERICAN**."

PREFACE to the 2005th edition:

Chapter 10 on Steel Material Data and Chapter 11 on Nonferrous Material show data from the recently released American National Standards ANSI B32.100-2005 on Preferred Metric Sizes for Flat, Round, Square, Rectangular, and Hexagonal Metal Products. The proposed drafts ANSI B32.200-200X Preferred Metric Sizes for Round, Square, and Rectangular Tubular Metal Products Other Than Pipe, and ANSI B32.300-200X Preferred Metric Sizes for Equal and Unequal Leg Angles, T- and Channel Sections, IPN- and Wide Flange-Beams Structural Steel are also referenced and they are pending approvals. All these material standards reflect existing ISO standards for nominal sizes and tolerances. They are *therefore* well suited for global design, manufacturing and marketing, and will help create USA manufacturing jobs. Use the METRIC STANDARDS for Worldwide Manufacturing latest book edition to find ways to cut costs and to increase export of manufactured
Products from the company you work for.

PREFACE to the 2006th edition:

Chapter 2 International System of Measuring Units (SI) and Chapter 17 Conversion Factors and Program are now made available free of charge from the web site http://www.kok.com/. This public service feature help educate Americans on the correct use of the global metric system.

Several companies now make the electronic version of the METRIC STANDARDS for Worldwide Manufacturing book available on their Intranet. Contact Rosemary Maginniss <RMAGINNI@ansi.org> at ANSI for quotes. This will help companies reduce the cost of metric training and implementation. It also makes the top quality METRIC STANDARDS material immediately available throughout the organization in marketing, manufacturing and engineering.

PREFACE to the 2007th edition:

Data from the new standard for Metric Continuous and Double End Studs ANSI B18.31-2005 was added to Chapter 9 and the tables in Chapter 11 now have the preference ratings specified in the American National Standards ANSI B32.100-2005 on Preferred Metric Sizes for Flat, Round, Square, Rectangular, and Hexagonal Metal Products.

The latest national and international standards references are shown in this edition as well as new links to national and international standard documentations sources.

Knut O Kverneland

The completion of the large project of writing the first edition of this book was possible only because of the extensive cooperation of top management people within the Massey Ferguson organization. Standards engineers, working for this multi-national company throughout the world, have provided substantial input to this publication in the form of national standards information and other data. The author, therefore, wishes to express his appreciation to Massey Ferguson, his former employer, for its encouragement and exceptional support in enabling him to undertake and complete the first edition of this volume. Without Massey Ferguson worldwide resources, without access to the company's computer capabilities, and without the company's generous backing in stenographic assistance, the time required for researching and preparing this manuscript would have been many times greater.

The third electronic edition has been completed with the help of my own resources through the company **KOK metricUSA™.org, Inc.** Countless hours have been spent typing and updating the manuscript.

I would like to extend special thanks to the family of the late Dr. Lawrence D. Eicher, Secretary-General of ISO (International Organization for Standardization), who has expressed his views in the foreword. In addition, the ISO Central Secretariat in Geneva has helped update several chapters of this book, for which I am most grateful.

My sincerest thanks also to Mr. Roy P. Trowbridge, former president of the American National Standards Institute who, during the initial planning stages of the first edition of this book, visualized the need for such a publication and gave the author encouragement and support.

My sincere thanks to the publisher of the second edition of my book, ASME Press, that had the vision to take on this large project and to grant me permission to publish the following electronic editions.

The author wishes to express his sincere appreciation to the following individuals and organizations:

KOK metricUSA™.org, Inc., Statesville, North Carolina, USA

Massey Ferguson Inc., Detroit, Michigan, USA
E. J. Flewelling, Manager (Former Supervisor); J. W. Carson, Standards Engineer

Major American Contributing Organizations[1]

American National Standards Institute (ANSI)
American Society of Mechanical Engineers (ASME)
Industrial Fastener Institute (IFI)

Other Contributing American Organizations[1]
American Gear Manufacturing Association (AGMA)
American National Metric Council (ANMC)
American Society for Quality (ASQ)
American Society for Testing and Materials (ASTM)
American Bearing Manufacturers Association (ABMA)
Cemented Carbide Producers Association (CCPA)
Institute of Electrical and Electronics (IEEE)
Rubber Manufacturers Association (RMA)
Society of Automotive Engineers (SAE)

Contributing International and National Standards Organizations[1]
British Standards Institute (BSI)
Committee of the Russian Federation for Standardizations (GOST R)
European Committee for Standardization (CEN)

[1]Addresses of the organizations listed are shown in Chapter 1 Table 1-1.
German Standards Organization (DIN)
French Standards Organization (AFNOR)
Italian Standards Organization (UNI)
International Electrotechnical Commission (IEC)
International Organization for Standardization (ISO)
Japanese Industrial Standards Committee (JISC)
Standards Australia International (SAI)
Standards Council of Canada (SCC)

Chapter 1
Anke Varcin-Head of Promotion and Press Services, ISO Central Secretariat, Geneva
W. A. McAdams-Past President, USA National Committee of the International Electrotechnical Commission, General Electric Company

Chapter 3
PERA Training Charts, Ford Motor Company, Ltd.
L. W. Foster-Vice Chairman ANSI Y14.5; Honeywell Inc.

