METRIC STANDARDS FOR WORLDWIDE MANUFACTURING

2007 Edition

Knut O. Kverneland

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FOREWORD

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

INTRODUCTION

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

PREFACE

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 2005 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 2006 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 2007 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

ACKNOWLEDGMENTS

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 metric*USA*™.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.

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KOK metric*USA*™.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)

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Japanese Standards Association; Japan Iron and Steel Exporters' Association
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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

Special Courtesy Note to Contributing Standards Bodies and Companies

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

CONTENTS

Chapter 1

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

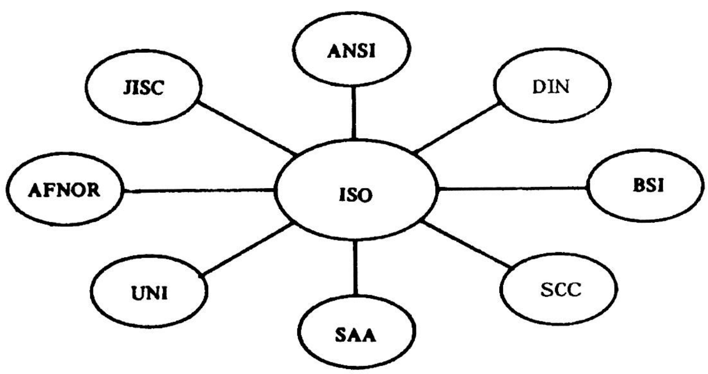
By definition, standards are rules set up and established by authority, often for the measure of quantity, weight, extent, value, or quality. Monetary standards, used in determining the weight of silver and gold pieces for the exchange of goods, were among the first to be developed.

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.

ISO METRIC STANDARDS – THE KEY TO WORLD TRADE

The WTO (World Trade Organization), which is supported by more than 120 countries, now replaces the GATT (General Agreement on Trade and Tariffs) with the result being a considerable strengthening of its standards codes. The WTO urges governments to make maximum use of International Standards to prevent unnecessary obstacles to the free flow of goods.

The EU (European Union) has been in existence for a few years now, and they have published a large number of European Standards identified by the prefix EN (European Norm)[1] Approximately 41% of these standards conform to an existing ISO or IEC standard on the subject.

For example, ISO 898-1 on Mechanical Properties of Fasteners is now identified within EU as: DIN EN ISO 898-1 (Germany); NF EN ISO 898-1 (France); BS EN ISO 898-1 (United Kingdom); and UNI EN ISO 898-1 (Italy).

ISO standards adopted as EN standards are put into effect with a minimum effort on the part of EU, and two important goals are met such as:

1. allow free flow of goods among the EU countries; and
2. allow free flow of goods to and from EU meeting the ISO standards.

Regional trade agreements and related activities in other parts of the world are similarly leading to greater use of international standards. For example, the Pan American Standards Commission, which is trying to develop uniform standards for the Latin-American Free Trade Association, has now agreed to use the ISO and IEC standards wherever possible. Also, the countries of Eastern Europe have become increasingly active in the development of international standards; apparently they are using them as the basis for trade in that region and in opening trade channels with the rest of the world as well.

Another factor in the use of international standards is the increasing number of international cooperation programs. A prime example is the North Atlantic Treaty Organization (NATO), which has been ordering a great deal of its equipment in terms of ISO and IEC standards. This also is happening within many of the social and economic programs of the UN. and other world organizations. One result is the adoption of many ISO and IEC standards by the developing countries.

[1]Norm means standard in English, German, and French

ACCELERATING PACE IN PUBLICATION OF ISO STANDARDS

The above-mentioned factors have accelerated the speed with which ISO develops international standards.[2] As an example, only 100 ISO Recommendations were published in the 1950s, yet approximately 1400 international standards agreements were reached in the following decade. See ISO in Figures.

Today, there are over 16 000 ISO standards, half of which have been published only in the last ten years. A further 9000 drafts and proposals are in preparation, and around 1250 new projects are added annually.

The time required to develop a standard in the Technical Committee has been reduced from an average of 76.8 months to 52.9 months. The central Secretariat has reduced the processing time for a proposed standard from 10.2 months to 7.5 months. The ISO target is to reduce standards development to three years from start to finish by the end of 1996.

How many international standards are needed is a matter of opinion. It has been suggested that in a highly industrialized society, the total requirement for national and international standards is on the order of 15 000, or a maximum of 20 000. This number is also suggested if all national standards were to be replaced by ISO standards. (When more than that number is found in a single country, there is usually some duplication and overlapping, which is the case in the USA, or, as is the case in socialist countries, what could be called "company standards" are listed as "national standards.")

