REPORT OF A SYMPOSIUM
ON
STANDARDISATION
IN THE
CHEMICAL FIELD
20 APRIL, 1949
REPORT OF A SYMPOSIUM ON STANDARDISATION IN THE CHEMICAL FIELD

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*This Symposium was arranged by the London and South-Eastern Counties Section of the Royal Institute of Chemistry and was held in the Lecture Theatre of the London School of Hygiene and Tropical Medicine on 20 April, 1949—Dr. J. G. A. Griffiths in the Chair.*
FOREWORD

BY

J. G. A. GRIFFITHS, B.A., Ph.D., F.R.I.C.—Chairman

Some degree of standardisation is implicit in all scientific work and it is, therefore, an essential factor in the advancement and expansion of the practice of chemistry. That it is an essential factor does not imply that it should of necessity pervade every confine of all the fields of chemistry, and opinions differ as to where and to what extent standardisation is advantageous or practicable in some directions.

The process of preparing standard specifications is usually a laborious and always a responsible operation for those who undertake this task, and at least part of the justification for the expenditure of the effort involved is the benefits which accrue to chemistry when the operation is complete. Consequent on these lines of thought, it was decided to hold a meeting of the London and South-Eastern Counties Section of the Royal Institute of Chemistry to provide an opportunity for the expression of opinions on the various aspects of standardisation and possibly to discover any general measure of agreement as to the extent to which standardisation is desirable, advantageous and practicable, and the forms or characteristics it should have in the various fields of chemical endeavour.

The Symposium was therefore arranged on a wide basis, and members of the large audience had the benefit of having their outlook broadened and their perceptions deepened by listening to an exposition of the philosophy and principles of standardisation by the Director of the British Standards Institution, before being invited to ponder what the experts in their own fields had to say about standards for materials, the standardisation of methods of analysis and apparatus, and the preparation of standards. The subsequent long and interesting discussion is a fitting commentary on the importance of the subject and the high quality of the main contributions to the Symposium.
THE PHILOSOPHY OF STANDARDISATION

By

P. GOOD, C.B.E.

(Director, British Standards Institution)

I have been asked to put before you a brief study of the general principles, or philosophy, of that particular branch of activity which is known as standardisation; it is therefore necessary to deal with the subject in a general way.

A standard definition of philosophy reads "the study of the general principles of some particular branch of knowledge, experience or activity." The word "standard" has many different meanings, but the meaning I am giving to it in this paper is an exemplar of measure, or an orderly arrangement of ideas.

SYMBOLS AND NOMENCLATURE

The chemical industry, long before it could call itself an industry, found it useful to standardise methods of expression, and evolved a series of symbols for the various substances with which it was familiar. In the earliest days gold was almost deified, and it was given the same symbol as that used for the sun. Other symbols of lesser celestial bodies were used for less important substances such as silver, which was given the symbol used for Venus, or in some cases the moon. Later, letter symbols which are nearly mnemonic were introduced and are now used throughout the world.

It is from this point that a series of standard symbols has been evolved for practically all known chemical elements or compounds and the relationships between them. It would be difficult to assess the value which that piece of standardisation has had in the development of the chemical industry.

In 1938 B.S.813: Chemical Symbols and Abbreviations was issued. This standard was based on the report of a Joint Committee of the Chemical Society, the Faraday Society and the Physical Society—a report which follows general principles, adopted after considering the views of representative bodies, including the International Conference of Physics (1934) and the American Standards Association. The report embodies the agreed views of British physicists and chemists.

B.S.974 provides for standard symbols for use on diagrams of chemical plant and reflects the engineering side of the chemical industry.

Whilst no one would wish to see a limit placed on the use to which words are put in literature, which is largely an art, it is essential to have a specific meaning attached to a term to describe a material or a property whenever scientific or technical matters are in question. In other words, the word must be limited to its particular job.
It is for this reason that the standardisation of terms and definitions is necessary. In fields where standardisation has proceeded some distance, a glossary fixing one meaning to each term is required, in place of a dictionary which shows the many meanings ordinary usage of the word has given to it.

It is, perhaps, an artistic loss that we no longer adopt the classical method of using as symbols the accepted signs for the gods, and do not select our names because some similarity is recognised between the alleged character of a god, such as Jupiter Ammon, and the virulent nature of a salt, such as sal-ammoniac. There are variations to this piece of history but this version is as good as any other.

The standardisation of terms for scientific and industrial purposes is a process of “christening,” and every effort should be made to secure that the words adopted have a fair chance of being accepted internationally, and that they are of such a nature that the printed word is recognisable in all the Western languages.

The terms used in the chemical industry—not only the names attached to the elements and compounds, but the terms used to describe the various characteristics of these materials—have, to a large extent, been agreed, and are used almost universally throughout the English-speaking world. In the pharmaceutical field, the Latin names are universal throughout the Western world. There is, however, a need to-day for standardising, both nationally and internationally, the terms used to describe many of the modern products of the chemical industry.

It cannot be gainsaid that throughout the whole of the chemical operations required to transform the raw material taken from the earth, sea or air into the simplest, as well as into the most complex, material there is a loss of efficiency whenever loose terminology is used. It is for this reason that standardisation commences with nomenclature and symbols. An interesting example of this is B.S.526 which defines the terms “gross” and “net” calorific value for gaseous and solid fuels.

**DIMENSIONAL STANDARDS**

It can be assumed that man has been prepared, since the beginning of time, to accept standardisation of terms and symbols, but it was not until later that he found it necessary to have standards of weight, length or volume. These must have been evolved when man began to exchange his products for the products of others.

Over a very wide range of his activities the chemist has adopted the metric system, but he is not a slave to it. The English-speaking world has refused to become a slave to any system, and continues to use many traditional units and the natural sub-divisions, the half, quarter, etc. It is, however, essential that there should be an agreed fixed ratio between the measures, and in both this country and the U.S.A. legislation is likely
to fix that ratio at 25·4 mm. = 1 inch. It is desirable that for all industrial purposes the most suitable unit selected from either the inch/pound or the metric system should be used, regardless of the system to which the unit belongs. The selection of a suitable size of unit should be the major consideration and, in general, it may be asserted that it is easier to use smaller numbers than larger ones. A unit should, therefore, be chosen to give the simpler numbers for everyday use.

Dimensional standards are laid down for convenience of interchangeability, for limiting the number of sizes in the interest of economic production and marketing, and for defining the size of apparatus for particular purposes. In certain cases, dimensional standards are a measure of quality or fitness for purpose.

The B.S.I. has been actively at work for some time on standards for laboratory ware and a number of specifications have been issued for various items of equipment, which are mainly dimensional standards, although they include certain other requirements to ensure a satisfactory article. B.S.470: Manhole Openings is a further illustration of dimensional standardisation. This standard lays down the size of openings in chemical plant. A dimensional standard of somewhat different character is provided by B.S.975, which gives density composition tables for aqueous solutions of nitric acid for use with density hydrometers.

QUALITY STANDARDS

There are references in early writings to the refining of metals, which implies recognition of a standard of quality. It is probable that the first measures of properties other than weight, volume or length were standards for gold and silver.

It may be noted that to set up a standard of quality, it is desirable first to decide what special function the material or article is required to perform, or what properties it is desired it should have, and then to find a means of measuring those properties. The ideal standard will provide methods of test of the physical and chemical properties in terms of objective measurements and will fix limits within which the results must come.

There are a number of British Standards which come within this category, such as the standards for materials for electroplating and the wide range of standards for paint ingredients.

STANDARD TESTS

In general, the results of tests cannot be given in absolute terms, and so empirical tests have to be used, the results depending on the precise method of carrying out the test. Without an agreed method no proper comparison can be made.

The standardisation of test methods and of the materials and appliances used therein is an important phase of the subject.
Whilst it may be true that it is possible to secure a substantial degree of accuracy in the assessment of properties by sight, taste or touch, yet the variability of the reaction of our senses leads to the conclusion that only objective tests can be looked upon as providing completely satisfactory standards, although there are still cases where objective tests are not yet possible, or are too difficult for ordinary use.

Many British Standards have been issued in this field, of which the following may be taken as typical:

- **B.S. 647**: Methods for testing glues (bone, skin and fish glues).
- **B.S. 757**: Methods for sampling and testing gelatines.
- **B.S. 894**: Determination of the flow and drop points of fats.
- **B.S. 1309**: Sampling and analysis of vegetable-tanned and chrome-tanned leathers.
- **B.S. 1548**: Analysed samples for metallurgical analysis.

**Sampling**

To test a bulk of material, or a quantity of articles, it is generally necessary to select samples. Sampling has often been little more than guessing, but it is now possible to achieve both precision and economy of inspection through the use of statistical methods. Sampling materials is not basically different from sampling articles, and in both cases it is necessary in specifications to lay down standard methods of sampling.

