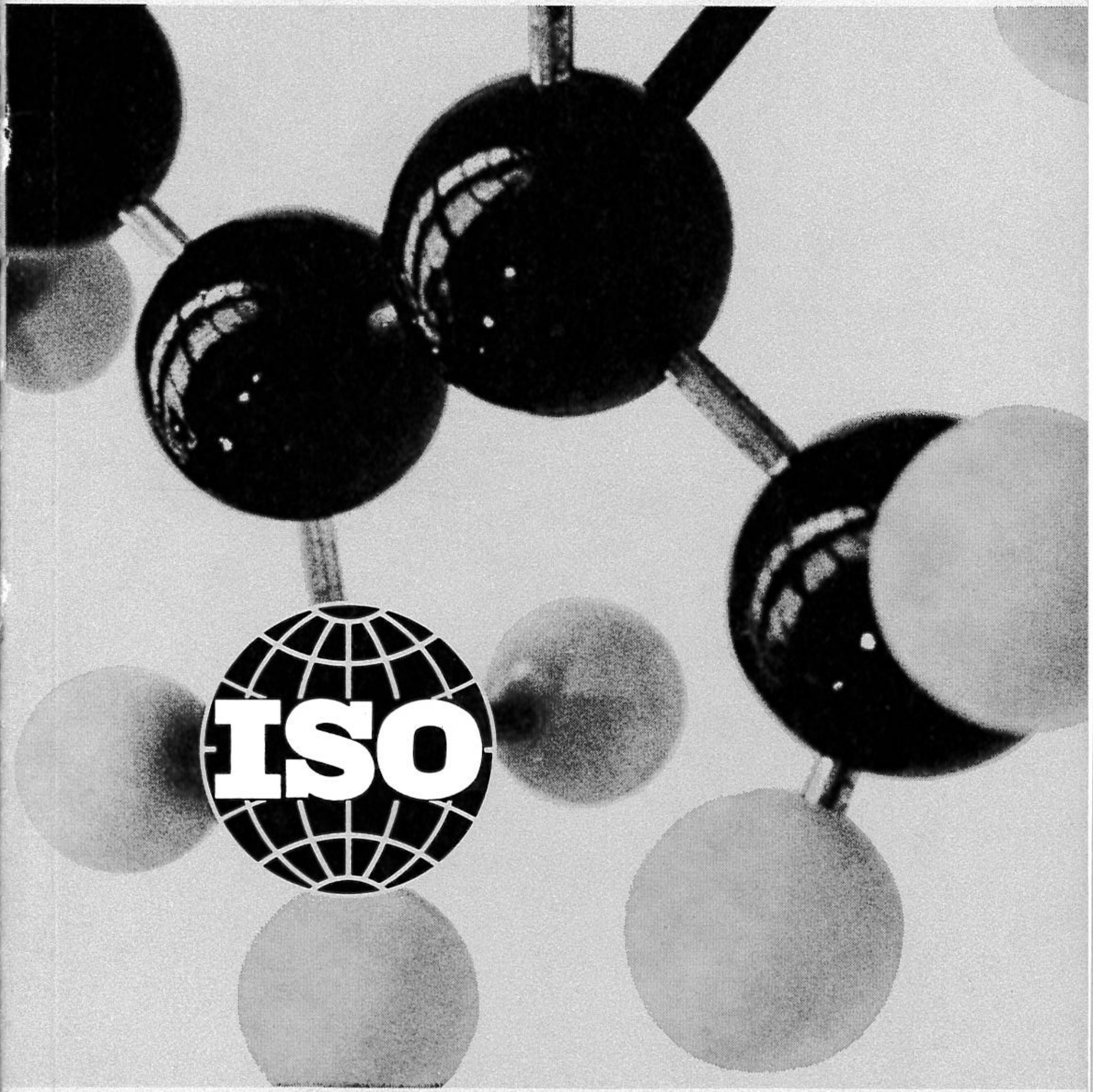
The aims and principles of standardization



The aims and principles of standardization

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Foreword

For many years, standardization was widely regarded as of secondary importance; a desirable enough activity, provided that one could afford it. In many companies a standards department would develop in the good years and retract or be disbanded altogether during the lean years in the quest for economy. In fact, the opposite approach would have been more appropriate. Likewise, standards people at both the national and international levels became accustomed to the fact that their activities were generally regarded as *desirable* rather than *vital*. Too few people recognized that standardizing was—and remains—the most effective means of all of making real economies.

Today, the attitude towards standardization has changed entirely. In line with rapid technological development, improved transportation methods and increased integration between companies, countries and even continents, the desire to standardize has been replaced by a *need* to standardize. We can no longer afford *not* to standardize.

This change of attitude is particularly evident in the international field. One can identify three major factors which have helped to create this new climate of opinion. First, there is the growing influence of the great multinational companies which sell their products and services on a world-wide market. In many cases, different national regulations and standards have forced them to produce costly and unnecessary variants of the product. With the development of international standards, however, those technical barriers to trade are being resolved.

A second powerful group are the developing countries, which now represent more than 60 percent of the total membership of ISO. For these countries, international standards are important when trying to build up a domestic industry that is both independent and competitive. International standards will allow them to buy and sell to the best possible price.

Thirdly, there is the phenomenon of the organized consumer. Today the consumer is represented nationally and, to an increasing extent, internationally, by influential consumer organizations which demand the best possible value for money.

International standards will allow the consumer not only to compare products from different companies and countries, but also to know the characteristics and the quality of the products.

The growing demand for international standards means that more and more people become involved in and affected by the work. Standardization is no longer the exclusive concern of industry. In the 1200 working parties of ISO, more than 50 000 experts—covering an extremely wide range of topics—take part. They come from governmental authorities, industry, research institutes, laboratories, consumer organizations, etc.

ISO has a standing committee charged with the study of the principles of standardization and this committee—code name STACO—has produced many useful reports and has contributed in no small measure to the evolution of the discipline of standardization as we now know it.

This book is an attempt to condense some of the general philosophy of these STACO studies, together with views expressed in certain other papers and documents emanating from leaders in close touch with international standardization. The book has been compiled and edited by the Chairman of STACO, Mr. T. R. B. Sanders (United Kingdom) with the assistance of members of the committee.

I should like to take the opportunity to thank Mr. Sanders and his colleagues on STACO for their work, and I sincerely hope that this book will be a useful addition to the current literature on standardization.

OLLE STUREN
Secretary-General

Introduction

Standardization is not new; it relates to an activity which is " as old as the hills ", an expression which may be interpreted literally since nature itself has shown the path for standardization discipline. For example, nothing is more perfectly standardized than the atom of oxygen or the molecule of water; also, on a higher level, the suns and their planets, or proteins which make living material; finally, beings themselves. Turnips are standardized, so are ducks. Nature, as it assembles particles, fits celestial bodies into space, peoples the earth with human beings, carries everything out according to pre-determined rules.

What more wonderful example is there of a precise industrial standard than the swallow's nest or the bee's honeycomb—or of the discipline of standardization than the work of bees, ants or beavers.

What is new about standardization is the twentieth-century approach to the subject. In an ever enlarging civilized world, demanding better communications, more and more trade between nations and an insatiable demand for manufactured goods and appliances, standardization has emerged both as the key to open many doors and also as a discipline which must be accepted by any civilized community if it is to enjoy the goods and services which it is now demanding. This has led in the twentieth century to a whole new science of standardization and to the development of product standards, firstly at national level and later at international level.

Any improvement in the life of man rests on the possibility of his being able to give the necessary time and thought to the cultivation of his spirit and his heart. For this, the threefold needs of man—food, lodging and clothing—must require from him and his fellow men less and less time, and the constant improvement of his equipment must afford him more and more effective means to make both his individual surroundings and his public life more beautiful. Production is at the root of this problem in all countries and in all climates. If this production is not disciplined, the looked-for results are not obtained and the economy may suffer. Standardization is one of the most efficient methods of furthering the harmonious and beneficial development of production sought for in the general interest. But to achieve this aim, standardization must itself rest on the scientific foundations of efficacity.

Standardization saves trouble in thousands of everyday matters. Every man's working day depends to an increasing degree on the interaction of typical solutions consciously chosen and established, and on mutual adaptation of one to the other. It depends on the normal appearance of an object and the parts of such, on the normalcy of recurring situations. The degree to which our physical—and perhaps to an even greater extent our psychical—forces are impaired and exhausted depends on the operation of the factor of normalcy. Standardization is therefore one of a group of factors comprising the general state of the culture of a society. It was once indispensable in the formation of language and the art of writing—a highly perfected means of expressing thought and therefore of the development of science. It played no small role in the development of such an art as music, and it contributed to the beauties of architecture.

The present development of international sport would be unthinkable without standardization. Rules must be established and equipment standardized, so that chances are equal for all in competitions, and so that results may be compared.

Standardization has eliminated and continues to eliminate the chance and uncertainty which characterize primitive relationships and hamper the creative human mind. Such an important element as confidence is acquired from standardization which gives a solid foundation to repetition and disciplined procedure. Standardization facilitates mental work, introduces order, simplifies and clarifies. It is a factor which assists the profitable exploitation of material wealth and the wealth of the mind already accumulated over various ages and in various fields.

Safety is also to a large extent dependent on the establishment of order and on defining the characteristics of environment, on the elimination of chance and the prevention of the occurrence of new situations in circumstances in which diversity of phenomena and conditions have not been mastered. The same is true of safeguarding—by means of standardization—manufactures and products, as well as entire buildings, machinery and equipment, since it is in standards that the appropriate requirements are defined.

One of the indications of a society's material culture is the degree to which success has been achieved in such matters as the control of corrosion or the limitation of damage in transit by means of sophisticated packing. Experience has shown that an important condition for cutting down losses is the understanding and use by the community of standardization methods, which give many general advantages in the same way as does the application of other principles of rational and effective procedure.

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The aims of standardization

The principal aims of standardization were defined some years ago by the ISO committee for the Study of the Principles of Standardization (code name ISO/STACO) as the promotion of:

1. Overall economy in terms of human effort, materials, power etc. in the production and exchange of goods.
2. The protection of consumer interest through adequate and consistent quality of goods and services.
3. Safety, health and protection of life.
4. Provision of a means of expression and of communication amongst all interested parties.

This definition of the aims was fairly widely accepted at the time and is still valid, but it now calls for examination and considerable amplification in view of the massive development of standardization at all levels during the past decade.

For example, there is now a much wider recognition of the value of standards as a means of communicating ideas and technical data, in creating order out of disorder and offering simplification in place of complexity. Moreover standards are now seen to play an essential role in the elimination of " trade barriers " between nations.

It is apparent that there can be no hard-and-fast division between the various aims of standardization since they are all inter-dependent on one another. Where safety and health are concerned, for example, it is seldom possible to adopt the most economical solution.

Where quality is specified the aim of communication is of the utmost importance since the particular conditions must be so expressed as to be clearly understood by all parties concerned.

It is important also to consider standardization as an activity, and to distinguish clearly between the aims of the activity on the one hand, and the methods and means employed for achieving them on the other: and also to distinguish between the methods employed and the effects which result from the activity.

We shall now take a careful look at the present-day aims of standardization and attempt to identify them.

Simplification

Modern standardization should perhaps first be considered as a process of simplification, combating the ever-increasing complexity of human life: Complexity may be compared to a flood tide surging relentlessly forward, which, if uncontrolled, will engulf all before it. Standardization is one of the primary means by which mankind is able to control the flood, to gather and disseminate information about it and to discipline its waters, directing them into approved channels for the benefit and safety of mankind.

Simplification is therefore perhaps the first and most important aim of standardization but communication, safety and economy follow closely behind.

Interchangeability

A very important aspect of simplification is the limitation of variety of manufactured goods and components. This is dealt with at some length in chapter 4 under the heading of " Variety reduction ". It can be applied at all levels of standardization but is particularly beneficial in terms of overall economy to the individual company, where it is the most direct and immediate means of effecting cost savings at the manufacturing stage.

Variety reduction presumes the principle of interchangeability—that is the ability of the manufacturer to produce a large batch of parts which are sufficiently identical in size, shape and performance to enable any one part to be substituted for another, to give the same performance.

No two parts can be absolutely identical and it is the duty of the standard to specify the degree of tolerance (departure from the theoretical conditions) which can be permitted without losing the advantage of interchangeability. A good example of dimensional interchangeability is the ordinary bolt and nut. Screw threads are now so highly standardized that, although vast quantities of bolts and nuts are made all over the world, those of a given diameter and pitch manufactured in one country are completely interchangeable with those manufactured in another.

Sometimes it is not necessary that the internal construction of one article shall be identical in all respects with another, so long as each complete article is dimensionally interchangeable and able to perform identical functions. Examples of this are the standard for ball bearings, where it is sufficient to specify the external dimensions of the complete ball race, together with its performance as regards load and speed, while leaving to the individual manufacturer the choice as to the size and exact number of balls to be used in the assembly. Or again, in the case of an electric motor, essential dimensions and electro-mechanical

characteristics may be specified while leaving to the manufacturer the choice as to the number and arrangement of wires in the winding.

In such cases it is usual to talk of " Functional Interchangeability " a term which is defined in Chapter 2.

Standards as a means for communication

We cannot make anything of our social, political or working environments unless we have adequate means of communicating about our needs, opinions and ideas with others. Man's concern, self-preservation apart, has always been essentially to communicate, whether through literature, art, philosophy or scientific discovery. Indeed, the leaps forward in technical and scientific knowledge have very often been milestones in the history of communications: the invention of printing, the development of newspapers, the discovery of radio waves, which have opened up entirely new cultures in radio and television and boundless possibilities in telecommunications, on this earth and in space.

A primary function of standards is to provide a means of communication between the manufacturer and the customer, to list the things which are available, their size and performance and to inspire the customer with confidence that if he orders goods which comply with a standard he can rely on their quality and reliability. As international standards come in, harmonizing and in some cases taking precedence over national standards, the aim of communication becomes even more self-evident.

A great many national and international standards now give a considerable amount of design data as well as advice on how to use the standard and on how to select from it the article most suitable for the particular requirement. This can exercise a powerful influence on customer demand and can assist the overall economy by channelling the demand into certain recognized lines. It has very great advantages but it has its dangers too, if the committees who prepare standards are too much dominated by manufacturing interests. An adequate strength of user opinion and of independent experts and professional men is essential if the standard is to reflect the best and latest practices and achieve its widest usefulness.

Symbols and codes

In international affairs differing languages are always a problem, but in some cases this can be overcome by the use of internationally agreed symbols and codes. Some important examples which may be quoted are the ISO Recommendations on Engineering Drawing Practice (ISO/R 128 and 129); and on the SI units and their use (ISO/R 31 and 1000). The former enable designs to be submitted all over the world, both simplifying the process and minimizing the language problem. The latter provides a means of communicating dimensions and physical quantities which is world-wide.

Similarly, in the electrical technology, communication between engineers throughout the world is facilitated by the standard letter symbols and graphical symbols given in IEC publication 27 and by the recommended graphical symbols given in IEC publication 117.

Overall economy

Some persons may claim that economy in its broadest sense is the first and ultimate aim of all standardization activity; and that, apart from standards directed towards safety, where the most economical solution can seldom apply, all standards should show clear economic advantages if they are to be promoted at all. But the problem is not quite so simple as this.

In the standardization of products, the achievement of overall economy is bound to be a compromise in that it will not be attained when all its individual components are each one at their optimum, because they are interdependent one on another. For example, the greatest economy in labour may preclude the greatest economy in materials, and vice-versa. Or again, the greatest economy in design and manufacture may give rise to a product which is not the most economical in running expenses. Moreover, it is necessary to pay equal regard to the economy of the producer and that of the consumer.

The economic effects of a particular standard are generally so complex that, until very recently, standardizers at all levels have tended to neglect them altogether, concentrating their attention only on the technical aspects. But this attitude is changing very rapidly and many attempts are now being made to assess the economic advantages and to bring them to the notice of producers and consumers alike. The subject is discussed more fully in Chapter 5.

Safety

There are many product standards prepared solely for the protection of human life and health. Examples are safety belts for motorists or airline passengers, industrial protective clothing of all kinds, life-belts for use at sea. Many countries make these standards mandatory in use. There are other standards solely concerned with safety which are more in the nature of Codes of Practice. They would include such items as fire regulations to be observed in the construction of buildings, or regulations dealing with the installation of electric wiring. In addition, a vast number of national, and a growing number of international standards have safety requirements written into them as one aspect of the particular standard.

More now than ever before it may be said that safety and protection of human life are one of the principal aims of standardization.

If the primary aim of the standard is to ensure safety then this aspect will take precedence over everything else. Goods must be manufactured with the utmost care to ensure a very high degree of reliability and in addition re-inspection and check testing will be called for at intervals during the life of the goods. All these requirements will need to be set out in the standard and compliance with the standard is frequently made enforceable by law. This naturally tends to make the goods more expensive but it must be remembered that the cost of accidents or of breakdown of vital equipment can be very much greater. Economy must always take second place where safety is concerned.

Consumer interest

Almost all standards are prepared for the ultimate benefit of the persons who are going to use the products and so the consumer should be equally concerned with the manufacturer in preparing them. Unfortunately the majority of consumers are not very well organized for presenting a collective opinion, and in most cases are not technically qualified to do so. Nevertheless the implementation of the majority of standards rests ultimately with the consumer, since if he does not have confidence in the standard, he is unlikely to buy the product.

The protection of consumer interest is undoubtedly one of the most important aims of standardization, and it is clear that the notion of quality of goods comprises their properties both at the time of purchase and in the process of their subsequent use (e.g. durability, reliability etc.). As proof of the growing recognition of the importance of protecting consumer interest through the medium of national standards it may be stated that 37 countries now operate a certification system in connection with their national standards and many more countries are contemplating one. By such a system the conformity of products to the relevant standard is certified by the national standards body.

Community interest

Nowadays it is not only the manufacturer and the consumer who are concerned with standards. There is a wider community interest which has to be catered for; this is exemplified very forcibly in relation to environmental aspects to which our attention is turned so dramatically at this time. Unless this broad community interest is fully provided for, the work for standards at both the national and international levels will fall progressively short of what is wanted for living standards. So we have to bring into the consensus these views also, i.e. those of Governments, of the medical profession, of research centres, of social organizations and the like.

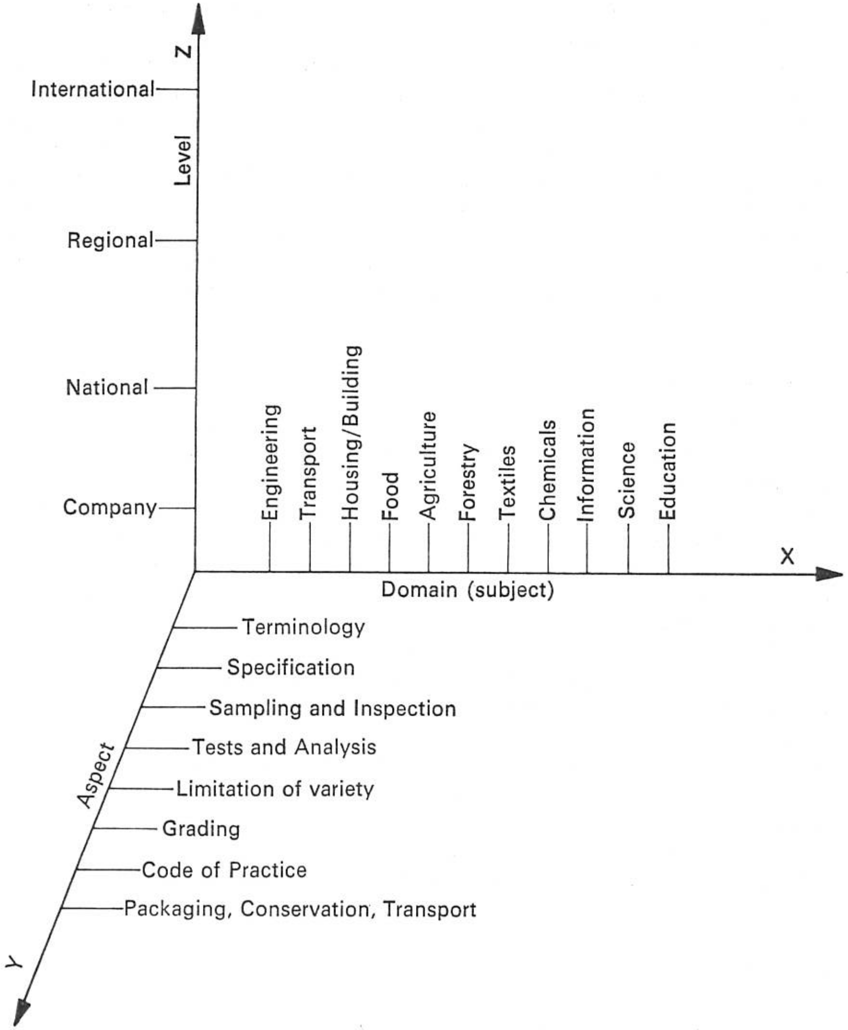

FIG. 1. **Diagrammatic Representation of Standardization Space**

Trade barriers

The rapid advances in technology which are taking place all over the world and the vast increase in volume of manufactured goods now passing between one country and another have created a demand for new and up-dated standards bearing international status to a degree which was never conceived until very recently. It is not really desirable that standards, be they national or international, should be applied with the force of law unless this is necessary for reasons of public safety, health or environment, or occasionally for avoidance of gross deception. But the policy of legislating by " reference to standards " instead of attempting to issue separately devised technical regulations, is becoming more and more frequent, and more and more necessary, as technology develops and trade expands. The aim of standardization must therefore be: firstly to reach agreement in a forum of international experts, such as is provided in the technical committees of the ISO and IEC, on the technical content of standards, including the quality of goods and the methods of ensuring it and on the codes of good practice for putting the goods into service and utilizing them: secondly to apply the principle of " reference to standards " in drafting laws and regulations in individual countries. Only in this way can the right of independent nations to frame their own rules and regulations be made compatible with the universal desire to eliminate trade barriers. Only in this way can we avoid cumbersome legislation and make the best use of scarce technical resources; and at the same time provide the optimum solution in the dynamic circumstances created by the pace of technological progress.

The recognition of this comparatively new role for international standards accentuates the *urgency* in providing them, since there are many areas in which they do not exist at present and the mere absence of an approved standard may lead to conflicting regulations in different countries which can be a far more effective barrier to trade than any tariff laws which existed in the past.

Summary of the aims

To conclude this discussion, we may summarize the modern aims of standardization today under the six headings:

1. Simplication of the growing variety of products and procedures in human life.
2. Communication.
3. Overall economy.
4. Safety, health and protection of life.
5. Protection of consumer and community interests.
6. The elimination of trade barriers.

The principles of standardization

There is evidence that knowledge in the physical sciences has been growing at an exponential rate, doubling itself every fifteen years or twenty years. With the advent of mass production and more recently of automation in industry, the variety of articles becomes more and more abundant and complex. Anxious for a more efficient life, man has consciously worked to reduce the variety and number of types in his commodities and even in his manner of life. The conscious effort of reduction to manageable proportions is the beginning of standardization. Thus—

Principle 1

Standardization is essentially an act of simplification as a result of the conscious effort of society. It calls for a reduction in the number of some things. It not only results in a reduction of present complexity but aims at the prevention of unnecessary complexity in the future.

This conscious effort of society towards simplification can succeed only through the mutual cooperation of all concerned. The method of establishing a standard should be based upon general consensus. A *consensus* in standardization practice is achieved when substantial agreement is reached by all the interests concerned, according to the judgement of a duly appointed authority. Consensus implies much more than the concept of a simple majority but it does not necessarily imply unanimity. Thus—

Principle 2

Standardization is a social as well as an economic activity and should be promoted by the mutual cooperation of all concerned. The establishment of a standard should be based on a general consensus.

The final objective of standardization activity is to bring about the conditions of efficient and comfortable life of the people. The effect of standardization can be appreciable only if standards are implemented. Formulating or publishing a standard is merely a means to approach the goal. Even though the published standards were of excellent content they would be of no value if they were not widely implemented in every field of practical activities of production and consumption. Implementation generally calls for sacrifice by some because more often than not a standard which involves no sacrifice by anybody will prove to be of only limited value. It will be no more than a reiteration of practices already established and accepted. Therefore, the cooperation of all persons concerned is essential, and for obtaining such cooperation strong propaganda or public relations is indispensable. Thus—

Principle 3

The mere publication of a standard is of little value unless it can be implemented. Implementation may necessitate sacrifices by the few for the benefit of the many.

The selection of standardization subjects and aspects should be made carefully from various viewpoints. The order of priority should be considered according to the particular situation; and since the direct object of standardization is to change complexity into simplicity and superfluity into adequacy the course of action may be as follows—

(1) to select rationally the most appropriate things from many alternatives;

(2) to make the selected ones firm, or secure from change, for a certain period.