Other suggest that in the future, as industries merge and multinational companies further develop, some of the present national standards will become company standards, but there will always be a demand for some national standards to cater to specific local needs.

However, recent experience indicates that as new technologies emerge, there is an accompanying demand for new standards that have never existed at a national level. The scope for new international standards is, therefore, increasing continuously.

[2]Since ISO documents are constantly being upgraded, for simplicity the author refers to all ISO publications in the text of this book as "standards," designating a particular document as "ISO..." followed by the appropriate identification number.

However, the actual status of a particular ISO document might be: (a) *Recommendation*, in which case it would be officially designated by "ISO/R..." preceding the appropriate identification number. (b) *Draft International Standards*, ("ISO/DIS..."). (c) An officially adopted international standard, in which case the initials "ISO" followed by the identification number is the appropriate designation. The ISO references given at the end of each chapter describe the current status of the standard. Information on the various designations is given at the website http://www.iso.org or in ISO catalogs and supplements available from: American National Standards Institute, 25 West 43rd Street, 4th Floor, New York NY 10036

A VISION OF THE FUTURE

Since 1986, the leadership of ISO and IEC has placed increasing importance on the necessity to understand and respond effectively to new needs for international standards. In 1987, approval was given to establish two important new groups for this purpose.

THE ISO/IEC PRESIDENTS' ADVISORY BOARD ON TECHNOLOGICAL TRENDS (ABTT)

This is a group of top-level industrial and technology policy leaders invited by the two Presidents to advise ISO and IEC on global trends in technology and industrial development, and their consequential impact on the demand for global standardization.

THE ISO/IEC AD HOC GROUP ON LONG-RANGE PLANNING (LRPG)

This is a new group of individuals nominated by the ISO and IEC members for Canada, France, Japan, UK, USA, and the former USSR. The group undertook the task of forecasting future needs for international standardization in specific sectors. These two groups have worked interactively since they started operating in 1988, and the results of their efforts are presented in the publication *A Vision for the Future- Standards Need for Emerging Technologies.*

ISO DEFINITION OF STANDARDIZATION AND STANDARD

The definition of standardization and standard differ in the many publications on the subject. The following are the excerpts from the *ISO/IEC Guide 2: 1991- General Terms and Their Definitions Concerning Standardization and Related Activities.*
Standardization- activity of establishing, with regard to actual or potential problems, *provisions* for common and repeated use, aimed at the achievement of the optimum degree of order in a given context

NOTES:
(1) In particular, the activity consists of the processes of formulating, issuing and implementing standards
(2) Important benefits of standardization are improvement of the suitability of products, processes, and services for their intended purposes, prevention of barriers to trade, and facilitation of technological cooperation.

subject of standardization — topic to be standardized

NOTES:
(1) The expression "product, process or service" has been adopted throughout to encompass the subject of standardization in a broad sense, and should be understood equally to cover, for example, any material, component, equipment, system, interface, protocol, procedure, function, method, or activity.
(2) Standardization may be limited to particular aspects of any subject. For example, in the case of shoes, sizes and durability criteria could be standardized separately.

field of standardization — (deprecated: domain of standardization) — group of related *subjects of standardization*

NOTE: Engineering, transport, agriculture, quantities, and Units, for example, could be regarded as fields of standardization.

state of the art — developed stage of technical capability at a given time as regards products, processes, and services, based on the relevant consolidated findings of science, technology, and experience
acknowledged rule of technology — technical provision acknowledged by a majority of representative experts as reflecting the *state of the art*

NOTE: A *normative document* on a technical subject, if prepared with the cooperation of concerned interests by consultation and *consensus* procedures, is presumed to constitute an *acknowledged rule of technology* at the time of its approval.

level of standardization — geographical, political, or economic extent of involvement in *standardization*
international standardization — *standardization* in which involvement is open to relevant bodies from all countries
regional standardization — *standardization* in which involvement is open to relevant bodies from countries from only one geographical, political, or economic area of the world
national standardization — *standardization* that takes place at the level of one specific country
provincial standardization — *standardization* that takes place at the level of a territorial division of a country

NOTE: Within a country or a territorial division of a country, *standardization* may also take place on a branch or sectoral basis (e.g., ministries), at local levels, at association and company levels in industry, and in individual factories, workshops, and offices.

consensus — general agreement, characterized by the absence of sustained opposition to substantial issues by any important part of the concerned interests and by a process that involves seeking to take into account the views of all parties concerned and to reconcile any conflicting arguments
NOTE: *Consensus* need not imply unanimity.

IMPORTANT OBJECTIVES OF STANDARDIZATION

A primary purpose of standardization is to manufacture goods for less direct and indirect incurred costs and to adapt the finished products to the demands of the marketplace.

