data have been known to lead to great losses in industrial enterprises, and to much wasted effort in research investigations.

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The National Standard Reference Data System*

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The National Standard Reference Data System is a government-wide effort to give to the technical community of the United States optimum access to quantitative data on the physical and chemical properties of substances and their interactions, critically evaluated and compiled for convenience. The general functions of the system are to coordinate and integrate existing data evaluation and compilation activities into a systematic, comprehensive program, supplementing and expanding technical coverage when necessary, establishing and maintaining standards for the output of the participating groups, and providing mechanisms for the dissemination of the output as required. The plan of operation and the general status of activities initiated by the National Bureau of Standards are described.

"Of course, it's important, but I wouldn't want to do it myself." This is a view of data compilation activities expressed by many, or perhaps most, scientists when their possible interest in undertaking a particular project is discussed with them. It is significant, however, that this is probably not the view of many of the leading and most creative specialists in most fields of physical science.

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Their view is perhaps better expressed this way: "Of course, it's important and I want to do some of it myself, but not full time."

The latter attitude is a recognition that an essential and normal step in the advancement of science is the independent and objective review by specialists of the work of other scientists in their field. Indeed, the report of any experimental investigation is not complete and is usually not accepted for publication if the author does not show that he is adequately aware of related work by others, and that he has evaluated the similarities and differences between his own and the earlier results. Systematic data compilation projects are simply an extension of this normal process of science so that it constitutes a larger fraction of the normally diverse workload of the individual scientist.

Hundreds of individual scientists recognize the importance of critically evaluated data compilations, and especially the fact that carrying out data evaluation and compilation projects helps make them more productive scientists. This recognition makes the concept of the National Standard Reference Data System a practical one.

This paper describes the National Standard Reference Data System, a recently established systematic effort by the technical agencies of the Federal Government, under the leadership of the National Bureau of Standards, to evaluate and compile quantitative information on the physical and chemical properties of substances and their interactions. Knowledge of these properties is of such varied and important use that compilations of data have been a familiar tool of scientists and engineers almost as long as there have been people who called themselves scientists and engineers. Numerous compilations have been produced, largely in response to an urgently felt need of some part of the technical community. Some compilations were one-shot projects resulting in a product that was never updated; others have been continuing activities lasting over many years. In recent years, some have been sponsored by mission-oriented agencies of the U. S. government; others have been sponsored by private organizations. There was no coordination or standardization of format or quality, and in some technical areas there was extensive duplication. Perhaps of most importance, the rate of appearance of new data in the world's literature in most fields was, and still is, far greater than the rate at which the data are extracted, evaluated, and compiled for general use.

During the past several years, murmurs of concern over the situation rose to a clamor that something be done. Committees of the President's Science Advisory Committee and of national professional societies carried out studies and made recommendations (*1*). The National Academy of Sciences endeavored to stimulate new and expanded activities through its Office of Critical Tables (*2*). Mission-oriented agencies initiated crash projects to satisfy long-standing needs of which they became newly aware (*3*). The Coordinating Committee for Materials Research and Development of the Federal Council for Science and Technology urgently recommended that a comprehensive program be started. The National Bureau of Standards laid plans for increasing the level of effort in its organization.

ESTABLISHMENT OF THE NATIONAL STANDARD REFERENCE DATA SYSTEM

Recognition of the problem and the cost to the nation of failing to solve it are the reasons behind the recommendation that a National Standard Reference Data System be established. This system came into being in 1963 through action of the Federal Council for Science and Technology and the President's Office of Science and Technology (*4*). It is envisioned as the total group of activities within the Federal Government, as well as all private organizations that wish to participate, leading to the production of systematic compilations of property data. Responsibility for its administration was assigned to NBS. The National Standard Reference Data System is considered to be one of the components of a broad national scientific and technical information system now being developed by the Committee on Scientific and Technical Information (COSATI) of the Federal Council for Science and Technology.

Briefly, the responsibilities of NBS are the following: (1) promote compilation of evaluated data; (2) coordinate related work under the auspices of all government agencies; (3) establish standards of quality for all products of the system; (4) operate a National Standard Reference Data Center at NBS; and (5) establish standards of methodology and such other functions as are required to ensure the compatibility of all units of the National Standard Reference Data System.