Illustrations of this type of standard are:

- **B.S. 403**: Sampling of small fuel up to 3 in., embodying some general principles of sampling.
- **B.S. 627**: Sampling fats and fatty oils in packages or in bulk.

**Use of Standards**

Standards, whether written or implied, are required at every stage of manufacture where the material passes from one process to another. When the material passes from one owner to another, a written standard becomes desirable.

**Summary**

The practical expression of these fundamentals in terms of industrial standardisation, as evolved by the B.S.I., can be summarised as follows:

1. Terms, definitions and symbols;
2. Standards of quality, fitness and purpose;
3. Dimensional standards;
4. Methods of test;
5. Methods of sampling.
It will be recognised, therefore, that whilst there is a philosophical background to the idea underlying standardisation, its main roots are in the needs of industry and commerce. The growth of standardisation in modern times is due to the recognition of its necessity, not only as an efficient aid to industrial production, but also as a means of encouraging improvements in products, because, as soon as the quality can be effectively assessed, there is an incentive to improvement.

On looking at industry as a whole, it is not difficult to recognise that those industries which have progressed the fastest are those which have recognised the necessity for standardisation. In this matter, the chemical industry is not behind the other industries.
STANDARDS FOR MATERIALS IN THE CHEMICAL INDUSTRY

BY

W. C. JOHNSON, F.R.I.C., AND
G. H. OSBORN, F.R.I.C.

Later in this paper we shall survey the existing published specifications and standards for chemical products, but it seems appropriate first of all to pay some attention to the fact that in the chemical manufacturing industry there are probably many times as many unpublished as published specifications. For instance, the organisation represented by one of the authors of this paper contributes to the publication of about 300 reagent specifications, but has specifications to the number of nearly 2,000 in internal use for chemicals of other grades, apart from B.P. and B.P.C. standards. Chemical products are probably subject to a more elaborate degree of quality control than almost any other. In most other industries it can be assumed, up to a point, that standardised manufacturing methods yield a sufficiently standard product, and that a scheme of inspection will provide any necessary safeguards. In many branches of chemical manufacture such assumptions are far less justifiable and the manufacturer must maintain an extensive (and expensive) system of analytical control on his final products, both for his own information and in his customers' interests. The terms of these internal specifications will generally be made known to customers on enquiry, and special provisions will usually be agreed by the manufacturer to meet individual requirements. With the increase in scientific control in industry such questions and requests become increasingly frequent.

In many other instances the terms of the specification may originate with the user. In these circumstances the user should and, fortunately, usually does, consult with the manufacturer as to what can readily be achieved before presenting him with a series of uncompromising stipulations. He may thus save himself quite considerable sums of money.

Apart from all this there is an increasing tendency on the part of manufacturers to publish specifications for their regular products, and a number of well-produced brochures of this kind have become an important feature of their technical services. They represent a very welcome step towards the replacement of the old vague terms such as "commercial," "pure," "puriss" and "reagent," with far more objective statements. There are many such valuable publications from commercial houses, varying from precise specifications to the rather more descriptive literature; the former, in particular, reflect the willingness of the chemical industry to meet the ever-increasing stringency of the demands made upon it by all those other industries that consume chemicals. Paper restrictions during
the last few years have prevented wide distribution of these publications, but they should find an important place in any library used by practical chemists. The chemicals of the text-book are not always the chemicals of commerce. This is said without any implied slur on either the text-book or the commercial product. There is usually a perfectly good reason for any difference that may exist, and the chemist or the chemical buyer will be well advised to base his calculations on what exists in real life.

In framing these standards, whether published or not, the manufacturer has to be guided by various considerations. Some of these are more particularly concerned with his own problems. For instance, he must know what impurities are likely to be contained in his raw materials, and must set a standard that ensures the elimination of those impurities, or at least their reduction to negligible amounts, in his final product. The quality of raw materials has varied very considerably in the recent difficult years. Some impurities are liable to be contributed as a result of plant corrosion, and these must also be taken into account. Then he must also have regard to the customer's particular point of view and the purpose for which the product is intended to be used. This implies close liaison with the users, and most chemical manufacturers maintain for this purpose a technical department—sometimes a section of the laboratory, sometimes a separate sales service department—in close touch with the users' problems on the one hand and with their own research and production on the other.

Of mutual interest to both producer and user is the question of economics. It is usually possible to produce a purer chemical at a price far higher than the user is prepared to pay. The standards employed must therefore represent a compromise in which economy is an important factor.

These commercial standards cover a very wide variety of chemicals of all grades, but standards for various special classes of chemical products are issued from official sources and from trade associations. We propose now to deal with these more specialised fields of standardisation.

Considering first the cruder types of chemical product, there is little to say beyond mentioning that the standards applying to fertiliser grades are those made under the authority of the Fertiliser and Feeding Stuffs Act of 1926.

The sphere of fine chemicals naturally provides the most interesting examples of chemical standardisation and, in that sphere, pharmaceutical chemicals are covered by one of the most important, and at the same time the most long-standing, series of specifications. It is natural that the necessity for systematic standardisation in the chemical field should have made itself evident first of all with respect to products for medicinal use. Standards of purity, of nomenclature and of definition for medicinal substances became necessary for the protection of the public and as a basis of understanding between the physician and the pharmacist who
dispensed his prescriptions. For such reasons the first British Phamacopoeia came into existence in 1864, being actually a successor to several local pharmacopoeias. The B.P. has been through a number of issues since that date, the seventh and latest being published in 1948. The Pharmacopoeia is published for the General Medical Council and by authority of Act of Parliament and has the legal significance that all substances included in it must comply with its provisions when sold for medical purposes.

A companion volume to the B.P. is the British Pharmaceutical Codex, or B.P.C., published by the Pharmaceutical Society. The Codex contains information on all B.P. substances, though it does not quote the standards in full. It covers also a considerable number of other items falling into two main classes. On the one hand, it includes a number of substances that have, for various reasons, been dropped from past issues of the B.P., but which continue to be prescribed and should, therefore, be subject to some kind of standard. On the other hand, the Codex deals with a certain number of substances that are not yet sufficiently well established in medical practice to satisfy the more conservative policy of the B.P. A number of other types of materials and preparations are included, for reasons that need not concern us here. The B.P.C. has always been a rather more informative publication than the B.P. (in which the whole of each monograph except the chemical formula ranks as standard), but the new edition of the B.P.C., which will be published this year [1949], although it will retain much of its more informative character, will also contain definite and comprehensive standards for almost every item included. The B.P.C. has not the same definite legal standing in this country as the B.P., but has come to be regarded as the presumptive standard for the supplementary items with which it deals and has, on occasion, been accepted as a standard in court proceedings under the Food and Drugs Act, although not specified in that Act. In certain other countries, e.g. Australia and New Zealand, the B.P.C. standards have the same legal significance as those of the B.P.

Both the official B.P. and the semi-official B.P.C. are concerned with medicinal and pharmaceutical substances and preparations, although the B.P.C. adopts a wider interpretation of those terms than the B.P. It is natural that these standards should have found their uses in the food and drink industries. They have, in fact, come to be recognised in the food industries as the standards for certain spices, oils, gums, sugars, starches and a number of purely chemical substances such as glycerin, citric and tartaric acids, sodium bicarbonate and others.

Many chemists are familiar with the B.P. and the B.P.C., but a large proportion of chemists, whose occupations do not happen to bring them into any pharmaceutical contacts, can remain completely unacquainted with these books. This seems rather a pity. The standards, the analytical methods and much of the other material have potential uses in many
branches of pure and applied chemistry. The industrial chemist who has been in the habit of regarding the B.P. and the B.P.C. as books of crude drugs would be surprised to find that, particularly in the later issues, they deal quite largely with pure and synthetic chemicals and may provide a ready-made standard or analytical method quite appropriate to some purpose or requirement of his own.

A number of therapeutic substances and preparations are assayed by biological procedures. Into this category fall certain antitoxins, vitamins, insulin, some arsenical drugs, penicillin, and so on. The biological assays referred to require the use of standard preparations for comparison purposes and these standard preparations are maintained and issued—some of them under the provisions of the Therapeutic Substances Act—by the National Institute for Medical Research, Hampstead. These are, however, mostly International Standards, not national specifications.

Consideration of medicinal products provides instances of the fact that standardisation in the chemical field is not always concerned with stipulating the highest possible purity. Often this is neither necessary nor desirable. For a number of reasons a low figure for the content of the principal constituent may be given and "stronger" samples must be reduced to standard by dilution. This principal is adopted officially with certain drugs, e.g. Powdered Opium, which is adjusted by addition of lactose or powdered cocoa husk to contain 10 per cent. of anhydrous morphine.