Thus—

Principle 4

The action to be taken in establishing standards is essentially one of selection followed by fixing.

Notwithstanding what has been said above, all standards need to undergo periodic review and revision. The interval between revisions will vary quite widely, depending on individual circumstances. It should not be too short, for the reason explained in principle 4. But standards can never remain static for long. For most standards it is desirable that there should be a check every five years to see whether revision is needed. At the other end of the scale, nearly all standards are likely to need substantial revision within ten years of publication. Thus—

Principle 5

Standards should be reviewed at regular intervals and revised as necessary. The interval between revisions will depend on the particular circumstances.

When drafting product standards it is usual to specify the main characteristics of the product as well as the performance to be expected from it in service and, where appropriate, the properties of the materials from which it should be constructed. For each of the characteristics which are specified, means must be found for a clear and non-ambiguous determination to be made as to whether a particular product or batch of products does comply with the standard or not. Therefore the standard should include the methods of test to be adopted and if necessary a description of the test apparatus.

If sampling methods are adopted (see Chapter 9) the method of sampling should be specified.

Thus—

Principle 6

When performance or other characteristics of a product are specified, the specification must include a description of the methods and tests to be applied in order to determine whether or not a given article complies with the specification.

When sampling is to be adopted the method, and if necessary the size and frequency of the samples, should be specified.

The question of whether legal enforcement of a standard is desirable needs to be considered very carefully with due regard to all the circumstances. The decision will depend on the nature of the standard and the level of industrialziation of the society, as well as on the constitution and laws of the country or countries in which the standard is intended to operate. There are many cases of standards legally enforced—standards of measurement for example (in French " étalon "). Where safety and health are involved some legal enforcement will frequently be desirable. Sometimes this will be done internationally, by agreement between nations. Examples are traffic regulations (on land, sea and in the air) or standards needed for the control of pollution.

Codes of practice may also call for some legal enforcement, but most product standards rely on implementation by consent which is much better if it can be achieved. In many cases legal enforcement would prove impracticable and if the customer always insists that the goods which he buys shall comply with the appropriate standards, this can be a much more powerful sanction against sub-standard goods and services than a law which is difficult to enforce. However, in the developing countries, where the accumulated practices in industry have not firmly taken root, some additional step about legislation may be worthy of consideration.

Thus—

Principle 7

The necessity for legal enforcement of national standards should deliberately be considered, having regard to the nature of the standard, the level of industrialization and the laws and conditions prevailing in the society for whom the standard has been prepared.

SUBJECT, ASPECT AND LEVEL OF STANDARDIZATION

The terms subject, aspect and level have already been used in describing the aims and principles of standardization. We now propose to consider more precisely what is meant by each of them.

Standardization subject

The majority of standardization subjects are material objects such as bolts and nuts, copper tubes, domestic appliances, dental instruments and there are many hundreds of these. But there are a great many more abstract subjects also such as limits and fits, grading or sampling of minerals, noise assessment: or again there are letter and graphical symbols like the electrical ones, or those used to denote surface texture. Because there are so many standardization subjects it is convenient to group them together into " domains ". A standardization domain is a group of related subjects and the following are a few examples: engineering, packaging and transport, food, agriculture, textiles, chemicals.

In the orthogonal system of three axes, illustrated in Fig. 1, denoting " standardization space " subjects and domains are presented along the X-axis: and, since there are a very great number of standardization subjects, for convenience only examples of domains are indicated on the figure.

Standardization aspect

A standardization aspect is a group of requirements or conditions which must be satisfied by a standardization subject if that subject is to be regarded as conforming to a standard. There are many aspects and to name only a few of them: specification, analysis, testing, sampling and inspection, code of practice.

These are presented along the Y-axis in Fig. 1.

Standardization level

Standards can be promulgated at different levels, the four most important levels being:

(1) *The International level*—standards such as those of the ISO and IEC, resulting from cooperation and agreement between a large number of independent sovereign nations having common interests. Such standards are intended for world-wide use.

(2) *The Regional level*—standards initiated by a limited group of several independent nations, or by a regional standards body, for their mutual benefit. Examples of the latter are the European Standards Committees CEN and CENEL, the Pan American Standards Commission COPANT and the Eastern European Group CMEA.

(3) *The National level*—standards promulgated after consulting a consensus of all the interests concerned in a country, through a national standards organization which is recognized as the proper authority for the issue of such standards.

(4) *The Company level*—standards issued by an individual company (or in some cases a group of companies), prepared by common agreement between various departments of the company for guiding its purchases, manufacture, sales and other operations.

The levels of standardization are presented along the Z-axis in Fig. 1.

A " Standard " may be regarded as a document containing a solution of a standardization problem: and the problem, which may be concerned with one or more subjects, generally with several aspects and handled at a certain level, will occupy a defined volume of " standardization space " * in Fig. 1.

It is obvious that the " standardization space " as described above cannot be taken as a mathematical space of either continuous or discrete variables; it is to be regarded merely as a convenient device to illustrate the three important attributes of standardization problems.

From the above description of the standardization space, it will be clear that the field of standardization today has become much more extensive than it was, let us say, about half a century ago, when it first began to develop as an engineering activity aimed chiefly at simplification and limitation of variety. In particular, the multiplicity of variables along the aspect axis of standardization space shows the growth of this complexity during the past several decades, and there is no indication that this growth has reached a saturation point. On the contrary, judging from the rate of progress of present-day science and technology, there is every reason to believe that a great many new variables will continue to be added to the subject as well as the aspect axes of the standardization space, although we may take it that the level axis will remain, more or less as now conceived subject to regional variations.

* This concept of " Standardization space " as a logical means of presenting standardization problems was first proposed by Dr. Lal Verman, Director General of the Indian Standards Institution from 1947 to 1955

2

Terms and definitions

Perhaps the most basic of all kinds of standard is the definition of terms and, with the growing interdependence of nations upon one another, this calls now for much work to be undertaken at international level.

Even at national level it is all too easy to create confusion by using different words to refer to the same thing: and it is even more bewildering when a single word has come to have a variety of meanings in different industries or in different parts of one country. Internationally, with the added problem of translation into other languages, the possibilities for misunderstanding are unlimited.

There are a number of basic terms used in standardization documents which have special meanings ascribed to them. Some of the terms are special in themselves—terms not often found elsewhere in literature: but more often they are quite well known terms which in other contexts have different meanings but in standardization work are used in a very special sense.

ISO has already published a preliminary list of some basic terms with definitions in English, French and Russian; and several countries have adopted them and translated them into further languages. Already this is helping to promote greater uniformity and easier understanding throughout the world. It may happen that the ISO definitions differ from those given in national dictionaries. But it must be emphasised that the definitions adopted by ISO in this way are intended for use only in the specific field of standardization where the words have their own special meaning. In other contexts the words may have somewhat different meanings ascribed to them.

A selection of these terms—ones used fairly frequently in this book—are listed below.

Group I—Standardization and related terms

Standardization

The process of formulating and applying rules for an orderly approach to a specific activity for the benefit and with the co-operation of all concerned and in particular for the promotion of optimum overall economy taking due account of functional conditions and safety requirements.

It is based on the consolidated results of science, technique and experience.

It determines not only the basis for the present but also for future development and it should keep pace with progress.

Some particular applications are:

(1) units of measurement;

(2) terminology and symbolic representation;

(3) products and processes (definition and selection of characteristics of products, testing and measuring methods, specification of characteristics of products for defining their quality, regulation of variety, interchangeability, etc.);

(4) safety of persons and goods.

Standard

The result of a particular standardization effort, approved by a recognized authority. It may take the form of:

(1) a document containing a set of conditions to be fulfilled (in French " norme ")

(2) a fundamental unit or physical constant, for example, ampere, metre, absolute zero (Kelvin). (In French " étalon ".)

Specification

A concise statement of a set of requirements to be satisfied by a product, a material or a process indicating, whenever appropriate, the procedure by means of which it may be determined whether the requirements given are satisfied.

NOTES

1. A specification may be a standard, a part of a standard, or independent of a standard.
2. As far as practicable, it is desirable that the requirements are expressed numerically in terms of appropriate units, together with their limits.

Simplification (variety reduction)

A form of *standardization* consisting of the reduction of the number of types of products within a definite range to that number which is adequate to meet prevailing needs at a given time.

Unification

A form of *standardization* consisting of combining two or more *specifications* into one, in such a way that the products obtained are interchangeable in use.

Specialization

This term is properly speaking not within the sphere of standardization. If it is used, it should have the following meaning:

A process by which particular production units concentrate on the manufacture of a limited number of kinds of products.

Functional interchangeability

This condition is achieved when those characteristics of the finished product which affect its operation (frequently including characteristics other than linear dimensions) have been *standardized* to the necessary degree of accuracy.

Group II—Quality and related terms

The problem of finding one single definition for " Quality " which is universally acceptable seems insurmountable—at least nobody has been able to devise one yet. The difficulty lies in the many different shades of meaning attached to the word when used in different contexts. In the event it does not seem possible to offer a definition for the term " Quality " without defining at the same time such dependent phrases as " Quality assurance " and " Quality control ". The following two definitions for quality have each received fairly wide accord and they are not very dissimilar.

Quality provisional definition by ISO/STACO—

The term covering any and every characteristic property and/or performance of a product or service that can be evaluated to determine whether the product or service meets the specified requirements.

An alternative definition which finds favour with both the American Society for Quality Control (ASQC) and the European Organization for Quality Control (EOQC) is—

The totality of features and characteristics of a product or service that bear on its ability to satisfy a given need.

Quality Control has been defined in the ISO statistical vocabulary (R 1786) thus—

Quality Control

(*a*) In the wider sense: the set of operations (programming, coordinating, carrying out) intended to maintain or to improve quality, and to set up the production at the most economical level which allows for customer satisfaction.

(*b*) In a more restricted sense: the verification of the conformity of a product to its definition or its specifications.

Statistical Quality Control

Quality control using statistical methods (such as control charts and sampling plans)

The term Quality Assurance also gives rise to some difficulty. Frequently it is taken to be some third-party verification of conformity to specification: but amongst the manufacturing community, particularly those who believe in the value of advanced factory quality control arrangements, it tends to mean a properly organized system in the plant which will ensure that the manufacturer's claims to meet specifications are justified.

A definition which enjoys a good deal of support is:

Quality Assurance a system of activities whose purpose is to provide an assurance that the overall control of quality is in fact being carried out effectively at all stages. The system employed must involve a continuing evaluation of the adequacy and effectiveness of the overall quality programme with a view to having corrective measures initiated where necessary. For a specific product or service this involves verification, audits, and the evaluation of the quality factors that affect the specifications, production, inspection and use of the product or service.

If we accept these definitions, we see that quality control has to do with making quality what it should be and quality assurance has to do with making sure that the resulting quality is what it claims to be.

Quality control and quality assurance are discussed more fully in later chapters.

Class

Where a collection of materials or products which are quite heterogeneous have to be segregated into groups on the basis of one or more specific characteristics, each group should be termed a "class", e.g. Mineral aggregates are classed according to their petrological characteristics, e.g. Basalt, Granite, Limestone.

Type

When products which are similar in their general purpose and construction need to be identified according to some specific use, the word "Type" should be used. For example, electric lamps may be identified by the type of lamp such as automobile lamps, aircraft landings lamps, general purpose lamps, street lighting lamps.

Grade

When for any one type of product it is desired to specify a number of different categories the term "Grade" (in French "catégorie") should be used, e.g. weldable structural steel can be graded on the basis of its tensile strength (expressed in hectobars) such as Grade 40/48, 43/51, 50/62, 55/70.

Group III—Certification and related terms

The following terms are fully discussed and provisionally defined in Chapter 8.

Certification
Marking
Informative labelling
Comparative testing

The International Electrotechnical Vocabulary (IEV)

A more formidable task than to define basic terms is to control and define the new terminology which is developing in almost every technological field. Here the use or misuse of words which are not understood, or are mistranslated, can lead to utter confusion.

The IEC was a pioneer in this field and on its foundation immediately began to compile "The International Electrotechnical Vocabulary" (IEV). The task involved considerable work but nevertheless the first edition was published in 1938. It has since been re-edited and expanded, and the second edition, containing over 8500 terms and definitions in English and French and the equivalent terms in six other languages (German, Spanish, Italian, Dutch, Polish and Swedish) is undoubtedly one of the most valuable publications of the IEC.

The IEV at present is composed of the following 24 booklets:

50(05) (1954)	Fundamental definitions.
50(07) (1956)	Electronics.
50(08) (1960)	Electro-acoustics.
50(10) (1956)	Machines and transformers.
50(11) (1956)	Static convertors.
50(12) (1955)	Transductors.
50(15) (1957)	Switchboards and apparatus for connection and regulation.
50(16) (1956)	Protective relays.
50(20) (1958)	Scientific and industrial measuring instruments.
50(25) (1965)	Generation, transmission and distribution of electrical energy.

50(26) (1968) Nuclear power plants for electric energy generation.
50(30) (1957) Electric traction.
50(31) (1959) Signalling and security apparatus for railways.
50(35) (1958) Electromechanical applications.
50(37) (1966) Automatic controlling and regulating systems.
50(40) (1960) Electro-heating applications.
50(45) (1970) Lighting.
50(50) (1960) Electrochemistry and electrometallurgy.
50(55) (1970) Telegraphy and telephony.
50(60) (1970) Radiocommunications.
50(62) (1961) Waveguides.
50(65) (1964) Radiology and radiological physics.
50(66) (1968) Detection and measurement of ionizing radiation by electric means.
50(70) (1959) Electrobiology.
50(00) (1970) GENERAL INDEX OF THE IEV.

Each of these chapters will be revised as often as is necessary and additional chapters are being added, to follow the rapid development of the technology.

To give an idea of the scope of the IEV, two examples have been chosen at random and are presented below.

66-15-355	**Electroscope:** Appareil permettant de mettre en évidence une charge électrique à l'aide de forces mécaniques qui s'exercent entre des corps électriquement chargés.	**Electroscope:** An apparatus for indicating an electric charge by means of mechanical forces exerted between electrically charged bodies.	**Elektroskop.** **Electroscopio.** **Elettroscopio.** **Elektroscoop.** **Elektroskop.** **Elektroskop.**

The term electroscope is comparatively straightforward and easily recognisable in other languages, but there are other terms which necessitate more detailed treatment and some explanatory matter, for example " delay ".

60-10-040	**Retard** (dans un quadripôle passif, un amplificateur ou un récepteur); **Délai de réponse à un échelon** (dans un quadripôle passif, un amplificateur ou un récepteur): Temps qui s'écoule entre l'instant où une action représentée par une fonction échelon est appliquée à l'entrée d'un quadripôle passif, d'un amplificateur ou d'un récepteur, et l'instant où la réponse atteint pour la première fois la moitié de sa valeur finale en régime établi.	**Delay** (of a receiver or amplifier to a step-function excitation); The time interval between the application of a step-function excitation and the instant when the response first attains half the steady-state magnitude.	**Einschwingverzögerung** (bei sprungformigem Eingangssignal). **Retardo** (en un receptor o amplificador para una excitación escalón). **Ritardo** (in un doppio bipolo passivo o in un amplificatore o in un ricevitore) **rispetto** ad una eccitazione agradino. **Stapfunctie looptijd.** **Opóźnienie** (odbiornika lub wzmacniacaza przy wzbudzeniu sygnalem schodkowym). **Frödröjning** (av språngformad signal i mottagare eller förstärkare).

60-10-045	**Retard** (dans un quadripôle passif, un amplificateur ou un récepteur); **Délai de réponse sinusoïdale** (dans un quadripôle passif, un amplificateur ou un récepteur): Temps qui s'écoule entre l'instant où une action représentée par une fonction sinusoïdale est appliquée brusquement à l'entrée d'un quadripôle passif, d'un amplificateur ou d'un récepteur, et l'instant où l'enveloppe de la réponse atteint pour la première fois la moitié de sa valeur finale en régime établi.	**Delay** (of a receiver or amplifier to a suddenly applied sinusoidal voltage): The time interval between the application of a suddenly applied sinusoidal voltage and the instant when the response attains half the steady-state magnitude.	**Verzögerungszeit** (bei Anschaltung einer Sinusspannung). **Retardo** (en un redeptor o amplificador para una excitación sinusoidal repentina). **Ritardo** (in un doppio bipolo passivo o in um amplificatore o in un ricevitore) **rispetto ad una eccitazione sinusoidale instantanea.** **Sinusfunctie looptijd.** **Opóźnienie** (odbiornika lub wzmacniacza przy nagłym przyłozeniu napięcia sinusodialnego). **Frödröjning** (av sinusformad signal i mottagare eller förstärkare).

In addition, some 150 specialized IEC technical committees and subcommittees are contributing to the growth of organized terminology either within the framework of the recommendations they are preparing for their particular field, or in relation with the future revision and expansion of the various chapters of the IEV.

The ISO vocabularies of technical terms

Starting a good deal later and with much wider fields to cover, the ISO vocabularies of technical terms are not yet so far advanced as those of the IEC but they are making good progress. Standard glossaries are needed to define the terminology, quantities, symbols and units used in each particular industry or technical field. Many already exist: many more have still to be prepared. This work is being tackled vigorously and, indeed, terminology is now treated as one of the most important aspects of all ISO activities. A few figures will help to illustrate this point:

95 ISO vocabularies have already been published.

45 Drafts are in the course of preparation.

Current ISO Recommendations already contain over 3000 terms with definitions in both English and French:

Recommendations in draft form add another 2000 to the above list: and of these 5000 terms some 2800 are available also in Russian, 1200 in German, 1000 in Polish and Dutch, 900 in Czech, 200 in Swedish, Spanish and Italian.

A few examples of the above vocabularies are:

Paper vocabulary: prepared by ISO Technical Committee 6 giving terms used in the paper industry, with their definitions, in English, French and Russian and published in six series.

List of equivalent terms used in the plastics industry: published in English, French and Russian. Corresponding terms are also published in German, Polish, Dutch and Czech.

Vocabulary for the refractories industry: published in English, French and Russian, with other languages pending.

Vocabulary of information processing: prepared by ISO/TC 97, already incorporates several hundred terms in English and French.

These examples are but a part of the whole effort which is being put into terminology but they do serve to illustrate the size of the problem. Moreover, it has recently been decided to establish a card-index of terms and definitions in English and French, and when available in Russian. It is estimated that the initial index will contain approximately 7000 terms, covering the work of over a hundred ISO technical committees.

Symbols and coding, which can readily be adapted to any language, provide a useful means of overcoming at least some of the linguistic difficulties. Examples of this are to be found in ISO/R 128, 129 Engineering Drawing, ISO/R 406 Inscription of linear and angular tolerances, and in ISO/R 1101 Tolerances of form and position. Taken together, these recommendations enable engineering drawings of any one country to be correctly interpreted in any other country, which is a very great achievement.

Standard terminology is as vital in the old-established industries in helping to consolidate accepted practice, as in the newer technologies such as data processing, electronics or work study, which are developing their own languages virtually from day to day, with emphasis on the standardization of new terms and definitions at the outset. It may be asked whether the rapid growth of such new technologies is not due in part at least to this devotion of so large a

proportion of their energies to standardization, and to the high rate of exchange of information within these industries which standardization encourages.

The IEC and ISO are not alone in finding it necessary to devote a large proportion of their effort to terminology. In almost every other field of international work the same problem arises and the misuse or misinterpretation of words is acting as an impediment to more rapid progress in international affairs.

Discipline in the use of words is an essential requisite for intercommunication amongst the peoples of the world. More and more in the future are we going to find that definitions, carefully prepared and accurately translated into several languages constitute an integral and vital part of international work.

3

Measurement

Measurement is an essential function of civilized society and, to quote a famous saying attributed to Lord Kelvin: " I often say that when you can measure what you are speaking about and express it in numbers, you know something about it: but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind."

Even the very earliest civilizations made some attempts to master the concepts of measuring systems. The Sumerians, the Egyptians, the Greeks and the Romans in turn all developed their systems. Indeed throughout all ages, the ability to measure accurately has formed the foundation of commercial life and technological progress. It is particularly vital to all types of engineering since it is the basis on which it is possible to make components to be interchangeable; and through rationalization, to introduce immense economies together with greatly increased efficiency. Standardization could not begin until the science of measurement—i.e. metrology—was sufficiently far advanced and even as late as the nineteen-twenties it was quite possible for an engineer to purchase a consignment of nuts from one manufacturer to fit a special line of bolts supplied by another firm, only to find the accuracy of measurement was such that the components would not fit together and were useless to him. The only way of avoiding this was to spell out individual requirements in full—a laborious and time-consuming practice unthinkable in the high speed, productivity-geared world of modern industry, where reference to a common Standard specification now provides an instant, succinct means of technical communication, at the same time greatly reducing the incidence of error in both interpretation and manufacture. Thanks to the tremendous developments in metrology over the past half-century and to the high degree of international cooperation engendered by ISO and IEC, metrology standards have become world-wide and we now have a single system of units of measurement. But first let us take a brief look at the early history of measurement.

Early systems of measurement

Linear units were the first units of measure to be devised by men and, despite an enormously long history, they are the basis of certain units still in use, related for the most part to members and proportions of the human body.

The most important were the cubit, derived from the length of the forearm; the foot, the digit or inch (the word inch is derived from the Roman " uncia " meaning twelfth part); the pace, which gave rise to the English yard (also a double cubit); the Roman mille-passus (1000 paces) or mile. Weighing was a later development than linear measurement, but the earliest civilizations were familiar with this technique also. There are many ancient Egyptian illustrations of balance scales and an Egyptian balance with weights made from limestone dating from about 5000 BC has recently been found.

Early weighing was largely restricted to determining the mass of gold or other precious metals or stones. The units used included the " mina ", which was subdivided into " shekels ", the Greek " drachma " and the Roman " libra " (pound) which was divided into 12 unciae (from which is derived the English ounce).

The earliest units adopted for capacity were mostly local in origin and use and there seems to be little or no interrelationship between them. The basic Roman unit of capacity was the " sextarius " (about 0.6 of a litre). Six sextarii constituted a " congius " and eight made an " amphora ".

Notwithstanding their imperfections and inconsistencies some of these early units persisted well into the Middle Ages and even until a century or two ago.

Most of the units used in Europe in the Middle Ages were derived, but badly distorted, from those in use in the Roman Empire. At the end of the eighth century Charlemagne tried to establish uniform weights and measures throughout his vast Empire, but the effort failed. By the thirteenth century, however, all European rulers had begun to establish and enforce legal standards for existing units of measurement in their respective realms. Metal standards for weights, linear and volumetric measures were fabricated and placed in some official depository: and from these secondary standards were made and used to promote uniformity.

Unhappily there was hardly any uniformity between the standards of different realms and there was even much variation in the customs and usage in different parts of one realm. This situation pertained until the arrival of the metric system.

Evolution of the metric system

On the statue of King Goudea, a legacy of Chaldean statuary dating from the first millenium B.C., the artist has sculpted a scene describing the main merits of the king. At his knees, pictures and figures are interpreted as having been the standards for construction. But the main part is a graduated rule about 27 centimetres long, divided by lines 17 millimetres apart; this unit was taken as a " metre " by the carpenters and sculptors of Babylon and other places. It may have been the origin of the name.

However, the first concept of a metric system combined with decimal arithmetic and with some interrelationship between the units for linear, mass and volumetric measurement, is generally attributed to the Dutch mathematician Simon Stévin (1548-1620). In 1585 he advocated with some vigour the adoption of " le système métrologique decimal " which he recommended " aux hommes futurs pour leur grand advantage ". Two more centuries were to pass by before his ideas took effect. However, during these two centuries many learned men were focusing their attention on metrology and were carrying out experiments. Thus, between 1666 and 1684 Newton had discovered the laws of gravity which led to experiments to determine the size of the Earth and the length of pendulum which gave a swing of one second.

In 1670 the Abbé Monton de Lyon proposed one minute of arc of the Earth's circumference as the standard for linear measurement; several other learned men, notably in England Sir Christopher Wren, in France the astronomer Picard and in the Netherlands Huygens proposed the length of the second pendulum for the same purpose.

Finally in 1790 Talleyrand put the matter before the Constituent Assembly of the French Republic, for by this time the need for reform was apparent to everybody: and on 30 March 1791 the Constituent Assembly decided to establish an entirely new system of units based on the decimal principle. This may be taken as the birth date of the modern metric system.

Yet another decade was to pass by while efforts were being made to determine the length of the metre—defined at that time as 1/10,000,000 part of the meridian quadrant—and the mass which corresponded to one cubic decimetre of water since this was to be the basis for the kilogramme. But a French law passed on 7 April 1795 adopted nomenclature for the metric system which is virtually the same as that existing today and another law passed on 9 December 1800 made the decimal metric system legal in France.

