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EVALUATION AND COMPRESSION OF SCIENTIFIC AND TECHNICAL INFORMATION AT THE NUCLEAR SAFETY INFORMATION CENTER

Wm. B. Cottrell

ABSTRACT

An brief resume of the operation of the Nuclear Safety Information Center with emphasis on those functions which constitute evaluation or compression of technical information was presented. The computerization of the center's information store and the several information retrieval programs includes some evaluation. However, in addition to expediting searches of categorized information, the use of computers is desirable in freeing technical personnel for more productive uses as in the preparation of technical review articles and state-of-the-art reports. A "compression" ratio greater than 100 is a reasonable expectation for such documents and offers the most promising hope to the individual desirous of maintaining his currency in a particular technology. A recent development involving the storage of data files on computer tape and the development of programs to evaluate the data in response to preconceived criteria was also described.

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by

Wm. B. Cottrell

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A. INTRODUCTION

It was intended that this session of the symposium present a survey of existing scientific information centers and the methods they employ for evaluating the information and compressing it for greater utility. My paper is directed to the several functions of the operation of the Nuclear Safety Information Center at Oak Ridge National Laboratory, which serve these ends. That there is no need today to justify the evaluation and compression of technical information is a reflection on the widening comprehension, at all levels of the professional society, of the ramifications of the information explosion in their everyday work. This recognition of the need is quite recent but should rapidly accelerate the implementation of proven techniques for compression and evaluation of the information being generated in many areas of science, business, and administration.¹

Since its inception four years ago, the Nuclear Safety Information Center has grown in both scope and function, with a concomitant increase in both size and services rendered. Perhaps the most significant single reason for this growth may be found in the fact that the many functions and/or services of NSIC were based on the presumption that the evaluation and compression of technical information in the area of nuclear safety has always been our primary task. In some functions we have pioneered either in the development of the mechanism or the application of the mechanisms or both. In the following I will discuss each function and attempt to define the problems we faced as they related to information evaluation and compression and then to show how they were resolved. I will leave unanswered, for the time being at least - although it may be the subject of a subsequent panel discussion - the question of the effectiveness or absolute value of the things we have done or are undertaking.

In order to provide background for this presentation, however, I shall first briefly describe the various activities undertaken by the Nuclear Safety Information Center. I shall then conclude with a brief discussion of some of the implications of our work for ourselves and others.

B. FUNCTION AND SCOPE OF NSIC AND RELATED ACTIVITIES

The AEC established the Nuclear Safety Information Center (NSIC) at Oak Ridge National Laboratory (ORNL) in March 1963. It is funded by the office of the Assistant Director for Nuclear Safety, Dr. J. A. Lieberman of the Division of Reactor Development and Technology. The center serves the nuclear community by collecting, storing, evaluating, and disseminating safety information relevant to the design and operation of nuclear facilities.² It was in operation almost immediately after its establishment because the scientists and engineers necessary to the operation of a center, and without which an information center is hardly more than a specialized library, were already on the ORNL staff or available through existing consulting contracts.

The center is organized at the Laboratory as a semiautonomous group, responsible to an Assistant Laboratory Director, who is in turn responsible for all information problems; but it is administered within the ORNL Reactor Division. At the present time the staff is composed of 16 technical specialists (most of whom serve on a part-time basis), a technical editor, 2 information specialists, and 4 secretary-typists, as listed in Table 1.

The scope of the center's technical cognizance is roughly outlined by the 18 general categories listed in Table 2 into which we found it convenient to group our work.

One of the half-time staff scientists or engineers is assigned to each of Categories 6, 7, 9, 11, 14, 15, 16, and 17. Surveillance in the other areas is on a lesser level, usually about one-tenth of the time in each. In the other fraction of their time, all specialists work in an experimental or analytical group active in their particular subject area.