A more detailed description of the objectives is as follows:

(a) Lower the production costs, when the aim is to:

(1) facilitate and systematize the skilled work of designing
(2) ensure optimum selection of materials, components, and semifinished products
(3) reduce stocks of materials, semifinished products and finished products
(4) minimize the number of different products sold
(5) facilitate and economize the procurement of purchased goods

(b) Meet the demands of the marketplace, when the objective is to:

(1) conform to regulations imposed by governments and trade organizations
(2) stay within safety regulations set forth by governments
(3) facilitate interchangeability requirements with existing products

DEVELOPMENT OF STANDARDS

The Conditions for a Standard. When there is a question of working out a standard, the conditions must first be analyzed before actual technical standardization work can be carried out. Preparatory analysis must be as comprehensive as possible and must take into account both technical and economic conditions. It is not sufficient to study only the internal circumstances. It must also be understood that, with regard to standards, the company is dependent on such external factors as the suppliers' stocks of products, the production program of competitors, the customers' wishes, existing standards, governmental requirements, etc.

Waiting for the right moment to begin a particular standardization is most important. An investigation should be made as to whether an intended standard could possibly impede any technical development already under way. Lack of a standard is more often the condition, and it is important to engage in standardization at an early stage, at least to the extent of working out an experimental standard of a temporary nature.

A certain type of regularly recurrent part may, for example, be used in many products in functionally equivalent, but constructionally different, forms. In such a case, the task of standardization will be to create order out of chaos through variety-reduction, size standardization, etc. The work should be started as soon as the possibilities of direct cost savings in purchasing, production, inventory, etc., and indirect cost savings in engineers' time can be established.

STANDARDIZATION TECHNIQUES

Two basic principles for the preparation of a standard are commonly used; these are as follows. *analytical standardization* — standard developed from scratch
conservative standardization — standard based, as far as possible, on existing practice

In practice, it appears that a standard cannot often be a completely prepared in one or the other of these two methods, but emerges from a compromise between the two. The quintessence of the standardization technique should be to utilize the basic material, the rules, and the aids available, in such way that a valid and practical compromise solution is reached.

The basic material could be comprised of such items as:

- former company standards
- vendor catalogs
- national and international standards
- requirements of the company's customers
- competitors' material

Increasingly important are the national and international standards in existence on the subject; they should always play an important role in any conservative standardization work. It would be foolish to create a unique new metric standard without first considering some existing European metric standards.

NORMAL DEVELOPMENT LEVELS OF A STANDARD

The most common standardization levels are:

- company standard
- professional society or trade standard
- national standard
- regional standard
- international standard

The normal path through which a standard must pass in the developmental stages depends on the organization level and the standardization technique applied. A new international standard generated by applying the analytical principle follows the organization levels in a numerical order, while a company standard prepared after the conservative principle might be based directly on the applicable international standard.

A more recent trend in international standardization is to draft a new standard directly when a need for it has been established.

USER ACCEPTANCE OF STANDARDS

The development cycle of the standards is completed when the user applies the standards in his or her work. The designer should, whenever possible, use internationally standardized parts and components. This would result in an increase of the demand for the standard sizes and a decrease in manufacturing costs for the parts. With the above principle applied to the increasing world flow of material and products, a substantial increase in worldwide productivity can be visualized.

STANDARDS ORGANIZATIONS INTERNATIONAL LEVEL

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies, at present comprising 146 members. The objective of ISO is to promote the development of standardization and related activities in the world with a view to facilitating international exchange of goods and services, and to developing cooperation in the sphere of intellectual, scientific, technological, and economic activity. The results of ISO technical work are published as *International Standards.* The scope of ISO covers standardization in all fields except electrical and electronic engineering standards, which are the responsibility of the International Electrotechnical Commission (IEC).

ISO brings together the interests of producers, users (including consumers), governments worldwide, and the scientific community, in the preparation of International Standards. Its technical work is carried out through 2940 technical bodies utilizing more than 30 000 experts, resulting in the publication of 14 000 ISO standards.

A listing of acronyms and addresses for standards organizations is found in Table 1-1.

Origin

International standardization started in the electrotechnical field some 90 years ago. While some attempts were made in the 1930s to develop international standards in other technical fields, it was not until ISO was created that an international standards organization devoted to standardization as a whole came into existence.

Following a meeting in London in 1946, delegates from 25 countries decided to create a new international organization "the object of which would be to facilitate the international coordination and unification of industrial standards." The new organization, ISO, began to function officially on February 23, 1947.

Members

A member body of ISO is the national body "most representative of standardization in its country." It follows that only one such body for each country is accepted for membership in ISO. Member bodies are entitled to participate and exercise full voting rights on any technical committee of ISO, are eligible for Council membership, and have seats in the General Assembly.