With the metric system firmly established in France and with its growing use throughout Europe, the accuracy of its fundamental units became a matter of importance. So in 1869, the French Government, communicating through its diplomatic channels with various nations, invited delegates to a conference to be held in Paris to discuss the construction of a new prototype metre as well as a number of identical replicas of this standard for use by the participating nations.

This international commission met first in 1870, but due to the outbreak of war between France and Germany, the session was short-lived. It met again in 1872 and was more successful. It decided that the new standards for linear measurement were to represent the length of a metre at 0 degree Celsius and that the material was to be an alloy of platinum (90%) and iridium (10%). The actual bars were to be constructed from a single ingot produced in one casting and carefully annealed. The international kilogram was to be determined with reference to its weight in a vacuum. In addition to other recommendations, the commission advocated the founding of an international bureau of weights and measures, to be located in Paris, which would be international and neutral and was to be supported by contributions from each participating nation. The work of the bureau was to be supervised by an international committee of weights and measures, which itself operated under the jurisdiction of the General Conference of Weights and Measures, to be held at intervals of not greater than 6 years.

On May 20, 1875, a treaty was concluded in Paris, wherein the recommendations of the commission were put into effect. The treaty was signed by the USA, Germany, Austria, Hungary, Belgium, Brazil, Argentine Confederation, Denmark, Spain, France, Italy, Peru, Portugal, Russia, Sweden, Norway, Switzerland, Turkey and Venezuela. The only countries represented in the commission that did not sign were Great Britain and Holland, but in September 1884, Great Britain did sign the treaty.

As a site for the bureau the French offered, without charge, the Pavillon de Breteuil, situated on a tract of land near the bank of the Seine at Sèvres. In 1889, after the actual standards had been constructed and examined, the conference adopted the international prototypes of the metre and the kilogram as the standards of length and weight.

Later measurements of the quadrant found the measurement from which the metre was derived to be in error by one part in 3000, so that a new unvarying and indestructible unit had to be discovered. Moreover the use of a material standard as a unit of length proved inconvenient as it could not readily be reproduced with sufficiently high accuracy. Consequently attention was given to re-defining the metre in a more convenient way.

Since 1961, the metre has been established as equal to 1,650,763.73 wave lengths of the orange-red light given off by krypton 86. This new determination of the metre is accurate to 1 part in 100,000,000 and has the advantage of being reproducible in scientific laboratories throughout the world.

It was unfortunate that neither Great Britain nor the USA recognized the full value and international character of the metric system at a much earlier stage. Had they done so, a single world system of weights and measures would have grown up, before the vast machinery of modern manufacture and industry came into being, and the costly change to the metric system now facing Britain, and likely in the near future to face the USA, could have been avoided.

There were many discussions in the British Parliament and elsewhere from 1872 right through until 1964 concerning the possibility of British conversion to the metric system but no official action was taken since the consensus of opinion was that any conversion would have to be accomplished simultaneously with a conversion by the USA.

Following World War II there was a further trend towards the metric system and in 1956 India formally adopted it. This gave a strong lead to the many developing countries who were beginning to establish national standards for the first time. All of these without exception adopted the metric system from the outset.

By 1965, with nearly half of Britain's exports being shipped to countries on the metric system, and with more and more countries adopting this system, the need for a single international system of units was paramount. Fortunately this was available in the newly established derivative of the European metric

system, namely the " Système International d'Unités " (SI Units). And so at last, with the support of their Government and all major sectors of British industry, Britain decided to make the change which is now (in 1972) well on its way towards fulfilment. The USA has the matter under very active consideration and may well decide to make the change before very long.

Development of the Système International (SI)

Once the basic metric standards were establishd, it was necessary to choose convenient subdivisions for use in calculations and the earliest to be adopted were the centimetre, gramme and second. This was known as the cgs system and was the one most largely used by scientists and mathematicians. However, for industry and trade these units were rather small and there was a growing use in metric countries of the metre, kilogramme and second, known as the MKS system.

The world of electrical engineering had always been accustomed to metric units and in 1935 the IEC formally adopted the MKS system, with the addition of a fourth basic electrical unit which remained still to be chosen. In 1950 the IEC recommended that the ampere should be adopted as this fourth basic unit. Thus was born the MKSA system, sometimes also called the Giorgi system.*

It soon appeared that this system of units, applied with success in the electrotechnical field, would also be useful in other branches of applied science. In 1954 the 10th General Conference of Weights and Measures (CGPM: Conférence Générale des Poids et Mesures) decided to adopt, as a basis for a practical system of units for international use, the MKSA units with the addition of two further base units: the kelvin degree for thermodynamic temperature and the candela for luminous intensity. This system was designated in 1960 by the 11th Conference as the International System of Units (SI). Finally, the 14th CGPM adopted in 1971 a seventh SI base unit, the mole, which is the unit of amount of substance.

Hence the base units of the SI are:

Quantity	Name	Symbol
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
luminous intensity	candela	cd
amount of substance	mole	mol

* For full details of this development refer to IEC publication No. 164.

However, it is not practical to limit usage to these alone. There is a long list of derived units, recommended multiples and sub-multiples and alternative nomenclature for certain units which are permitted to be used with the SI system.

Thus it would not be practical to discontinue entirely the use of such terms as hour, day, year, even though these are not direct decimal multiples of the second. It has also been necessary to retain the customary divisions of the circle into seconds, minutes, and degrees even though these are not direct decimal multiples or sub-multiples of the radian.

The policy of ISO, IEC and other world standards organizations has always been to promote additional international standardization rather than to discourage units which have been world standards for centuries and thus there are quite a few of these " impurities " in the SI system which remain as permitted alternatives to the pure coherent units, which latter should however always be used in calculations.

The SI units for plane angle and solid angle, the radian (rad) and the steradian (sr) respectively, are called supplementary units.

The expressions for the derived SI units are stated in terms of base-units; for example, the SI unit for velocity is metre per second (m/s).

For some of the derived SI units special names and symbols exist; those approved by the Conférence Générale des Poids et Mesures are listed below:

Quantity	Name of SI unit	Symbol	Expressed in terms of basic or derived SI units
frequency	hertz	Hz	$1\ \mathrm{Hz} = 1\ \mathrm{s}^{-1}$
force	newton	N	$1\ \mathrm{N} = 1\ \mathrm{kg \cdot m/s^2}$
work, energy, quantity of heat	joule	J	$1\ \mathrm{J} = 1\ \mathrm{N \cdot m}$
power	watt	W	$1\ \mathrm{W} = 1\ \mathrm{J/s}$
quantity of electricity	coulomb	C	$1\ \mathrm{C} = 1\ \mathrm{A \cdot s}$
electrical potential, potential difference, tension, electromotive force	volt	V	$1\ \mathrm{V} = 1\ \mathrm{W/A}$
electric capacitance	farad	F	$1\ \mathrm{F} = 1\ \mathrm{A \cdot s/V}$
electric resistance	ohm	Ω	$1\ \Omega = 1\ \mathrm{V/A}$
flux of magnetic induction, magnetic flux	weber	Wb	$1\ \mathrm{Wb} = 1\ \mathrm{V \cdot s}$
magnetic flux density, magnetic induction	tesla	T	$1\ \mathrm{T} = 1\ \mathrm{Wb/m^2}$
inductance	henry	H	$1\ \mathrm{H} = 1\ \mathrm{V \cdot s/A}$
luminous flux	lumen	lm	$1\ \mathrm{lm} = 1\ \mathrm{cd \cdot sr}$
illumination	lux	lx	$1\ \mathrm{lx} = 1\ \mathrm{lm/m^2}$

It may sometimes be advantageous to express derived units in terms of other derived units having special names; for example, the SI unit of electric dipole moment (Asm) is usually expressed as Cm.

Decimal multiples and sub-multiples of the SI units are formed by means of prefixes given below.

Factor by which the unit is multiplied	Prefix	Symbol
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10	deca	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

The symbol of a prefix is considered to be combined with the unit symbol to which it is directly attached, forming with it a new unit symbol which can be raised to a positive or negative power and which can be combined with other unit symbols to form symbols for compound units.

Examples

$1\ \mathrm{cm}^3 = (10^{-2}\ \mathrm{m})^3 = 10^{-6}\ \mathrm{m}^3$

$1\ \mu\mathrm{s}^{-1} = (10^{-6}\ \mathrm{s})^{-1} = 10^{6}\ \mathrm{s}^{-1}$

$1\ \mathrm{mm^2/s} = (10^{-3}\ \mathrm{m})^2/\mathrm{s} = 10^{-6}\ \mathrm{m^2/s}$

Compound prefixes should not be used; for example, write nm (nanometre) instead of mμm.

4

Standardization of products

During the first phase of national standardization the primary effort of all national bodies was directed towards the preparation of Product standards—that is standards which defined and specified a particular range of products of industrial, agricultural or natural origin, including raw materials, semi-finished and finished products. They included such items as steel in various forms and sizes, bolts and nuts, bearings and a whole host of small parts used by manufacturers to produce their goods.

Although new product standards are constantly being published, to keep pace with the growth of modern technology, there is an even bigger increase in the rate of publication of standards for abstract subjects such as units, glossaries of terms and symbols, safety rules, codes of practice, and human activities; for want of a better term these are all designated as abstract standards, to distinguish them from the individual product standards.

The appearance of all these abstract standards may be regarded as the second phase of national standardization.

It is in the area of product standards that simplification comes really into its own. In the more newly industrialized countries it has been possible to start off with a reasonable and logical range of sizes and types; but in the older industrialized countries, where sizes and types have grown up haphazard over three-quarters of a century and have been perpetuated by customer demand, there are far too many sizes and types still listed in national standards and indeed far too many standards. The reason for this is not far to seek. Earlier standards were frequently promoted by a particular section of industry and directed towards a particular end use. Thus such anomalies as wire ropes for ships, wire ropes for cranes, wire ropes for coal mines could all appear as individual standards despite the fact that the end uses are all very similar and that a single standard suitably drafted could serve them all.

The rules for selection of sizes and the benefits of variety reduction are discussed later and it is only necessary to repeat here that in variety reduction are to be found the greatest and most immediate economic benefits from standardization and that product standards provide the most fertile field for variety reduction.

Before writing a product standard it is desirable to be quite clear on the aims to be achieved and also to have a clear answer to the followng questions:

(1) What products or groups of products are intended to be standardized?

(2) What nomenclature should these products have in order to distinguish them from other products in the same field, and what designations should be established for them?

(3) What are the economic benefits of the standardization in this particular case?

(4) What considerations are necessary in regard to quality, dimensional and safety standardization?

(5) Under what basic considerations should the standardization be carried out, and what influence will this standardization have on other products?

(6) What sequence of steps would be reasonable for this standardization, and what are its limits?

(7) Could the national standardization under consideration later become international, viz: European (CEN), for instance, or world-wide (ISO)?

(1) Kinds of products

It is necessary in the first place to be clear about what products are to be included in the standard. In this connection it is important to know whether a single product, a series of this particular product in different sizes, or a group of similar products are to be standardized. This distinction should also be made obvious from the title of the standard. It is then necessary clearly to define the product or group of products in question, in order to distinguish them from other products or groups.

Example: Standardization of different shapes and sizes of grinding wheels to be used for grinding metal products only, excluding those used for dental purposes and for the grinding of glass products.

(2) Terminology, definitions and designations

The standardization of products inevitably requires the adoption of a certain number of special terms or existing terms used with a very special meaning. Some of these may already have been defined in the ISO and IEC technological vocabularies but others may not. If misunderstandings are to be avoided special terms, or existing terms that may be ambiguous, must be clearly explained.

Further, it is generally desirable to establish a method of designation for the standardized products. For example, shall they be designated by nominal size, by weight or carrying capacity, by strength, or by some other particular feature?

(3) Aims

Not all of the aims discussed in Chapter 1 will be applicable to every product standard. It is essential to be fully aware of which specific aims are intended to be reached in this particular standard. Only then will it be possible to decide on what method of standardization shall be adopted, what features and details of the product are to be specified, and how far the standardization should be carried. For example, if simplification, is the aim is it simplification in the process of manufacture or simplification in the total range of sizes?

(4) Considerations regarding quality, dimensional and safety standardization

A general definition of the term "quality" is given in Chapter 2. The term embraces a very wide range of meanings. In principle, quality does not only apply to performance and reliability in practical application, but equally to safety in use, accuracy of dimensions, and many other features.

A product may be reliable in use while showing a bad performance, and vice versa. It is therefore essential to know exactly which of the characteristics is intended to be standardized: the performance, the reliability, the outer appearance, etc., or combinations of these characteristics. This is an extremely important matter, which cannot be settled by any formulation of a general policy. It depends on the nature of the individual product whether the standardization should cover a combination of these characteristics or only one of them.

Once a decision has been taken, the functional characteristics necessary and sufficient to fulfil the aim set must be selected and defined. A logical further step is to establish methods and procedures for measuring and testing those characteristics, fixing the conditions for carrying them out, and including, if appropriate, methods of sampling. The latter is important if there is to be confidence in a scheme to establish reliability.

Dimensional standardization generally means the standardization of the linear dimensions of a product, such as length, width, height, diameter, etc.; but it may include other characteristic features which can, in a broad sense, be expressed by physical quantities (e.g. weight-carrying capacity of cranes, efficiency of motors, power of engines).

Dimensional standardization is an important aspect of nearly all product standards. It is used for interchangeability, for reduction of types and sizes or to provide a general classification by means of a standard, and for comparing products of different origins.

Only those dimensions of products should be considered which are essential for reaching the desired *aim* of standardization. The remaining dimensions and features which are not important for reaching this aim need not necessarily be included. For example, if dimensional interchangeability of a product is the intended aim, it will be sufficient to specify only those dimensions and features which are essential for this interchangeability. Thus, in the case of an electric light bulb, it is necessary to specify only the dimensions where the bulb fits into the socket, the voltage and the amount of illumination which the bulb will give.

If dimensional standardization is to cover series of different sizes of the same product rather than one single product, it is of decisive importance for economic production that the different values of a series show a reasonable gradation of sizes. It is wrong just to pick out some of the existing sizes of a product and make them standard sizes, because this would, in most cases, result in an irregular gradation which is likely to prove uneconomical in the long run. As far as possible, the frequency of application of the different sizes within the total range should also be considered.

In many cases the series of preferred numbers contained in ISO/R3 will provide a suitable range of sizes since they offer a uniform geometric gradation and therefore cover a given range of sizes with a minimum number of values. The subject is dealt with more fully later in this chapter.

Safety in the use of a product is a matter requiring special attention. If safety is a principal aim of the standard, then those characteristics necessary and sufficient to achieve safety should be selected and defined and values for these characteristics should be specified. The methods of testing should be specified very fully and mention should be made as to whether or not the standard has to meet public safety regulations established by law, or merely advises as to the best means of securing safety.

VARIETY AND COST REDUCTION THROUGH STANDARDIZATION

If the aim of standardization is simplification, then clearly one of the principal methods of achieving it is by reducing the number of nearly similar goods which are available to the minimum consistent with providing an adequate choice to the customer. This process is generally described as " variety reduction ". It has already been mentioned several times in this book and the following pages are devoted to considering the various aspects of it in rather more detail.

Common to all aspects is the fact that variety costs money. If the customer wants reliable goods at the cheapest possible price, then he must be prepared to sacrifice some part of his individual desires. On the other hand the needs of all people are not the same and too much limitation of variety would lead to a

very dull and drab existence. It is only necessary to look at a street in which all the houses are identical to realize this.

Like all things in standardization the degree to which variety reduction can be applied is a compromise and each individual case has to be considered on its merits.

Variety reduction can be applied at every stage of manufacture but the considerations affecting it are somewhat different at different stages. Thus:

Complete equipments

Under this heading would fall such things as motor-cars, refrigerators, television sets. Complete equipments are normally assembled from a large number of sub-assemblies and an even larger number of small components. It is usual for the precise dimensions and other detailed particulars of all these components to be specified in the individual product standards relating to them. Where there is a standard for a complete equipment it is likely only to specify such aspects as performance, safety requirements, quality and overall dimensions. Style and quality must have their place and standards must not be too restrictive in these respects. However, it is often possible for a manufacturer to offer several varieties of finished goods from what is virtually only one set of components. Nevertheless all variety costs money and customers wishing for economical costs must be prepared to accept some restriction in choice or else to pay a special price for a special article.

Small components

A very large number of product standards are concerned with small components. Since complete interchangeability is needed, each standard must list precise dimensions and tolerances as well as material and performance when these are necessary. For the reasons given in Chapter 7, company standards should always restrict the choice of components to an absolute minimum: but national and international standards must offer a wider choice, based on a logically selected range of sizes. The rules for selecting such a range are given later, and whenever possible the selected range should be approved internationally. Such a policy will call for concessions by some countries in abandoning existing practices, but in the long run all will benefit from the international status of the new standard.

If it proves impossible to restrict a range of sizes or types to a single logical series internationally approved, a useful interim procedure is to list first and second, and if necessary third, preferences. The second and third preferences will include any sizes for which there is a strong existing demand and which cannot suddenly be eliminated. Gradually, however, the tendency will be for customer demand to switch towards the first preferences at the expense of second and later preferences.

Materials

The benefits of variety reduction are not limited to size and shape. They apply equally to materials.

There is nothing more aggravating for a manufacturer than to be faced with a choice of say fifty or more nearly similar material specifications and without knowing which one is really the best for his purpose, or whether any of the fifty might do equally well. It is just as aggravating for the producer of the material to have to meet all these different orders, when perhaps five or at the most ten variations would be adequate for all purposes.

New materials are constantly being developed and specifications prepared, to name but a few examples: fibre glass insulation, high temperature greases and the moulding in plastics of a single part which previously had to be an assembly of parts. It is important to withdraw obsolescent specifications as soon as they can be replaced with new ones. Unfortunately this is rarely done.

Specifications for materials should list the physical properties and methods of test, and if necessary the chemical composition. The permitted tolerances should also be stated: but one should be wary of specifying the purpose for which the material is to be used, as this can lead to great duplication, and an unnecessary multiplicity of standards. This in turn renders stockholding very much more complex, with the serious risk of some batches of material losing their identity.

In many factories it is found that about 80% of the business of the company is derived from 20% of the products offered for sale. This has come to be known as the 80/20 rule from the large number of individual cases where these proportions have been found to pertain. By eliminating some of the less popular lines and concentrating on the more popular ones, many a company has moved from a state of near bankruptcy into one of profitability. Items dropped from one company are frequently picked up by another and adapted to fit in with their pattern of sales.

It has been said that standardization is a continual battle for simplicity against complexity—the overwhelming growth in complexity of human life. It is an advantage for every company to examine its pattern of sales from time to time in accordance with the 80/20 rule in order to see just where its real profitability lies.

It will nevertheless also be recognized that too rigid an application of variety reduction can lead to lack of progress and inhibition of design. Provision must always be made for the introduction of new and improved designs both of complete equipments and of component parts, even though in

their earlier stages these new designs may not immediately be profitable. This is one of the reasons why important decisions on standardization policy must always be taken at the top level of management and not just left to juniors.

RULES GOVERNING THE SELECTION OF A SUITABLE RANGE OF SIZES FOR A PRODUCT

When planning the production of any commodity there are a number of factors which must be taken into account in deciding the number of different sizes for which provision has to be made. The demand of consumers for a very wide range of choice has to be balanced against the increase in the costs of production, stock-holding and distribution that will result from the production of an unnecessary number of sizes.

When a standard is in course of preparation and the subject calls for a range of sizes, an appropriate procedure is, first, to determine what are the smallest and largest sizes required and how many intermediate sizes are needed, and then to set out a table of sizes, each being approximately a uniform percentage larger than its predecessor. The reason behind this will be clear from what follows.

It is obvious that for any particular application there will be certain steps in size which are of a magnitude likely to be significant from the point of view of the user, while smaller steps would be unimportant and, indeed, possibly embarrassing. The size of the significant step is usually fairly closely proportionate to the size of the dimension or article with which it is associated. Thus, for example, a step of 0.25 kW between a 0.75 kW and a 1.0 kW motor would be significant and reasonable, whereas a similar step from 10 kW to 10.25 kW would be insignificant and useless. This leads to the idea that a range of sizes should advance in a regular geometrical series rather than by arithmetical or any other empirical progression.

Having established the general principle that the range of sizes should advance in a geometrical series, there remains the question of the basic figures at either end of the range and the common ratio of the progression. Here there is no fundamental principle involved but one obvious consideration is that, since the system of arithmetic throughout the world is a decimal system, it is desirable that the series should repeat itself in successive powers of 10. In other words the common ratio should be some root of 10.

Preferred numbers

Several series based on the above principles have been promulgated from time to time but those which have now been accorded first place are the

BASIC SERIES OF PREFERRED NUMBERS

Basic series R 5	R 10	R 20	R 40	Calculated values
1.00	1.00	1.00	1.00	1.0000
			1.06	1.0593
		1.12	1.12	1.1220
			1.18	1.1885
	1.25	1.25	1.25	1.2589
			1.32	1.3335
		1.40	1.40	1.4125
			1.50	1.4962
1.60	1.60	1.60	1.60	1.5849
			1.70	1.6788
		1.80	1.80	1.7783
			1.90	1.8836
	2.00	2.00	2.00	1.9953
			2.12	2.1135
		2.24	2.24	2.2387
			2.36	2.3714
2.50	2.50	2.50	2.50	2.5119
			2.65	2.6607
		2.80	2.80	2.8184
			3.00	2.9854
	3.15	3.15	3.15	3.1623
			3.35	3.3497
		3.55	3.55	3.5481
			3.75	3.7584
4.00	4.00	4.00	4.00	3.9811
			4.25	4.2170
		4.50	4.50	4.4668
			4.75	4.7315
	5.00	5.00	5.00	5.0119
			5.30	5.3088
		5.60	5.60	5.6234
			6.00	5.9566
6.30	6.30	6.30	6.30	6.3096
			6.70	6.6834
		7.10	7.10	7.0795
			7.50	7.4989
	8.00	8.00	8.00	7.9433
			8.50	8.4140
		9.00	9.00	8.9125
			9.50	9.4406
10.00	10.00	10.00	10.00	10.0000

FIG. 2

" Renard Series of Preferred Numbers ", so named after the French engineer Colonel Charles Renard who first proposed their use. There are four of these series (R5, R10, R20 and R40) as well as an additional series R80 intended for special application where very small steps in size are needed. These series are published as ISO/R 3 and are listed in Fig. 2.

It will be seen that all these series repeat themselves in successive powers of 10. The R5 series gives 6 sizes from 1 to 10 inclusive, with approximately 58% increase in size between steps. Similarly, the R10 gives 11 sizes with approximately 26% increase, the R20 gives 21 sizes with 12% increase, the R40 gives 41 sizes with 6% increase and the R80 gives 81 sizes with 3% increase.

In actual fact the common ratios are $\sqrt[5]{10}$ $\sqrt[10]{10}$ $\sqrt[20]{10}$ $\sqrt[40]{10}$ and $\sqrt[80]{10}$. As these lead to recurring decimals, the above percentages are approximate only, as are the Renard numbers themselves which have departed slightly from the strict mathematical series to give convenient rounded numbers.

The utility of preferred numbers depends mainly on their general acceptance and use, in cases to which they are appropriate, in preference to arbitrary values selected by individual designers. The uncontrolled use of alternative approximations, even to the same theoretical series, will not only lead to the perpetuation of such divergencies as it is the object of preferred numbers to avoid, but may also, as will be seen later, render difficult the interpolation of suitable intermediate values, should this subsequently be required. On the other hand, preferred numbers must be recognized for what they are—a tool to be used, and not a master to be served. Standardizing bodies should therefore regard them primarily as a guide, to be followed as far as may be found expedient, and should not accept any particular series as obligatory for universal application without modification of any kind. The possibility of modification to suit the special circumstances attaching to different applications must be admitted. But such modifications should be adopted only on the basis of national or, preferably, international agreement.

One interesting and valuable feature of all these series derives from the fact that the tenth root of 10 (= 1.2589) is very nearly the same as the cube root of 2 (1.2599) so that each successive third entry in the R10 series, or sixth entry in the R20 will be almost exactly double the preceding entry. Thus the " fractional " numbers 2, 4, 8, 16 conveniently fall into the general decimal series.

Preferred sizes

It should here be explained that a number is not a dimension. For example, a hole may be described nominally as 20 mm diameter; but the actual dimensions of the hole may be $\genfrac{}{}{0pt}{}{20.5}{19.5}$ mm or perhaps $\genfrac{}{}{0pt}{}{20.8}{20.0}$ mm. The difference between the highest and lowest permissible figures is known as the " tolerance " and the *dimensions* of the hole are the higher and lower limits of size as stated.

