is more precise information needed on existing knowledge; additional information is required on new scientific areas. The increase in scientific knowledge also necessitates a decentralized approach to the problem. The principle of cost-sharing and the need to locate experts in particular areas make international coordination in compilations of critically evaluated numerical data eminently feasible. International coordination avoids duplication of effort and, by setting up agreed standards of excellence, can often improve the quality of ongoing work. The result is often an upgrading of experimental work.

A recognized international plan also often makes it easier for national groups to obtain support for their work. While the sophistication necessary to produce data compilations of high quality in many large areas of science is found only in the major countries, it is recognized by ICSU and CODATA that smaller nations often excel in selected areas, in which they can make valuable contributions to the overall effort. Although the various national and international compilation projects and this particular ICSU endeavor have the same basic goal—production and dissemination of the highest-quality compilations of standard reference data—there is no danger of unnecessarily overlapping or duplicating areas of responsibility. The national or international operational programs are responsible for the funding and management of specific efforts, and obviously are not bound by international decisions by outside bodies. The international approach being undertaken by ICSU entails the provision of advice, stimulation, coordination, communications, standards, and assistance in the planned coverage of all areas.

I may note in conclusion that the initial success and enthusiasm surrounding this project have given hope for a related but much broader effort in the field of science information. By use of the CODATA experience as a model, a similar mode of operation is being contemplated with regard to a joint project that ICSU is undertaking with UNESCO. Working together, these two organizations hope to explore the feasibility of bringing about compatibility and voluntary coordination among the various components of systems of scientific information being planned or operating in various countries and various disciplines. Considerable attention is being given by many groups to the creation of systems for handling science information, but so far no concerted effort has been mounted to make systems compatible with one another so that information can be transferred between them. Systems barriers are being created between disciplines, languages, and differing computer technologies, and to some extent between nations. As each system evolves further, the difficulty of ensuring compatibility between them will increase. Therefore ICSU and UNESCO have agreed to study the feasibility of a worldwide system for science information; to this end they are preparing for the first of a series of meetings to outline the basic framework of the study. It is hoped that the experience gained from CODATA and the degree of cooperation that should result from present efforts will contribute to the success of this more complex and extensive project.

The National Standard Reference Data System

Edward L. Brady and Merrill B. Wallenstein

Improvement in the effectiveness of the nation's system for scientific and technical information is a matter of great popular concern these days. Much is being said and written about the flow of information from the generator to the user, and much is being done to try to speed the process. Taking the broadest possible approach, the President's Office of Science and Technology is examining all aspects of the problem (*1*).

The Chemical Abstracts Service of the American Chemical Society is in the midst of a long-range program designed to increase the retrievability of information within its concern (*2*). Similarly, the American Institute of Physics has embarked on a comprehensive study of means to make the world's output of information in physics more readily available to individual users (*3*); the Engineers Joint Council has a similar program (*4*). The Atomic Energy Commission, the Department of Defense, the National Aeronautics and Space Administration, and other major federal technical agencies are all increasing their efforts to improve the use of information generated within their programs.

These government activities are coordinated through the Federal Council for Science and Technology by means of its Committee on Scientific and Technical Information (COSATI), consisting of representatives of all government departments and independent agencies that have major technical-information programs. It was the initiative of COSATI and its parent council that led to establishment in 1963 of the National Standard Reference Data System, a federal interagency activity concerned with one aspect of the broad problem of scientific and technical information—improvement of access by the American technical community to compilations of critically evaluated data on the properties of substances.

Such compilations have been among the basic tools of scientists and engineers throughout the history of technology; each owns at least one handbook containing, among other useful information, table after table of data on the properties of the substances and systems that he deals with daily. Systematic compilations of data also contribute in a fundamental way to prog-

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ress at the forefront of science. Samuel Goudsmit (*5*) recently emphasized this importance with the following words:

> Experimental results in measurements are the backbone of physics. No theory is acceptable unless it agrees with the experimental data. Conversely, a systematic study of experimental results can suggest new theoretical approaches. Tables and graphs of numerical data therefore play an important role in the progress of physics. . . . It is thus obvious that specialized data compilations are of great importance and should have the full cooperation of those producing the data. It is also clear that modern computer techniques can handle such data more efficiently than old tabulations could, especially since their number and variety are growing so rapidly.

Since the numerical data that result from measurements of properties normally appear somewhere in the world's literature, why not let the individual scientist or engineer look them up whenever he needs a value? There are two major reasons why this procedure is not efficient: First, it is often very difficult to locate a desired value among the millions of papers stored in a technical library; searching indexes, abstracts, and papers can consume many hours. Second, conflicting values for the same property are often reported; unless the user is a specialist in the field, he will have difficulty in deciding which value he should use. These inefficiencies translate directly into money. If the average scientist or engineer were to save only 10 minutes a week that he now spends finding and evaluating data, the annual saving to the nation's research and development program would be of the order of $100 million. This estimate takes no account of the benefits of having better data, evaluated by an expert in the field, at hand when needed. Obviously, very significant economic benefits can be readily gained by organizing a coordinated, comprehensive program for reviewing the literature, extracting and evaluating the property data contained therein, and disseminating them in convenient form.