The fact that a substance may change on keeping necessitates a standard that allows for a reasonable period of storage. Thus some substances, such as phenol, change colour readily and an allowance has to be made for this. The B.P. description for phenol states "Colourless, needle-shaped, deliquescent crystals, or crystalline masses which may acquire a pinkish hue on keeping." Allowances have to be made also for changes of potency on storage. Thus Liquid Extract of Ergot B.P. is described as follows: "Liquid Extract of Ergot, when freshly prepared, contains 0·06 per cent. w/v of the total alkaloids of Ergot, calculated as ergotoxine; after storage, it contains not less than 0·04 per cent. w/v of the total alkaloids of Ergot, calculated as ergotoxine." This allows for a reasonable period of storage for an extract prepared from good samples of the drug. Unstable substances are sometimes preserved by the use of stabilisers, and the tests applied must make allowances for the added substance. Thus Chloroform B.P. is stabilised by the addition of 1 to 2 per cent. v/v of alcohol, and, in consequence, the B.P. boiling-point specification states "A small and variable fraction, usually not exceeding 15 per cent. v/v, distils below 60°, and the remainder distils between 60° and 62°."

The same idea obtains with many organic dyestuffs. Many of these are handled most conveniently, both by the manufacturer and the user, in a somewhat diluted form. During the war some of the materials used as diluents became very difficult to obtain and many dyes are now issued in
much stronger form, this fact being indicated by a suffixed figure such as 100, 150 or 200, denoting the per cent. concentration relative to the older mixture.

There is a notable divergence between American practice and ours in respect of standards for certain classes of chemical products. The American Bureau of Standards issues chemical specifications for a number of organic dyes employed for the colouring of drugs, foods and cosmetics—the D.F. and C. series. In fact the use of dyes for internal or external application is closely controlled by official regulation in the U.S.A. In this country we have a certain number of dyes for colouring medicines standardised in the B.P.C., but so far as foods are concerned the situation is covered by manufacturers' own specifications and several very satisfactory series of food dyes are issued on this basis.

Another valuable series of chemical specifications is that for solvents, issued by the British Standards Institution. This series already covers 18 items and includes a number of alcohols, esters, acetone, ether, acetic acid, carbon disulphide, carbon tetrachloride, hexachloroethane and trichloroethylene. The Institution also issues a number of other standards for chemical products. These include benzole and allied products (based on the specifications of the National Benzole Association), phenols and cresols, pigments, chemicals for electroplating and oils for a wide variety of purposes. A number of chemical specifications having particular reference to aeroplane dope will also be found in a special series of British Standards for aircraft materials and components.

The next important class of chemical products to be considered is the one that comprises analytical reagents. We refer to this class of chemicals as an important one from present considerations because the standardisation of reagents is a very large and complicated task to undertake. Almost every reagent must be considered with reference to a wide variety of possible impurities and an even wider variety of potential uses. Even then it is not possible to have any stereotyped understanding as to what impurities may be present and in what amount; the manufacturer must therefore provide sufficient particulars on the label of each bottle to enable the user to satisfy himself as to the suitability of the reagent for whatever usual or unusual purpose he has in mind. Some makers publish in book form the complete terms and analytical methods for their standards. Others make a point of stating on their labels the numerical results of their tests for impurities rather than the maxima permitted by their standards.

The continual and rapid introduction of new methods and even new systems into analytical chemistry brings with it the frequent necessity for new reagents and for the revision of old standards, the latter tending always in the direction of greater purity. The increasing popularity of so called "instrumental" methods has not decreased the number of reagents required or lowered the standard of purity demanded. Very much the
reverse. These new techniques often require new reagents. Sometimes they reveal unsuspected impurities in existing reagents or demonstrate the insufficient sensitivity of older tests. The manufacturer of analytical reagents finds it essential, therefore, to keep well abreast of developments in analytical chemistry and to maintain continual improvement in his methods and his standards.

We have emphasised the temporary nature of reagent standards and their need of frequent revision. In view of this it is not surprising that the compilation of these standards has been left to direct collaboration between manufacturers and users. There is, in fact, quite a healthy spirit of competition in specifications between the various makers. Standards were prepared for some 80 reagents during the 1914-18 War by a joint committee of the Society of Public Analysts and the Institute of Chemistry, purely as a wartime emergency measure, and these standards were allowed subsequently to become obsolete. It is possible that national or even international standards may eventually be agreed. It does appear to us, however, that though this may provide a common basis for some of the broader principles, it will still be necessary for the makers to take care of the finer points of urgent progress by issuing supplementary standards for their own products. This sort of thing actually takes place in the United States, where the American Chemical Society issues a limited number of reagent standards and certain makers advertise their reagents as "better than A.C.S."

There are two other rather special classes of high grade chemicals. The first is the series of micro-analytical reagents, the standards for which are based on the published methods of Pregl and other specialists in this field. The other is the series of metals and metallic compounds issued with certificates of spectroscopic examination. These form valuable reference standards for analytical research.

Finally it may be interesting to cite an example of a chemical that occurs in a number of different quality classes, and for this purpose we have chosen ammonium sulphate. The fertiliser quality must have its nitrogen content stated and must not contain more than 0·025 per cent. of free acid. The B.P.C. specifies physical characteristics, requires a neutral solution and imposes limits for residue on ignition, arsenic, lead, chloride and iron. Ammonium sulphate of analytical reagent quality has to pass more stringent tests for the impurities just mentioned and in addition to meet tests for nitrate, phosphate, thiocyanate, heavy metals and moisture. An assay is also included. It is evident from this example that the grades of quality required by chemical standards may vary widely.

In conclusion we would express our indebtedness to Mr. T. C. Denston and Dr. R. E. Stuckey for information and advice.
STANDARDISATION OF METHODS OF ANALYSIS

By

D. C. GARRATT, B.Sc., Ph.D., F.R.I.C.

It would appear that in analytical chemistry, as in many other walks of life, we are changing from the age of craftsmanship, where the skill and individual talent of the analyst ensured results of unassailable accuracy, to the outlook of mass production.

We may expect this change in outlook to continue and it cannot be disputed that regimentation, with standardisation of methods, has come to stay. The Standards Sub-Committee of the Analytical Methods Committee of the Society of Public Analysts and Other Analytical Chemists has been collecting a list of methods, standard, recommended or recognised in some way or another; even the titles of those published in Great Britain and the U.S.A. alone are sufficient to fill a fair-sized book. However, there is a tendency to over-elaborate such methods and reliance on them may tend to decrease the efficiency, the personal skill and the creative interest of individual members of the analytical profession. Further, many so-called “standard methods” have not stood up to critical study, and there is need for very careful analytical investigation before a method can properly be published as “standard.” Some, it would seem, must have been devised by persons who never intended to perform them practically; they are rarely used and are discarded without regret.

Some standard methods are desirable and even necessary, particularly for assessment in trade, where quality, a correct estimation of content, or even an arbitrary figure of content must be used to determine selling price; but results by such standard methods should be obtainable in normal practice, without precautions and manipulation which would make the processes unbearably tedious.

A standard method is one which accurately determines a substance or constant and is, therefore, necessarily reproducible, and which by long experience is found to be satisfactory without modification; it becomes accepted as a method to which analysts will refer and which they can quote for convenience; in other words, it is “adopted for reference.” Simple gravimetric and volumetric determinations come in this category. In some cases, where accuracy of determination is unattainable because of lack of knowledge of the exact chemical nature of the substance being determined, it is a reproducible method in the hands of all skilled analysts; such a reservation is necessary, since no method should be expected to give reliable results when a casual determination is performed by a worker inexperienced in the normal day-to-day manipulation of the technique. Accuracy should be the first aim, then uniformity of results. If the former is possible without difficulty, the standardisation is unnecessary; if it is possible with particular care, then publication of the
necessary precautions found by considerable experiment is desirable; if accuracy is difficult to assess, uniformity of results between workers is useful, and standardisation of technique then becomes a necessity.

There should be a differentiation between recognised methods, which by their soundness and constant use have become standard, and those methods of test which are no more than fixed methods of procedure elaborated to ensure the same results as an arbitrary basis for negotiation on quality between two interested parties, say buyer and seller. If the scientific standard of the collaborators is high, the latter type of method might gain the distinction of becoming a true standard method. Hence the criterion of the value of this type of "standard method" is the standing of the authority under which the work is done, and it must not be thought that, for example, methods of analysis published by a research organisation are necessarily "standard." It speaks well of the efficiency of such organisations in this country that their publications are invariably of this standing. Nevertheless, the multiplicity of methods available indicates that rationalisation is necessary. This class must include empirical methods where, by strict adherence to detail, it is possible to obtain concordant figures, even if these bear little relation to working results of the material in practical use. For example, the ash, volatile matter and calorific values of coal determined in the laboratory give figures not expected in practice; viscosity measurements such as those determined by the standard Redwood apparatus give comparable results bearing no direct relation to absolute viscosity; the salt spray test for corrosion of metals carried out in a specified manner gives an indication of the expected life, but it is never anticipated that these conditions will arise in practice. These methods of test, elaborated particularly by commercial organisations, are better referred to as "specification methods" or "trade specifications." Standards for chemical products and tests for purity would come into this category.