The nominal size 20 mm is simply a convenient means of communication and a form of designation for ease of identification.

A cylindrical shaft or pin may be similarly described but if it is required to fit into the hole it may be necessary to specify dimensions such as $\begin{matrix}19.8\\19.0\end{matrix}$ mm. This would permit the largest pin (19.8) to fit into the smallest hole (20.0). The difference between 19.8 and 20.0 is known as the " allowance ". These matters are dealt with fully in ISO/R 286, " Limits and fits ".

The point which has been made in the preceding paragraphs is that Preferred Numbers are a most useful guide to the selection of a range of nominal sizes but they are not *dimensions*.

To illustrate further the use of Preferred Numbers in solving day-to-day managerial problems the following example may be quoted:

In a market survey on domestic saucepans, the saucepans were described by their nominal diameter in centimetres. It was found that the customer demand followed the pattern of size indicated in Fig. 3.

The most popular sizes are clearly in the region of 20-24 cm but it may be presumed that the average housewife would not distinguish such a small step as 2 cm and would be equally prepared to accept a saucepan either of 20 cm or of 22 cm diameter. Doubtless her choice would be governed by availability or other chance circumstance.

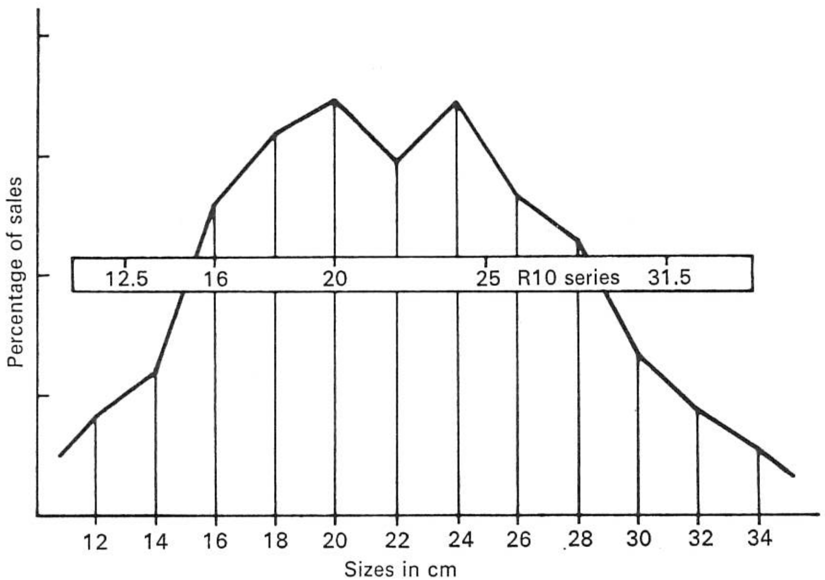

FIG. 3

If it is accepted that there are production savings from marketing fewer sizes, the problem now confronting management is to decide which sizes would be best to concentrate upon. Reference to the R10 series suggests that the best sizes to concentrate on might be 12, 16, 20, 25, 32 cm but it will be noted that this would involve leaving out one or two of what are at present the most popular sizes. However, standardization is always a matter of compromise; if nothing is conceded nothing will be gained. In the example quoted there are eleven sizes between 12 and 32 cm in the existing range. Adoption of the R10 series would reduce them to five and these five would probably provide the housewife with a perfectly adequate choice. There may of course be other considerations to take into account and it is not proposed to say just what decision the management ought to take in this case; but there is no doubt at all that reference to the Preferred Numbers series does focus attention where it is needed and does give a very good pointer to the action which should be taken.

5

Standardization as a tool of management

We have seen how the need for standardization has developed during the twentieth century to meet the demands of a modern industrialised society for an ever increasing volume of goods and for labour-saving devices in every walk of life. The challenge to industrial management is to provide all these goods in the necessary volume, with the degree of reliability and at the competitive price demanded by society. These requirements cannot be achieved without introducing standardization into industrial life on a scale which was never contemplated by our ancestors. The present chapter is devoted to analysing the status of standardization in modern management. But before doing so it is necessary to look back a little way to see how the present situation developed.

The industrial revolution of the nineteenth century generated the demand for machines to do the work of men and for mechanical power to drive them. It also produced an era of inventive genius, such as has seldom if ever been equalled. But before the new machines could be built, lathes and other machine tools of sufficient accuracy had to be made and this took time. For example, it took ten years after the invention of James Watt's improved steam engine before a boring mill was available capable of boring the 1800 mm cylinder to the accuracy necessary to enable the engine to work.

During the early nineteenth century European engineers, and especially British engineers such as Henry Maudslay and Joseph Whitworth, devoted their primary attention to developing the tools to do the job. Quite a lot of the machine tools of this period have survived in museums. They were built with superb craftsmanship and were general purpose tools of great flexibility as well as precision. The work turned out on these machines was essentially of a " one-off " character, mating parts being fitted individually to one another, a situation which persisted in most of the workshops of Europe until as late as about 1920.

By contrast, in America during this same period there was a great demand for goods and an acute shortage of skilled labour. American engineers were therefore concentrating their attention on work of a repetitive character, giving rise to a large volume of interchangeable parts of less precision but produced with a minimum of skilled labour. This system, now known as mass production, was at the beginning of the century known as " the American system ".

Perhaps the most significant example of it was the famous Model T-Ford motor car, which was regarded by many as a crude piece of engineering. Yet it was by far the most sophisticated mass-produced product in the world at that time and it made motoring possible for millions of people.

The American system had a profound influence on management, for immediately the need for standardization of products became of first importance for the efficient running of the factory. The skill moved away from the system of craftsmen building individual machines and reappeared in the form of strong teams of design engineers and production-line planners.

The labour on the shop floor was relatively unskilled. Costs were calculated, not on the individual cost of building one machine, but on the average cost of building a large number of similar machines. And the greater the production the cheaper the unit cost.

Product standards were an absolute necessity for this form of manufacture, although at this stage i.e. the beginning of the century, they were almost all individual Company standards. The day of the national or international standard had not yet come. With the end of the First World War national standards forged ahead in almost every industrialized country, although perhaps not quite so much in the USA where company standards had already gained such a hold. Machine tools had reached such a degree of precision that mass-produced parts could be made to very close tolerances. This gave rise to a huge new field of dimensional standards. Today it is still true that some 40% of all standards are dimensional standards, specifying precise dimensions and limits of size for a standardized range of products.

Almost every country and every industry has now adopted what we call Mass Production methods and many have moved on to automation as the volume of sales increases. The moment there exists a good reliable Standard for a product which is assessed by management to have a secure life for a period, then is the moment to make a careful analysis of production costs in order to determine the most economical method of production. Depending on the volume of sales which is anticipated, the decision will be for batch production, continuous flow production line or full automation as the case may be.

We will now take a look at a typical factory of moderate size, for which the organizational chart of management functions might be somewhat in accordance with the outline given in Fig. 4 and see how standardization affects each function and acts as a primary and essential means of communication between them.

It will be noted that in the diagramatic representation of Fig. 4, standardization has been shown as functionally responsible to design, which is most frequently the case. However this must not be allowed to infer that it is not the concern of, and concerned with the affairs of all the other functions within the diagram.

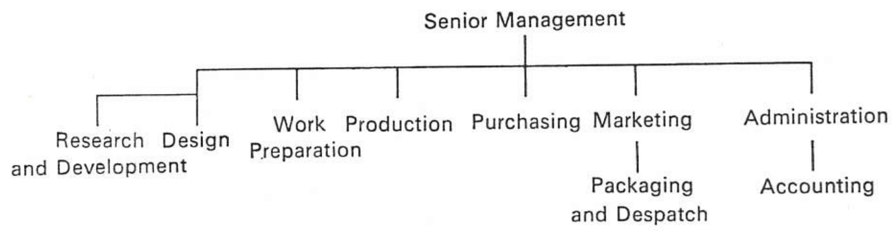

Fig. 4.

In design

If we conceive standardization as a wheel, with spokes radiating to every part of the circumference—a circumference which embraces every aspect of an industrialised community—then undoubtedly the hub of the wheel represents the design department. Products are constantly improving, fresh designs are being prepared, and it is the design department which is responsible for this progress. To fulfil these tasks it is necessary to maintain the closest touch with research and development in order to introduce improved materials and techniques just as soon as it is appropriate to do so. But in the main the design department relies on a vast number of proved materials, components and sub-assemblies whose details and performance are recorded in standards. It is with the aid of these that the new design is prepared. Only where no suitable standard part exists does the design department proceed to develop a new one, calling on research and development resources if need be.

Where new parts are designed it is possible that they may have other applications and consideration must be given as to whether they should be introduced into the standard, either in addition to what is there already, or displacing some item which is now obsolescent. Standards are never stagnant; constant revisions are necessary and it is as important to take out obsolescent items as it is to introduce new ones. Nevertheless changes ought not to be introduced until there is a sufficient step forward to justify the change.

In production

The phenomena which economists describe as economy of scale is now so well understood as to need little explanation. Generally speaking, the more articles produced to a given pattern, the cheaper the unit cost of manufacture, and the simpler the task of management. The production manager, if he has a large order for standard articles, can concentrate his energies on speeding up production, improving efficiency and lowering costs. The period between commencement of manufacture and completion of the finished article is also much reduced and this means that for a given number of articles there is less money tied up as work-in-progress. Stocking and storing of parts and articles is much reduced and availability is increased.

Once an article is standardized it is possible to estimate the demand over a period of years and divide overhead costs, such as design and tooling, into the total number of articles to be made over the period. By this means the unit cost comes down very much and that in itself may well generate an increase in demand over and above what was originally estimated. None of these benefits are possible without standards: and standards for this purpose are *documents*, describing the article in precise terms and specifying the performance to be expected of it and the test procedure to ensure conformity.

The Production Management will be mainly concerned with Company standards. The extent to which the Company standard conforms to its national or international counterpart will be a matter of more concern to other members of the team of higher management, notably those responsible for sales and for purchasing.

With the necessity for standards so apparent on the shop floor and with all these obvious advantages which follow on from good standards correctly applied, one is tempted to ask " Why is not this procedure followed always? " In most cases it is followed, but there are still a surprising number of cases in which it is not and many more cases where the procedures are not applied as effectively as they should be. In these latter cases the fault may generally be traced to ignorance—ignorance right at the top—of the correct procedures and of the improvements which could still be effected. Lower down in the management team there is often ignorance, or at least a lack of availability of knowledge, regarding existing standards documents at various levels, and lack of cooperation between sections—fear that there will be interference with personal responsibilities.

Not all this fault is attributable to the management of firms. Much of it is attributable to the very poor public relations exercised by the standardizing bodies. All too often these bodies tend to behave as if their task is completed as soon as the document is published. Far too little attention is paid to publicizing the standard amongst interested sections of the community and explaining how the standard should be implemented and the advantages of doing so.

Only by having a competent standards department in the Company organization can full use be made of standards and this matter is dealt with more fully in the chapter on company standardization.

In purchasing

Few companies, if any, manufacture everything they need. More often they purchase a large proportion of what they use in the form of raw materials, semi-finished or finished products and then proceed to manufacture or assemble these into their finished goods. Apart from standards being an essential means of communication between purchaser and supplier, the availability and cost of

standardized goods must be lower than for non-standardized, and the volume of stocks which need to be maintained behind the production line will also be much lower. The job of the purchasing manager is simplified: mistakes and disputes are minimized and there is less waste.

As an example of reduction in waste, there may be quoted the case of a joinery company manufacturing doors and windows for houses. By concentrating production on standard types and sizes it was possible to order the correct sizes of timber to ensure re-sawing with a minimum of waste, and this firm was able to reduce its waste in off-cuts to under 4%. Previously, when manufacturing to individual order the waste had been as high as 15%.

Not only does the purchasing manager benefit from standardization in the products of his own company, he can benefit perhaps even more from being able, when placing his orders for raw materials and purchased items, to quote from recognized standards when stating his needs. The ease of communication, avoidance of misunderstandings and wider sources of supply are too obvious to be in doubt.

In marketing

Standards here provide firstly a means of communication, secondly a possible guarantee of performance and thirdly a wider and a more reliable market, thereby ensuring a steady load on the production line and enabling minor depressions in the order book to be filled in with manufacture for stock.

There is no need to recapitulate the value of standards as a means of communication but it is perhaps worth emphasising here the particular value of standards at the international level. For, not only does it constitute a very good selling point if the goods which are being offered to a foreign country can be stated to be in accordance with standards which have been approved internationally but the comparison of tenders from different competing countries is greatly facilitated. Indeed it is difficult to make any fair comparison of tenders from a number of countries if all are to different and perhaps contrary standards; and if the standards in force in the purchasing country are markedly different from those of the countries who tender, and specify different quality levels. Moreover sometimes countries, and particularly developing countries, are able to manufacture some parts of an equipment themselves, importing the remainder and assembling the whole in their own country. This process is made very difficult if the standards of the purchasing country differ substantially from those of the supplying country.

Finally, there is the question of trade barriers—where legal restrictions are placed upon the import of goods which do not comply with the laws and standards of the importing country. Unless some very special considerations of safety pertain, most countries will hesitate to legislate against a standard which has received the seal of international approval. It is true that a country may sometimes be slow to implement an international standard if this differs appreciably from current national practice but seldom will a country legislate against the international recommendation.

Good standards are a guarantee of good performance and this in itself is an important selling point. But here it may be observed that it is no use specifying a performance in a standard without also specifying the test procedure to be carried out in order to establish conformity of the goods with the standard. This is true no matter what level of standardization we are considering.

For consumer goods with a limited life—electric lamp bulbs or motor car tyres are good examples—compliance with an international standard signifies more certain availability when the time comes for replacement. It is not always necessary for the replacement items to be identical with the discarded ones provided they satisfy the needs of functional interchangeability (defined in Chapter 2). For example, a 24-inch wide conveyor belt manufactured in the USA could be functionally interchangeable with a 600 mm wide one manufactured in Germany, even though the mode of construction might be somewhat different.

Modern equipments are often very complex and huge development and tooling costs are incurred in bringing them to the stage of production. There are a growing number of cases where two or more countries combine their resources to bring a project to fruition—the Anglo-French Concorde supersonic airliner is an example. Such pooling of resources is almost impossible if the basic standards of the two countries are not aligned.

For these and many other reasons the value of international standards is particularly apparent in the sphere of marketing and exporting.

In administration and accounting

The volume of work in administration and accounting increases rapidly with the variety of goods handled but can be curtailed by careful and accurate cataloguing. Standards can thus exercise a dual benefit, the one in reduction of unnecessary variety and the other in providing an efficient basis for cataloguing and listing the many goods and materials employed in the company's business. All levels of standardization contribute to simplifying administration and accountancy work but the principal benefits will be derived from maintaining good company standards.

VALUE ANALYSIS

Value analysis is a method of approach to management problems which was first initiated in the USA but has since been developed and is now employed by many big companies all over the world. It deserves some mention here. Value analysis pre-supposes that every action and the effects of every decision of management can be assessed in monetary terms. Related solely to a standardization activity it is almost the same as examining the economic effects of the standardization, asking such questions as: What is the purpose of the standard? How much will it cost to prepare it? Is it worth while? Is there a better solution? What will be its value if it is prepared? But in management techniques it calls for a much wider approach.

Value analysis is " analysis by function ". It is first necessary to identify the function and then to establish the value of the function by considering the lowest cost of performing that function reliably. It aims at the identification and removal of unnecessary costs, namely costs which do not provide usefulness, life, quality, appearance or customer's needs.

Definitions

Value analysis is an organized effect directed at analysing the function of hardware, systems and methods with the purpose of achieving the required function at the lowest overall cost consistent with requirements for performance, reliability and maintainability.

Value is made up of " Use value "—the qualities and properties which accomplish a service or use—and " Esteem value "—the properties or features which make it a desirable thing to own.

Value is the minimum amount of money which must be spent to create the appropriate use and esteem functions.

This definition of value analysis in itself contains the seeds of a reduction in quality but only in the sense of the suppression of what may be considered superfluous, since the only quality necessary is that which corresponds to the real needs of the consumer. It is on the notion of " quality " that standardization and value analysis come closest together, but they merge in other fields also since they use the same techniques. Indeed standardization was the technique which most closely resembled value analysis before the latter came into being. In any case they almost always complement one another. The standardization activities of an enterprise must employ value analysis techniques: and conversely, value analysis will hope to find in standardization ready-made solutions to many of its problems, in the form of standards already proved and tested and representing the lowest cost consistent with requirements. If this is not so, the standards of the enterprise need to be re-examined in accordance with the principles of value analysis.

When applied to the preparation of standards, value analysis calls first for an identification of the various functions of the product and then an examination of the product to see just how each function is fulfilled. If the standard provides a lot of data which is irrelevant to any of the functions, then that data is superfluous. Conversely if the standard leaves the reader in the dark as to how some important function is to be fulfilled then the standard lacks something.

This is perhaps a new notion for certain standardizers who have been accustomed to think in terms of well defined components and not in terms of functions but it deserves to be developed.

Value analysis is inevitably a team effort because it obliges the design, manufacturing and purchasing departments to combine in thinking " lowest cost without reduction in necessary quality ". This objective is very similar to that of standardization and should ultimately lead to " standardization of functions ".

When related to design, the designer who applies value analysis will ask himself the following questions regarding the use of standards:

1. Has the design been coordinated with those who may be using similar designs, circuits, parts, components or materials to get optimum benefit from standardization and past experience?
2. Are the standard components, parts, hardware, circuits, processes etc. the lowest-cost standards which will provide the minimum required function?
3. Can the use of each non-standard part be justified?
4. Can any new non-standard part be replaced by a non-standard part which has already been approved?
5. Do the specification drawings make it clear that a standard part is being specified when such is intended?
6. Has standardization been carried too far, with the result that the cost of excess function is greater than the gains resulting from high quantity?

ECONOMIC CONSIDERATIONS

In Chapter I we defined one of the first aims of standardization as " Overall Economy in terms of human effort, materials, power etc., in the production and exchange of goods ". We now propose to examine the economic effects in more detail and also to see how far it is possible for them to be estimated in advance.

Standards, whether national or international, have to be agreed. Experts have to be called together and sometimes a programme of research has to be undertaken. All this costs money but the cost may in part be offset against the fruitful interchange of ideas between experts which is a clear benefit.

Standardization of a product will generally result in a larger volume of sales and will therefore lead ultimately to low cost goods. Provided there is some scope for expansion of the market, low cost should generate further consumer demand. However, in the initial stages of implementing a new standard, capital costs may be incurred in re-tooling which have to be offset against the eventual economies of larger scale production.

Standardization is likely to increase competition within industry and this may lead to price agreements or to mergers.

In general the market is likely to be affected, to the benefit of the consumer and of the large supplier, but perhaps to the detriment of the small supplier. On the other hand the availability of low cost mass produced materials and components can often help the small supplier of low volume specialist goods to achieve considerably lower costs than would otherwise be the case. Consistent quality and improved reliability may be expected from new and better standards and these factors are a benefit to everybody.

Governments are likely to approve of gains in safety and health and also of the reduction in real costs of production that standardization may be expected to bring. They may also find its military consequences advantageous. But the effect on balance of payments may or may not be welcome depending on the commodity and on the augmentation or restriction of trade that results.

These are but some of the conflicting effects that can arise and the overall economic picture can be very complex. But fortunately not all these factors arise in every case and in several large areas, as for instance in the packaging and transportation of goods, the economic advantages of internationally approved standards are large and obvious: and in varying degree they are shared by the whole world.

In very many cases also standardization leads to simplification and to the reduction of unnecessary variety and where this is so, the ultimate benefits are almost always substantial.

The majority of people will readily accept the positive benefits of good standards properly applied, but within this general acceptance there may well be reservations from sectors of the community about some particular aspect of standardization or about the degree to which standardization is desirable in any particular case. Standards will affect different people in different ways. What is beneficial to the manufacturer in effecting savings of materials or labour may be marginally disadvantageous to the customer in restricting his choice of size, quality or style, although both will benefit from the considerable lowering of cost. To standardize a range of goods on the basis of favouring the ones in most popular demand may help the majority but may prove very hard on a small minority of customers—for example the majority of right-handed persons as opposed to the minority of left-handed.

Economic considerations should be an important factor in determining which are the most urgent subjects for standardization at any one time, although they are not the sole factor. Health and safety can be of even greater importance, as for instance in standards for control of pollution. The world has suddenly woken up to the dangers of pollution and within the next decade a number of standards are likely to emerge at both international and national level, the implementation of which may prove very costly.

Economic considerations should also determine how far a particular standardization activity should be carried. For example, modern industry could not survive without standard screw threads in diameters from 1 to 50 mm but the need for such a high degree of standardization in diameters 100 to 500 mm is more debatable. In the very largest sizes the usage is so small that the effort of carrying the standardization activity right through to the tabulation of standard nuts and bolts may scarcely be justified, certainly it cannot be given the same priority.

Before embarking on a standardization activity therefore we should examine the economic effects and determine just how far the standardization should be carried and hence determine what priority should be accorded to it. Can we do so?

It is indeed difficult and some people may say impossible to arrive at an exact answer to such a complex problem: and yet, more difficult problems have been successfully tackled before. Moreover do we need an exact answer? Is not a reliable approximation all that is necessary, backed by some statistical data and empirical rules?

The situation is somewhat analogous to that of the real-estate agent whose task is equally complex: but long experience has led valuers to carry out their task with the aid of empirical rules and to arrive at a value for a property which is generally very near to what the market will pay.

Priority of work

Several methods have been tried for assessing priorities. One is a " points " system. In its simplest form a number of headings are selected, say 10 in all, and points up to a maximum of 10 are awarded under each heading. Thus 100 points would be the maximum possible. A standardization activity which scored say 67 would be deemed more valuable and worthy of higher priority than one which scored only 37. Negative points can be awarded under a heading where damaging economic effects are foreseen. Although this method of assessment is an arbitrary one and of doubtful accuracy, it is far better than nothing. It is a method employed in many other contexts, for example it is frequently used in preparing a short list of candidates for an appointment when a large number of applications have been received.

The headings employed in any particular case will depend on the nature of the standard and they need to be selected with care.

For a product standard of engineering significance the primary and secondary headings could be somewhat as follows*:—

* Chosen from document ISO/STACO 424 submitted by Professor S. Matuura of Japan.

1. *Procurement*

Reduced inventories of materials to be purchased: bulk purchasing and hence lower cost: reduced storage and decrease of dead stock: easier purchase planning and shorter waiting time for material supply: simplified procurement procedures.

2. *Design*

Reduction of products or parts: decrease of design errors and shorter design time: easier to control drawings and design data.

3. *Manufacture*

Reduction of products or parts: less time spent on set-up of machines and processes: possibility of automatic operation: improved quality: easier training of personnel: decrease in accidents: improved production efficiency.

4. *Inspection*

Volume to be inspected decreases as lot-size increases: possibility of better inspection equipment and improved accuracy of inspection. Less storage of products awaiting inspection: easier to train inspectors.

5. *Safety*

Improved safety by specialization of equipments or decrease of equipments: reduced accidents: easier to maintain business control over safety and security.

6. *Business and Management*

Speed-up of delivery of goods: decrease in stocks and storage areas: rationalization of packaging: despatch and transport: concentration of sales effort where most needed and simplification of sales management: easier to train salesmen: better communication and inter-departmental coordination.

A variation of the " points system ", used for determining the importance of a particular standard *after* it has been prepared is to analyse the number of other standards in which reference is made to the particular standard. At least one National Standards Institution has done this analysis and a few examples of the result are given below.

Number of reference	Title of Standard
361	General testing methods for reagent-chemicals.
295	Rolled steel for general structure.
150	Gray iron castings.
131	Bronze castings.
129	General testing method for intermediates from coal tar.
116	General rules for inspections on non-ferrous metal materials.
113	Unified fine screw threads.
107	Brass sheets and plates.
105	Unified coarse screw threads.
104	Carbon steel for machine structural use.
99	Brass rods and bars suitable for forging.
96	Carbon steel forgings.
94	General rules for chemical analysis of iron and steel.
79	Free cutting brass rods and bars.
73	Physical testing methods for vulcanized rubber.
70	Hydrochloric acid.
68	Method of tension test for metallic materials.
67	Stainless steel bars.
65	Carbon tool steel.
64	Hexagonal head nuts (Whitworth thread).
63	Limits and fits for engineering.