Because of their usefulness and economic benefits, many compilations of data (*6*) have been produced throughout the world, largely in response to urgent needs of the technical community. However, existing mechanisms have not been able to keep pace with the flood of new data appearing in the literature, except in a few specialized areas. Some compilations were "one shot" projects, resulting in products that were never updated; others have been continuing activities lasting many years. Some have been sponsored by mission-oriented agencies of the United States government; others, by private organizations. However, many newly recognized properties are not covered at all, and the time lag between the appearance of data in original literature and their evaluation for inclusion in a critical compilation has been rapidly increasing. Moreover, even in the areas covered by active projects there was little coordination or standardization of format or quality, and in some technical areas there was extensive duplication. The National Academy of Sciences, which in earlier years had been responsible for production of the widely used International Critical Tables, made an important contribution to coordination and stimulation through its Office of Critical Tables, but this office has neither directive nor resources to manage an operational program.

Recognizing the deficiencies of the existing situation and the stake of the U.S. government in the financial support of the nation's research and development activity, COSATI decided that a government-wide coordinated effort was needed; thereupon it recommended that a proposed plan of action for increasing the level of effort of the National Bureau of Standards in this field be expanded to encompass the total federal effort within all agencies, with administrative responsibility assigned to the Bureau. Adopting this recommendation, the Federal Council for Science and Technology and the President's Office of Science and Technology, then headed by Jerome Wiesner, promulgated a federal policy establishing the National Standard Reference Data System (NSRDS).

The NSRDS is regarded as a subsystem within the concept of the "National Measurement System" (*7*). The "National Measurement System" is envisioned as comprising a central core of national standards of measurement, a set of consistent instruments (calibrated through appropriate application of the national standards), a body of reference data that provides users with ready-made answers to questions on the properties of substances, and finally the entire set of meaningful measurements made throughout science, technology, and the economy. From this viewpoint, NSRDS is regarded as a portion of the activities leading to dissemination of ready-made data for use by the technical community of the United States.

Responsibilities of the National Bureau of Standards

In accepting the charge from the Federal Council for Science and Technology, the Bureau has taken responsibility for (i) promoting the general objective by sponsoring critical-evaluation and data-compilation projects as needed, (ii) coordinating related work under the auspices of all government agencies, (iii) establishing standards of quality for products of the system, (iv) operating a national center for standard reference data, and (v) establishing standards of methodology and such other functions as are required to ensure the compatibility of all operational components of NSRDS. The goals of NSRDS are to be achieved through operation of an integrated network of data-evaluation centers and related projects located wherever special technical competence for a particular project may exist.

Since data can be adequately evaluated only by specialists whose judgments are respected by their peers, each data center is to be concerned with a carefully delimited technical scope; normally it will be established as an adjunct to the work of an individual or group having an established reputation for competence and vigor. This principle of operation was strongly recommended in the report of the Weinberg committee (*8*), and its importance has been fully demonstrated in NSRDS operations.

As described so far, the technical scope of the standard reference data system undoubtedly appears limitless. However, the Bureau, with the concurrence of the interested federal agencies involved in NSRDS, has endeavored to avoid being cast into the infinite sea of data that exist for scientific and technical properties and substances of all types.

Guidelines have been established to limit the boundaries of NSRDS, which, hopefully, restrict its program to a manageable size. The program is to be concerned with (i) the data of physical science only (data relating to biologic phenomena will be excluded); (ii) well-defined substances only (substances whose composition, structure, and energy content are so precisely known that measurements of the property under consideration do not wander erratically); and (iii) only well-defined properties that are intrinsic to the substance or system being studied (properties that must be defined in terms of the sys-

tem used for measurement—such as Brinell hardness and Charpy breaking strength—are excluded). With these constraints, the task of NSRDS is probably feasible. Because of limitations of manpower and funding resources since the establishment of NSRDS, the task has not yet been determined to be practical. Although we who are connected with the program sometimes feel overwhelmed by the magnitude of what we are trying to do, wherever we look we see exciting and challenging opportunities to make important contributions to science and technology.

Operation of the National Standard Reference Data System

Within the National Bureau of Standards the responsibility for administering NSRDS has been assigned to the Office of Standard Reference Data, created for that purpose within the Institute for Basic Standards. Three major groups of activities within the Office of Standard Reference Data have been initiated: these are concerned with (i) the planning and implementation of projects for compiling data, organized into several broad technical areas; (ii) an information-systems design and research activity; and (iii) various specialized information services to be provided to the technical community.