There are a few methods of analysis having legal standing. Firstly, there is the presumptive standard of the Pharmacopoeia which is required to be published under Section 44 of the Medical Act, 1858, and hence, by inference, the methods of test may be considered to have legal signification. Even here it may be observed that although the assays "are the official methods upon which the standards of the Pharmacopoeia depend, the analyst is not precluded from employing an alternative method in any instance if he is satisfied that the method which he uses will give the same result as the Official Method. In the event of doubt or dispute, the methods of analysis of the Pharmacopoeia are alone authoritative." Other standard methods having legal standing include those laid down in the Regulations under the provisions of the Fertiliser and Feeding Stuffs Act; the precise conditions for conducting the phosphatase test in the Heat-Treated Milk (Prescribed Tests) Order, 1944; and standard procedures under various Food Standards Orders.
Few standard methods are original: they are generally developments or refinements of well-known basic methods. The modifications are, on the whole, necessary to add specificity to the determination and, unfortunately, for that reason the methods tend to become unwieldy. The methods are usually produced by the collaborative work of a committee of specialists who critically examine a published method, verify or refute the criticisms—often after considerable experimental work—and from the results formulate the recommended method. This work is undertaken almost entirely voluntarily, and a mark of appreciation should be accorded to all such workers. The voluntary nature of the work is of prime importance and is a necessity for the best results; it gives the full collaborative experience of a large number of teams of practical workers. Therefore, where methods of analysis are being discussed, those leading analysts in industry who are asked to collaborate should, if they themselves are not or have not recently been engaged on the actual experimental work, delegate the man who has been so engaged to be present at the working committee. Far too many “arm chair” alterations have resulted in the final method being successfully criticised when re-examined by later investigators, who have noted a failure in practice.

With so many trade organisations, professional bodies and technical institutes issuing recommended methods of their own, there is a tendency to overlap; so much so that it is becoming common to find that methods published by professional bodies are adopted completely for specifications by the trade organisations. It would be preferable for trade organisations to leave methods to professional societies or institutes, the specification and quality requirements based on these methods being formulated by the trade organisations.

The Society of Public Analysts and Other Analytical Chemists was in the forefront of professional bodies in this country in organising collaborative investigational work on standardisation of chemical methods. American standardisation had already been started, including the work of the Association of Official Agricultural Chemists, the Bureau of Standards, the American Society of Testing Materials, etc. In May, 1924, the Society of Public Analysts formed its Analytical Methods Committee, which at that time consisted of only five members, whose specialised knowledge leaned towards what we may term the “food and drugs” side; although the Committee now consists of some 24 members representative of a very wide range of interests, the reports published to date are all concerned with subjects which may be considered to fall within the range of the work of the original Committee. This may be due to several causes, mainly the covering of other fields, such as petroleum, ferrous and non-ferrous metals, by research associations, the Institute of Petroleum or the British Standards Institution. The original general terms of reference by the Analytical Methods Committee to sub-committees are worthy of attention and could with advantage be borne in mind by all investigators undertaking
such work. They were "To unify methods of analysis, including both the process of analysis and expression of results. This will involve review of existing methods and consideration and trial of new methods which may be prepared. Methods recommended should be as far as possible of wide application and generally available."

Since most of the standard methods are devised for the testing of particular materials, it seems unnecessary to proceed to a high degree of specificity when a far simpler method would, in many cases, be adequate; the added overhead cost to industry must be heavy. The tendency to give a shortened test as an alternative method for general use is welcome. The standard method can be used as a yard-stick and, provided a more rapid method will give an accuracy within reasonable limits of tolerance from the standard when tested against it, the quicker method should be used in routine work.

The American practice of issuing a method as "tentative" or "official 'first action'" for a considerable period before finally adopting it as standard allows a more searching examination of the validity of the method by practising analysts other than the Committee who devised it. The discovery of faults, under conditions or with material not examined originally, avoids the necessity of alteration and consequent casting of doubt on the quality of the final standard method.

Where a method is being investigated for its suitability, the work should be planned carefully. The tendency to examine a well-recognised method may make the planning of the examination somewhat scanty, and it may be incorrect to assume that, because all the co-operating analysts get a closely similar figure for a determination on a specimen circulated for test, the method is therefore accurate; it may be only reproducible for the conditions used and the material actually under test. The help of a statistician is of value in obtaining the necessary information with the smallest expenditure of effort; the statistician is also of value afterwards to interpret the findings with as clear a picture of their meaning as possible.

When a standard method is being used in the laboratory, the tendency is to assume that no errors of determination are involved and that relatively inexperienced staff or workers lacking in initiative may be employed on these tests. Often this is justified, but the adoption of mere cookery-book manipulation enhances the danger that errors in manufacture or abnormal composition of a product under examination may be missed. In the writer's opinion, standardisation discourages individual thought and the development of individual skill and satisfaction in work.

With the acceptance of the necessity for specification of methods in trade practice, it is natural that these should primarily centre around the industrial requirements of basic materials used in considerable quantities. Some sections of analytical work are practically without standard methods, particularly in the physical, biological and biochemical fields. In sections
of analytical work where exact determinations have not yet been evolved there is a good argument for the standardisation of technique so that comparable results may be obtained.

International standardisation of methods presents many difficulties but the British Standards Institution is co-operating directly with standardising movements in the Empire so that industrial co-ordination is being achieved in some measure.
THE STANDARDISATION OF APPARATUS

By R. H. Powell

1. History

Before the 1914-18 War there was only a small laboratory apparatus manufacturing industry in this country. Most of the apparatus used was imported from Continental sources and serious difficulties were experienced during the war in obtaining sufficient scientific equipment. The position has radically changed since then and, although Great Britain is not completely self-supporting, yet the great bulk of her apparatus requirements can now be supplied from home sources and about £10,000,000 worth of apparatus is exported per annum.

Having in mind, however, the history of the industry, an examination of the range of its products discloses an irrational state of affairs in regard to shapes and sizes, which are frequently based upon original Continental models; and since there have been added to these models sizes and shapes thought to be peculiar to British needs, a welter of heterogeneous sizes has grown up, few of which bear any rational relation one to the other. There is now, therefore, a pressing need for a fundamental reconsideration of shapes, designs, materials and function of much chemical apparatus, if the laboratory apparatus industry is to be capable of meeting modern needs. Standardisation has become essential if the industry is to increase in efficiency. The attitudes of user and manufacturer towards standardisation are often opposed. Some users have characterised standardisation as "monopolistic regimentation." It is far from the manufacturers' desire to put the user, as it were, into a strait jacket; but volume output must be increased and diversity reduced if apparatus demands are to be met.

We must ask ourselves, I think, what is meant by standardisation of "apparatus." Physical methods are now widely used in chemical laboratories and I do not think that the term "apparatus" should, in this connection, include such physical instruments as balances, spectrographs, absorptiometers, polarographs, pH meters, etc., but only apparatus of the type exemplified by beakers, flasks, porcelain, lampblown glassware and some metalware.

2. Users of Apparatus

The types of user who would be affected by standardisation can be classified conveniently as follows:—

(a) Technological. In the main this, the most important type of user on a volume-consumption basis, is interested in apparatus used in routine analyses and in tests prescribed by the important standardising bodies. This apparatus may be used in tests the results of which must be agreed by two parties often thought to
have opposed interests, e.g. buyer and seller, where disputes may be reduced to a minimum by the use of apparatus and of procedure mutually agreed. In these cases I believe that there should be specified such apparatus dimensions and details as will eliminate uncertainty in the accuracy of the results due to doubt as to apparatus construction. In broad terms it may be said that it is useless to specify a method of test without also closely specifying the apparatus employed in that method.

(b) *Research.* In research, the result is more important than the tools used to achieve it. Standardisation has, in this case, the incidental advantage of enabling the research worker to build up whatever equipment may be required and to effect replacements with the minimum of inconvenience.

(c) *Educational.* An abundant supply of inexpensive apparatus is the main requirement for educational use, without any particular desire for a rigid specification. A similar benefit, however, accrues to the educational user as to the research worker.