Summing up these numbers in broad groups, the order of priority of standardization subjects as estimated by means of frequency of reference is tabulated as follows:

Order	Number of reference summed up	Category of standardization subject
1	793	Steel
2	527	Method of chemical analysis
3	488	Screw threads
4	453	Copper and copper alloy
5	292	Testing methods for metallic materials
6	207	Cast iron malleable
7	177	Bolts and nuts

Use of empirical graphs

Another method of approach, described briefly below, is to estimate the probable economic advantage by reference to a " standard " graph. This method has recently been developed by Professor S. Matuura of Hosei University Japan as a means of estimating the benefits of variety reduction. It is primarily intended for application at the Company (or Industry) level of standardization where very large reductions in variety are sometimes possible, but the method has obvious possibilities in national and international standards as well.

Fig. 5 shows two empirical curves

$y = x^{-0.25}$ and $y = x^{-0.3}$

where y represents the unit cost of a product expressed as a percentage and x represents the number of units produced, x and y being plotted to any convenient scale.

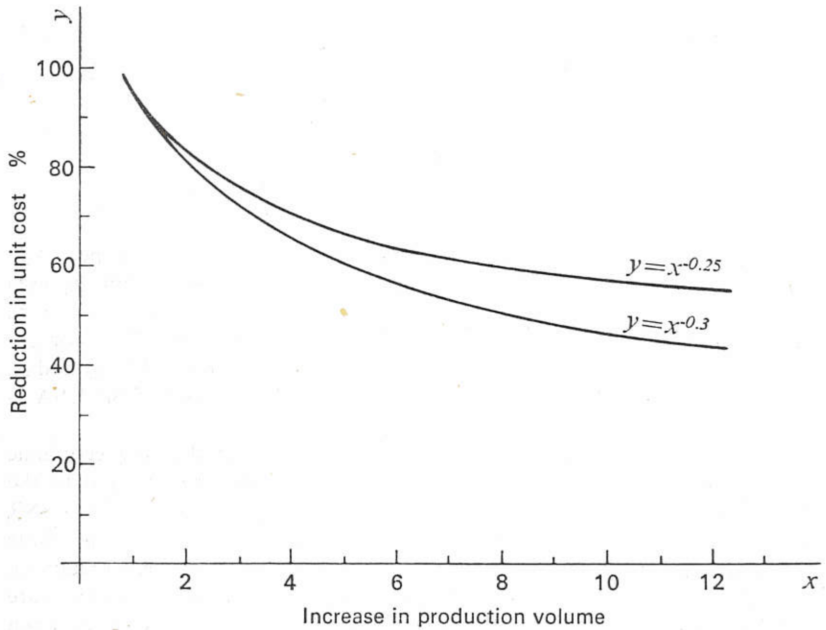

Fig. 5.

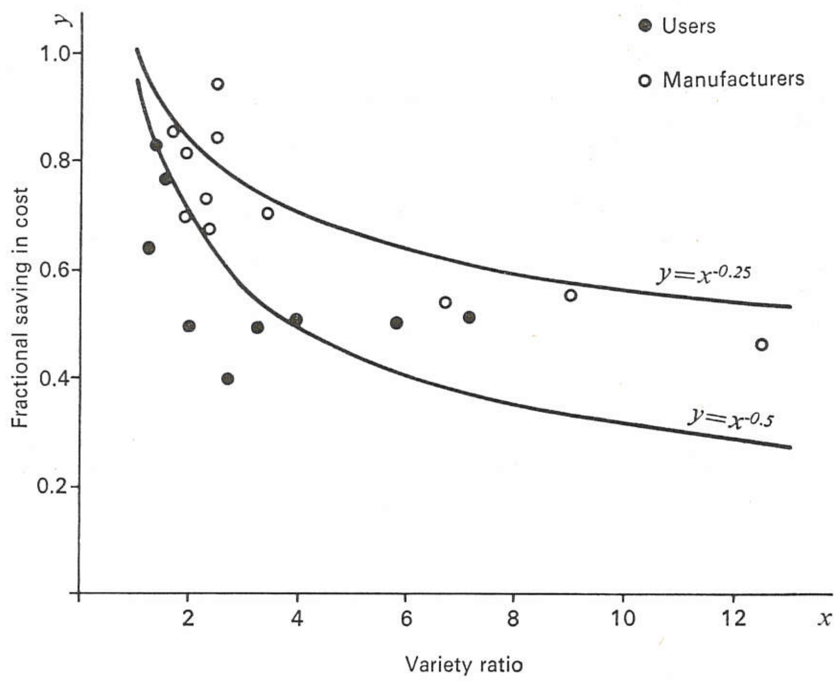

FIG. 6.

There is evidence over quite a wide range of manufacture that the fall in unit cost resulting from increased volume of production lies within the area bounded by these two curves. The formula $y = x^{-0.25}$ or $y = x^{-0.3}$ can be regarded as being verified by the experience of Ford Model T motor car (1909-1919), by the law of Caquot (1939), by the analysis of G. Maxey and A. Silberston for the motor industry (1959) and by the experience of the USA in building type T 2 tankers (1942-45).

In the manufacturing industries it may be supposed that the economic benefits resulting from variety reduction will be nearly proportional to the benefits resulting from higher volume of production. Thus in the USSR " Methods for calculating economic effects of standardization " the State Committee of Standards adopt the formula $y = x^{-0.3}$ for variety reduction. The results available so far from case studies on variety reduction are plotted in Fig. 6. In this figure the solid circles represent users and the open ones represent manufacturers.

It will be noted that the economic benefit gained by the manufacturer side is nearly similar to the results recorded for unit cost plotted against production volume, and conform approximately to $y = x^{-0.25}$. The benefit gained by the user or consumer side is however, much greater, conforming more nearly to $y = x^{-0.5}$. Thus, on this evidence, variety reduction would seem to be somewhat more beneficial to users than to manufacturers of products, an interesting result.

Although the two curves are entirely empirical—that is they have no mathematical foundation, they do seem to provide the boundaries within which will lie the benefits from any given variety reduction. Thus, to a first approximation at least, we may expect that the unit cost will fall to about 85% at a variety reduction ratio of 2, 70% at about 3 and 60% at about 4. In the highly developed industries it may be hard to find a possible variety reduction ratio much greater than 2 but in many of the smaller manufacturing companies and in the case of user companies buying in large varieties of stores the possibility exists for much larger variety reduction ratios.

This method of approach to determination of the economic benefits from standardization merits a good deal more study. Empirical curves could be developed for other features besides variety reduction. Enlargement of market and changes in volume of trade might well be studied in this way.

6

Standardization at the international level

There has always been a need for standardized products and methods. The Stone Age potter did not fashion a new shape of pot every time; to save time and effort, he specialized in a limited number of patterns, with specified dimensions.

Today, standardization is a much more sophisticated operation, but the aims are the same: to simplify, to clarify, to diminish the risk of errors, and to capitalize on lessons already learned.

The principal change is, however, a geographical one. The Stone Age potter could not envisage a more widespread distribution of his products: his clientele was generally limited to the people living in the same village, since transport outside the village was time-consuming and hazardous.

Today, the situation has changed radically. New transportation methods —not least the ISO container—have made it possible to transport almost any goods over long distances. Improvements in communications mean, in turn, faster technological development. While an invention like the wheel took thousands of years to reach into every corner of our planet, the electronic computer has become an accepted universal tool within a generation.

Early examples of international standardization are difficult to pin-point; it tended to come gradually by evolution. In medieval times, conquering nations customarily imposed such standards as they possessed on their new subjects, and if these standards were good ones they probably took root and survived. Europe, and indeed the world, owes much to the early Roman Empire in this respect.

Some of the earliest international standards which appeared by evolution were those to do with time and with navigation. An example of this was the acceptance by the world of the Greenwich meridian as the zero for longitude which dates from 1884.

Founding of the IEC

Electrical engineers were among the first to realize that international standardization would become a necessity in the modern world. A number of electrical congresses were held at the end of the 19th and the beginning of the

20th centuries, and it was agreed that a permanent organization capable of carrying out international standardization in a methodical and continuous manner was necessary.

The International Electrotechnical Commission came into being in 1906 as a result of the resolution passed by the Chamber of Government delegates to the Saint Louis (U.S.A.) International Electrical Congress in 1904, on a motion by Col. R. E. B. Crompton (United Kingdom):

" that steps should be taken to secure the co-operation of the technical Societies of the world by the appointment of a representative Commission to consider the question of the standardization of the Nomenclature and Ratings of Electrical Apparatus and Machinery."

Fourteen National Committees having been officially formed, the Council met for the first time in London in 1908 and approved the first statutes which remained almost unchanged until 1949. At Turin in 1911, following a resolution passed by the International Congress on the Applications of Electricity, the Council of the IEC accepted the responsibility of organizing all future international congresses on the application of electricity. The first President was Lord Kelvin and the first General Secretary was Charles Le Maistre, a post which he was to hold until his death in 1953. Mr. Le Maistre was succeeded by Mr. L. Ruppert, who retired from office at the beginning of 1969.

At the time of the formation of the organization, a Central Office was set up in London, which was to remain the seat of the Commission until the Central Office was transferred to Geneva in 1947.

In 1947, the International Electrotechnical Commission became affiliated with the International Organization for Standardization (ISO) as its electrical division, whilst preserving its technical and financial autonomy. In this capacity, the Commission has at present consultative status (Category B) with the Economic and Social Council of the United Nations.

Today the International Electrotechnical Commission is composed of 41 National Committees. The work of the Commission is carried out by more than 600 Technical Committees, Sub-Committees and Working Groups covering subjects over the whole range of electrotechnical activities such as:

— Electrical terminology, units, symbols, standard ranges, standard test methods;

— Materials important in electrical practice: copper, aluminium, solid, liquid and gaseous insulants, magnetic materials;

— Apparatus used in power generation, transmission and industry;

— Electrical installation components—cables, instruments, relays, fans, batteries, lamps, fuses, appliances and accessories;

— Electronic components and assemblies used in radio, television communications and in industrial controls and systems;

— Performance, safety and reliability of applications of electric power and control in different kinds of installation—in buildings, ships, electric traction, mines, machine tools, hospitals, process control—and in specialized uses such as welding, heating, refrigeration and air-conditioning.

New Technical Committees have come into being in recent years to keep pace with the developments in technology in general and the electrotechnical sectors in particular.

Thousands of electrical and electronic engineers, experts in their specialized field, are engaged in the preparation of electrotechnical Recommendations, which are appearing at the rate of 4000 printed pages a year.

At the present time, more than 100 meetings of Technical Committees and Sub-Committees are being held yearly throughout the world. This figure does not include the numerous meetings of the 400 or so Working Groups or other ad hoc bodies.

The 41 countries in the five continents which at present have IEC National Committees are responsible for well over 95% of the world's electrical power production and more than 90% of electrical exports and imports. Engineers from developing countries, however, are now taking an increasing interest in the Commission's work as knowledge and experience of electrical and electronic techniques become more widespread.

Founding of ISO

Meanwhile discussions had been taking place about the possibility of international cooperation in other areas of standardization, notably in mechanical engineering, but it was not until 1926 that some of the world's leading standards bodies (by this time there were about 20 of them) arranged a conference in New York and decided to group themselves together into the "International Federation of the National Standardizing Associations (ISA)." The accent at that time was strongly on mechanical engineering, though some early work related to other questions such as paper sizes, cinematography and textiles. These documents foreshadowed the tremendous range of subjects which would eventually come within the scope of international standardization.

With the threat of war looming in the late 'thirties several countries withdrew their membership and by 1942 ISA officially ceased work. In 1944, the United Nations Standards Coordinating Committee (UNSCC), consisting of the national organizations of 18 allied countries, succeeded ISA but this was essentially a temporary war-time organization.

On 14 October 1946, 64 delegates from 25 countries met in London to consider the establishment of a new international organization " whose object shall be to facilitate the international coordination and unification of industrial standards ". Discussions led to the setting up of ISO, and the first provisional General Assembly of the new body took place in London on 24 October 1946.

The ISO Constitution and Rules of Procedure were unanimously adopted by the General Assembly and it was decided that ISO should begin to function on an official basis as soon as the provisions had been ratified by 15 national standards bodies. The 15th ratification was received by the provisional Central Secretariat on 23 February 1947. At the same time, IEC was affiliated to ISO and, while preserving its autonomy, functioned henceforth as the Electrical Division of ISO.

When ISO was created in 1947, there were already a total of some 150 000 national standards in existence. Consequently, efforts were concentrated on an attempt to harmonize those national standards. In those post-war years, however, there was only limited interest in efforts aimed at international agreements. The national work had priority, and in many countries international work was considered as a useful, but hardly an indispensable activity.

Thus, ISO did not really get into its stride until the early 'fifties. It concentrated in the first instance on the basic abstract standards of mechanical engineering, such as drawing practice, limits and fits, units and symbols; and on product standards for the more important components of mechanical engineering such as screw threads, bolts and nuts, ball and roller bearings, steel specifications, etc. In all these subjects progress was retarded in consequence of the widely differing practices of the leading industrialized countries. These practices were deep-rooted, and no country wished to change such basic standards. Frequently it was necessary to embark on protracted programmes of research to establish newer and better practices on which to found the international standards so that a positive advantage could be demonstrated to those who were asked to make the changes. Nevertheless considerable progress was made during the next decade and as ISO moved into the newer technologies such as plastics, chemical engineering, data processing, atomic energy, packaging, etc., work progressed much faster and the recommendations of ISO were quickly picked up and implemented by the industries of the world. This demonstrates very strongly the advantage of starting international talks early, before any deep-rooted practices have had time to develop in the different sectors of the world.

As recently as 1957, when ISO was celebrating its tenth anniversary, the results were still very modest. By that time 37 ISO recommendations were approved, but it was significant that those results emanated from no fewer than 17 different technical committees—the ISO work was beginning to bear fruit on a broadening front. The number of draft recommendations had risen to 117.

It was in the 'sixties that international standardization really began to break through. The aforementioned revolution in transportation methods, which contributed to an explosive growth in international trade, was one of the factors. But there were other reasons, notably:

— The development of multinational companies which found their commercial activities hampered by conflicting national standards;

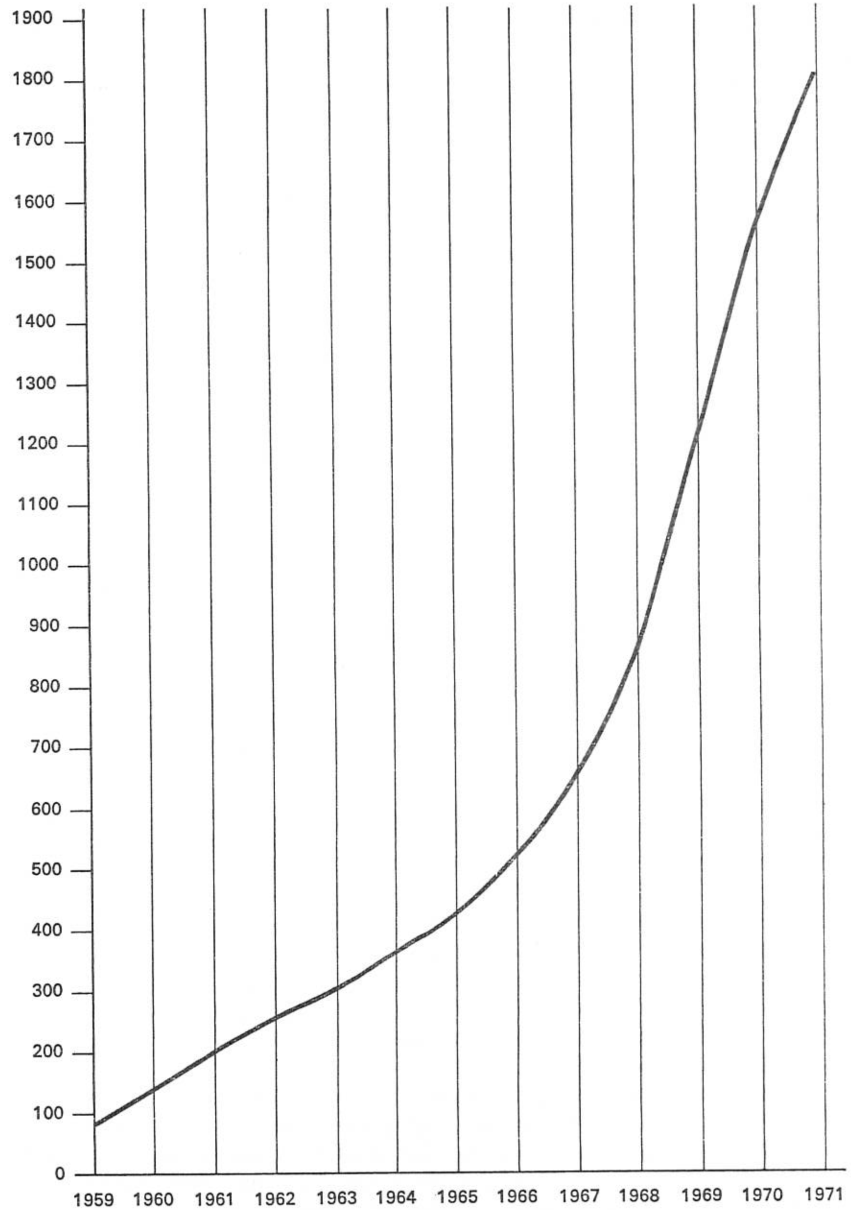

FIG. 7. **Number of ISO standards published**

More than 50 percent of the ISO standards have been published in the last three years.

— The growing interest of governmental authorities in an international, technical platform, for the development of harmonized regulations;

— The creation of standards institutions in a great many developing countries, which realized the need for a sound international basis for their national work;

— The widening scope of ISO, which engaged more and more people from different interest groups—not least the consumer movement;

— The recognition by other international organizations of the need for rules in technical questions.

In other words: there was a *demand* for international standards. The climate was right for ISO's growth. The result: while only a hundred standards were published in the 'fifties, some 1400 documents were approved in the following decade.

Growth of ISO

In May 1972 there were nearly 2000 ISO standards in existence, half of them published in the preceding three years. A further 2000 drafts and proposals were then in the pipeline. The total number of ISO standards is confidently expected to double within the next four or five years.

Now, on each working day of the year, four or five ISO meetings are taking place somewhere in the world and in 1971 ISO meetings were held in 21 countries—attended by a total of some 18 000 delegates. In all, 50 000 experts in widely different fields are engaged in the ISO work. In 1971, ISO published some 5000 pages of new international standards.

Concern for international standardization was originally restricted largely to the manufacturing industry. Today, however, governmental authorities, research institutes, consumer associations and other international organizations are deeply involved in the movement. The old delusion that standardization is primarily a matter of screw threads, nuts and bolts, is further than ever from the truth. Even if some 20 percent of the ISO standards produced fall within the *mechanical* field, the most comprehensive results of ISO have been achieved in the *chemical* field, where some 600 standards—equal to 30 percent of the output—have been published. The areas of *metals* and *agriculture* each account for some 10 percent.

Other areas of activity may be expected to account for a larger proportion of ISO work in future. Particularly important is the field of *transportation*, where ISO standards for automobiles, aircraft, ships, containers, and packaging will facilitate the exchange of goods and services. Consequently, transportation questions now enjoy high priority in the ISO work. *Building* and *information processing* are also fields where increasing international trade and interdependence make world standards imperative.

Traditionally, international standardization work has been concentrated on three aspects: *terminology*, *dimensions* and *test methods*. The overwhelming majority of all ISO standards are concerned with at least one of these aspects. For example, some 10 000 defined terms are to be found in published and draft ISO standards, and a great many more are under study. Many of these terms have been translated into other languages for direct incorporation into national standards which reinforces their utility as an evolving multilingual dictionary of great importance.

A common technical language is a basic requirement for international understanding in every sense. An ISO activity of special significance is,

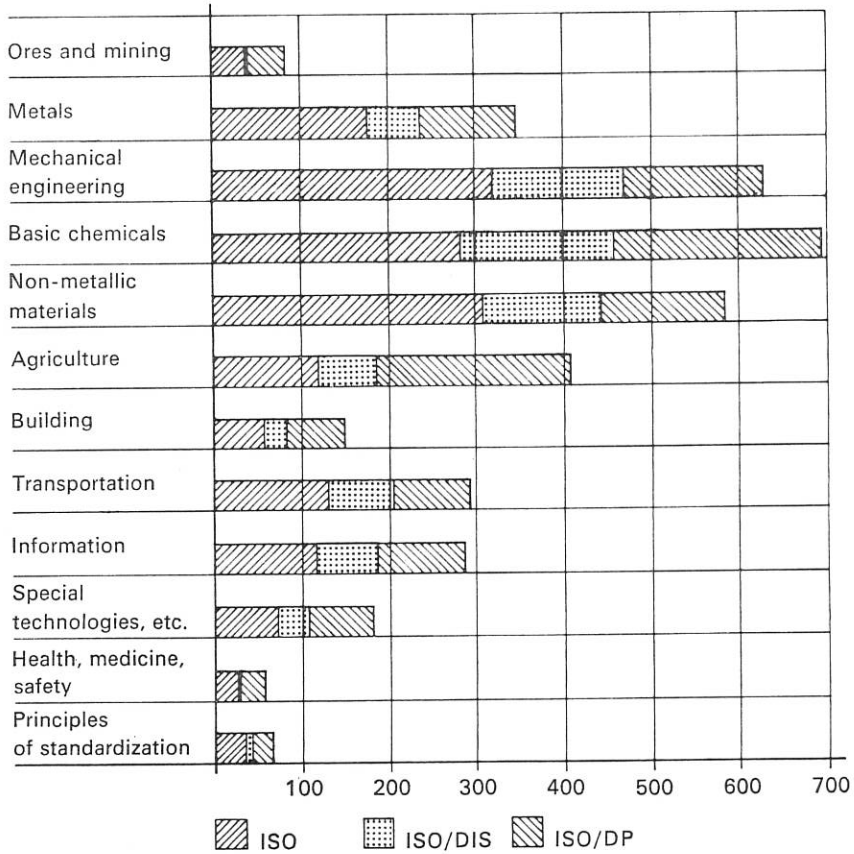

FIG. 8. **ISO work in different fields**

therefore, the development of international standards for units, symbols and drawing practice. Methods of testing materials and products constitute another cornerstone in international standardization. More than 50 percent of all ISO standards include the testing aspect.

Supplementing the three classical aspects—terminology, dimensions and test methods—is a fourth category of *performance standards*, including questions of safety and quality. An international standard for protective helmets, for example, should enable one to compare helmets from different countries. Likewise, an engineer looks to ISO for an objective universally recognized standard to compare the performance of lifting chains from different manufacturers. Half of the ISO technical committees created in the last five years are charged with the development of performance standards.

The need for international standardization first became apparent in Western Europe and for many years other regions played only a relatively minor role in the ISO work. As late as in the 1950s, almost all ISO meetings were held in Europe, and Western European countries held practically all the ISO technical secretariats.

In recent years, however, ISO has developed into a truly international organization. One significant sign of this trend is the composition of the 1972 ISO Council, which is charged with the operation and administration of the Organization between meetings of the General Assembly. France, Germany, Italy, Norway and the United Kingdom are members of the Council, but a healthy balance of interest and geographical location is provided by the presence of such member countries as Australia, Brazil, Canada, India, Iran, Japan, Romania, USA and USSR.

The United Kingdom (BSI), France (AFNOR) and other West European countries have traditionally held a large proportion of the technical secretariats within ISO. The distribution has now become more widespread as countries such as USA, USSR, India, Japan and Australia have assumed greater responsibilities. In 1972, secretariats are located in 28 countries.

Present membership of ISO

ISO has in 1972 a total of 70 member countries, made up of 55 member bodies and 15 correspondent members. This compares with a total membership of 25 in 1947.

Approximately half of the ISO member bodies are governmental institutions. The others are semi- or non-governmental bodies, most of them receiving some form of government subsidy.

How an international standard is developed

An International Standard is the result of agreement between the member bodies of ISO. An International Standard may be used as such, or may be implemented through incorporation in national standards of different countries.

Up to the end of 1971, the results of the ISO work were presented in the form of Recommendations. Following an ISO Council decision in 1970, ISO standardization agreements are now published as International Standards.

A first important step towards the International Standard takes the form of a *draft proposal*—a document circulated for comment within the technical committee.

A draft must pass through a number of stages before it can be accepted as an International Standard. This procedure is designed to ensure that the final result is acceptable to as many countries as possible. Too hasty a preparation and approval of a document could seriously diminish the chances of the ISO standard's widespread adoption.

When agreement is finally reached within the responsible technical committee, the document is sent to the Central Secretariat for registration as a *Draft International Standard* (DIS); the DIS is then circulated to all member bodies for voting. If 75 per cent of the votes cast are in favour of the DIS, it is sent to ISO Council for final acceptance as an *International Standard*. Although by this stage the fundamental technical issues have normally been resolved within the committee, the final member body and Council voting ensures that no important objections have been overlooked.