The director of the information center is the coordinator of ORNL's nuclear safety research and development program and the editor of Nuclear Safety. The assistant director, who is responsible for the day-to-day operation of the center, is an assistant editor of Nuclear Safety. The technical staff is composed entirely of senior people who have been working in their areas of specialty for a number of years and who continue to work in these areas. These scientific middlemen are the backbone of NSIC. In fact, as it was so aptly expressed in the "Weinberg Report" in 1963, "The essence of a

Table 1. Organization of the NSIC

Wm. B. Cottrell, Director		
Joel R. Buchanan, Assistant Director		
Jeanne Thomas, Secretary		
H. B. Whetsel, Technical Editor		
Celia Murphy, Chief Information Specialist		
Shirley Hendrix, Information Specialist (part-time)		
Ann Hayes, Information Specialist and Secretary		
Dianne Lane, Secretary		
Janet Davis, Secretary		
<u>Technical Staff Assignments</u>		
Scientist or Engineer	Subject Area	Time Spent Working for NSIC (%)
J. P. Blakely	General safety criteria Sources of energy release under accident conditions	20
E. N. Cramer	Operational safety and experience	50
R. L. Scott	Safety analysis and design reports	25
W. K. Ergen	Reactor transients, kinetics, and stability	50
M. H. Fontana	Heat transfer and fluid dynamics	10
D. G. Jacobs	Radionuclide release and movement in the environment	50
G. W. Keilholtz	Fission-product release, transport, and removal	50
T. F. Lomenick	Environmental surveys, monitoring, and radiation exposure of man	50
J. G. Merkle	Structural integrity	10
J. B. Ruch	Radiochemical plant safety Plant safety features	10
L. B. Shappert	Transportation and handling of radioactive materials	10
C. S. Walker	Nuclear instrumentation, control, and safety systems Electrical power systems	50
H. G. O'Brien		
T. L. McLean		
M. L. Winton	SDI program	50

Table 2. NSIC Subject Categories

-
1. General Safety Criteria
 2. Siting of Nuclear Facilities
 3. Transportation and Handling of Radioactive Materials
 4. Aerospace Safety
 5. Accident Analysis
 6. Reactor Transients, Kinetics, and Stability
 7. Fission-Product Release, Transport, and Removal
 8. Sources of Energy Release Under Accident Conditions
 9. Nuclear Instrumentation, Control, and Safety Systems
 10. Electric-Power Systems
 11. Containment of Nuclear Facilities
 12. Plant Safety Features
 13. Radiochemical-Plant Safety
 14. Radionuclide Release and Movement in the Environment
 15. Environmental Surveys, Monitoring, and Radiation Exposure of Man
 16. Meteorological Considerations
 17. Operational Safety and Experience
 18. Safety Analysis and Design Reports
-

good technical information center is that it be operated by highly competent working scientists and engineers — people who see in the operation of the center an opportunity to advance and deepen their own personal contact with their science and technology."³

A variety of information services is offered by NSIC to the nuclear community. The principal ones are listed in Table 3. The Nuclear Safety journal is available by subscription only, but all other NSIC services, including state-of-the-art reports, may be obtained from the center without charge by persons who are active in the nuclear field. Those who do not fall in this category may purchase such reports for a nominal sum from the Clearinghouse of Federal Scientific and Technical Information, Springfield, Virginia. While the center does provide reference lists, generally developed from a

computer search, we do not supply copies of any reports except those which we generate, although sources are identified. The services that relate uniquely to this symposium will be discussed later in more detail.

Table 3. Principal Services of the NSIC

-
1. State-of-the-art reports
 2. Nuclear Safety journal
 3. Indexed bibliography of accessions
 4. Selective dissemination of information
 5. Technical inquiries
 6. Counseling and guidance
 7. Special bibliographies
 8. Program and proposal reviews*
 9. Computerization of reactor data
-

*For the Atomic Energy Commission

C. SPECIFIC TASKS RESULTING IN THE EVALUATION AND COMPRESSION OF INFORMATION

It is obvious from the preceding description of the functions of a scientific information center that the entire basis of its operation - in fact the principal justification for its existence - is, first, the collection and organizing of the millions of small pieces of relevant knowledge and, second, the efficient retrieval of the pertinent pieces in response to a particular need. The net result is the evaluation and compression of the available knowledge. Although simply stated, this objective is approached in many different ways by different centers. Even a single center, such as the Nuclear Safety Information Center, in the system it has established, as well as the products and services which it provides, achieves this end in devious fashions. I will discuss some of the more significant of these.

1. Computerized Information Storage

Our information center was initially established on two false premises, 1) use of a manual card file system and 2) complete evaluation of all incoming

information. The former amounted to living in the stone age of information handling and the latter proved to be an economic impracticality. We resolved the first issue by developing a computerized information system⁴ for storing the information (as well as suitable programs for its retrieval) and compromised on the second. This probably sounds heretical at a meeting on the evaluation of scientific and technical information, but let me describe the information which is stored on the computer and you will see what I mean.