By January 2003, the number of member bodies was 94.

More than 70% of the ISO member bodies are governmental institutions or organizations incorporated by public law. The remainder have close links with the public administration in their own countries.

A *correspondent member* is normally an organization in a developing country which does not yet have its own national standards body. Correspondent members do not take an active part in the technical work, but are entitled to be kept fully informed about the work of interest to them. They may attend the General Assembly as observers. Nearly all the present correspondent members are governmental institutions.

By January 2003, the number of correspondent members was 37.

Technical Work

The technical work of ISO is carried out through *technical committees (TC).* The decision to establish a technical committee is taken by the ISO Technical Management Board which also approves ISO scope. Within this scope, the committee determines its own program of work.

Work in the field of information technology is carried out through a joint ISO/IEC technical committee, ISO/IEC JTC I

Information Technology, established in 1987 by the ISO and IEC Councils.

Each technical committee may, in turn, establish subcommittees (SC) and working groups (WG) to cover different aspects of its work.

Each technical committee or sub-committee has a secretariat, assigned to an ISO member body: in the case of technical committees, by the Technical Board on behalf of Council, and in the case of subcommittees, by the parent committee. For each working group, a convener is appointed by the parent committee.

By January 2003, there were 188 technical committees, 550 subcommittees, 2175 working groups, and 24 ad hoc study groups.

A proposal to begin work in a new field of technical activity normally comes from within ISO itself, but it may also originate from some other international organization. Since the resources are limited, priorities must be considered. Therefore, all new proposals are submitted for consideration by the ISO member bodies. If accepted, either the new work will be referred to the appropriate existing technical committee, or a new technical committee will be established.

To ensure coordination of work in all matters of common interest, liaisons are established between related technical committees.

Each member body interested in a subject for which a technical committee has been authorized has the right to be represented on that committee.

subcommittees (ISO/TC/SC) — This is the level at which most of the technical decisions are made and is also the level at which much of the technical liaison takes place. Subcommittees are charged with the study of one or several items within the scope of the technical committee.

working groups (ISO/TC/SC/WG) —The technical committees and subcommittees may set up working groups composed of a restricted number of individuals to prepare working drafts for standards development. The group may function between meetings of the parent committee, but it is automatically disbanded on completion of its task.

ad-hoc working group — a group that may be formed to deal with a matter on which it is required to report to the parent committee at the same meeting in which it is formed.

EVOLUTION OF AN INTERNATIONAL STANDARD

Prior to July 1971, subjects proposed and approved by ISO were known as "ISO Recommendations." Although the ISO charter included provision for the approval and publication as ISO standards, the procedure had never been invoked. In mid-1971, a decision was made to publish all ISO draft Recommendations as draft international standards and, subsequently, as international standards. At the same time a new category of document, to be known as a "Technical Report," was introduced. The descriptions which follow reflect current terminology.

draft proposals — a draft submitted to the participating (P) members of a technical committee for study which is intended eventually to become an International Standard. A given subject may undergo several successive committee drafts, i.e., first draft, second draft, etc.

draft international standard (DIS) — a committee draft which has received substantial support from the participating members of the technical committee and is transmitted to the Central Secretariat for registration. This is then circulated to the P-members and all the other Member Bodies for final letter ballot.

international standard — a draft international standard which has been adopted by a two-thirds majority vote of the P-members of the technical committee and approved by 75% of all the Member Bodies voting

technical report — there are three types of technical reports, as follows

(a) When the required support cannot be obtained for a DIS to pass the approval stage, or in case of doubt concerning consensus, the committee may decide, by a simple majority vote of its P-members, that the document should be published in the form of a technical report.

(b) When the subject in question is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an international standard, the committee may decide that the publication of a technical report would be appropriate. The decision to publish the technical report requires a simple majority vote of the P-members of the committee. A technical report of type (b) may be used for "prestandardization" purposes.

(c) When a committee has collected data of a different kind from that which is normally published as an international standard (this may include, for example, data obtained from a survey carried out among the national bodies, data on work in other international organizations, or data on the "state of the art" in relation to standards of national bodies on a particular subject), the committee may decide, by a simple majority vote of its P-members, to publish such data in the form of a technical report. Such a document will be entirely informative in nature.

Technical reports of types (a) and (b) are subject to review not later than three years after their publication. The aim of such a review is to reexamine the situation, and if possible, to achieve the agreement necessary for the publication of an international standard to replace the technical report.

FINANCE

ISO is maintained by the financial contributions of its members; the amount varies according to the circumstances of the country concerned. Additional revenue, however, is gained from the sale of international standards and other publications.