For program management the data-compilation projects of the Office of Standard Reference Data have been subdivided into seven broad subprograms: (i) nuclear properties, (ii) atomic and molecular properties, (iii) solid-state properties, (iv) thermodynamic and transport properties, (v) chemical kinetics, (vi) colloid and surface properties, and (vii) mechanical properties. In each, 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, government, and industry. Some of the projects are conducted within the experimental divisions of the Bureau; others, in university laboratories or in other government laboratories; and a few, by industry. None is under the direct operational supervision of the Office of Standard Reference Data, which is exclusively for program management.

The level of effort in each project supported by the Office of Standard Reference Data is determined by a practical compromise involving three considerations: (i) the degree of comprehensiveness of the literature review, (ii) the procedure for critical evaluation applied to the data, and (iii) the need for continuity in updating the compilations. These three considerations require further discussion.

The raw material for any data-compilation project is the results of measurements by the whole world. Normally, these results are reported in the literature, some in journals which, however, may be obscure or difficult to obtain. Moreover, an increasing fraction of results worth saving for posterity is now appearing in government reports. Furthermore, in some areas (data on neutron cross sections are one example) many of the data generated in the laboratory never appear in any report or publication; in such instances the compiler personally may have to pry the data from the measurer. For a specific case, the degree of comprehensiveness that can be achieved must be a practical compromise between the desired 100 percent and the cost in time, money, and effort of achieving that goal. For most existing projects the comprehensiveness probably attains 90 to 99.8 percent.

The procedure for "critical evaluation" varies widely from project to project. In present practice in some data centers, the experimental technique is reviewed, calculations are spot-checked, values of the fundamental constants are checked to ensure that the latest values were used, the temperature scale is checked (if appropriate), and limits of experimental uncertainty are independently assessed. In other centers, the data evaluator may decide, for intangible reasons that he may find difficult to formulate, that one particular value in the literature is "better" than another value. Such a judgment by a specialist of broad experience should not be underrated; the value obtained is much more likely to be accurate than the result of unweighted averaging. Most people agree that the first procedure provides a better "critical evaluation" than the second. However, for the practical purposes to which many compilations are applied, such a review is not justified, and the second procedure, or an intermediate one, is employed.

The question immediately arises, then, of what degree of critical evaluation is required for a compilation to be considered "standard" reference data. It is probably desirable to use the word "standard" sparingly; it has connotations that apply to few existing compilations. For the present, when measurement results for most properties are uncertain and many are in dispute, the shorter term "reference data" would avoid the implications aroused by use of the word standard. "Standard reference data," the ultimate goal of NSRDS, are to be striven for constantly, but perhaps not reached in many fields for years. Because of the variation in procedures for critical evaluation, all publications of NSRDS are to describe the criteria used for judgment and the argumentation used to derive the recommended values.

For each individual compilation project, requirements for continuity must be examined. The overall program of NSRDS is designed to ensure continuity of effort in production of data compilations needed by scientists and engineers. In some areas a revised and updated compilation may be needed every 6 months; in others, only every 4 or 5 years. In almost all areas, continuing literature review and indexing operations are required to maintain a current awareness of the state of development of the field. Therefore most new projects undertaken by NSRDS are expected to be long-term, continuing activities, maintained as one component of the normal range of professional activity of the leader of the program.

The types of activities and products of these data centers will now be examined in some detail. Figure 1 is a schematic diagram of the broad types of activities and products that are normally associated with a data center. The left-hand column represents activities, while the right-hand column indicates a product that may result from the corresponding activity on the left. Following the initial selection of relevant papers from the literature (an activity basic to all evaluation and compilation projects), a bibliography may be prepared, in which the literature to be evaluated is classified into several relatively broad categories. After the

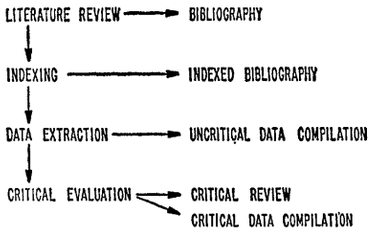

Fig. 1. Activities and products of data-evaluation centers.

initial selection, the papers are indexed; this process consists of assigning a number of key words or symbols to each paper to indicate the data content of the reference. The indexed bibliography resulting from this activity is very useful to many groups of specialists.

Figure 2 shows a page from one of the most comprehensive and successful of these indexed bibliographies, called CINDA (*9*) (Computer Index Neutron Data); it is concerned with sources of data on neutron cross sections. The first several columns contain symbols and numbers representing the target nucleus, the range of incident neutron energy, identification of the reference in a list following the table, and identification of the laboratory at which the measurements were carried out. Next come additional remarks characterizing the measurement more fully, the date of addition of the item to the computer file, identification of the person who prepared the entry, and an accession number for the entry. CINDA is particularly noteworthy because it represents the combined efforts of scientists in the United States, the United Kingdom, France, Germany, the U.S.S.R., and other countries.