3. **Benefits of Standardisation**

The benefits, to the manufacturer, of wider standardisation may be summarised thus:—(a) A reduction in diversity of types; (b) the manufacture of larger batches; (c) increased efficiency of production; (d) a larger output from a given number of man-hours; (e) a consequent lowering of costs; (f) a reduction of storage space in warehouses; (g) a better service to the user and a shorter delivery time.

If all these benefits could be secured simultaneously, the laboratory furnishing industry in this country would immediately become markedly more efficient. At present, with the great diversity of types, each manufactured in batches that are smaller than could be the case, the individual attention required for handling them is a serious burden upon the industry as a whole.

4. **Standardising Bodies**

The main official bodies concerned with the publication of specifications for special types of apparatus are The British Standards Institution (B.S.I.), The Institute of Petroleum (I.P.), and The Standardisation of Tar Products Test Committee (S.T.P.T.C.).

The Air Ministry publishes D.T.D. specifications, and the Society of Public Analysts and the British Pharmacopoeia each promulgate some standards; but their volume is small in comparison with those of the other organisations. Standards are also issued by various Research Associations and Trade Associations the most important of which, in the laboratory apparatus field, is the British Laboratory Ware Association (B.L.W.A.).
(a) The British Standards Institution. The contributions made by this organisation to this Symposium are sufficient evidence of its importance. Its activities cover a vast technological field—perhaps too vast for speed and convenience in the preparation of workable specifications. Its method in Committee work is excellent in principle, involving, as it does, intimate collaboration between user and manufacturer, or between buyer and seller: the one says what he would like to have, the other says "but if you have it this way, it would be better or cheaper and just as good." Impartial experts may be co-opted on the Committees and, within the writer's experience, members of research organisations and of industrial concerns have provided invaluable assistance. Yet, despite this, too many B.S.I. specifications have imperfections, arising largely, in my view, out of neglect of the cardinal principle that if a method of test is prescribed, then the apparatus used should be specified with fully detailed and dimensioned working drawings, where these are applicable. Many examples could be quoted where sufficient constructional data are not provided.

(b) The Institute of Petroleum issues a Handbook of 616 pages covering 122 specified tests with comprehensive dimensioned drawings of apparatus required, which are agreed with the manufacturers.

(c) The Standardisation of Tar Products Test Committee. This organisation serves the interests of the coal carbonisation industry and it works in close liaison with the B.S.I. and the I.P. The British Laboratory Ware Association is assisting it to ensure that designs published for use by its members are sound and practical from the manufacturing viewpoint.

(d) The British Laboratory Ware Association represents manufacturing interests only and numbers among its members all the important laboratory furnishers in Great Britain. This Association has a Technical Committee, which is an autonomous Industry Committee of the B.S.I. It was formed in 1943; it holds monthly meetings and is concerned with all aspects of chemical apparatus design, function and specification. It delegates representatives to sit on the apparatus Committees of the other bodies. It has so far issued about 50 standard blue prints of laboratory glassware, and 20 rationalisation schedules, but there is still a vast amount of work to be done.

In considering the design of laboratory glass condensers, for example, a survey showed that 93 different types were offered for sale by members throughout the country. The bulk of the demand was shown to be confined to a few types, which included the Thorpe's Inland Revenue Condenser. It was found practicable to reduce the number of different types listed by manufacturers to seven, without any inconvenience to users.

Again, it was found that, taking the products of all the manufacturers in the country, 352 different types and sizes of beakers and flasks were available and that war-time production was being impeded by this great
diversity. A careful analysis of the spread of the sales showed that it should be possible to reduce this number to 147. It was recognised, however, that some of the non-rationalised sizes might have been standardised in some works' methods and that inconvenience would result if the non-rationalised sizes were to be withdrawn from manufacture. It was therefore agreed, in conjunction with the manufacturers, to encourage the use of the 147 sizes by using heavy type for their catalogue descriptions, to try to offer better delivery of these sizes and thus to canalise the demand, and to review the position in due course. A certain measure of success has attended these efforts, but the natural conservatism of a highly individualistic class of chemical user still finds a clamant voice.

Other types of apparatus which have been dealt with by rationalisation include Soxhlet apparatus, dropping, separating and filtering funnels, calcium chloride tubes, gas absorption tubes, porcelain-ware, specimen and test tubes, thermometers and Orsat apparatus. The Orsat apparatus illustrates one of the difficulties attendant upon all standardising work. It was recognised that from interchangeability of Orsat glassware, e.g. stop-cock rails, absorption pipettes, etc., great convenience would result to users who purchased replacement parts from different sources. The B.L.W.A. therefore prepared a design which, as an Industry Committee of the B.S.I., it passed to that organisation for consideration in the preparation of a British Standard. The B.S.I. deputed Committee SFE/17/2 (Methods of Analysis for Flue Gases) to include the Orsat design in its programme of work. The members of this Committee condemned the use of a palladium-asbestos tube for the determination of combustibles, on the grounds that the method is inaccurate and that if these constituents are to be determined a Haldane apparatus, which is also included in its programme, should be employed. The B.L.W.A. provision for a palladium-asbestos tube was therefore withdrawn. Yet there is a sufficient demand for the palladium-asbestos tube in the smaller type of works to justify its manufacture. The difficulty arises that if the SFE/17/2 Committee insists on the absence of the tube, manufacturers will continue to make Orsats into which the tube can be fitted between the stop-cock rail and the absorption pipette and so will be committed either to making two types, or to refusing to make the British Standard type. Another sub-committee has now been appointed to reconcile the two points of view.

It is hoped that these examples are sufficient to illustrate some of the problems involved in this kind of standardisation and to establish that no high-handed "monopolistic regimentation" is being carried out.

5. METHODS OF STANDARDISATION

It will be appreciated that in discussing the standardisation of apparatus, the writer approaches the matter with a bias towards the manufacturer's view-point, though, he hopes, not neglectful of the needs of the user. In the standardisation of apparatus the object should be to design
for physical interchange of parts and components in such a manner as to ensure quantitative analytical agreement, ideally without increasing the cost of apparatus production. The method to be adopted must depend largely upon the type of apparatus under consideration. The apparatus will become dearer if the dimensional limits by which it is specified are closer than is necessary. That this is the case with British Standards for burettes, measuring cylinders and delivery pipettes is shown by the fact that these specifications are now undergoing revision for relaxation of some of the tolerances. Hand-made glass apparatus is expensive and its dimensional reproducibility may be low unless excessive time is taken in manufacture. Moulds can be used to overcome this if the quantities justify such a course and if other factors permit it.

The object of the B.L.W.A. Technical Committee has been to provide standard blue prints of chemical apparatus in common demand, the dimensions on which are such as to ensure reasonable interchangeability by specifying tolerances which can readily be achieved in manufacture without excessive cost. The method adopted in this work may be illustrated as follows:

(a) Rationalisation. Rationalisation has been defined as the scientific organisation of industry to ensure the minimum waste of labour, the standardisation of production and the consequent maintenance of prices at a constant level (O.E.D.). As applied by the B.L.W.A. it consists in the re-examination of the range of types and sizes offered, with the object of determining the minimum number which can efficiently fill the requirements of users, and of eliminating such irrationalities as, e.g., the No. 00 designation of different Inakers having diameters and/or capacities which may differ by as much as a factor of 2. After sales data have been considered and users and manufacturers have been consulted, one of three courses may be taken:

(i) Non-dimensional rationalisation may be effected, where makers are recommended to concentrate production on the sizes which the sales data have shown to be in greatest demand. No alteration of dimensions may be contemplated here, since frequently the investment in moulds is heavy. A case in point is that of beakers and flasks already mentioned.

(ii) The question may be considered whether any better apparatus is known to have been described since the date of the original. Liebig condensers may be used to illustrate this point. The traditional Liebig condenser has a wide jacket, but the Liebig-West (Ind. Eng. Chem., 1928, 20, 737) has a narrower jacket, uses less glass, secures a higher velocity of flow of cooling water for a given consumption, through the narrower annular space, and is likely to be easier to support and more convenient in use. This improved condenser has therefore replaced the old type of Liebig condenser.
(iii) The possibility of making simpler and cheaper apparatus by the use of newer materials now available may be explored.

From all this there may come answers in the affirmative, following which a new design can be evolved in the B.L.W.A., leading to the preparation of a Technical Committee drawing (T.C.D.) and ultimately to the publication of a British Standard.

The answers may, however, be in the negative and no improvement on, or modification of, the original may be considered practicable with the knowledge available. Despite this, however, advantages may still arise from the preparation of a T.C.D. which, adopted by the industry as a whole, makes practice uniform throughout the country. Users then have the satisfaction of knowing that replacement parts from any source of supply which observes the dimensional requirements will fit the original. The Esbach albuminometer was considered by the B.S.I. to lack the accuracy of results which would justify the publication of a British Standard. However, much confusion existed among makers about the correct basis of calibration and graduation; after the manufacture of samples and their test by independent laboratories, a T.C.D. was issued for use by the industry, which at least ensures the uniformity of albuminometers in the hands of all users.