For each reference the information shown in Table 4 is stored on the computer tapes. The technical specialist establishes items 2, 3, 12, and 13, of which the most important are the key words for information retrieval and the abstract from the point of view of adequately describing the document. The stored information is organized in linear fashion on the tape so that everything concerning one item appears together serially.

Table 4. Computerized Information Stored

1.	Type, such as report, journal article, etc.
*2.	Evaluation of contents (as to pertinency)
*3.	Category (such as Accident Analysis)
4.	Journal abbreviation (ASTM's Codes)
*5.	Date
6.	Language
7.	Country
*8.	Corporate author
*9.	Personal author(s)
10.	Title
11.	Description, such as pages, figures, and tables
12.	Abstract
*13.	Key words

*Asterisk indicates computer searchable information

Key words are weighted for searching, with an acceptable total weight being specified, and negative weights are permitted. Search elements can be connected on an and/or basis. Another form of weighting is used when the

references are indexed by assigning an asterisk to the key words of primary importance in each document. These asterisks show in the various printed outputs of the center.

I would like to call your attention to the first two items on the above list, "Type" and "Evaluation of contents," since even classifying by Type frequently implies an evaluation of sorts. We have identified 18 different information types, (e.g., progress reports, topical reports, thesis, patent, news release, etc.) and have established four evaluation categories (excellent, good, average, poor). It was our original intention that our technical people become personally familiar with and evaluate each information source prior to its inclusion into our system. It did not prove to be possible to do this and everything else as well, so we settled for a quick scan of the literature that is sufficient to assess its relevance but, depending upon the reviewer's time and interest or prior familiarity with the document in question, may or may not make possible an immediate evaluation of the document. The complete evaluation can, however, be added to the computer tape at any time. It should be noted, further, that although the information search may include the evaluation as one criterion for retrieval, it is an in-house tool only and is not included in the printout of any of our several retrieval programs.

2. Retrieval Programs

While numerous programs and subprograms have been developed to check, maintain, and update the information, General Search, Bibliography, and SDI are the three retrieval programs with which we are most concerned here. More specifically, we are concerned with the capacity to redefine a search undertaken for any one of these retrieval programs so as to "close-in" on information sources of greatest relevance. This is one aspect of information compression and is effected by appropriately "weighting" the machine searchable "key words" (see Table 4). This can be illustrated by a typical example taken from the files of one of the 750 participants in our SDI program, and it would work the same for any retrieval program.

Physicist A was initially profiled to receive all of Category 6 on "Reactor Transients, Kinetics, and Stability." Tabulation of the returns from the first feedback cards was as follows for 146 citations:

Documents of much interest	32%
Documents of some interest	17%
Documents of no interest	51%

Category 6 covers both analytical and experimental studies of reactors and critical facilities. An examination of the key words assigned to the documents that were of no interest to Physicist A revealed that many of them were concerned with experimental determinations or with critical assemblies. As a result the profile was altered so that reports with either of the key words, "measurement, general" or "criticality safety," would not be cited. This was done by giving these two terms weight of -1 with a target score held at 0 (zero) so that all other references in Category 6 would continue to be selected. Results of the next four feedback cards revealed some improvement in the pertinence, with a total of 56 citations breaking down as follow:

Documents of much interest	41%
Documents of some interest	25%
Documents of no interest	34%

Since there was room for further improvement, the next step taken was to communicate directly with Physicist A for more insight into his actual interest. This disclosed he wanted all references in Category 6 that entailed the use of reactor transient parameters but that he was not interested in the determination of these parameters. This more explicitly confirmed our analysis of the early feedback cards and suggested further profile alterations. With this information and further study of the key words assigned to the irrelevant documents, a longer list of key words was developed for negation. The following were allotted weights of -1 and assigned to the group of two terms already designated:

Analytical model	Metal-water reaction
Critical experiment	Shock wave
Doppler effect	Temperature coefficient
Flooding coefficient	Void coefficient

After this change was made, three additional feedback cards from Physicist A were reviewed. A total of 20 references was cited with the following results:

Documents of much interest	65%
Documents of some interest	25%
Documents of no interest	10%

This example illustrates clearly how individual profiles can be adjusted to close in on the user's actual needs. Further adjustments of this particular profile are probably not warranted, since it has reached a range of "no interest" below which it is difficult to make significant progress. Indeed, we feel that it is probably undesirable to reduce the irrelevant figure below 10%. To do this would increase the likelihood that some relevant documents would not be cited at all. Therefore we have concluded that an SDI profile is functioning satisfactorily if the number of irrelevant items cited falls in the range 10 to 20%.