In consultations to determine the needs of the technical community of the United States for data compilations of all kinds, the staff of the Office of Standard Reference Data have been told often that an indexed bibliography of this type would satisfy most of the needs of the specialists, since many of them would prefer to evaluate the data themselves and wish only to avoid the labor of locating the sources of the information. However, this attitude does not prevail among those who need a particular value for a calculation of some kind and are not themselves involved in research in the field.

The next step in the production of a critical compilation is the extraction of data from the literature that has been selected. At this stage an uncritical compilation could be issued, if determined to be useful to the technical community. Figure 3 is an example of this kind of product: a print-out of data on the ionization and appearance potential of cyanogen ion, retrieved from the files of the Mass Spectrometric Data Center at the National Bureau of Standards in Washington. This material is retrieved as required to satisfy the requests of individual inquirers. A similar product is now being considered by the Nuclear Data Project at Oak Ridge National Laboratory, in response to requests by members of the U.S.

MAY 1 1965 PAGE 257 CHROMIUM

ELEMENT S Z A	QUANTITY	ENERGY MIN MAX	REFERENCE SOURCE	DATE	TYPE	LAB	REMARKS OR VALUES	ENTRY DATE	NO.
CR 24 050	N,N PROTON	14 7	NP 63 615	3/65	THEO-JOUR	GER	BUTTNER+ STAT MDL CALC CFD XPT	650420EU	500866
CR 24 050	N,N PROTON	14 7 16 7	NP 63 615	3/65	THEO-JOUR	GER	BUTTNER+ STAT MDL CALC WITH G COMP	650420EU	500867
CR 24 050	ENERGY LVLS		PRL 1 307A	0/58	-		PORTRBARTOL 780KV AS XPECTDFOR2P	650210U	9225
CR 24 050	ENERGY LVLS		BAPS112 468	0/58	-		PORTERBARTOL780KV PPPR 2P NEW LVL	650210U	9226
CR 24 050	ENERGY LVLS		PR 112 468	0/58	-		INELAS SCAT P(R) OBS	650210U	9227
CR 24 051	RESON PARAMS		PR 109 1243	2/58	-		JNSON ORNL INV PN DIFFMDLS PSTRFN	650210U	584
CR 24 051	SPECT NGAMMA	THR	PR 125 2037	3/62	-		COIN CS GAM ENERG LVL SCHEME	650210UA	585
CR 24 051	N,ALPHA	14 7	NP 60 49	N/64	THEO-JOUR	USA	GARDNER PREDICTED BY EMPIRICAL FORM	650407EU	500868 SAC
CR 24 052	TOTAL XSECT	40 3 30 5	*PG NEWSON	6/56	-		DUKE	650210U	586
CR 24 052	TOTAL XSECT	KEV	PR 111 288ANL	7/58	-		COTE TRNS ONLY NO RES BELO 15KEV	650210U	587
CR 24 052	TOTAL XSECT	85 4 65 5	AP 17 319DUKE	3/62	-			650210UC	588
CR 24 052	TOTAL XSECT	1 4 65 5	BAPS7 289G11	4/62	-		DUKE NDG RES PAR	650210UK	589
CR 24 052	TOTAL XSECT	98 5	NP 54 417	6/64	THEO-JOUR	OXF	OPTMDL FIT TO TOWLE GILBOY	650210UU	18655
CR 24 052	RESON PARAMS	51 4 14 5	*PG NEWSON	6/56	-		DUKECHIEFLY WT 4RES	650210U	590
CR 24 052	RESON PARAMS	51 4	ANL 5498 P60	6/56	-		89B ON W 28 2 538 S 1D2 1D7KEV	650210U	591
CR 24 052	RESON PARAMS	40 5 41 5	ANL 5554HI8DON	8/56	-		WT A ASS 30 LVLS	650210U	592
CR 24 052	RESON PARAMS	51 4 41 5	PR 108 414ANL	0/57	-		HIBDON 11EOS WN A1RSLN	650210U	593
CR 24 052	RESON PARAMS	KEV	PR 111 288ANL	7/58	-		COTE TRNS ONLY NO RES BELO 15K5V	650210U	594
CR 24 052	RESON PARAMS	51 4 65 5	AP 17 319DUKE	3/62	-		S AND NON-S-RES PAR.NUC.TEMP=1.20	650210UC	595
CR 24 052	RESON PARAMS	RES	NSA 16 3245	9/62	-		ABSTR 24818,DUKE THESIS,NDG	650210UT	596
CR 24 052	STRNTH FNCTN	40 5 41 5	ANL 5554HI8DON	8/56	-		2P2 AVGOF10RES SMALL GB TH CR53	650210U	597

Fig. 2. Illustrative page from CINDA (*9*), an indexed bibliography.

nuclear-physics community; it would consist of a reproduction of the raw data extracted from the papers published in the field of nuclear structure. The normal product of the Nuclear Data Project consists of carefully evaluated energy-level diagrams and other quantitative data, and will continue to appear regularly.