(b) Standardisation has a number of possible methods of treatment, which must be selected in accordance with the type of apparatus to be "standardised."

(i) Dimensional. Dimensions are laid down in the Handbook published by the I.P., the B.S.I. and the S.T.P.T.C., and the liaison between the user and the manufacturer is becoming increasingly close. This method has all the advantages already enumerated and is welcomed by the manufacturers. Cases of difficulty, however, arise. Bomb calorimeters, if completely dimensionally specified, could not include the features of design of all the different manufacturers in the country; yet if such a specification were produced, manufacturers could not be expected to drop their own, perhaps patented, apparatus, and a rigid standard might lead to stagnation in design. Hence we proceed to:

(ii) Functional specification. The bomb calorimeter standard specifies that the bomb is to have a capacity of not less than 300 ml., to be charged with oxygen to 25 atmospheres, and is to have a water-jacket with a capacity of not less than five times the thermal capacity of the calorimeter. On the remainder of the specification the ingenuity of the manufacturer then has full play in devising improved methods of rendering the bomb pressure tight, of supporting the crucible, of making the electrical connections, of providing an efficient stirring apparatus with a
low rate of temperature rise due to the energy communicated by stirring, and in studying convenience in use. This type of specification, provided the functional specification is clearly defined, is acceptable, but great care must be exercised in drafting it.

(iii) Performance specification. Some types of apparatus do not lend themselves to this method of treatment. If we take for example B.S. 1033 “Priming Paints, lead base, for the protection of steel sheets,” Fig. 2, Corrosion Chest for Paint Testing: the “specification” merely provides a rectangle indicating the oven wall and an infinity sign to indicate fan blades. Water in the base of the chest is heated and is intended to cause the chest to operate between 42° C. and 48° C. No period for the cycle is prescribed and the performance details given are quite inadequate to enable manufacture to be undertaken without a great deal of experimental work, which may not be justified where, as in this case, a very limited market is to be served. In that event one traces, through the B.S.I., the parties who originally sponsored the design as specified—only too frequently to find that the specification was based upon a piece of research equipment, which is no longer available as it has been taken to pieces and used to build some other equipment!

6. Conclusion

Enough has now been said to show that the standardisation of a wide variety of chemical apparatus is actively in hand; that dependence of this country on Germany as a source of supply for chemical apparatus has largely been overcome and that the United Kingdom has a vigorous laboratory apparatus industry alive to the need for improvement; that co-operation between the standardising bodies is close; and that benefits to both maker and user accrue from standardisation.

It is altogether to the good that the work which is being done should be more widely known. There is a great body of knowledge and experience amongst the scientists of the country, which can be brought to bear upon the question of apparatus designs, so as to effect improvements upon traditional types and assist the production of better, more efficient and standardised chemical apparatus.
THE PREPARATION OF STANDARDS

By R. Duncafe

(Chairman, General Council, British Standards Institution)

I must say at the start that I am a profound believer in the contribution which wise measures of standardisation have made, and can continue to make, to the efficiency of industry, the quality of our goods and a better standard of life for our people. I am therefore sure it can prove a powerful aid in the problems which face our nation to-day.

I am equally sure that in the industrial field standardisation must be a function which is discharged by industry itself with all the guidance and help it can secure from science, Government, producer and consumer. Further, that for this purpose a body such as the British Standards Institution is essential to co-ordinate informed opinion and to provide a suitable platform for discussion, and proper representation on democratic lines of all the interests concerned in any specification, as well as the trained staff to service its committees engaged in formulating standards.

The early history of standardisation is lost in the mists of the past. I shall not attempt to follow Mr. Good through those fascinating fields of long ago when the immortal gods were called to human aid in the standardisation problems of those days, so that their names and characteristics were used as symbols for the precious metals and the more virulent salts; too close an investigation into the family life and morals of Olympus would be needed! I must, however, remark that the silver symbolised by Venus could not, if I have correctly understood the life story of that most charming goddess, have been of such purity as would conform to modern standards, whilst Jupiter’s different modes of presentation—a swan, a bull, and even a shower of gold, for instance—would have posed a problem as intractable to a B.S.I. Technical Committee as it was dangerous to a number of self-respecting and unsuspecting ladies!

I wonder, however, whether you appreciate the extent to which mankind had developed standards in Roman days—standard roads so good that they remain to this day; obviously standardised mortar (or ought I to call it cement?) for the construction of their buildings which have withstood the storms of 2,000 years so that their Pharos still looks over the Straits of Dover. Time does not permit me to enlarge upon the steps which led up to the standardised Roman coinage, or to the Julian Calendar which has persisted, with minor alterations, for nearly 2,000 years. You will not expect me to deal with the preparation of these standards: I will only say that there must have been some pretty good committee work in those far-off days!

Agreed standards of weights and measures have existed over many centuries, and the study of their creation and development would provide
ample material for a paper on this subject alone: I must not, however, dwell upon this theme to-day.

No paper on standardisation in the chemical field could fail to make mention of that monumental work, the British Pharmacopoeia. Whilst there is little doubt that, at certain points, its work and that of the B.S.I. tend to converge, I am satisfied that in the main these two are complementary; certainly, their methods of approach are similar, and the honesty and sincerity of purpose running through their work places both on a high pedestal of disinterested effort. Our discussion may indicate views as to the definitive field for each, and I should be most interested to learn more about the procedure by which the British Pharmacopoeia is revised and kept up to date.

Reference must also be made to the great work by men of science over many years which has given us those generally accepted methods of chemical analysis without which we could not test the composition and purity of chemical substances. Whilst the B.S.I. in its British Standards always adopts as far as possible those methods which are in general use, we are often compelled to define them and are on occasion forced by special circumstances to supplement and extend them, in order that our standards of quality and performance may be made clear. On these occasions we get the greatest help from your Institute, the Society of Public Analysts and the other scientific bodies.

Before I explain how we prepare standards, I must say a word about the structure of the B.S.I., which was formed in 1901 and incorporated by Royal Charter in 1929. It functions under a General Council of about 70 members, which elects an Executive Committee of about 15 and a Finance Committee of 8. Under the general jurisdiction of the Council the work is controlled by 4 Divisional Councils—Building, Chemical, Engineering and Textile—each composed of the elected representatives of the Industry Standards Committees included in the Division and of members nominated by Government departments and national scientific, professional and technical institutions.

This afternoon we are more particularly concerned with the Chemical Divisional Council. My informed audience will know that there is no generally accepted definition of what constitutes the chemical industry, but in constituting the Chemical Divisional Council of the B.S.I. we have adopted a very wide one which at first sight may cause you some surprise. The following Industry Standards Committees are represented upon it: Adhesives; Dairying; Disinfectants; Fine Chemicals; Glass; Heavy Chemicals; Leather; Oils, Fats and Greases (other than petroleum and tar) and Soaps; Paper; Pest Control Products; Petroleum; Photographic; Pigments, Paints and Varnishes; Plastics; Rubber; Tar Products; Wood Preservatives. Members are also nominated by the Department of Scientific and Industrial Research, the Association of British Chemical Manufacturers, the British Pharmacopoeia Commission, the General
Medical Council, the Royal Institute of Chemistry, the Society of Public Analysts and Other Analytical Chemists, as well as by Government departments.

The demand for new standards usually comes from the industries concerned or from the distributing trades or users. Any one of these groups—frequently operating through a trade association—first communicates with the British Standards Institution, setting forth its members' views as to the need for a particular standard.

When a standard is proposed from any quarter the proposal is submitted to the relevant Industry Standards Committee, which, after due consideration, calls a conference of all the interests concerned—the industry, the distributors, the users (including Government departments), and the professional bodies—for the purpose of confirming, or otherwise, that there is a sufficiently widely expressed need for such a standard. Thus, there is no further work unless there is the need for it. Given the need, the Industry Standards Committee then proposes the formation of a Technical Committee, representing all the relevant interests, to set about the task of studying the field and formulating a draft standard. The proper representation of Government, scientific and technical institutions, producers and consumers is of fundamental importance, and the Committee is so constituted. Following confirmation by the Divisional Council, the Technical Committee is set up and arrangements are made for its service by the technical staff of the Institution. I must make it clear at this point that in all the work which follows it is the Committee which reaches the decisions and not the B.S.I., whose functions are confined to providing trained service to the Committee and to assistance in interpreting its decisions.