3. State-of-the-Art Reports

A state-of-the-art report encompasses all the literature on a particular subject and presents the author's evaluation of the present state of knowledge and, frequently, also what needs to be done. These reports provide a mechanism for the individual staff members to analyze and evaluate the experimental and theoretical data developed in their particular subject area. They are very comprehensive and require several man-months of technical effort to produce. Subjects that have been or are currently being covered include iodine monitoring practices,⁵ iodine behavior in reactor containment systems,⁶ reactor-containment practices,⁷ reactor secondary shutdown systems,⁸ nuclear safety research and development projects,⁹ U.S. nuclear standards,¹⁰ air-cleaning systems,¹¹ reactor pressure-vessel integrity,¹² international nuclear standards,¹³ reactor-operating experience,¹⁴ reliability considerations in reactor protective systems, height of rise of effluents, and tritium behavior.

It is inherent in the nature of NSTC that state-of-the-art reports are relatively few in number, particularly in comparison with the possible topics that would fall within the scope of our work. Other centers, particularly data centers with their narrower scope do not have this problem, at least to

the same degree. In any event, each of the state-of-the-art reports does represent a milestone in that particular area in that it encompasses all the prior, known relevant information on that subject into a single report. Of course the adjective "relevant" is subjective and by "known" we mean "known to us," but by and large these reports seem to serve their purpose well.

The extent to which these reports both evaluate and compress is difficult to measure, even though those objectives are specific requirements of such reports. Some insight as to the extent of but not the quality of the compression may be obtained from Table 5, which compares the number of pages in ten published state-of-the-art reports with both the number and pages in the references in each.

Table 5. Compression of Information in NSIC
State-of-the-Art Reports

Reports	Pages	References		Reference Pages (est.)	Compression Ratio Ref. Pages ÷ Pages
		Total	Found		
ORNL-NSIC-3	103	186	156	10,704	104
ORNL-NSIC-4	95	219	208	20,549	216
ORNL-NSIC-5	1409	1026	-	-	-
ORNL-NSIC-7	86	90	52	16,425	191
ORNL-NSIC-10	596	1839	-	-	-
ORNL-NSIC-11	92	25	-	-	-
ORNL-NSIC-13	145	319	281	7,190	50
ORNL-NSIC-15	55	110	80	4,703	86
ORNL-NSIC-17	101	27	-	-	-
ORNL-NSIC-18	34	3	-	-	-

It must be noted that compression of pages of information may or may not be synonymous with compression of information, and furthermore the pages of information thus compressed in many cases will contain information relevant to other subjects and thus are not involved in the actual compression of information on the subject in question. Despite these limitations the

"compression ratio" presented in Table 5 does have some real significance, and it is obvious that the factors are substantial. It is also true that the compression ratio is never as meaningful as at the time it is first obtained, since the state-of-the-art reports soon become obsolete in any dynamic technology.

4. Journal of Nuclear Safety

While the state-of-the-art reports are complete and comprehensive technical documents, they "cover" only a portion of the technology. Therefore we endeavor to "cover" the entire technological spectrum at least once a year in the Technical Progress Review, Nuclear Safety, which we prepare for the AEC. However, in contrast to state-of-the-art reports, Nuclear Safety articles cover only the developments in a particular subject that occurred since the last article appeared. While articles on a particular subject usually appear at one-year intervals, the intervals may be more or less frequent as the prevailing interest and available information warrant. The total pages, articles, and total references for a number of volumes of Nuclear Safety are given in Table 6.

Table 6. Compression of Information in Nuclear Safety

Volume (Issue)	No. of Pages	No. of Articles	No. of References	Compression Ratio ¹ (Ref × 40 ÷ pages)
7(1)	136	22	402	119
7(2)	134	22	378	113
7(3) ²	138	21	455	132
7(4)	126	22	407	119
5(1) ²	138	26	454	132
5(2)	80	16	248	124
5(3)	67	14	138	82
5(4) ^{2, 4}	144	26	489	136
3(1)	104	26	346	134
3(2)	85	25	319	150
3(3)	92	23	301	131
3(4) ³	122	19	310	102
Average				123

¹Assuming 40 pages per reference based upon information in Table 5

²Contains feature article. ³3(4) contains index for Volumes 1-3.

⁴5(4) contains index for one volume only.