The greater part of the work is done by correspondence, and *meetings* are convened only when thoroughly justified. This procedure means that a great number of documents are circulated before and between meetings. In the metals field alone—representing five of the 150 technical committees—it is estimated that some 1000 working documents are circulated annually; all of them requiring comments and action from the member bodies concerned.

Most standards require periodic revision. Technological evolution, new methods and materials, new quality and safety requirements—all these factors combine to render a standard out of date. To take account of this technical development, ISO has established the general rule that all ISO standards should be reviewed every five years. On occasions it is necessary to revise a standard earlier.

In some cases, a standard may be revised time and time again. It is essential, therefore, that users have access to the latest edition. All ISO standards are available from the ISO member bodies.

Regional standardization

The following is a list of the principal regional standards organizations in existence at the present time with brief details of their constitution and aims.

CEN

The European Committee for Standardization (CEN) was set up in 1960 with the aim of establishing common standardization documents in order to promote the development of trade. Its member bodies are the national standards organizations of the countries of the European Economic Community (EEC) together with the countries of the European Free Trade Area (EFTA).

CEN unification documents which initially aided the alignment of the national standards of its members are now to be replaced either by " European standards "—a series of technically identical standards based in the main on ISO and IEC standards, which can be referred to in international legislative agreements (see Reference to standards in Chapters 1 and 10)—or by " Unification Reports " which will show the degree of harmonization achieved with a particular specification.

CENEL

The European Electrical Standards Coordinating Committee (CENEL) was also set up in 1960, as the electrotechnical counterpart to CEN. It has the same aims within its specific field and broadly the same constitution. One achievement has been the detailed identification of barriers to trade presented by divergences from international technical agreements, notably IEC publications. It is also responsible for the administration of the harmonized scheme for electronic components of assessed quality in Western Europe.

CEE

The International Commission on Rules for the Approval of Electrical Equipment was established for European countries in 1946. Its aim is to define the conditions with which certain electrical equipment should comply in order to protect the public against the risks which may result from the use of equipment of poor quality, particularly from the point of view of danger to life and risk of fire. It is also the purpose of CEE to bring about as much uniformity as possible between the national regulations in force in the various member countries.

There is mutual recognition of test certificates proving conformity to CEE specifications and use of a common approval mark is being developed.

COPANT

The Pan American Standards Commission (COPANT) was initiated in 1961 and acquired its present constitution in 1965.

Membership includes the USA, Mexico and most of the South American Republics.

In so far as regional conditions permit, COPANT's declared policy is to make use of ISO and IEC recommendations and standards for the development of standards in the Latin American Common Market.

ASAC

The Asian Standards Advisory Committee (ASAC) was established in 1966 as with the other regional groups. ASAC aims to make the fullest possible use of ISO and IEC recommendations and standards only adding to or adapting these to the extent necessary to meet the needs of the regional community. The latter presently consists of Australia, Cambodia, Ceylon, China, India, Indonesia, Iran, Japan, the Republic of Korea, Malaysia, New Zealand, Philippines, South Vietnam, Singapore and Thailand.

ASMO

The Arab Organization for Standardization and Metrology came into existence in 1967. Its membership includes Jordan, Iraq, Syria, UAR, Kuwait, Lebanon and Libya. Its basic aims are to perform for its own region the same services which COPANT and ASAC perform for theirs.

CMEA Standards Committee

The Council for Mutual Economic Assistance (CMEA) promotes economic integration within a group of countries which includes the East European bloc. A comprehensive programme for the further extension and improvement of cooperation among the CMEA countries has recently been agreed, and standardization is an important factor in the programme.

7

Standardization at national and company level

The national standards body

It is difficult to state with precision the dates when the earliest standards institutions came into existence since most had some early beginnings before acquiring official recognition as the national institution. However it is certain that there were none in existence at the close of the nineteenth century whereas by 1920 at least a dozen were firmly established, with many more in process of formation.

This period of 20 years may therefore be taken as the great period of recognition of the need for national standards.

The recognition came from the growth of industrialization throughout the world, bringing with it increased trading and establishing the need for standard specifications, as a recognized basis for trading. Standards are essential if purchasers are to be provided with an assurance of the suitability and quality of the products that are being sold. They are also necessary to limit the proliferation of needless variety and as a means of exercising some form of quality control at the point of production to ensure that the products, as despatched, are in fact of the quality that is claimed for them. The preparation and promulgation of the requisite standards is the principal task carried out by a national standards body. But for a developing country that is endeavouring to develop its industry on an efficient and economical basis, there is also the initial and important task of preparing a planned and coordinated programme of standards which will integrate the industrial activities which are expected to take place.

For the bigger countries, where national standards bodies have now been in existence for a good many years, a comprehensive library of national standards has already been created and the current tasks are: firstly to augment, revise and maintain the national standards, secondly to make strenuous efforts towards harmonizing them with those of other nations.

For the developing countries who are engaged in preparing national standards for the first time, the order of priorities will be firstly a coordinated programme of work identifying those standards which are most urgently needed: secondly a careful examination of what already exists in the form of outside standards of international repute: thirdly selection of the most appropriate outside standards and preparation of national standards from these. This reduces to manageable proportions what would otherwise be an overwhelming task.

There is nowadays the clear trend in all countries, whether highly industrialised or developing, to work for international standards first and to treat national standards as a consequence of, and in accordance with, prior international accord.

It is fortunate that the future holds greater hopes than the past because of the greatly improved prospect for International Standards.

Having prepared the necessary standards the next task is to encourage their use. The application of standards in industry, with the resulting simplification and economy of technological effort which this brings, the technical know-how given by access to the codified information provided by standards, gives strength to an economy. An economy which does not know of these techniques, or does not apply them effectively, is at a relative disadvantage. This is particularly true of a rapidly-developing economy where the demands for scientific and technological manpower are so much greater than the resources.

The functions of a national standards body

These tasks of advancing the knowledge of both national and international standards and encouraging their use are normally entrusted to a national standards body. The main functions of such a body can therefore be summarized as follows:

1. The preparation and promulgation of national standards.
2. Promotion for the adoption and application of standards.
3. Quality assurance and certification of products.
4. Provision of means for disseminating information on standards and related technical matters, both national and international.
5. The representation of its country in international standards work.

In some countries the work on 3 is centred in the national standards body; in other countries work under this heading is done wholly or partly through a separate agency or agencies. The most essential thing is that this important field is recognized as a main objective of the whole subject of standards in application.

Although almost all industrial countries now have a national standards body these vary considerably in their constitution, size and the range of work they undertake.

The recognized procedure in the drawing up of national standards and codes of practice is to arrive at agreement amongst all the various interests concerned—government, manufacturers, users, professional bodies and distributive bodies—on the technical requirements to be included. This procedure

means that a standard is inevitably a distillation of ideas and in seeking the best solution it is almost always necessary to accept the most reasonable compromise from amongst a variety of conflicting interests. It is, however, a matter of major importance that agreement shall be reached, as otherwise implementation of the standard may prove difficult if not impossible. Those concerned with the drafting of the standard need to be persons of experience, motivated by a desire to promote the optimum overall solution rather than just to secure the maximum concessions to their own local interests. The national standards body therefore is an organization with authority to set up technical committees to cover specific sectors of industry. The committees are constituted so that they include technical experts representing the various interests directly concerned who are therefore competent to draft the standards required in that particular field of technology.

The co-ordination of the standards activity across the whole field of industry, with its planned co-ordinated programme, and the responsibility for the running of the affairs of the organization as a whole is usually vested in a Council, which includes representatives of government and industry.

Constitution

The responsibility for the national standards body may, at one end of the scale, be vested solely in government and in a number of countries this is the case. At the other end of the scale, however, the national standards body may be set up as an organization entirely independent of government and maintained and supported essentially by private industry. In practice the extent of Government participation in the work of the national standards bodies throughout the world varies widely. But whatever the form, unless the national standards body has the full backing of its Government in its work, it is not likely to be effective either at home or abroad.

Accordingly, however it may be constituted, a national standards body should conform to certain definite principles such as the following:

(*a*) It should be recognized by law and should have a legal status as the body responsible for preparing national standards and for representing its country's interests in standards matters at the international level; for example, in the work of the ISO and IEC.

(*b*) The executive council which governs the national standards body should be established in such a way as to ensure representation of all relevant interests—government, industry, professional institutions, consumer bodies, research organizations.

(*c*) The preparation of standards will be carried out by specialist committees and these should be required to be representative of all the main interests directly concerned in the specific field of work referred to them.

(*d*) The standards organization should either possess or have access to testing and research facilities in order that queries and difficulties which may arise in the work of the technical committees may be resolved.

(*e*) It should be authorized to represent the country in those international organizations concerned with the preparation of standards, whether required for voluntary use or for purposes of legislation.

Because of the variation in organization which has been described, it is difficult to suggest a " standard set-up " for a national standards body. Political, economic and environmental conditions vary greatly throughout the world. What is important, however, is that the national organization be constituted in such a way that it is able to play its full part in international work.

Financing a national standards body

The pattern for financing the national standards body obviously depends on the constitution of the body. If it is supported solely by government then the funds necessary are the responsibility of government. If its constitution does not include government participation it is necessary to secure financial support from industry and this usually takes the form of voluntary subscriptions which vary according to the size of the firm and the extent of its interest in the standards work. There is, however, no fixed pattern for the basis for such subscriptions. Many independent organizations also receive considerable financial support from government since all share in the benefits which result from the work on standards.

In addition most organizations have an income from the sales of standards and sooner or later from fees for such services which the organization renders in the testing of products and in the supervision of any certification schemes it may operate.

General organizational basis

Whatever the extent of the resources which can be afforded for a national standards body, it will always be the case that standards work will be successful for the economy of the country to the extent to which its work is widely understood and supported by all sectors of industry and trade. To achieve this aim it is essential that all these sectors should become involved in the work of standards and to induce the feeling of association with and responsibility for the standardization activities there should be a governing body or Council on which all the most important and influential of these interests should be represented.

Such a Council should be responsible for the conduct of the affairs of the standards body—it should develop a plan for the preparation and revision of

standards required by the industries in the country. To carry out this plan Technical Divisions should be set up for sponsoring the development of particular specified sectors of the work so that the standards are developed in knowledgeable industrial groups which include all those directly concerned as users, producers and research workers.

Technical Divisions should have considerable autonomy as regards the technical work and each should be represented on the Council so that co-ordination within the main programme will be achieved.

Technical divisions will, in turn, find it convenient to create a considerable number of specialist committees reporting to them for specified subjects. In each case effort should be made to get representation from as wide a section of the community as possible wherever there is knowledge and interest relating to research, producer or user experience.

As has been mentioned earlier, these specialist committees should be encouraged, wherever practicable, not to attempt to draft a standard *ab initio* but to base their standards on the relevant international standard or, if one does not exist, to select an existing authoritative national standard which is most suitable for their requirements and to adopt or adapt it as appropriate.

In order, therefore, to provide the Technical Committee with the tools for their work the first task is to create a full library of the leading standards of international repute properly classified and maintained. This will provide a central point of information to give knowledge and to foster interest. It will enable all concerned to learn from world experience and to profit from the standards and the codes of practice already available to them.

A step which should accordingly be taken at the earliest possible date is to establish membership with ISO and to negotiate something similar with IEC so that the relevant international standards and current reports of work in progress may be obtained. Such relationship will also enable the facilities that are established between national standards bodies to be used for acquiring on special terms copies of such national standards of other countries as may be required.

Staffing

Obviously any country setting out to form its own national standards body will need to proceed step by step, gaining experience in those fields of industry that are of first interest to the country. The technical staff with the expertise needed in handling standards work will in this way be built up slowly. There are nowadays a number of ways and means open for new technical staff to spend a period of training with national standards bodies that are recognized leaders in the standards world. Taking advantage of such opportunities not only enables the experience of others to be drawn on but it serves to create those links between national standards bodies that have resulted in work in the international field making a valuable contribution, both in world trading and also in the wider field of understanding between countries.

Company standardization

Company standards represent a very important level of standardization, in some respects the most important level of all, for it is at this level that the greatest and most immediate economies can be effected. Every company, however small or however large, should possess company standards and should have an organization for creating them and for keeping them up to date.

So far as is practicable, company standards should be prepared for everything which the company purchases on the one hand or markets on the other. These can never be static but, on the contrary, are subject to continual revision, new items being brought in as outmoded ones are phased out. It is a matter for careful judgement by the higher management of the company to decide just when these changes should be introduced in order to work out existing stocks and place orders for the new ones.

Company standards will be based on national or when possible on international standards, but with this important difference: that whereas national and international standards have inevitably to be drawn up on a broad basis, to cater for a large number of diverse industries, types, qualities, sizes and so forth, company standards should be drawn up on a very restrictive basis, only those items being included which are essential to the proper functioning of the individual company or enterprise.

For example ISO Recommendation 775 lists nineteen preferred diameters for shaft ends between 25 and 75 mm. An individual company may well be able to get on with only two or three of these. If so, the remainder should not be included in the company standard, otherwise somebody will start using them and thereby introduce a quite unnecessary degree of variety.

Similar arguments can be applied to sheet and wire thicknesses, screwed fasteners, bearings, motive units including electric motors and reduction gears and a host of other things, in fact almost everything. There are plenty of instances of companies all over the world, both large and small ones, who have been able by careful selection to reduce the number of different items held in the company stores by as much as 60% or even 80% without any detriment to the quality or volume of goods being marketed, and the economic benefits from pursuing such a policy are enormous.

Here a differentiation should be made between articles which are inherently different in size or performance and those which merely differ in style of finish or quality. A variety of styles, qualities and finishes is perfectly permissible, and can be of great assistance to the sales department, provided all are assembled from standard components and sub-assemblies.

The aim may well be to offer the widest range of styles and finishes compatible with the minimum variety in component parts.

There are certain fundamental principles to be observed about company standards, irrespective of the size of the company, as for instance the following:

1. They must be recorded in a book (and not just left to memory or to habit),
2. The book must be accessible to, and understood by, all relevant sections of the company.
3. The impetus to maintain and implement company standards must be derived directly from the managing director or other senior executive in close touch with him.

In the smallest companies the managing director, or senior executive, will probably keep the book himself, in manuscript, and will have it on his desk to refer to frequently when quoting or ordering or when examining production schedules or work-in-progress. When he decides on a new design or on incorporating a new component, if there is any likelihood of it being used subsequently in other designs or assemblies, he should see that a brief description and essential details are added into the standards book. Periodically also he should peruse the book with a view to eliminating unnecessary variety that will have grown up by additions to the book. If all other persons in a position of authority in the firm, i.e. those in charge of design, production, store-keeping, ordering of raw materials and bought components, have access to the book and use it regularly, a great deal of management time will be saved in every department and much costly duplication of human effort and of materials will be saved.

In moderate sized firms the principles are the same but a special executive is put in charge of standards, with such staff under him as may prove necessary. He will be responsible, under the managing director to whom he should have direct access, for maintaining the standards book and for issuing copies to other departments as may be necessary. If possible he should assume responsibility for ensuring that all copies are kept up to date and should personally initial and date all amendments.

A standards book prepared and maintained in this manner is one of the most powerful tools available to a managing director for exercising his jurisdiction throughout the company.

The book is also of the utmost value in rapid training of new personnel entering the firm. But it also follows that a certain degree of security may need to be exercised in ensuring that the contents of the book are not broadcast to potential competitors. Sometimes, for example, one or two copies of the book have special information added, such as prices, sources of supply, etc. and these copies are available only to those who need access to such special information.

In the very large firms, or in groups of companies, the standards department can be very large, comprising as many as 50 or 100 personnel. In such cases more formal methods will have to be adopted and the chain of authority clearly defined. Amendments and instruction sheets will be issued from time to time and the large departments or subsidiary companies who receive these instructions will themselves have to appoint a standards officer to ensure implementation within their own department.

Company standards affect every department of the organization but there must be a focus and the focus is clearly the design department where the aim should be to obtain the greatest flexibility of design and performance from the minimum number of different component parts. Before designing any new part the designer should first look both in his company standards book and elsewhere to see what already exists. Only if he finds nothing suitable there should a new part be designed and even then he should look at the materials listed in the book to see whether the new part can be designed using these rather than different ones. This is in no sense intended to inhibit design. If nothing suitable exists a new design must be prepared and when prepared should be included in the book for the benefit of future designers. This is progress.

An energetic pursuit of the policy outlined above can yield not only appreciable savings in design effort but consequential savings in other departments. There are valid grounds for stating that up to 10% of drawing office time spent on maintaining and perfecting the company standards book will result in a noticeably higher output from the drawing office as a whole. It is frequently argued that the drawing office has no time but if the company standards are maintained in good shape, much more than 10% of drawing office time will be saved on actual projects.

We have referred to the need for company standards to be based on national standards (harmonised so far as possible with international standards) but to be very much more selective, eliminating from what is available the greatest possible amount, while still leaving an adequate choice for the purpose of the particular company. It is here that the managing director must assert his authority, both in restricting the initial choice and in permitting non-standard items to be used when he is satisfied that there is nothing equally satisfactory within the permitted standards. For example, a particular machine might need a 4 kW. motor to drive it, but the standards book might only list 2, 3.5 and 5 kW. The decision as to whether to permit the introduction of a 4 kW. motor or to use a 5 kW. one, or to design down to a 3.5 kW. should not be taken lightly. Only if there are real advantages should the 4 kW. be chosen.

Most firms are divided into a number of sections or departments, which will include all or some of the following:

Design	Sales
Supply of raw materials	After-sales service
Production	Spare parts
Inspection	General stores
Despatch	

We have already dealt with designs: dealing now with the other sections, it has been emphasised elsewhere in this book that standards are a form of communication. The officer responsible for maintaining the flow of raw

materials into the firm will find the standards book most helpful and, in addition, will be able to save costs and avoid waste by having a clear understanding of what the production line will need.

Production, inspection and despatch will find company standards useful chiefly as a means of communication, both within the company and as between manufacturer and user, to describe the characteristics and possibly the performance of the object in question.

On the factory floor, it is obvious that the fewer the parts to be made the longer the runs, the less time lost in setting up special work, or in preparing new jigs and fixtures, the less time spent in training new operatives, the easier the avoidance of bottlenecks.

Many salesmen are under the mistaken impression that any form of standardization is a disadvantage to sales in that it restricts the customer's choice, but this is a fallacy. There are no more potent arguments available to a salesman than lower cost and earlier delivery. Standards, when properly applied, make a tremendous contribution to both: they make a tremendous contribution also to reliability. So the salesman should be briefed to explain to the customer the advantages of the standard article as opposed to the non-standard one in price, early delivery, reliability, after-sales service and availability of spare parts. However it is still open to the salesman to offer as much variation in style and ultimate finish as he can obtain from different assemblies of standard components.

So far as after-sales service, spare parts and stock-holding are concerned, the advantages of standards are too obvious to need enumerating here, but they are dealt with more fully in Chapter 4 under the heading of variety and cost reduction.

8

The consumer and standardization

Undoubtedly one of the principal aims of standardization is to give assurance to the purchaser that the goods which he buys are of the quality which is claimed for them and are satisfactory for the use to which they are to be put.

Manufacture, distribution and consumption form an economic trilogy. All are vitally concerned with standardization, but whereas the first two are normally well organized and have means at their disposal to ensure that due attention is paid to their interests by the standardizers, the third group, the final user, is frequently not so well placed. Situated at the end of the line and without the protection which is afforded to the others by industrial and trade organizations, the user tends to be the deprived man unable to secure a hearing at the time when the standards are being drawn up. It is only quite recently that that great body of users—the general public—have begun to assert themselves and to group themselves into consumer organizations in order that they too may be able to play their full part in standardization work. This need for grouping has also been felt outside the national level, as is shown by the foundation of several international organizations. However, despite the fact that their interest in standardization has seen a tremendous advance in the last decade, there is not as yet full agreement on the methods to be adopted by consumers to achieve their desired aims.

To appreciate the current state of affairs it is necessary, in the first instance, to trace the history of the consumer movement.

The Growth of the Consumer movement

The first indications of collective consumer interest in standards occurred in the United States where consumer research was started in the late 'twenties and a Consumer Union was formed in 1936. Other countries and notably Britain followed on and from about 1950 onwards consumer organizations of varying types sprang up in a number of countries.

The ISO began work in this field soon after its formulation and in 1949 established a Committee (ISO/TC 73) to consider consumer questions; but for its first fifteen years it concerned itself only with standardization marks, a fact which was apparent from its title " Marks indicating conformity with Standards ". This Committee was responsible for three ISO Recommendations: ISO/R 189 issued in 1961 on " Principles of operation of standards marks ", ISO/R 526 in 1966 on " The significance for consumers of standards marks ", and ISO/R 436 in 1965 on " Informative labelling ". It has also maintained up to date a comprehensive directory of national standards marks.

In 1964 the ISO Council charged ISO/TC 73 with broadening its contacts in the consumer field and a meeting was held in Paris in March 1966, at which all the main international organizations having consumer interests were represented; these including the International Co-operative Alliance, the International Centre for Quality Promotion, the Consumers Contact Committee of the European Economic Community, the International Federation of Purchasing, the European Organization for Quality Control, the International Organization on Legal Metrology, the International Organization of Consumers Unions, and the International Union of Family Organizations. During the course of this meeting, round table discussions were held with members of ISO Committees dealing with consumer products; but the subjects of these discussions—paints, textiles, refrigerators and clocks—are indicative of the small part which consumer goods played in the overall programme of ISO at that date.

Resulting from this meeting the scope of the Committee was broadened and its title was changed to " Consumer Questions ". Three sub-committees were formed, namely :

SC1 Marks indicating conformity with standards

SC2 Informative labelling and comparative tests

SC3 Documentation

It was Committee SC2 that provided the channel which consumer organizations had really been seeking and they participated enthusiastically in its work. At a meeting held in Stockholm in February 1967 a number of international organizations were represented in addition to delegations from the various national standards bodies which latter included many representatives of national consumer organizations.

A preliminary list of 14 products was selected for which test methods were required: blankets, carpets, cutlery, fruit juice, furniture, gas cookers, lawn mowers, margarine, paints, record players, slide projectors, smooth floor coverings, and tents. The characteristics regarded as important for each of these products were agreed. A model ISO recommendation intended for consumer information was drawn up which set out the characteristics to be tested and described appropriate test methods. ISO recommendations were to be used if they were available, otherwise appropriate national standards would be used provisionally. Where no published standards existed, tentative methods would be suggested.

Some of the requests for test methods were referred to existing ISO or IEC committees and in other cases new ISO technical committees were set up. In one case, cutlery, it proved impossible to establish a new technical committee

and the work was therefore referred back to ISO/TC 73, which set up a special sub-committee for the purpose.

One of the essentials which all the consumer organizations had consistently stressed to ISO was the need for speed, and it became clear that a high-level body was needed which could mobilize and direct the increasing number of technical activities being undertaken on behalf of consumers within the framework of ISO and IEC. Representations were therefore made to the Councils of both bodies, as a result of which the International Steering Committee on Consumer Affairs (ISCA) was set up with the status of an advisory committee to the Councils of both ISO and IEC. There were three representatives each from these two bodies and four from international organizations concerned with consumer questions: the International Organization of Consumers Unions, the International Centre for Quality Promotion, the International Labelling Centre and International Federation of Purchasing.

ISCA held its first meeting in Geneva in 1968. It has added further requests for test methods and received reports on the progress of work in hand.

Consequent on this new development ISO/TC 73 decided to disband its three sub-committees and handle the work on standards marks itself. New proposals relating to test methods would be forwarded to ISCA and material collected by the Documentation Sub-Committee would be forwarded to the new ISO Information Centre.

Meanwhile, in parallel with all these activities the European Productivity Agency began to take a hand, sponsoring two meetings in 1957 and 1960, to which consumer associations of many countries were invited to send representatives. Thirteen did so.

The main topic discussed in EPA was how to inform consumers of the quality of products offered on the market by means of Comparative testing, Quality labelling and Informative labelling. There were fierce arguments between the advocates of comparative testing and those of informative labelling but there was general agreement that many so-called quality seals were suspect and required government investigation. There were also bitter disputes between those who believed in co-operation between consumers and producers and those who maintained that consumer organizations must be entirely free of manufacturing or governmental pressures.

Agreement was reached, however, on a motion that " as regards testing methods utilization should be made as far as possible of existing standards and of the experience possessed by ISO and by national standards bodies ".