The preliminary activities of literature selection, indexing, and extraction of data lead finally to critical evaluation of the data. The product of this work is a critical review of the state of quantitative knowledge in some

MASS SPECTROMETRIC DATA INFORMATION CENTER—NBS

Listed below is the requested information as obtained from the literature since 1955.

ION	REACTANT	OTHER PRODUCTS	IP or AP	METHOD	YEAR	DOC NO
CN+	CNI	I	18.1+0.1	SP	60	00073
CN+	CNBr	Br	18.3+0.1	SP	60	00073
CN+	CNCl	Cl	18.3+0.2	SP	60	00073
CN+	CH_3NO_2	?	19.15+0.09	IB	55	00090
CN+	CH_3NO_2	?	33.6+1.0	IB	55	00090
CN+	CN		14.5+0.2	SP	61	00154
CN+	CN		14.5+0.5	SP	61	00154
CN+	C_4N_2	C_3N	19.2+0.3	SP	61	00154
CN+	HC=C—CN	C_2H	19.8+0.2	SP	61	00154
CN+	C_6N_2	C_5N	20.0+1.0	SP	61	00154
CN+	$(CN)_2$	CN	21.5+0.3	SP	61	00154
CN+	cyclo-C_3H_5CN	C_3H_5	19.5+0.4	EVD	62	00202

TERM DESIGNATION

SP=SEMILOG PLOT
IB=INITIAL BREAK
EVD=EXTRAPOLATED VOLTAGE DIFFERENCE

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00202 Kiser, R.W. and Hobrock, B.G., "THE IONIZATION
00202 POTENTIALS OF CYCLOPROPYL RADICAL AND CYCLOPROPYL CYANIDE",
00202 J. Phys. Chem. 66, 957(1962)

Please note that we make no claim that the above information has been critically evaluated by NBS personnel nor do we make any claim that there is a preferred value.

We hope that we may be of further assistance to you in the future.

Georgia L. Apostolou
Mass Spectrometry Section
Institute for Basic Standards
National Bureau of Standards
Washington, D. C. 20234

Fig. 3. Print-out of data from NBS Mass Spectrometric Data Center, typical of uncritical-data compilation with bibliography.

limited area of a field, or a compilation of critically evaluated data. For NSRDS, a published product must contain sufficient argumentation for the user of the data to know how the results were obtained, as well as appropriate reference to the sources of the data used in the final evaluation. Figure 4 shows a page from a typical product of this type, with data expressed in the form of a table of numbers; data may also be expressed graphically (Fig. 5).

In accordance with the directives of NSRDS, only activities leading to the production of a critical review, or compilation of critical data, are considered appropriate for support by the Bureau's Office of Standard Reference Data. However, because the intermediate products are often very useful, NSRDS data centers may issue them also, along with other publications.

The physical form of the products of NSRDS activities may be anything considered convenient by the users to whom the product is directed; that is, the product may be a monograph, loose-leaf data sheets, a journal article, microfiche cards, IBM punch cards, punched paper tape, magnetic tape, or any other physical form in which information may be stored.

The information-systems design and research activity of the Bureau's Office of Standard Reference Data is concerned with the problems of handling data throughout the entire flow process; that is, from the time measurements are first made in the laboratory, through disclosure in some form to other persons who may use the results (as a journal article, a laboratory report, or perhaps a magnetic tape), through the review, selection, and evaluation procedures in the data center, and finally to dissemination among members of the technical community who have use for the evaluated product. The use of computers for all practical operations is emphasized; such applications to speed the flow of data from the measurer to the user have only just begun.

Several user services are being planned, utilizing the storehouse of data to be contained in the Bureau's Standard Reference Data Center. This storehouse will eventually contain a complete collection of compilations of critically evaluated data produced throughout the world.

The following list indicates the services that are available or definitely planned as part of the office program:

1) Referral: referral of a request for data on a specific subject to a center specializing in that subject.

2) Reference: provision of literature references in response to a request for information, with an indication of where the requester may locate relevant data.

3) Documentation: provision of copies of documents in response to inquiries (perhaps ranging from a Xerox copy of a page to a complete bound volume).

4) Data: provision of detailed data as required to respond fully to a request for information; the service might range from a reply to a question such as "What is the value of property P for substance S at temperature T?" to replies to questions such as "What substances have values for property P in the range c to d, and for property Q in the range f to g, but not for property R in the range j to k?"