The Technical Committee has to consider the form the standard will take, whether the standard relates to form or quality or performance, or all of them, and whether adequate methods of test exist and are defined sufficiently closely to render the standard precise. Much investigation is often required at this point, and it frequently happens that the first standard is that of methods of test, either of performance or physical or chemical qualities. Correct methods of sampling are of equal importance and have to be carefully laid down. However, the various problems are usually surmounted and a draft specification is thrashed out by general agreement as a result of full debate. Standards are not passed by majority vote. You may ask what happens if a section of the Committee is out of harmony with the rest. Do the members resign? Does the whole Committee dissolve? This seldom, if ever, happens, and although differences of opinion frequently occur they are nearly always ironed out. It is an interesting fact within my own experience that Technical Committees which have started in an attitude of extreme doubt and hesitancy have found that as the work proceeded they have secured a surprising unanimity, with the result that the members of the Committee have been the foremost protagonists of the standard which they themselves evolved.
The standards which thus emerge are eminently practical ones which can be adopted by the majority of those concerned, and it is an interesting psychological point that whereas people dislike to have a standard imposed upon them they willingly conform to a standard formulated by their own accredited representatives.

When a Technical Committee has finally evolved a draft Standard, this is circulated to all interested parties, including the Standards bodies throughout the Commonwealth, and an appropriate period (normally three months) is given for their comments, which are again considered by the Technical Committee; this Committee then formulates the final draft and submits it via the Industry Standards Committee to the Chemical Divisional Council before it is published. In order to secure publication, the authorisation of the following Committees is required in the order stated:—(1) the Technical Committee; (2) the Industry Standards Committee; (3) the Divisional Council; (4) the General Council.

You may consider this a rather cumbrous procedure, but it provides a very necessary safeguard and does not involve any serious hold-up of draft standards when once they have been approved by a Technical Committee. The control operates smoothly; only important questions of principle are referred to meetings, any points of difference being finally referred to the judgment of the Executive Committee, subject to the overriding authority of the General Council.

It will perhaps give some impression of the magnitude of the work when I tell you that in the B.S.I. we have nearly 2,000 Committees, with a membership of over 12,000; we average about 50 meetings a week; we have 1,500 Standards actively in use; we distribute about half a million copies a year; and our present annual expenditure is about £150,000. Under the Chemical Divisional Council and its Industry Standards Committees we have 240 Technical Committees which have already issued 275 Standards and have 210 new or revised ones in preparation at the present time.

There remains one further aspect of our work which I have not yet mentioned, namely, our work in the international field. This is of great importance, and in view of the reference which has been made to the need for international collaboration in the field of chemical standardisation, I ought to refer to it briefly. The B.S.I. has, from its earliest days, been responsible for a great deal of work in the international field. It is a founder member of the International Organisation for Standardisation and participates in the work of any other responsible international organisation interested in standardisation. In most cases, the Industry Standards Committee of the B.S.I. or the Technical Committee for a particular subject acts as the British National Committee, co-ordinates the British viewpoint and nominates delegates to international discussions.

It has been stated that UNESCO is interested in the standardisation of terms and definitions, and other branches of the United Nations and
Western group of nations are becoming actively interested in standardisation matters. In the view of the B.S.I. it is essential that there should be an effective national organisation behind international discussions on standardisation. It is important that industry and those participating in our work here should know in advance who will represent the views of this country in international discussions, and that those attending meetings should get into touch with the B.S.I. before delegates attend the meetings.

I claim that our structure, continuously evolving, provides an outstanding example of how to secure that enterprise—private, governmental and scientific—works in the national interest in a way which is transparently clear to all. By its independence of any one interest it secures the support of all, and avoids two handicaps—the first, that standards prepared by one interest, whilst they may be good, are sometimes apt to be looked at with some suspicion in other quarters; the second, that standards prepared by Government tend to be viewed with some measure of distaste. Certainly under our system British Standards have achieved world-wide recognition, forming important instruments of trade and commerce, providing valuable aids to production, and defining technical requirements for regulations made by Government and Local Authorities. It has set the example for standardisation throughout the world.

I ought to add that the use of British Standards is entirely voluntary; we neither exercise nor attempt to exercise compulsion on any person to adopt them. I hope you will appreciate from what I have said how truly democratic is the constitution for the preparation of British Standards by our Institution, and that you will perhaps agree with me that the B.S.I.—an autonomous and independent body which exists to provide, firstly, a trained technical staff well versed in standardisation, and secondly, a platform for informed debate and full criticism by all interested parties before a British Standard is launched—has evolved over 50 years, and for a specific purpose, a process which is very much akin to the thoughts and aspirations of the British people, which is entirely compatible with our ideals of freedom, and which is one example of a system which should be more widely developed throughout our British polity.
MR. P. KERR said: Nearly 30 years ago, the Institute of Petroleum began to standardise the methods used in sampling, measurement, analysis and testing of petroleum and its products. Under its Standardisation Committee 60 sub-groups now keep up-to-date the 600 pages of its book of "Standard Methods" and add new methods as developments demand. The substances dealt with range from gases, through spirits, oil and viscous liquids, to semi-solids and solids, some plastic, some rubber-like and some brittle. The Institute does not prepare specifications, either for petroleum products or for equipment, preferring in this not to duplicate, but to contribute to, the good work of the British Standards Institution. That Institution has accepted nomination of Institute representatives to about 120 seats on its Committees concerned with such questions.

Unsaturated hydrocarbons derived from petroleum are now used as raw materials for commercial chemical syntheses. Most of the resulting chemicals are substantially pure compounds, so that I can add little on this side to matters previously discussed. Petroleum itself, however, is a highly complex mixture, and even after the usual processes of fractionation and refining, most of its commercial products are still very complex. Several standard methods must generally be available for the measurement of any one physical constant, since the materials concerned range from gases to solids. Through research work sponsored by the Institute, great progress has been made in the spectroscopic examination of hydrocarbon mixtures, but the methods developed have not yet been standardised, largely because of the great complexity of commercial products. There is a strong and growing preference for the measurement of absolute rather than empirical properties; but the difficulties are such that many of the standard tests on petroleum are still empirical, and not infrequently equivalent to practical trials of the material concerned.

It is easy to devise empirical tests; it is extremely difficult to secure that any such test will be really satisfactory, widely applicable and informative. If it were not for the continued activities of our Standardisation Committee it is certain that, instead of having a single test for a single purpose, one would be faced with a choice between several such tests, all much less thoroughly investigated and understood. Standardisation is of course not an end in itself; it must pay, taking payment in a wide sense. Here the economies are obvious; less apparatus is needed in total, fewer failures need be investigated, and there is less risk of disagreement between buyer and seller. The Institute's aim is to provide a thoroughly investigated and reliable test in all cases where this is needed, neither omitting any test which is desirable nor including unreliable variants. A wide series of satisfactory tests has been produced, but an equally important result is that many unsatisfactory tests have been considered and eliminated.
Experimental work on new tests is now planned statistically at an early stage and results are submitted to statistical analysis. Earlier methods were not worked out so strictly and their revision to the newer basis will of course take some considerable time. A small but active Editorial group ensures that the text of all methods conforms to agreed general standards and arrangement; while Apparatus groups, which include representatives of the various apparatus manufacturers' associations, pass all new apparatus and keep older apparatus under review.

Much successful work has been done in standardising methods for sampling and measuring petroleum; much of this work, notably the methods for preparing capacity tables for tanks, has wide application to chemical liquids other than petroleum. Tables for the measurement of oil have been published; these are now the accepted standards in this country, and in many areas abroad, for the reduction of oil volumes to standard temperature and for the calculation of the weights of bulk oil quantities. These tables are now nearly out of print; a further and more complete set of tables is being prepared in close co-operation with the American Society for Testing Materials and with various Continental authorities. These new tables will be published jointly by the American Society mentioned and the Institute of Petroleum; it is possible that some metric authorities may also join in their sponsorship, since in addition to tables in American and British units, parallel tables in metric units will also be provided. Under Institute sponsorship, a general Manual of Oil Measurement Procedure will also be published. An Electrical Code, prepared by a sub-group of our Engineering Committee, has been published for comment; this lays down the special precautions in electrical matters which should be taken on oilfields, in refineries, in storage and marketing installations and in any places where similar risks arise.

Early criticism of proposed methods is always an advantage; for this reason, and for many others, the co-operation in our standardisation work of all those associations interested in petroleum or its applications is actively sought. Many of our Standardisation groups include representatives of Government departments, of users of petroleum, or of those organisations whose interests and problems run parallel with our own.

It would take much too long to describe here the work and methods of the 60 groups concerned, but this information will be made available to anyone interested. I am asked to make it clear that the Institute of Petroleum is ready to co-operate on any problem involving petroleum or its applications, either by inviting representatives of organisations interested to join in the work of its groups, or by nominating to membership of similar groups in other organisations one or more of its corporate members who have the specialised knowledge and experience required.