International Organization of Consumers Unions (IOCU)

Meanwhile IOCU had been founded in March 1960 by five independent consumer organizations, primarily engaged in comparative testing. These were: Consumers' Union of US Inc, Consumers' Association (UK), Australian Consumers' Association, Netherlands Consumers' Union, and Association of Consumers (Belgium). Biennial conferences took place, successively in Belgium, Norway, Israel, USA, and Austria. Originally set up as a clearing house for test methods, IOCU has developed over the years into an international forum for all kinds of consumer problems. It has consultative status with the Economic and Social Council of the United Nations and is particularly interested in aspects of the work of UNESCO, UNICEF, FAO and UNIDO. It participates in the ISO and IEC committees concerned with consumer goods. By 1971 IOCU had 56 member organizations in 32 countries. It now has a research committee concerned with comparative testing of goods and services, standardization, labelling, and legislation; an education committee dealing with materials and methods of consumer education; and an aid committee which encourages awareness of consumer interests in developing countries.

ISO and IEC both sent observers to the 1964 IOCU conference and tabled papers describing their work, but they were clearly regarded with suspicion by many of the consumer organizations present. However, at the 1966 conference an independent research paper on international standardization brought greater understanding, and participation by IOCU representatives in the meeting of ISO/TC 73 in the same year marked the beginning of increasingly close collaboration between consumers and standardizers.

The growth of certification

The whole concept of certification seems at the present time to give rise to fierce debate and discordant views. Much of the debate stems from confusion as to the correct interpretation to be placed on each of the many terms used in this whole area of activity to describe different conceptions. There are a bewildering number of such terms viz: Certification, Quality assurance, Mark of conformity, Informative labelling, Size marking, Comparative testing. Some of these terms have already been used earlier in this chapter and an attempt will now be made to explain what they all mean: but it must be stated at the outset that there are no definitions as yet which have received world-wide approval.

The very phrase " Quality assurance " is a case in point. An attempt was made to define the term in Chapter 2, but one of the difficulties is—assurance by whom? and to whom? Quality assurance can be, and constantly is, provided on the unilateral authority of the manufacturer himself and can be entirely unsupported by any independent evidence. It is sometimes taken to mean that the necessary steps have been taken at all stages of manufacture to provide reasonable assurance that the final product is of the quality and reliability that is claimed for it—a sort of glorified quality control. But sometimes the term is intended to convey an assurance to the customer that he is getting what he thinks he is getting. This latter use of the term (bordering on informative labelling) implies not so much a guarantee of quality as one of fitness for purpose.

To illustrate the above points, consider a motorist filling his motor-car at the petrol pump. If he chooses a well-known brand of petrol, the reputation of the oil company is such that he has confidence that proper steps will have been

taken by the oil company at all stages, in the refinery and during bulk delivery to the pump, to ensure that the motor spirit delivered to the pump does comply in all respects with the appropriate specifications. This is one aspect of quality assurance but it gives no assurance to the motorist that the petrol is suitable for his particular car. The latter calls for quite a different assurance, and one which must be given not by the oil company but by the manufacturer of the motor-car.

One clear distinction which can safely be made between certification and quality assurance is this: that whereas quality assurance does not necessarily imply audit by an independent third party, certification quite definitely does.

One of the best definitions of Certification available at the present time is: Assurance by or under the supervision of a competent and independent organization, that goods are consistently in conformity with a specification.

Where such an assurance can be given it is becoming customary for the competent authority to grant a licence for a " Mark of conformity ". This and some of the other procedures evolved for the protection of customers will now be described.

Mark of conformity (Certification Mark)

A mark backed by a full-scale third party certification scheme ensuring conformity to standards and involving continuing audit of the production process by type testing; by random sampling from the market; by informative labelling and related schemes; or by various combinations of these.

The following is a typical scheme.

A National Standard is prepared for a certain class of goods that specifies certain standards of quality which must be attained in order that the goods may comply with the Standard. Methods of test must be described in the standard, and also the test apparatus, in order that it may be possible to determine whether or not any particular article complies with the standard.

An individual manufacturing firm can then apply to the National standards body for permission to place the Certification Mark on its products.

Before such permission is granted it is usual to investigate the manufacturing resources of the firm and its methods of quality control and to confirm that the firm has installed the necessary test equipment to enable the tests described in the standard to be carried out.

If all the above conditions are satisfactory and an independent test of the product is also satisfactory, then a licence is granted to the individual firm permitting it to place the Certification Mark on its products. This is tantamount to giving an assurance to the purchasing public to the effect that those articles which bear the mark are being made in accordance with all the terms and conditions of the relevant National Standard. If possible the number of the Standard in addition to the mark is recorded on the goods.

It is the responsibility of the manufacturer to ensure that the goods bearing the mark do actually comply with the Standard.

It is the responsibility of the National Standards Organization to prepare the Standard in the first instance, and to maintain it and if necessary amend it from time to time, and to take steps to ensure that the mark is not being abused.

These latter steps will include continuing audit by (1) periodic unexpected visits to the factory to examine the methods of manufacture and the records of routine testing : (2) the continuing testing throughout the life of the licence, by an independent laboratory or test house, of an appropriate number of samples the results of which are compared with the manufacturer's own test records (3) occasional purchase of goods on the open market for further check testing. This may be useful but is no substitute for continuing audit under (2) above. If conditions at the factory fall below the desired standard then the licence to apply the mark is withdrawn until such time as those conditions have improved.

If the check testing from purchases on the open market reveal defects it is then necessary to ascertain whether the defects occurred in manufacture or after the goods left the factory. In any case the cause of the defect must be ascertained and appropriate action taken to prevent a recurrence.

This is the basic scheme as applied in those countries which have a mark Certification scheme in operation. Minor variations can be made to suit local conditions.

The conditions which *must* be fulfilled before the scheme can operate for any given class of goods are therefore:

1. There must be a Standard for the particular goods.
2. Methods of test must be devised and stated in the standard.
3. The manufacturer must possess, or have adequate access to, suitable test equipment.
4. Routine testing must be maintained and there must be a continuing audit of the factory and test results by an independent authority. Occasional check testing by purchase on the open market is an added safeguard.
5. The law should be prepared to intervene and administer justice in cases of serious abuse of the mark.

Unless all these conditions are fulfilled there is a serious risk that goods of inferior quality will appear on the market bearing the Certification Mark, the public will lose confidence in the mark and more harm than good will be done.

Many countries now operate a scheme broadly on these lines, and a few of the national marks are shown in Fig. 9.

Consumers seem generally agreed that a properly policed certification mark of conformity scheme is a useful assurance of the safety of a product, but there are divergent views as to whether or not a mark denoting a specified level of attainment is useful for other properties of a product since different levels may be desired for different purposes.

Fig. 9.

Individual shoppers, unlike industrial purchasers, rarely have any technical knowledge of the goods they are buying. It is therefore important that certification marks on consumer goods should either be complete fitness-for-purpose marks, or should set out clearly the particular characteristics covered.

Informative labelling

Used in its general meaning, informative labelling can cover many items of information useful to prospective purchasers of a product, including size, materials of which made, method of construction, performance characteristics, special properties such as shrink-resistance of textiles or non-stick finish on cooking utensils, instructions for use, warnings of possible hazards, advice on care and maintenance, as well as the model number and maker's name and address. But " Informative labelling " has come to be used as the term to describe the type of labelling originally devised in Sweden in the VDN system.

In principle the labels describe a product in a standard form and give gradings, based on specified test methods, for its most important performance characteristics. The manufacturer fills in the information for his own product under licence and the labelling institute checks that it is correct by testing samples. Whether or not the continuing production thereafter maintains this standard depends on the extent of " follow-up " action for ensuring that further checking has a sound statistical basis.

For an Informative labelling scheme to be successful it is necessary for the majority of manufacturers to co-operate and for shoppers to use the labels intelligently. If only a few manufacturers use the labels, their products cannot be compared with the many other brands on the market. There is also a danger of shoppers assuming that the product must be satisfactory because it bears the name of the labelling institute and not checking the performance figures to see if it has a satisfactory grading for the property which is the most important for the use to which they intend to put the product (e.g. durability for stair carpet, or fastness to sunlight for curtains for south-facing windows).

Only a few countries have so far established Informative labelling schemes and in 1967 they formed the International labelling centre whose aims include exchanging information; drawing up specifications to guide members in the production of uniform labelling schemes; ensuring the use to the widest possible extent of identical methods of measuring the characteristics and performance of the labelled products; and studying the possibilities of achieving an international system of Informative labelling. Members of ILC are the labelling institutions in the four Scandinavian countries, the Netherlands and France.

Comparative testing

A system for comparative testing is normally operated by an independent organization financed by members' subscriptions. In return for their subscriptions, members receive information from time to time on the relative merits of articles intended for similar use but from different manufacturers. Samples of the goods are bought anonymously on the open market and are subjected to comparative test by an independent test laboratory. The results of the tests are then published in the journal of the organization.

The success of the comparative testing organizations which are financed by members' subscriptions (e.g. Consumers' Union, USA, with nearly two million members' and Consumers' Association, UK, with over half a million members) indicates that many shoppers are prepared to pay for reports on consumer goods and services prepared for consumers by consumers. With a readership many times the number of subscribers, these reports can have a significant effect on sales. The validity of the reports depends in large measure on the test methods used. It is therefore in the interests of manufacturers of consumer goods to collaborate with a sense of urgency in preparing national and international specifications and performance tests, which are suitable for use by comparative testing organizations.

A system operating on these lines has its value but it suffers from three defects;

1. Comparative testing does undoubtedly affect sales. Ideally *all* similar-use goods available on the market should be subjected to test and report. This is frequently impracticable and manufacturers whose goods are not considered have a genuine grievance in that the general public will tend to consider them as of less importance than those which are tested.
2. Dependent as it is for its very existence on expanding its membership, there is a strong incentive for the organization to give emphasis to defects in poor quality goods rather than the reverse.
3. It is inevitable that single samples, or a small number of samples, can give misleading results not representative of general production. The testing of one sample of a product, in fact, gives reliable information only on that single item. The statistical sampling referred to in Chapter 9 would be far too expensive: and so moves to give greater validity to comparative test results are unlikely in the near future.

The future

A conclusion which emerges clearly from the earlier paragraphs of this chapter is that there is plenty of scope for weaving closer relationships between standardizers and consumers. There are fundamental questions which still need solutions in the making of standards which have a direct interest for the consumer. There is the first question of how standards bodies can secure the resources to include a greater programme of standards making work which is of consumer interest? Should it be the role of Governments to provide these extra resources? And if they are provided what is the right forum for setting priorities? Given that all Governments are now being urged to legislate by the principle of " reference to standards " there would seem to be a need for closer and more formal relationships between consumer organizations and the standards bodies, so that, on the one hand the consensus procedures do fully take into account consumers' own views despite the difficulties of consumer representation; and on the other that a programme of priorities for standards to be used by the legislators for the safety or health or protection of the consumer can be worked out, country by country, or (as for example in western Europe) on a regional basis, or in ISO and IEC themselves.

There seems, as yet, to be no marrying of the real consumer need in the various systems of marking and labelling described. The certification of conformity to standards ensures that continuing production meets the standards; but that must mean little to the consumer, who does not know the characteristics with which the standard is concerned. Though there is as yet no readily available research in documented form into what the Mark means to the average consumer, it is generally held to be taken to mean that the product is good value for money, reliable, and better quality than unmarked goods. It may, if that is what the standard is about, only be safe, and neither durable nor reliable as well. So not enough information is given to the private consumer by certification of conformity to standards. The comparative testing, and informative labelling schemes, do give the consumer information but do not seem generally to carry any assurance that month in, month out, the regular production of the tested model will behave like the one, or the few, tested. Somewhere these concepts must meet. For the standards bodies the first question is the setting of the standards, and methods of test, and the like, which must form the base of any marking operation. But in the actual marking area itself, the concept of combining information, with assurance of conformity to standard, seems to suggest that the best route of advance for standards organizations which have built up much expertise in the whole business of marking in conformity to standards, is that of informative certification marking. In brief this involves incorporating with the " mark of conformity " information on the main characteristics included in the standard, conformity to which is being ensured. These can include safety, durability, reliability, fastness of materials to light and the like.

Thus there are many problems still to be resolved and the best machinery has yet to be devised. However, this whole field of work is under urgent consideration by the ISO at the present time and a special committee (code name CERTICO) has been established for the purpose under the direct authority of the Council of ISO. This Committee is charged with the task of studying all these very intricate matters and with developing procedures which, in the long run, will not only give better information to the consumer but will also give him greater confidence that the goods which he is buying are reliable and satisfactory for his needs.

9

The control of quality

We have discussed in earlier chapters the meaning of Quality and the importance of ensuring that the goods as placed on the market are strictly in accordance with the specification. This chapter is devoted to a brief study of the methods available to the manufacturer for ensuring conformity to specification.

The ability to control quality by statistical methods has long been recognized but it is really only within the past fifteen years or so that the significance of developing specifications on a statistical basis has been fully appreciated and it is encouraging to note that many of the more recent product standards, published at both national and international levels, do now define the quality of the product in terms of a statistical approach which lends itself to incorporation in quality control procedures in the manufacture of the product.

Quality assurance relies on control exercised in the design and production processes and if this control is adequate the achievement of the quality defined in the specification is ensured: and the procedures associated with the certification of a product are simplified, remembering always that achievement of the specification must be seen to occur not only in the one-off purchase, but in the *continuing* production of the material, components or assembled product.

An ideal situation, seldom achieved in practice, arises when the control of quality in the manufacturing process can be relied upon to monitor processing so effectively that all production conforms to the requirements stated in the standard. In this ideal situation little additional check testing or inspection will be needed.

Frequently, however, a standard is drawn up in such a way that there is acceptance of a certain risk that a small number of defectives or defective material may be present in a consignment. It may be sufficient for instance to specify that not more than 1% of defectives or defective material shall be present. This makes the cost of the goods very much less than would be the case if the specification were written so as to provide for 100% compliance. Sometimes also this acceptance of a small proportion of defectives can be useful as an alternative to allowing wider manufacturing tolerances for the product.

It should, however, be recognized that because samples cannot always be representative of the whole batch or consignment, elements of risk are involved both for the supplier and the purchaser. Sometimes a good batch will be rejected by the purchaser because the sample inspected or tested has not been representative and an adverse result has been achieved. This is the supplier's risk. On the other hand, it is also possible for an inferior batch to pass inspection (based on sample data) and this is the purchaser's risk.

These risks cannot be completely eliminated although they can be accurately assessed by the use of statistical techniques.

According to the level of quality required, the standard will probably need to indicate the sampling procedure to be adopted by reference to a standard book of statistical tables. These are already available in many countries and the publication of ISO standard tables is unlikely to be long delayed.

The proportion of defectives which can be accepted varies tremendously with the particular product. At one end of the scale, where safety is of paramount importance, as in the production of aircraft, the failure of a critical component can lead to disaster and a 100% inspection of certain items is essential—although owing to human error even this cannot guarantee 100% certainty: but with the adoption of a suitable factor of safety—that is testing at a higher level of strength or endurance than will subsequently be demanded of the product in service—a virtually complete guarantee against failure in service can be achieved.

At the other end of the scale, let us consider a packet of seeds. It will be assumed that each packet supposedly contains 100 fertile seeds. The quantity will almost certainly be determined by weight and the actual number of seeds in an individual packet may well vary by $\pm 5\%$. The fertility will be determined by testing small samples drawn at random from a large bulk supply of seeds. Samples will vary giving figures for fertility between, say, 80% and 90%. The purpose of the specification is to ensure reasonable " good measure " at reasonable inspection cost. If the process control is set to give only an average of 100 seeds per packet, the customers might only get about 70 or 75 good seeds in an exceptional case. But if the process control is set to give an average of say 110 seeds per packet, then most customers should get reasonably good measure. This example illustrates how necessary it is for the standard to be written with full consideration as to the intended method for process control.

In between these two extreme examples there are many thousands of cases where the desirable degree of quality assurance must be measured against the cost of inspection and testing: but what is common to all cases is the need for the manufacturer to take all reasonable steps to comply with the specification and for the specification to indicate what level of defectives, if any, is acceptable.

In applying statistical concepts in standards, most authorities limit consideration to one or other of two main sampling inspection schemes. These are (1) Inspection by attributes and (2) Inspection by variables. Many detailed treatises have been written on both but for the benefit of the reader who is not familiar with the meaning of these terms a brief description of each is given in the pages which follow.

1. **Inspection by attributes.** Wherein certain characteristics are assessed and classified as conforming or not conforming to specified requirements, e.g. in gauging go or not go: defective or non-defective; satisfactory or unsatisfactory which may be only a visual examination or simple check of a certain qualitative characteristic (attribute).

Each product inspected is considered to have the attribute of " acceptability " or that of " defectiveness ". There is no measurement of degree of defectiveness, whereas in the alternative system of inspection by variables degree is taken into account.

Generally speaking this system is the most used in industry since it is simpler than inspection by variables and can be performed by relatively unskilled labour, for example with semi-automatic gauging processes. The procedure can best be illustrated diagramatically by use of operating characteristic curves which show in terms of a measure of probability what any particular sampling plan can be expected to do in regard to acceptance or rejection of batches of products.

If we had 100% inspection and could ensure 100% integrity of both inspection staff and inspection equipment then the ideal but unattainable operating characteristic curve would be as shown in Fig. 10. This would give (ideally) absolute discrimination at the percent defective level, which has been assumed as 1.5% in this case. It can be seen that for qualities with a percent defective less than 1.5% there is a region of acceptance and in the opposite case a region of rejection.

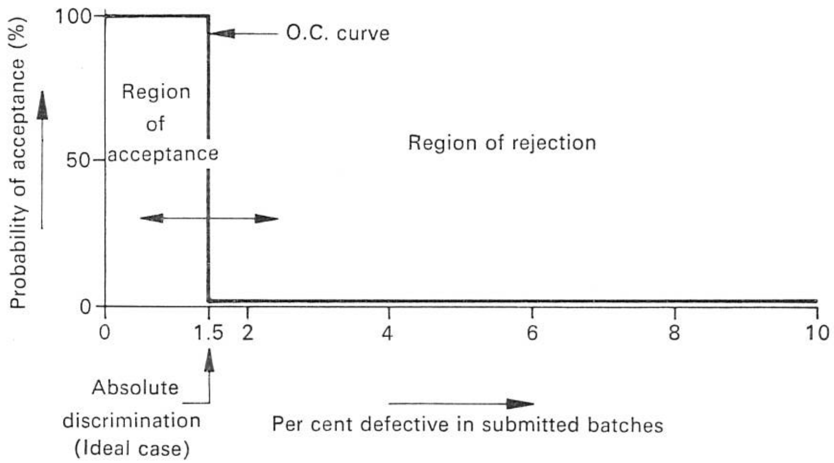

FIG. 10. **Ideal O.C. Curve 100% Inspection**

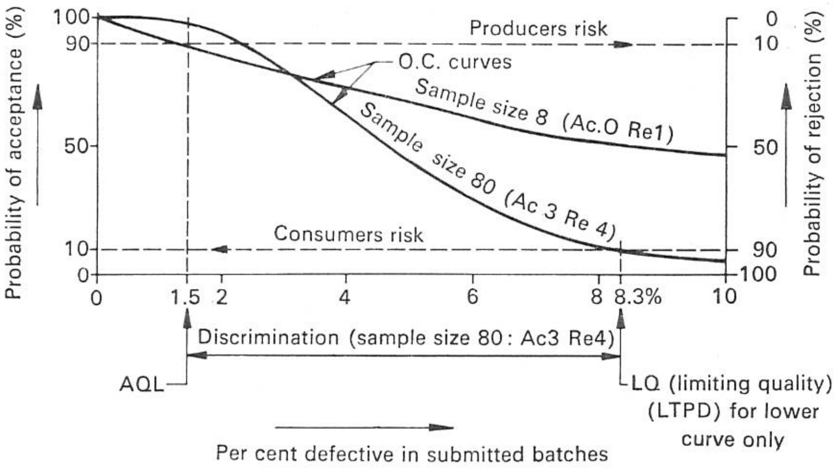

FIG. 11. **Typical O.C. Curves Illustrating the Effect of Sampling**

Once we introduce a method of sampling into the inspection system we lose the power of absolute discrimination shown in Fig. 10 and, depending upon the sample size and acceptance and rejection numbers for particular sampling plans, the penalty we pay for not inspecting every item is a discrimination dependent upon the slope of the operating characteristic curve. The form of this curve depends upon the choice of four quantities.

(i) What is known as the Acceptable Quality Level (AQL), or the proportion (percentage) of effective units in a batch which is regarded as desirable by the consumer; its complement is the proportion (percentage) of defectives which he is willing to tolerate. In Fig. 11 the AQL is defined in terms of 1.5% defectives.

(ii) The number of items to be tested in a sample (n).

(iii) The Acceptance number (Ac).

(iv) The Rejection number (Re).

In Fig. 11 operating curves are shown for:

(a) a sample of n = 8, with Ac = 0, Re = 1

(b) a sample of n = 80, with Ac = 3, Re = 4

In the first case a batch is accepted only if it contains no defectives (Ac = 0); in the second case if it contains no more than three (Ac = 3). For practical purposes it is usual only to show that portion of the curves as lies between the AQL and the Limiting quality (LQ), where the consumer's risk of acceptance has fallen, say, to 10%.

For single sampling procedures, as illustrated in Fig. 11 the Ac is always one unit less than the Re, so that a clear decision is always reached. In double or multiple sampling procedures, referred to briefly below, there will be an interval between these two numbers, and if the number of defectives falls within this interval, further sampling is required.

The AQL system of sampling was primarily developed for the examination of a *continuing* series of batches; and as a safeguard against a producer consistently producing articles just below the AQL defective level, switching rules are incorporated which introduce more severe conditions of sampling should a certain number of batches be rejected. Conversely, should the process average be such that little or no batches are rejected switching rules exist for a less severe form of sampling with consequent reduction in sampling inspection costs.

Where examination of a continuing series of batches is not the case (i.e. isolated batch sampling) then more attention should be paid to the value of the Limiting quality (LQ) which is usually taken at the intercept with the consumers' 10% risk line giving a 90% probability of rejection. In this particular case it can be seen that for a sample size of 80 with an acceptance number of three and a rejection number of four the consumer has a 10% probability of receiving a batch containing 8.3% defectives if a manufacturer is producing products consistently at the specified AQ level of 1.5%.

This may not be very satisfactory, but matters would be far worse from the consumer's point of view if a sample of only 8 items were tested, and Re has its minimum value of 1. Fig. 11 shows that there is then a 50: 50 chance of a batch containing 9% defectives being passed should this be presented for test: although a continuous supply of batches of this quality would soon be picked up. For most practical cases (sample sizes less than 0.2 of the batch sizes) the size of the batch can be ignored in developing the operating characteristic curve for a sampling plan. In other words, providing the sample size and acceptance and rejection numbers are stated, an operating characteristic curve can be prepared illustrating the producer's and consumer's risks as shown in Fig. 11. The reason why most sampling schemes relate sample sizes to batch size is the requirement that the sample should be representative of the batch (i.e. random selection) and this becomes increasingly more difficult as the batch size increases as does the penalty of incorrectly rejecting a good batch due perhaps to a decision based on insufficient sample data.

The effect of sampling is thus a classic compromise where producer's and consumer's risks need to be delicately balanced. To reduce these risks appreciably for both parties the sample sizes need to be adequate (usually double or treble figures) whereas for economic reasons the usual desire is to specify the sampling sizes in single or double figures. This can lead from the single sampling discussed hitherto (where the decision to accept or reject the batch is based on the data from a single sample of x items) to double, multiple, sequential or continuous sampling schemes; whereby, if the number of defective

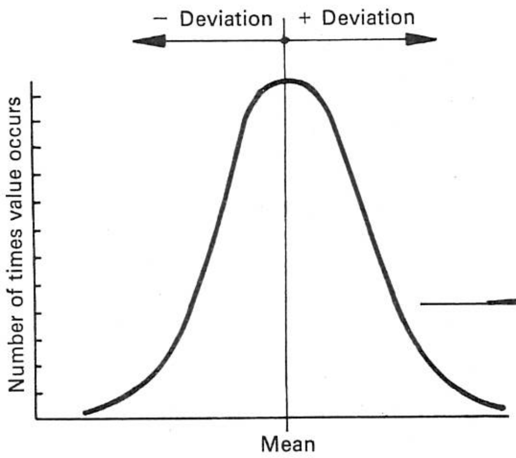

FIG. 12a. **The Normal Distribution Curve**

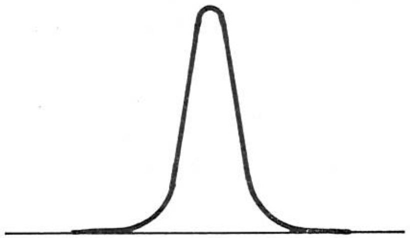

FIG. 12b. **Curve with Narrow Spread and Small σ**

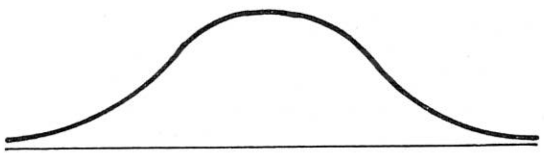

FIG. 12c. **Curve with Wide Spread and Large σ**

items falls between the " first-trial " acceptance and rejection numbers, decisions may be delayed pending the accumulation of additional data from further samples and retrospective re-analysis. The latter schemes, although in some cases theoretically more efficient than single sampling, have tended to be little used owing to the practical and administrative problems involved. It is to be hoped that in the future as knowledge of these schemes increases and apparatus becomes more readily available for their semi-automatic use they will be increasingly utilized.