5) Current-awareness: periodical or aperiodical announcement of new prod-

C II

Ground State $1s^2 2s^2 2p\ ^2P^o_{1/2}$

Ionization Potential 24.376 eV = 196659.0 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
687.059	10	3360.9	27	4413.2	24
687.35	10	3361.09	27	4618.9	26
687.355	10	3361.75	27	4628.1	26
858.092	9	3581.80	18	5132.96	14
858.559	9	3584.98	18	5133.29	14
903.624	3	3585.83	18	5137.26	14
903.962	3	3587.68	18	5139.21	14
904.142	3	3588.92	18	5143.49	14
904.480	3	3589.67	18	5145.16	14
1009.85	4	3590.87	18	5151.08	14
1010.07	4	3876.05	22	5640.50	13
1010.37	4	3876.19	22	5648.08	13
1036.34	2	3876.41	22	5662.51	13
1037.02	2	3876.67	22	5889.4	20
1065.88	6	3878.22	22	5889.97	20
1065.9	6	3879.60	22	5891.65	20
1066.12	6	3880.59	22	6578.03	11
1323.9	5	3881.2	22	6582.85	11
1334.53	1	3883.8	22	6779.74	12
1335.66	1	3918.98	17	6780.27	12
1335.71	1	3920.68	17	6783.75	12
2173.8	15	4074.53	23	6787.09	12
2174.1	15	4076.00	23	6791.30	12
2509.11	7	4267.02	21	6798.04	12
2511.71	7	4267.2	21	6800.50	12
2512.03	7	4267.27	21	6812.19	12
2746.50	19	4371.59	25	7231.12	16
2747.3	19	4372.49	25	7236.19	16
2747.31	19	4374.28	25	7236.2	16
2836.71	8	4411.20	24	18895	29
2837.60	8	4411.52	24	18916	29
2992.6	28				

Self-consistent field calculations by Weiss [1], and Biermann and Lübeck [3], and a high current arc experiment by Maecker [2] are utilized for the tabulation. The results for the lower and moderately excited transitions should be quite uncertain because in the calculations the strong effects of configuration interaction are essentially neglected, and the experimental work is subject to large systematic uncertainties.

References

[1] Weiss, A. W., private communication (1964).
[2] Maecker, H., Z. Physik **135**, 13–22 (1953).
[3] Biermann, L. and Lübeck, K., Z. Astrophys. **25**, 325–339 (1948).

Fig. 4. Illustrative page from *Atomic Transition Probabilities* (*11*), a critically evaluated compilation.

ucts and services of NSRDS, describing in some detail the properties, substances, and ranges of parameters covered by compilations, and explaining the means of access to the items described.

At present, services 1 and 5 are active. The Bureau hopes that it will not be swamped with requests for data as a result of this announcement, because it is not equipped to process many inquiries. The current-awareness service consists of a monthly newsletter sent to persons requesting it; it is now free but soon there may be a small charge.

Products and services still under consideration include:

1) Special handbooks: preparation of handbooks containing selected portions of data compilations needed by individuals or mission-oriented segments of the community (such as data needed by oceanographers, upper-atmosphere physicists, or desalination engineers).

2) Format conversion: conversion of data compilations from one physical form to another; for special purposes, a customer may wish to have data on a magnetic tape rather than on a printed page, or on punched cards rather than punched paper tape, or, in general, in some form other than that of the original product.

3) Property computation: computation to special order of experimental properties that may be stored as mathematical relations, or that must be calculated from theoretical or approximation equations.

4) Remote access: making the central bank of stored data accessible to a remote console anywhere in the United States (or conceivably anywhere in the world by way of microwave relay or a communications satellite).

The program decisions of the Bureau's Office of Standard Reference Data have relied heavily on the advice of a representative cross section of the American technical community. As overall program-review committee for the work of the office, the executive committee of the Office of Critical Tables of the National Academy of Sciences–National Research Council provides policy recommendations and is an important channel of communication with many segments of the technical community. Program officers in other government agencies have been consulted to determine the needs of their mission-oriented programs for the products and services that the standard reference data system is intended to provide. Considerable reliance has been placed on the recommendations of panels of specialists in each of the technical categories in which a program is being operated; one or more meetings of *ad hoc* panels have been held in each area. Some of these panels were existing committees of the NAS–NRC, established primarily for other purposes; others have been assembled for the purpose directly by the Bureau. These advisory panels are now being organized on a continuing basis under the auspices of the National Academy of Sciences–National Academy of Engineering. The NAS–NRC Office of Critical Tables has provided frequent advice on needs, priorities, and other operational details, and has also served as a channel of communication to segments of the technical community in the United States and abroad that would be difficult to reach in other ways. In all, more than 200 leaders of American science and technology have given generously of their time and experience in helping to make NSRDS most responsive to the needs of the technical community.