Chapter 5
R. G. Lenz - Past Chairman, USA Technical Advisory Group (TAG); ISO/Technical Committee (TC) 57; General Motors Corporation

Chapter 6
F. H. Briggs - Computer Program Consultant, Massey Ferguson Inc

Chapter 8
T. C. Baumgartner - Past Chairman, ANSI B1; Standard Pressed Steel Company

Chapter 9
R. B. Belford - Past Chairman, USA TAG ISO/TC2

Chapter 10
E. A. Domzal – Past Senior Project Engineer, Materials, Massey Ferguson Inc
F. V. Kupchak – Past Chairman, USA TAG ISO/TC62; Chairman, ANSI B32; Westinghouse Electric Corporation
Japanese Standards Association; Japan Iron and Steel Exporters' Association
German Steel Trade Association – VDEH

Chapter 12
P. S. Given – Past Director, SKF Industries, Inc
J. R. Hull – Past Chief Engineer, The Torrington Company
C. A. Moyer – Past USA Delegate , ISO/TC4 SC9; Assistant Chief Engineer, The Timken Company
A. O. Dehart – Past USA Observer, ISO/TC123; General Motors Corporation
W. G Looft – Past USA Delegate, ISO/TC4 SC7; Manager of Engineering, REXNORD

Chapter 13
B. C. Cummins – Past Manager, The Louis Allis Company, Litton Industries
W. D. Erickson – Past Chief Engineer, The Gates Rubber Company
Dr. F. Buchsbaum – Past President, Stock Drive Products
G. W. Michalec – Author and Professor
C. K. Reece – Past USA Delegate, ISO/TC32; Vice Chairman, ANSI B92; John Deere Waterloo Tractor Works

Chapter 14
J. I. Morgan – Past Chairman, USA TAG ISO/TC131; Executive Vice President, National Fluid Power Association

Chapter 15
W. Jenninck – Past Assistant Chief Engineer, Illinois/Eclipse, A Division of Illinois Tool Works, Inc
R. W. Berry – Member, ANSI B94; Director, Cutting Tool Research, VR/Wesson Company

Chapter 16
Donald Marquardt – ISO/TC176 Ad Hoc Task Force
Maureen Breitenberg – USA Department of Commerce, NIST
Roger Frost – Press and Communication Manager, ISO
David Zimmerman – Interim Secretary, ISO/TC176 - Quality Management and Quality Assurance

Tables and figures where a standards reference or a company abbreviation is shown in parenthesis have been reprinted with the permission of the organization that hold the copyright of the works cited.

Tables and figures without any reference have been reproduced courtesy Massey Ferguson Inc., Detroit, Michigan, and **KOK metric*USA*™.org, Inc.** , Statesville, North Carolina.

The author also wishes to express his sincere appreciation to the referenced organizations for granting permission to use their tables, figures and standards in this publication. Special thanks go to the American National Standards Institute (ANSI), the American Society of Mechanical Engineers (ASME), the International Organization for Standardization (ISO), and Industrial Fastener Institute (IFI). Without their comprehensive support, the publication of *METRIC STANDARDS for Worldwide Manufacturing* , with its extensive standards material, would not have been possible.

Finally, the author's sincere gratitude is extended to the following organizations and companies for granting permission to republish their standards, figures, or tables: the American Society for Testing and Materials (ASTM), Philadelphia, Pennsylvania; Ford Motor Company, Ltd., Brentwood, Essex, United Kingdom; Chrysler Corporation, Detroit, Michigan; Gates Rubber Company, Denver, Colorado; Stock Drive Products, New Hyde Park, New York; and the Metric and Multistandard Components Corporation, Hawthorne, New York.

Please always refer to the most recent edition of the referenced standards. In the United States, American National Standards, International Standards, and national standards of other countries may be obtained from the American National Standards Institute (ANSI), New York, NY. Outside of the United States, sales of standards are transacted through the national standardizing body for the particular country.