2. **Inspection by variables.** Wherein certain characteristics are evaluated with respect to a numerical (quantitative) scale and are expressed as points along this scale. The distribution of these points as established by measures of their central tendency and dispersion can be mathematically related to specified requirements to determine the degree of conformance of these characteristics.

This type of sampling is based on the assumption that the data or measurements follow the Normal or Gaussian distribution law illustrated in Figs. 12 a, b, c. In such a distribution small deviations occur more frequently than large. There is no absolute limit to the value of a deviation, but a finite limit can be chosen which corresponds to a specific chance of the value being exceeded. Such a limit is expressed in terms of the *standard deviation*—a function which measures the *spread* of the curve (i.e. the range over which values are distributed) derived from a particular sample. The symbol for the standard deviation is the Greek letter σ (sigma).

This law is the basis of all classical statistics and in Fig. 13, where the curve is defined in terms of the mean and standard deviation σ, the symmetrical dispersion about mean is such that over 99% of the area is contained within the limits $\pm 3\sigma$. In the absence of proof to the contrary this probability distribution is assumed for most practical cases where variables sampling is adopted.

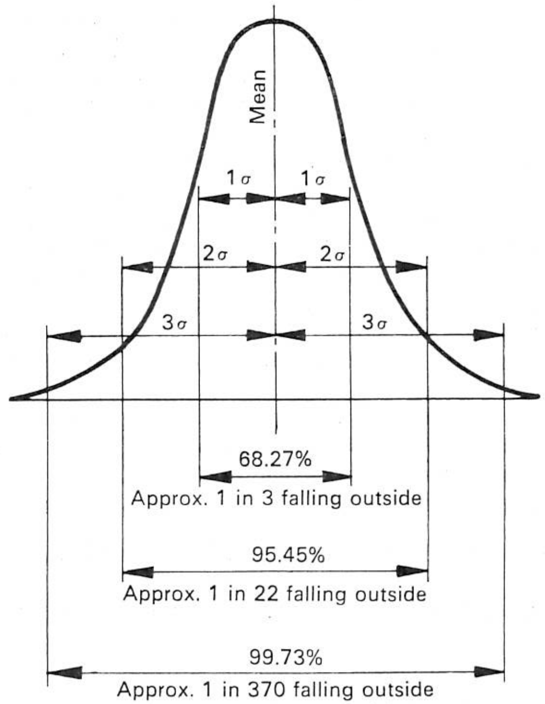

FIG. 13. **Limits Corresponding to 1, 2 and 3 Standard Deviations**

One simplified method of setting specification limits from variables sampling data which has proved useful in some industries is to set the specification limits at $\pm 4\sigma$ initially. This method is carried out in anticipation of there being slight estimation errors in the mean and standard deviation originally calculated from the first series of samples.

Where disputes arise concerning the normality of the distribution there are several types of tests for assessing the validity of this assumption. Documentation on this subject is currently being developed within ISO/TC 69.*

Generally speaking, if sampling by variables can be undertaken the sampling size may be reduced relative to that used for attribute sampling since in the former case more information is derived from the sample data by taking account of actual measurements rather than the simple pass/fail decision taken in attribute sampling. Of course this has its drawbacks since one of the reasons put forward for the restricted use of this type of sampling is that it requires more skilled labour and laboratory type conditions.

This type of sampling is particularly useful in developing specification limits for products and also for setting control chart limits to ascertain whether a process is in or out of control. Much of the standard works on the theory of statistics are based on the assumption of normality and many useful volumes of tables are available which enable the standard deviation to be estimated by applying a factor to the range (of values found) which is usually dependent upon the number of observations taken.

It is a primary need that the sampling be random so that it can be regarded as representative of the body of items from which it is drawn. Tables of random numbers are available to help in ensuring random selection and the more observations that are made the closer the pattern resembles that predicted by theory. Consequently if a sample contains a few items only its relationship to the population is uncertain. This uncertainty means that the properties of the population can be summarized only as broad limiting values and can be predicted as being likely to lie within certain limits around the calculated mean and standard deviation. As the sample size increases so uncertainty as to the positions for the true value of the mean and standard deviation diminishes. Confidence limits for these unknowns (usually 95%) can be developed from this classical theory and of particular interest in standardization are the standard errors of the parameters:

Standard error of the mean $= \frac{\sigma}{\sqrt{n}}$ (true for all distributions).

Standard error of the standard deviation $= \frac{\sigma}{\sqrt{2n}}$ (true for the normal distribution).

* Ref. ISO/DIS 2602 Statistical interpretation of test results—estimation of the mean confidence interval.
ISO/DIS 2854 Statistical treatment of data—problems of estimation and tests relating to means and variances.

It will be seen from the above that the reliability of the estimate of the mean value varies directly as the standard deviation and inversely as the square root of the sample size. Thus the error in estimation of the mean diminishes as the sample size increases, a factor which is made use of in certain specifications.

A great deal of the potential advantage of applying statistical concepts in standards is lost if they are concentrated on sampling alone since statistical principles can also be applied to:

(1) the precision of methods of testing goods:

(2) the setting of limits of performance and testing in specifications, including the relation of these limits to test results obtained in the operation of process quality control:

(3) the reliability of goods during their expected operational life.

(1) *Precision of methods of testing*

As was stated previously, the specification of the method of test is essential and this should also be allied with setting the degree of precision of the test method. This helps to minimize disputes between manufacturer and purchaser. For each method it is also advisable to establish the limits of reproducibility and repeatability so that the limiting values of properties specified in the standard may be interpreted in a rational manner. The assignment of values for reproducibility and repeatability are best determined on the basis of test programmes in which samples of the product are distributed to different laboratories and ' within ' and ' between ' laboratory test results are accumulated and then analysed statistically. This subject is currently under consideration by ISO/TC 69 ' Applications of statistical methods '.

(2) *Specification of values of properties and of performance*

Statistically-based methods of sampling and testing are techniques aimed at the realistic interpretation of the limiting values of those properties of a product which are defined in a specification. The full advantage of these more refined approaches in sampling and testing will be gained only if the specification of properties has itself been drawn up in terms of statistical inference. It is at this level that the desired association with quality control during production may be achieved.

As an example of this approach there are many cases where the standard specifies not only the minimum value required for a sample taken from a single batch tested, but also the limiting value to be expected from a large number of batches defined in the following way.

$$\text{Limiting value} = \bar{X} - \frac{\bar{X} - L}{\sqrt{n}}$$

where n is the number of batches

L is the limiting value required for a single batch

and $\bar{X}$ is the limiting value required from a very large number of batches ($n \longrightarrow \infty$)

As these values will have been derived from good production techniques the standard provides guide lines on which a manufacturer can base his quality control, or an independent certification authority can establish requirements for the records to be maintained by a manufacturer whose product is being supervised.

For the purchaser, standards defined in this way give an indication not only of minimum quality to be expected from individual consignment but also of the average quality that is to be maintained in a sequence of consignments.

(3) *Reliability*

All specifications that define fitness for purpose actually give some assurance that the reliability of the product will be adequate; the term ' reliability ' being used in a qualitative sense. In recent years, however, the need to define reliability in quantified terms has become evident. This is especially true, for example, in the use of sophisticated electronic equipment and products containing a vast number of individual components. A broad definition of reliability is that it represents the probability that the product will function satisfactorily, when required, for the period required, in the specified operational and environmental conditions. Reliability assessment for this purpose requires a forecasting activity based on component failure information, considerations of equipment design and operation and the use of statistics. Although the compilation of data such as a mean time between successive failures of a component in an assembly is often an arduous and complex task, the forecasting of reliability is a feature which can be expected to be included on an increasing scale in specifications.

Points to be observed when drafting standards

From an economic standpoint specification levels should be agreed that are related to quality control during production so that the cost of testing a product for conformity with the specification will be as low as possible. This can be done only if the statistical factors that affect quality control have been recognized in preparing the standard. These include clarity of drafting and the specifying of appropriate procedures for inspection, sampling and testing.

Clarity in drafting

If the level of quality specified in a standard is to be safeguarded, it is important that the characteristics included in the standard by which the quality is achieved shall be clearly and precisely specified. It is, therefore, implicit that not only are the technical requirements known and appreciated but also that their values can be assessed with an accuracy that will ensure an acceptable level of quality. Subjective requirements and characteristics which cannot be so assessed ought not to be specified. It is also desirable that the range of characteristics which are included in the standard should be kept to a minimum and should essentially be those needed for controlling quality: although in addition it may be desirable to include requirements and characteristics that relate to the functional efficiency of the product. When specifying the values of the characteristics the permitted variation or deviation should also be indicated.

Inspection, sampling and testing

In order to safeguard quality the standard must not only clearly define the required quality and the methods of test by which the specified characteristics defining quality are determined, but it will frequently be desirable also to specify the procedure to be adopted for the inspection and sampling appropriate to the degree of testing necessary to ensure that in the process of manufacture the specified level of quality has been maintained. The degree to which this is so will depend on three main factors; the type of product, the process of manufacture and the proportion of defectives, if any, which can be permitted.

In describing the method of test by which each characteristic is to be determined, the accuracy of the testing equipment should be considered and an indication should be given of the reproducibility and repeatability of the method.

Summary

This ' new look ' at standards which aims at ensuring that they portray more reality and lend themselves better to interpretation in terms of quality control data—with the manufacturer's own in-process control given proper recognition—is well worth developing.

In Chapter 8 we have discussed the growing interest at national and international levels in quality assurance schemes, one purpose of which is to provide certification of compliance of a product with the specification relating to it. Given reliable certification, the purchaser has no need to retest products. He is thus relieved of expense and delays in delivery. But if certification is to be established on a sound economic basis, it should be related to the effectiveness of quality control at the point of production. This provides an added reason for establishing specifications that are drawn up on a statistical basis and thus allow the producer to link the statistical requirements with in-process quality control. Unfortunately there are still too few national standards organizations that have published statistical control standards which provide sufficient guidance to enable specifications to be drafted on the basis of recognizing variations in product populations.

It is hoped that ISO/TC 69 will provide much of this guidance in the near future. This Committee is currently developing proposals covering the following fields of work:

(1) Statistical terminology and symbols (ISO/R 645, ISO/R 1786, ISO/DIS 2823)

(2) Vocabulary for reliability

(3) Statistical treatment of data (ISO/DIS 2602)

(4) Guidance on the use of sampling procedures for inspection by attributes (ISO/DIS 2859)

(5) Precision of test methods.

All this work is of prime importance, with implications that are not confined to quality control alone but are spread across the whole field of standardization.

10

Future trends

In earlier chapters we have traced the growth of the standards movement and attempted to analyse present-day aims and procedures. We have seen that the very concept of standardization, as it is understood in the industrial world of today, is a development of the twentieth century while international standards, and the cooperative effort amongst nations which these involve, are largely a development of the past twenty years: indeed the really big surge forward has taken place within the past ten years. Many persons are now asking: "Where is all this international standardization leading?" It is dangerous to prophesy but certain trends are sufficiently obvious that they may be mentioned with some confidence.

Precedence accorded to international work

The first of these trends is the shifting of the main forum for technical discussion from the committee of the national standards body to that of the international. We have seen that proper standardization is achieved only by a consensus of expert opinion of users as well as producers including both commercial and general interests. It is a highly complex, specialized and time-consuming activity to bring together all the interests involved and patiently to negotiate a common solution which is technically right. To do this twice over, at both national and international levels, is wasteful of effort and should be avoided as much as possible. More and more we want to see national standards take the form of publications of international solutions.

It is true that reaching international agreement on refined technical detail can be a hard task; and where expertise in the traditionally industrialized countries has become entrenched in different national methods, the effort of persuasion to abandon traditional tenets for alignment and progress can be particularly difficult. Nevertheless the will to do this is becoming more and more apparent. It is noteworthy that the newer technologies—for example, data processing, electronics and plastics, which are not so hampered by the past—generally achieve international standards agreements at a much faster pace. Nations should judge their participation in international standardization with this in mind, remembering that work done *now* may avoid the growth of unnecessary technical barriers to trade in the future.

International standards, later to be incorporated into individual national standards, are now seen as vital aids to technical cooperation, making an important contribution to the expansion of international trade. But effective technical communication and a true spirit of international cooperation are prerequisites of their very formulation. It is the ISO and IEC which are able to provide a forum for the necessary exchange of technical knowledge on a worldwide scale. With the availability of data from such a wide circle of interests, international agreements arrived at in such a forum can incorporate the latest techniques wherever these are developed. This promotion of what might be termed a " free trade in ideas " can of itself provide a stimulus to developments in technology, which may be absent from exchanges on a purely national scale.

It is a great benefit in time, effort and usefulness to go straight to an international solution whenever this can be done and there are many encouraging signs that this is the modern trend. It must of course be accepted that not every subject in standardization is suitable for international treatment. There are far too many differences of climate, racial custom and environment to permit one single international solution to be applicable in all circumstances. For this reason we must expect to see regional or national agreements sometimes take precedence over full international accord. This is a tendency which will be the more apparent in the case of standards that are primarily concerned with safety, health and environment: but it will occur with some product standards also, for example in respect of materials appropriate to different extremes of climate. Nevertheless these tend to be the exceptions rather than the rule and in a majority of cases we may hope to see new standards worked out in the international forum and local standards adapted from these.

This accentuates the urgency of pressing forward with international work. If the international standards are not ready in time, who can blame the individual country or individual authority from framing specifications of its own devising?

Political considerations

The next trend which deserves mention is the greater attention being paid to political considerations. Ideally the implementation of standards should be by general consent but some international agreements must have the support of legislation if they are to be effective. For example, the positioning and general specification for motor-car head and tail lamps clearly needs to be prescribed by law.

Where standards having mandatory status are different or are subject to different levels of stringency of acceptance in various countries, then what are commonly known as " technical barriers to trade " arise. Goods cannot be sold abroad if they do not conform to the technical practices and statutory requirements of the importing country. Standards provide an enormous positive benefit in giving a clearly understood, unambiguous language for commercial and technological exchanges, in providing the answers to repetitive questions thus relegating routine questions to routine, in ensuring interchangeability, in bringing new techniques into generally accepted use; but they themselves cause barriers to trade unless unified standards can be agreed internationally to enable an exporter to work to a single specification for his product over the widest possible market.

The barriers erected by technical differences are frequently caused by *lack of standards* of international repute. The increasing rate at which technology advances demands an ever-growing volume of new and up-dated standards so that the new developments of technology can be incorporated and applied quickly. So far as is known no detailed survey has ever been conducted to measure the precise effects of these barriers on the flow of trade, but it seems to be generally accepted that they are substantial. Fortunately there are encouraging signs of progress and to mention but one notable example of regional cooperation, the European Economic Community (EEC) has recently accepted in principle the policy of legislating where possible by " reference to standards " instead of attempting to promulgate separately divised technical regulations. This policy is also supported in principle by the EFTA countries.

However, standards whether national or international ought not to be applied with the force of law unless it is necessary to do so for reasons of public safety or health and environment. This is a principle which should be pressed always with great emphasis. Compulsory standards make for rigidity, voluntary standards provide the target for progress and interchange based on the optimum solution obtainable at the time. It is right and necessary that some degree of rigidity be accepted where safety or health are concerned but in the interests of innovation we should at all times press that legal regulations be confined as far as possible to the enforcement only of standards necessary for safety or health and environment. It may be observed that these are the type of standards for which technical specifications can frequently be agreed upon fairly easily.

A great advantage for governments and other legislative bodies which decide to legislate by reference to standards lies in the fact that it is very much easier to update a standard than to go through the whole procedure of revising legislation. However, this also implies that in future a relatively greater proportion of the ISO and IEC effort will need to be devoted to revision of existing standards.

It goes without saying that a policy of " reference to standards " involves full recognition of the standards from Government departments and full participation by these departments in the consensus procedures used to produce the standards.

Approvals schemes

A further problem for trade is presented even when standards are international if the procedures for " approval to standards " are different in the exporting and importing countries. In a few cases reciprocal agreements exist which enable goods to be inspected by the Approvals organization of the country of origin and certified as conforming to the requirements and regulations of the importing country. Many more such reciprocal agreements are needed; lack of them makes it more difficult for foreign than for home manufacturers to secure acceptance of their products.

All that is really needed for a reciprocal agreement to work is confidence by one country in the integrity of the Approvals organization of the other. If a certification Mark System is in existence for the goods, it makes the whole business much easier. Thus international schemes for certification and approval to standards becomes a vital corollary to international standardization.

Storage and retrieval of information

Standardizers are not the only profession who are becoming alarmed at the vast accumulation of documents which constitute the present summation of human knowledge on the subjects with which they are concerned. This is a problem facing every discipline in every walk of life—so much so that often it proves easier to re-discover the knowledge from original research rather than discover where that knowledge, which is known to exist, is hidden away. Standardization is by definition a solution to a recurring situation. The certainty that the situation will recur is what justifies the standardization. A primary object of it is to ensure that the results from work done carefully once may be available later to all who encounter a similar situation. If the results are lost, or are stored away in such a manner that they cannot easily be found when wanted, then the benefit of the standardization is lost also.

Clearly there is a task here for the ISO and already a start has been made. In 1971 an Information Centre was established in Geneva as a department of the Central Secretariat of the ISO. The ultimate intention is that the Centre will hold information on all published standards of repute and will be able to answer enquiries about them on a world-wide basis.

The consecutive processes involved in the handling of information can be summarized as:

Acquisition	Retrieval
Storage	Dissemination
Analysis	Application

Perhaps the most important of these is *acquisition.* No information centre can create good information out of bad and so, if the acquisition is imperfect, so are all the subsequent processes which follow on.

— Information is most often acquired through the purchase or exchange of literature. The ISO Central Secretariat and the Member Bodies have an arrangement for the exchange of documents and consequently several extensive collections of national and international standards already exist; one such collection is located at the ISO Information Centre in Geneva. To meet growing demands many of these collections are being expanded to include specifications, codes of practice, international agreements, registers of testing and inspecting authorities and other literature relating to standardization and the application of standards, Each national centre, while maintaining an international collection, naturally specializes in material related to its own national activities and requirements.
The Information Centre of ISO Central Secretariat proposes to develop a complementary collection of material of a standardization nature emanating from international sources.
The larger information centres operated by ISO Member Bodies are already regarded as vital links in their national information networks. Centres will continue to develop and will play an increased role in national affairs.
Each is linked to other national centres and to the ISO Information Centre in Geneva, through the ISO network. A wise and selective policy in acquiring material will result in maximum efficiency without unnecessary duplication of effort.

— Automatic methods for the storage and retrieval of information are already being developed at ISO Central Secretariat and by many ISO Member Bodies. This activity will increase and information interchange techniques will be further developed within the ISO information network. Already considerable progress has been made in developing a multilingual thesaurus which will provide a common basis for indexing.
Information may be stored on computer tapes but document must be stored physically. As collections grow storage problems will be solved by increasing adoption of microfilm and microfiche techniques. This may be evident first in developing countries where there is less built-in resistance to those methods of presentation. The trend will accelerate as more documents become available in micro-form at prices much lower than for " hard copy ". In the USA the National Bureau of Standards already publishes microfiche versions of certain documents.

— Information needs are seldom fully satisfied by lists of documentary references. Even when provided with the actual documents the user often faces a formidable task. He must secure translations of those written in foreign languages and he must select and analyse the technical content and apply the result to his problem. For the user the perfect answer lies in an analysis of the contents of the documents, underlining the significance to him. This implies the techniques of the information analysis centre in which documentalists, information scientists and subject specialists work as a team.
Several ISO Member Bodies are already embarking upon information analysis activities and reference may be made to work in the USSR and to the Technical Help to Exporters Service (THE) of the British Standards

Institution. Developments of this type are likely to intensify and probably constitute the most important trend at the present time.

— As facilities improve the ISO information centres will be able to play a much more active role. At present they are largely occupied in responding to enquirers; in the future they may hope to process and disseminate information in anticipation of need. Autopatic storage and retrieval systems will allow the development of SDI (selective dissemination of information) in which the " profile " of the user is matched with items in the information store so that he may be provided with a regular flow of relevant information.

— It is difficult to divorce the provision of technical information from consultancy, and many users require expert assistance in applying information to their specific needs. Experts employed in analysing the information may well extend their activities to include this service thereby also providing a valuable feed-back as an aid to maintaining the effectiveness of the service as a whole.

— To summarize, information on standardization will be provided on a world-wide basis by an increasingly efficient information network linking the information centres of the ISO national Member Bodies and the ISO Central Secretariat. This network will link also with national technical information systems by virtue of the fact that centres operated by the Member Bodies belong to both.
Users will require more information, more broadly based information but they will no longer be satisfied with " raw " information. There will be a greater tendency to select and process material centrally in order to facilitate its assimilation and application by the user. Selective dissemination will act as a barrier to the flood of irrelevant material which today threatens to obscure items of real value by its sheer volume.

Expansion of international work

There are now some 30 countries which may claim to be fully industrialized and another 30 or more in various stages of developing their industrial potential. While circumstances vary greatly between countries, it seems that in round figures between 6000 and 10 000 national standards are needed by a fully industrialized country. This wide range in number is largely the result of different nations covering a wider or narrower scope in a single standard. Many countries will not need a full complement of standards for some years and some countries rely to a considerable extent on using standards of another country, merely altering the cover and title page. Thus it would be reasonable to predict that the total of important national standards may rest for the time being within a figure of about 100 000.

If we assume that, in time, all the primary national standards will be related to an ISO or IEC Recommendation, then we may predict that a minimum of 10 000, rising to say 15 000, of these will be needed. When they are available the tendency will be for national standards to be brought into line with them and if possible one would hope to see them given the same titles.

It will then be a much easier matter for two countries trading with each other to speak in a common language about their goods so far as specification, quality and performance are concerned. Another advantage will be the possibility of a fairer comparison of tenders when these are submitted by different countries. It seems clear therefore that the effort put into the preparation of international standards and maintaining them up-to-date will grow rapidly; but there should be a proportionate reduction in the work of maintaining national standards, since the bulk of the data in these will merely be a copy of the international standard. It is absolutely vital that the present long time lag between initiating the work and publishing the document should be reduced. It may be that only a strictly limited number of projects can be undertaken at any one time. Committee work will need to be reduced in the earlier stages: and to achieve this the initial drafting may have to be done by a competent secretariat after careful study of the needs and practices of different countries. This would call for one or two real experts in the particular field to be made available to the secretariat more or less full time for a short period. They could perhaps be loaned by industry for the purpose.

With these measures, twelve months should normally be sufficient between the initiation of the work and circulation of the first draft standard. Several national bodies already operate on these lines, with a dramatic saving in overall time.

Ample time for discussion and comment must, however, be permitted on the first draft if the proper ' consensus ' procedure is to be observed.

The Committee, when it meets, should be composed of experienced men, high enough in their professions to be able to make decisions, and empowered to make concessions; because every standard is a compromise between conflicting interests: and unless there are concessions the final document will tend to be a catalogue of different practices rather than an international standard.

It must be recognized that in many cases *the early publication* of an international standard may be the important thing, sometimes more important than the exact content of the standard. The search for perfection can prove to be an enemy to progress. However, the machinery for review and updating of standards will need to be greatly improved if this line of approach is to be accepted.

Conclusions

It is all too obvious that there is a paramount need for expansion of the ISO network—and of the IEC also, for what is true of the one is equally true of the other. How is this to be brought about? For greater resources are obviously needed, both in monetary terms and in human effort. But the prizes are very great. A really efficient and comprehensive system of international standards—one in which all the world had confidence—would save so much effort in so many other directions. The industries of the world will undoubtedly increase their help, but the greatest assistance which industry renders is the loan of its experts to serve on technical committees: and generally bearing the full expense of this service. Without such aid neither the ISO nor the IEC could function at all. With it they may justly claim to represent the best technical knowledge available at the time.

For the cost of printing and publishing standards and for the general overheads of the organizations, surely it will be necessary to look more and more to governmental sources for financial support. With this may come a measure of government control, for there is an old adage " Who pays the piper calls the tune! " but let us hope, despite this, that the concept of voluntary standards, prepared in a full consensus of all interested parties, will be maintained to the greatest extent possible.

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* E = English;
F = French.