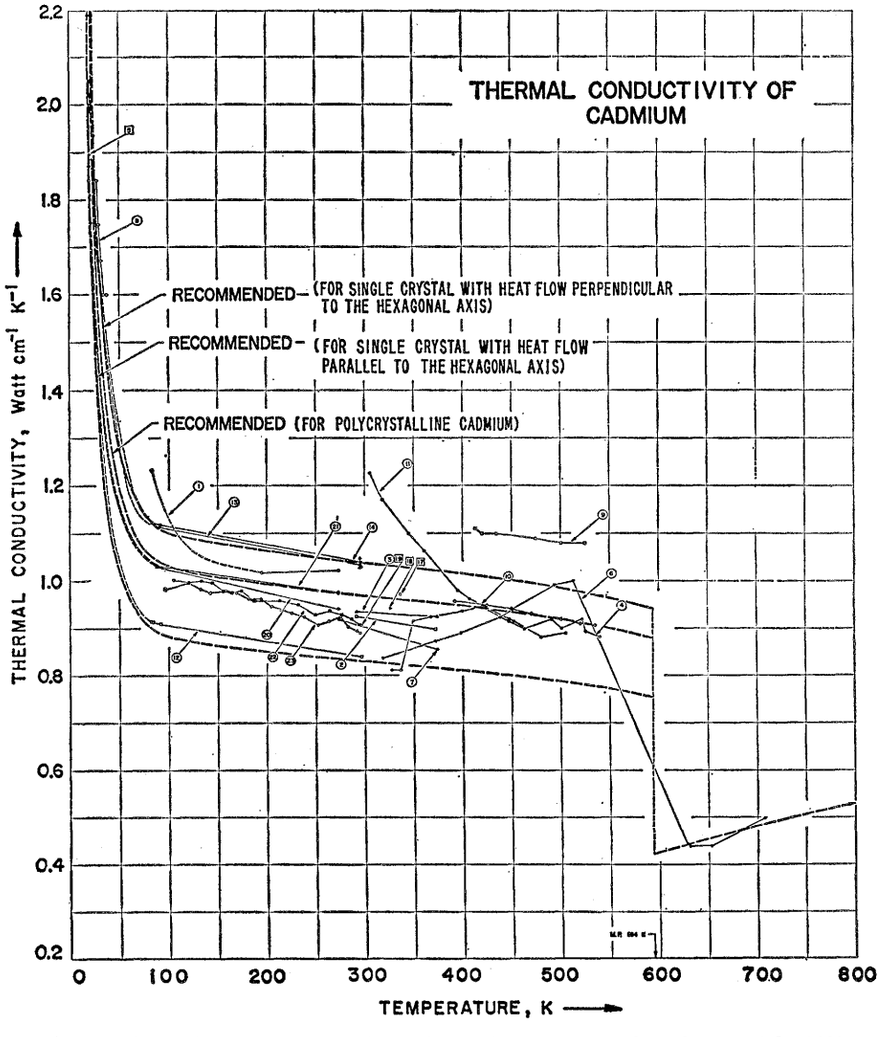

Fig. 5. Illustrative page from *Thermal Conductivity of Selected Materials* (*12*).

General Status of Program

As a result of the recommendations of advisory panels, greatest emphasis has been placed on initiation of new projects for evaluation and compilation and on expansion of old ones, leaving to a future of greater affluence the implementation of extensive and sophisticated information services. Significant progress has been made, especially in the areas of thermodynamic and transport properties and of atomic and molecular properties; these two cate-

gories have been judged to be of highest priority for additional effort. In the field of nuclear data, existing activities sponsored by the U.S. Atomic Energy Commission provide nearly adequate coverage of the technical scope required, although the level of effort needs to be increased to meet the rapid rate of appearance of new data. For solid-state properties, existing projects provide good coverage of the more classical areas (such as structural data), but greatly increased effort on the newer kinds of data (such as energy levels, band structure, and interaction with radiations) has been recommended by the advisory panel. For chemical kinetics, the advisory panel recommended that the first step be preparation of a series of critical reviews on the state of quantitative knowledge in certain selected aspects of the field, since the panel members were not at all certain that any quantitative data in the literature were worth a systematic compilation project.

For colloid and surface properties, the Bureau's Office of Standard Reference Data has established a cooperative relation with the NAS–NRC Committee on Colloid and Surface Chemistry, which had been planning an extensive program of data evaluation before NSRDS was established. For mechanical properties, from a preliminary critical examination, by a panel of Bureau staff members, it was concluded that most results of mechanical-property measurements are unlikely to satisfy criteria for "standard" reference data; this tentative conclusion is to be examined soon by a panel representing a broader selection of specialists from outside the Bureau.

More detail on the activities of the Office of Standard Reference Data and on the status of specific projects under the cognizance of this office are described in a recent report by the Office of Standard Reference Data (*10*).

Proposed Legislation

During the 3 years of the Bureau's administration of NSRDS, a start has been made toward satisfying the general obligation of supplying reference data to the American technical community. These years have, however, revealed the desirability of additional authority from Congress for increased efficacy. Seeking such authority, the Department of Commerce submitted draft legislation to the 89th Congress. After public hearings before the Daddario Subcommittee on Science, Research, and Development (House Committee on Science and Astronautics), a revised bill was reported favorably by the full Committee; it was passed by the House of Representatives in mid-August 1966. However, the Senate Commerce Committee, which oversees the program of the Bureau, did not hold hearings or report the bill to the Senate. The bill has been resubmitted for consideration by the 90th Congress.