Knut O. Kverneland

Foreword
Introduction
Preface
Acknowledgements
Contents

Chapter 1
World Standards Organizations

Chapter 2
The International System of Measuring Units (SI)

Chapter 3
Engineering Drawing Practice

Chapter 4
Preferred Numbers

Chapter 5
Surface Texture

Chapter 6
The ISO System of Limits and Fits - Tolerances and Deviations

Chapter 7
The ISO System of Limits and Fits – Inspection of Workpieces

Chapter 8
Screw Threads

Chapter 9
Fasteners

Chapter 10
Steel Material Data

Chapter 11
Nonferrous Material

Chapter 12
Bearings

Chapter 13
Mechanical Power Transmission Systems

Chapter 14
Fluid Power Systems and Components

Chapter 15
Manufacturing Engineering

Quality and Environmental Management System (ISO 9000 and ISO 14000)

Chapter 17
Conversion Factors and Program

General Index

ANSI Index

ISO Index

World Standards Organizations

SUMMARY

International standards are herein listed and compared to major industrial (63% of global GDP) national standards throughout this book (see Fig. 1-1). American National Standards for metric products are the basis for all tables in this publication when available. Pertinent global ISO (International Organization for Standardization) standard numbers are shown for each product, and related ISO and national standards are shown with hyperlinks to the standards organizations at the end of each chapter. Acronyms, standard prefixes, name and addresses as well as email and telephone numbers to a number of important national and international standards sources are shown in Table 1-1. Key standards groupings with links to ISO search engines are shown in Tables 1-2 and 1-3. ISO Members Worldwide list provide contact information for standards organization in each country.

A strong emphasis on cost savings and rationalization of parts and material has been stressed; Chapter 4, Preferred Numbers, provides detailed descriptions of the best tools to help rationalize metric sizes and products.

ROLE OF STANDARDIZATION: PAST, PRESENT, AND FUTURE

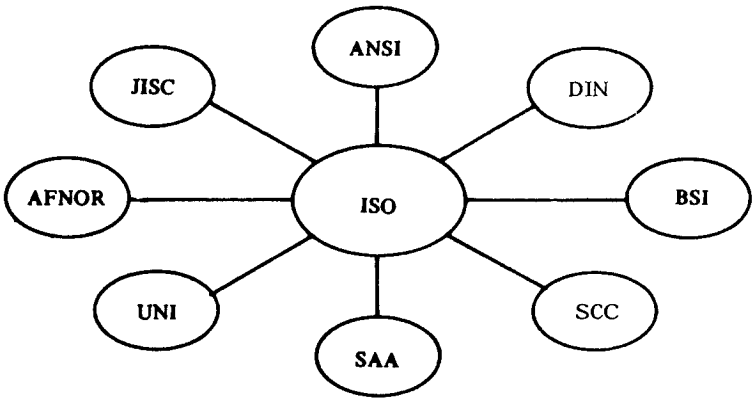
By definition, standards are rules set up and established by authority, often for the measure of quantity, weight, extent, value, or quality. Monetary standards, used in determining the weight of silver and gold pieces for the exchange of goods, were among the first to be developed.

During the industrialization period, manufacturing plants developed and became more and more specialized. A need for standards to control such simple parts as fasteners evolved, hereby making them industrially interchangeable. The demand for company and trade organization standards grew apace with the formation of larger plants and the wider distribution of manufactured products.

The basis for most standards is a uniform unit of measure to check mass, length, volume, time, and other physical quantities. Many systems were developed over the years, and the original metric system was developed in France after the French Revolution. Since 1875, all international matters concerning the metric system have been the responsibility of the Conférence Générale des Poids et Mesures (CGPM), which was constituted following the Metric Convention signed in Paris that same year.

Before the invention of the metric system, a number of inch systems were used throughout the world, one of which is commonly known as the customary inch system. National and international standards were developed, however, based on *both* measuring systems. This made the worldwide interchangeability of simple standard components, such as fasteners, impossible.

WORLD STANDARDS ORGANIZATIONS



MEMBER COUNTRIES

LISTED IN ORDER OF GNP

ANSI	USA
JISC	Japan
DIN	Germany
AFNOR	France
BSI	UK
UNI	Italy
SCC	Canada
SAA	Australia

FIG. 1-1 PARTIAL ISO MEMBERSHIP STRUCTURE

METRIC AND INCH STANDARDS

An increasing number of multinational corporations and their local suppliers operating with two systems of measures and standards have found expenses to be continually increasing. In order to use available expertise in a central location, one machine might be designed in an “inch” nation, only to be produced later in a “metric” country, or vice versa. This obviously generates additional costs in the conversion of drawings, substitutions of standard steel sizes and fasteners, the conversion of testing and material specifications, etc.