The National Bureau of Standards is undoubtedly the appropriate organization within the Federal Government to undertake this responsibility. Compilations of critically evaluated data have been among the valuable products of NBS for many years. Indeed, this type of activity is specifically authorized in Section 2 of the Organic Act of the National Bureau of Standards, which states, "In carrying out the functions enumerated in this section, the Secretary is authorized to undertake the following activities and similar ones for which need may arise. . . : (19) the compilation and publication of general scientific and technical data resulting from the performance of the functions specified herein or from other sources when such data are of importance to scientific or manufacturing interests or to the general public, and are not available elsewhere. . . "

GOALS AND PLAN OF OPERATION OF NSRDS

The over-all goal of the National Standard Reference Data System is to provide to the technical community of the United States optimum access to critically evaluated quantitative data on the physical and chemical properties of substances and their interactions. The coverage is to be comprehensive, timely, and readily accessible.

Within the National Bureau of Standards the responsibility for administering the National Standard Reference Data System has been assigned to the Office of Standard Reference Data created for that purpose within the Institute for Basic Standards. The Institute for Basic Standards is one of the three institutes comprising the National Bureau of Standards; the others are the Institutes for Materials Research and for Applied Technology.

Three major groups of activities within the Office of Standard Reference Data have been initiated; these are concerned with: (1) the planning and implementation of a series of data compilation activities organized according to technical scope; (2) an information systems design and research activity; and (3) a variety of specialized information services to be provided to the technical community by the Office of Standard Reference Data.

In order to develop a comprehensive plan of operation, it is necessary to decide which fields of science and technology should be included in the scope and, in those fields, which kinds of data are appropriate for collection and evaluation. These decisions have been made in general terms, recognizing that in many specific instances the question of appropriateness of inclusion of a particular kind of data will not be easy to answer. First, it has been decided that the program will be concerned only with physical phenomena. Phenomena in which biological effects are a significant factor will not be included. Second, it has been decided that the term "Standard Reference Data" would be defined as follows: Standard Reference Data mean critically evaluated quantitative information relating to a property of a definable substance or system.

Operationally, these guidelines mean that the NSRDS shall not be concerned with the compilation of data relating to systems of uncertain, variable, or uncontrollable composition nor of data that are sensitive to unknown details of the structure of the material. This principle carries with it the corollary that a system or material may be well-defined for one property but not for another. In putting this principle into practice, the program of the NSRDS must include careful examinations of the available data in a variety of fields in order to determine whether the data are appropriate for systematic compilation activities; that is, a critical review of the state of quantitative knowledge is first required.

Application of the general guidelines also leads to the exclusion from the NSRDS of data whose value depends upon both the system or substance being measured and the measuring technique itself—in other words, data which are not characteristic of intrinsic properties of the system or substance. It is recognized that many such types of data have important applications and that the development of a separate, additional comprehensive program for their compilation is worthy of serious consideration.

Additional types of data not considered appropriate for systematic activities in the system are those that relate to proprietary materials, those that have validity for only a limited time, and those that relate to materials which are of interest only for highly specialized commercial purposes.

In developing and operating the data compilation program up to the present time, the Office of Standard Reference Data has established activities in seven broad categories of properties: (1) nuclear properties, (2) atomic and molecular properties, (3) solid state properties, (4) thermodynamic and transport properties, (5) chemical kinetics, (6) colloid and surface properties, and (7) mechanical properties. In each of these, responsibility for developing a comprehensive, coordinated program has been assigned to a Program Manager. Existing projects of other governmental and nongovernmental agencies are taken into account and project priorities are determined by consultation with groups of specialists from the academic world, from government, and from industry. One technique for consulting the technical community is a questionnaire on needs. Another paper in this symposium describes the results obtained when we asked the membership of the American Chemical Society how well existing compilations met their needs and what else they would like to have that they don't now have.