The legislation, as revised after the hearings of the Daddario subcommittee, contained the following provisions: (i) a declaration that it is the policy of the Congress to make critically evaluated reference data readily available to scientists, engineers, and the general public; (ii) a directive to the Secretary of Commerce to provide or arrange for the collection, compilation, critical evaluation, publication, and dissemination of standard reference data; (iii) a directive to the Secretary of Commerce to prescribe standard criteria and procedures for the preparation and publication of standard reference data, as may be necessary; (iv) authority for the Secretary, or a person or agency designated by him, to sell standard reference data and to allow the proceeds to be used by the Bureau; (v) authority for the Secretary to obtain copyright, on behalf of the United States as author or proprietor, in standard reference data prepared or made available under the Act; and (vi) an authorization for appropriations in such amounts as may be needed for the purpose of the Act.

International Cooperation

Evaluation and compilation of data on the properties of substances has been a joint activity of the world's scientists for many years. The International Critical Tables, produced mainly between 1920 and 1930, contained contributions from scientists all over the world, coordinated through the efforts of the National Academy of Sciences. The tables of Landolt-Börnstein, originally German, now contain contributions by scientists from many countries. Compilation and evaluation of neutron cross-section data have become a broad international effort, with participation by centers in the United States, Canada, the United Kingdom, France, the Soviet Union, and other countries.

The establishment of NSRDS in the United States has stimulated additional interest among scientists in other countries in the possibility of developing cooperative programs with scientists in the United States. Possible cooperation has been discussed with scientists from the United Kingdom, France, Germany, the U.S.S.R., and Japan. Such widespread interest leads immediately to the concept of a multilateral international program, incorporating activities from all countries wishing to participate. Indeed, multinational cooperation through several of the international scientific unions has been under way for many years. The International Unions of Pure and Applied Chemistry and Pure and Applied Physics and the International Astronomical Union have been especially active. In June 1966 the International Council of Scientific Unions created a Committee on Data for Science and Technology (now called CODATA) whose function is to coordinate projects for data compilation and stimulate the formation of new ones on an international basis. This committee is served by a small professional staff, headed on a part-time basis by the present director of the Office of Critical Tables of the National Academy of Sciences. For 1 or 2 years the office will be located in Washington, D.C., and then will probably be moved to Europe.

Competence and interest in an international cooperative program for compiling reference data are found in most of the technically developed countries. The products of such a program would benefit any nation that conducts a research and development effort of any size, not merely the most highly developed countries. International cooperation in this area has been a tradition of the world's scientists for at least half a century, but until recently no mechanisms for overall coordination and support have existed. In short, many arguments now favor the vigorous development of an international cooperative program.

There can be no doubt that the computer will ultimately change all practices in obtaining, collecting, evaluating, and transmitting data. On-line computers, coupled with new instru-

mentation, will increase enormously the rate of measurement of properties and of analysis of experimental data, raising immediate questions of what and how much should be printed in a publication. The processing of data and literature in an evaluation center will be handled largely by computers. Journal articles, monographs, and other printed records will be composed by computer-controlled photocomposition devices. Data and other information will be stored magnetically and will be available to scientists and engineers by way of remote-access consoles. All these developments now exist; they will undoubtedly transform the working habits of scientists and engineers everywhere. However, improvements in the mechanics of processing data can only serve as an aid to the evaluation process, which can be done only by well-trained human brains. For this reason we consider that the basic concept of NSRDS—establishment of a comprehensive network of centers in which experts evaluate data in their fields of specialty—has validity for many years to come.

Conclusion: A Word to the Technical Reader

An essential element in the control of any system is feedback. Successful control of NSRDS is impossible without feedback from the members of the technical community, which includes the readers of this journal. We need feedback from you in order to determine the priorities of compilation projects, to determine the kinds of services that you need the most, and to judge how successfully the system operates. Right now you, the reader, could let us know, for example, what properties, of what substances, you need to have in the form of a critically evaluated compilation. Let us know if you yourself are working on a critically evaluated compilation and need help to finish or publish it. Give us any advice you think we need. We seek the cooperation and assistance of the entire technical community in achieving our common goal of promoting the technical advancement of the United States.

Summary

The National Standard Reference Data System is a government-wide effort to give to the technical community of the United States optimum access to the quantitative data of physical science, critically evaluated and compiled for convenience. This program was established in 1963 through action of the President's Office of Science and Technology and the Federal Council for Science and Technology, acting upon the recommendation of the Council's Committee on Scientific and Technical Information. The National Bureau of Standards has been assigned responsibility for administering the effort. The general object of the system is to coordinate and integrate existing activities in data evaluation and compilation 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 dissemination of the output as required.

The NSRDS is a decentralized operation of nationwide scope, with central coordination by the Bureau; it comprises a complex of data centers and other activities carried on in government agencies, academic institutions, and nongovernmental laboratories. The independent operational status of existing data projects is maintained and encouraged. Data centers that are components of NSRDS produce compilations of critically evaluated data, critical reviews of the state of quantitative knowledge in specialized areas, and computations of useful functions derived from standard reference data.

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