Miss M. OLLIVER drew attention to the importance of international standardisation of laboratory methods, particularly in the food industry. For example, there were a number of countries producing pectin and
each had its own method of assessing and grading pectin, with the result that the food industry experienced considerable difficulty in obtaining a clear picture of the quality of pectin offered.

Miss E. I. Beeching asked Mr. Powell if it was possible for laboratory suppliers to produce universal stopcocks. Universal ground-glass joints were now commercially available, so why not universal stopcocks? Secondly, she asked if there was a demand for Soxhlet extractors with the syphon tube inside the body, to avoid breakage of the syphon arm. Thirdly, in connection with Dr. Garratt’s contribution, she referred to the need for specifying the concentrations at which analytical tests should be made.

Mr. Powell, replying to Miss Beeching’s points, stated that it was not possible to provide universal stopcocks, although steps had been taken to standardise sizes. Owing to continual rotation, the taper of both the key and the barrel of stopcocks altered during use, so that a new key would not fit an old barrel. Also, again due to wear in use, the bore through a standardised replacement key would not align with the holes in the barrel of the original stopcock. A new specification for stopcocks was under consideration and the National Physical Laboratory was considering a test whereby the leakage of stopcocks could be assessed and defined. On the subject of Soxhlet extractors he stated that internal syphon arms had been considered and rejected for general use. It had been found that, although they were less liable to breakage than the external arm, yet, once broken, they were more difficult, if not impossible, to repair. Internal syphon arms might become a commercial possibility if an easy method of repairing them could be found.

Dr. Garratt, dealing with Miss Beeching’s point concerning the specification of concentrations in analytical tests, pointed out that omissions of this kind from a specification were often a source of annoyance to analysts and other chemists. He suggested that this difficulty could be overcome by adopting the American practice whereby a new specification was registered as “tentative” for a given period. This enabled the method to be tried out by a large number of chemists and practical difficulties to be discovered and rectified; when the specification had survived a searching practical test of this kind, and not until then, was it registered as a “permanent” specification.

Mr. W. Kirby referred to the work on standardisation carried out by the Association of Tar Distillers. Prior to the 1914–18 War, tar distillation was a closed trade, works visits were discouraged and there existed no collaboration on testing between works. The result was acute disagreement in results. During World War I the Association’s Standardisation Committee was set up and standard tests were accepted; these had proved useful to the trade as a whole. The Association was now in the course of
the third revision of its compilation of Standards Methods. In this work it was receiving the valuable and continuous co-operation of the British Laboratory Ware Association and of the British Lampblown Scientific Glassware Manufacturers' Association. The two largest distillation industries in the country, tar and petroleum, were bound to overlap in much of their testing technique; a suggestion that a certain amount of collaboration in the standardisation of apparatus would be mutually beneficial was warmly welcomed by the Institute of Petroleum and this collaboration now took place. The biggest difficulties were found not in analysis but in sampling and the Mathematical Department of the National Physical Laboratory had been assisting in this problem and in the statistical evaluation of differences in analytical results. As examples of the work that had been carried out he mentioned that the Association had worked out standard leakage rates for stopcocks, similar to those mentioned by Mr. Powell, and, following American practice, the introduction of tentative specifications was being considered until a new method had been proved satisfactory. There was one respect in which the use of standard methods might be misleading: for example, in the estimation of calcium oxide in limestone there could only be one true result and the fact that a standard method was used did not necessarily mean that the result obtained was the true one.

Mr. H. J. Tabor, following Mr. Kirby's line of thought, said there was danger of confusion in what was meant by a standard method. There could only be one true result, and what industrial laboratories were concerned with was by how much results deviated from the true result. He agreed with Mr. Kirby that standardisation in sampling was as important as standardisation of analytical methods. He thought that analytical methods should be open to periodic revision: for example, the introduction of methods using X-ray technique might invalidate some of the previous analytical methods. As regards physical methods, he considered that it would be of advantage if instruments could be provided at lower costs. Simpler forms might perhaps be preferable and possibly the system of interchange of patents which existed in the radio industry could be applied. He thought that there was room for standardisation of types of product and mentioned the steel industry, where steels were classified into some 50 types covering all desired properties.

Mr. Powell, in reply, said that he shared Mr. Tabor's apprehension about the cost of apparatus, but the costs which manufacturers had to bear must be taken into account. They had to carry an appreciable research organisation; instrument makers and glassblowers were paid high wages; and overheads had increased considerably. On the other hand there might be no need to pay, say, £120 for an absorptiometer. There were simplified forms which might be suitable for the type of work envisaged. In some cases it was possible for the user to make simple instruments in his own laboratory.
DR. GARRATT, also replying to Mr. Tabor, said that there seemed to be confusion between standard methods and specification methods. He had hoped he had made it clear that in his opinion a standard method did not require revision; a specification method might. The two were quite distinct.

MR. DUNCALFE, commenting further on Mr. Tabor's remarks, thought there was a danger of confusion in nomenclature. In the case of British Standards tests, in order to arrive at methods of test by which products could be judged, it was always necessary to consider improvements.

DR. GARRATT then stated that, in view of these arguments, he considered that really Mr. Duncalfe and he were in agreement.

MR. KIRBY, in support of Mr. Tabor, instanced the old British Standards tests for creosote which had been improved by the Association of Tar Distillers.

MR. TABOR, elaborating his earlier arguments, pointed out that a standard method might have been gravimetric before the development of the analytical use of X-rays, which might have shown that a substance thought to be pure was in fact impure: that meant a revision of the standard.

DR. GARRATT, replying to these further points, said that if analysis was based on stoichiometric factors, there existed a fundamental basis which could not, in his view, lead to standard methods being upset or modified subsequently.

MR. A. G. D. EMERSON enquired whether any standardisation was contemplated in the field of chemical literature. The chemical literature was a tool used by all chemists. Often difficulties were caused by reference books being printed with a large page-size which took up an inordinate amount of space when the book was opened. At the other end of the scale, some volumes were in small page-size, and were too thick to use comfortably. At the present time trade and technical journals were printed in a variety of page-sizes; this produced a ragged appearance on the library shelf and made grading and classification difficult. On the question of presenting tabulated data he urged that some standard procedure should be adopted, preferably with the tables at the end of the book where they could easily be located when required for reference purposes. Turning to sketches and graphical presentation of data he deplored the fact that so many chemists were ignorant of the simple drawing-office conventions for preparing graphs and sketches: he urged that chemists should become acquainted with the British Standards relating to such matters.

MR. GOOD, in reply, stated that standards already existed for eight different sizes of books, but he considered that at the present time the paper shortage prevented their wider adoption by publishing houses.
MR. J. HASLAM warned members present of the danger of over-emphasising standardisation in chemistry. He considered that more real progress was likely to accrue from research and investigation, than by standardising methods; above all things, standardisation of the mind must be avoided.

MR. A. L. BACHARACH recalled the remark of the late Mr. J. H. Coste, who thought that there were disadvantages in the “standardisation” of analytical methods, because if two analysts got the same result by two different methods they were more likely both to be right than if they got the same result by the same method! A “standard” method—which need by no means necessarily be the routine method, for it might be too cumbersome for everyday use—must be the one giving the greatest accuracy (nearness to the true or absolute value) and precision (reproducibility)—using the two words in the senses recommended by the A.C.S. The accuracy of an analytical method could be increased as the result of research, but precision might be increased by standardising technique. He thought that the use of the description “standard method” was in any event open to objection. The results found by analysis were dependent on atomic weights, which were subject to periodical revision. An absolutely true result could never be guaranteed, but only the most accurate one attainable at a given time, so that it might be better to speak of specified or recommended or standardised methods. He was repelled by the thought of completely standardised books and journals, for there was in their production at least an element of art or craftsmanship. The B.S.I. had already assisted in attempts to reduce somewhat the range of sizes and shapes: they had also issued a specification on proof correction and similar matters. Under what Division did such miscellaneous specifications fall? He agreed that there was much room for improvement in the manner of presenting tabulated and graphical material, particularly as submitted by many authors, but this was an editorial responsibility. It was often found worth while to employ a professional draughtsman to act as a buffer between author and printer.

MR. GOOD, dealing with Mr. Bacharach’s point on miscellaneous specifications, pointed out that there were four main Divisions in the B.S.I. co-ordinating the work of Industry Standards Committees: in addition there were a number of committees responsible direct to the General Council, and the specification cited by Mr. Bacharach would be dealt with by one of these Committees.

DR. GARRATT, replying to the suggestion made regarding analytical results and their dependence on atomic weights, agreed with Mr. Bacharach that, from this view point, there could be no such thing as a standard method.
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