Some of the data compilation projects under the cognizance of the NBS Office of Standard Reference Data are conducted within the experimental divisions of the National Bureau of Standards; others are in university laboratories or in other government laboratories; a few are in industry. None is under the direct operational supervision of the Office of Standard Reference Data, which is exclusively for program management. The data evaluation and compilation activity is normally conducted as part of the on-going program of a productive experimental group, with an established reputation for competence and vigor. Data evaluation can only be done adequately by a specialist in the field, a person of mature experience whose judgment is respected by other experts.

The Information Systems Design and Research component of the NBS Office of Standard Reference Data focuses its attention on the problems of handling data, on communications and connections between data centers, and on the technology (hardware and software) required to make the data storehouse most available to the user in the U.S. technical community. A detailed outline of our present view of the long-range target system for handling data within our own office has recently appeared as an NBS Technical Note (5).

To place the information systems design into practice, a variety of services is being planned, making use of the storehouse of data in the NBS National Standard Reference Data Center in Washington. This storehouse will eventually contain a complete collection of compilations of critically evaluated data produced throughout the world. The services in the planning stage include supplying replies to specific inquiries, preparation of a "current awareness" publication, operation of a library of computer tapes and programs, and preparation of special data handbooks as needed by a particular group in the technical community. Other services may be added as the need becomes apparent.

PRESENT STATUS OF THE NBS PROGRAM

Since July 1963 the National Bureau of Standards has conducted NSRDS activities along the lines of the plan of operation just described. The needs of the technical community have been explored in cooperation with panels of specialists in each of the technical areas previously mentioned, including program officers in other technical agencies of the Government. Significant progress has been made in coordinating and extending existing coverage in some of the technical categories, especially in the areas of thermodynamics and transport properties and in atomic and molecular properties (which have been judged to be of highest priority for additional effort). In the field of nuclear data, existing activities sponsored by the Atomic Energy Commission provide coverage of the most

important technical topics, although the level of effort needs to be increased to meet the rapid rate of appearance of new data. Greatly increased effort on newer kinds of solid state data (energy levels, band structure, interaction with radiations, etc.) has been recommended by the solid state advisory panel.

In the field of chemical kinetics the first stage of the program has been the preparation of a series of critical reviews of the state of quantitative knowledge in selected aspects of the field. The activities in the area of colloid and surface properties are the result of a cooperative relationship with the National Academy of Sciences–National Research Council Committee on Colloid and Surface Chemistry, which had been planning an extensive program of data evaluation prior to the establishment of the National Standard Reference Data System. A preliminary critical survey of the field of mechanical properties has been carried out in order to determine appropriate activities.

Continuing efforts have been initiated to establish and promote effective working relationships with program officers in other government agencies (such as Atomic Energy Commission, Department of Defense, National Aeronautics and Space Administration, National Science Foundation, National Institutes of Health, and others) in order that the National Bureau of Standards' program might be responsive to the needs of these agencies. In some cases jointly funded projects have been established. In others, Office of Standard Reference Data staff members have served as a means through which program officers in other agencies were able to locate the competent staff needed to undertake the compilation activities required for their missions. Steps have been taken to ensure that persons working in closely related areas are fully aware of each other's activities. The search for competent technical people willing to undertake data compilation and evaluation projects continues.

A summary report describing the status of the program has been prepared and is available from the Government Printing Office (*6*).

FUTURE OUTLOOK

The program of the National Standard Reference Data System is regarded by the National Bureau of Standards and its other participants and proponents throughout the Federal Government as a permanent feature of the nation's future technical activity. The pace of scientific and technological progress shows no sign of slackening; the need for systematic data evaluation can only increase. With the support and participation of the technical community and of the United States Congress, the National Standard Reference Data System can make a vital contribution to the health and efficiency of our entire national technical effort.

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Needs of American Chemical Society Members for Property Data*

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The mission of the National Standard Reference Data System is to provide the American technical community with critically evaluated data in the physical sciences. To fulfill its mission of administering the NSRDS, the NBS Office of Standard Reference Data has recognized it must tune its operations to the needs of the users of data. In its early planning stages, the Office of Standard Reference Data sought advice and counsel for this purpose from a small number of specialists. It was always evident that it would be important to obtain input from large cross sections of the technical community—for example, from the membership of the American Chemical Society. Such information would be valuable in determining prior-

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