It will be noted that the compression ratios in Table 6 are comparable to those for state-of-the-art reports which is somewhat surprising since Journal articles generally do not analyze the information to the same depth. The concept of the compression ratio as applied to the Journal is, of course, also subject to the same reservations as expressed above in the discussion of state-of-the-art reports.

5. Computer Handling of Reactor Data for Safety

The Computer Handling of Reactor Data for Safety, or CHORDS, is a new assignment we have recently taken under the aegis of the NSIC that draws heavily on the resources of the Center, including the available expertise in both safety and computer technology. It appears that work of this type is covered in tomorrow afternoon's session, "Data Banks and Mass Memories," but since it — with appropriate retrieval programs — represents a new horizon in information evaluation, as well as compression, I have included a brief resume of the program and its justification here.

In certain areas of rapidly expanding modern technology, accumulation of information exceeds the capabilities of individuals to evaluate and constructively utilize such information. The sudden upsurge of commitments for nuclear electric generating stations in the United States during the past year is an extreme example of such a problem area. At the request of AEC Headquarters, we initiated a program directed toward cataloging design characteristics of the nation's nuclear power plants for rapid retrieval within a central computer. Later, continually current operational data and fault experience will be added to this store of information. Assistance in this program is being provided by the Computer Technology Center at K-25.

Initially attention is being focused on light-water power reactors, with emphasis on features closely associated with nuclear safety. As an aide to the regulatory branches of the AEC, computer interrogative programs will be given the capability of making comparisons between the various nuclear power plants in a quantitative fashion in order to reveal differences in design details and will include the analytical bases that were used in such designs. Input keyboards and graphic display consoles will be installed in Washington AEC offices with direct access by telephone line to the central computer so

that immediate response can be provided upon request. An interrogative conversational mode will be used as a means for rapid exchange of information between the user and the computer center. Eventually, similar remote stations will be established with telephone-line connection from the central computer facility to the AEC branch offices to form a national nuclear power plant information network.

While this project is just in its infancy there are already plans to expand its scope and to develop retrieval programs for much more sophisticated manipulation of the information than the comparative features mentioned above. The compressive aspects of such a computerized system are tremendous when one contemplates the storage of several feet of book shelf space into a roll of magnetic tape and the fact that selected portions can be retrieved at will at any station on the computerized network. The evaluation aspects of the system are, however, restricted to what the computer has been or can be programmed to do. That could be quite a limitation.

D. DISCUSSION AND CONCLUSIONS

It will be noted that no justification is presented, or indeed needed here, for any of the functions of a scientific information center. I believe that in comparable circumstances any one of the functions described would be a valid function of any given center. However, there are significant economies to be realized where the scope and objectives of a single center are sufficiently broad to require all, or at least several, of the functions simultaneously and the center is adequately financed to do so.

The biggest step any center takes is in becoming computerized -- although in special cases some other form of mechanization may be as appropriate. The computer permits a center to reap the full harvest from the investment of technical expertise in collecting, cataloging, and initially evaluating the information store. The harvest that may then be realized with virtually no further investment of technical effort are 1) special literature searches, 2) periodic or aperiodic bibliographies, and 3) a periodic selective dissemination of information (SDI). In addition, any of these may be accompanied by an author and/or keyword index that is completely computer prepared.

While some evaluation and compression are inherent in the above processes, in the conventional sense of the terms, technical information centers best exhibit these characteristics in the preparation of handbooks, data collections, and state-of-the-art reports. It should surprise no one that these are also the most expensive products of a center as they require the greatest investment of technical effort. How much a center can do in the preparation of such documents is determined by the available funding, which in turn is determined by many other factors, including such things as the national economy and program funding available. The latter will also be influenced by the need and interest in the work under way, the competence with which the studies are undertaken, and the convenience and availability of the ultimate product.

Perhaps the most intriguing recent developments are the prospect of the storage of data files on tape and the development of computer programs that can manipulate and evaluate the data in response to preconceived criteria. Thus the extent of the evaluation is inherently limited, but the amount of data that can be subjected to this evaluation is wide open. Although we at NSIC are at present concerned with the development of this capability for nuclear power plant evaluation, it would be suitable for any large data store for which the basis of the evaluation can be defined.

I trust that this insight into the operation of one scientific information center has been useful to you. We originally went to computers in order to give our technical people the time to do more state-of-the-art reports. The tables have since turned to the extent at least that we now recognize that for well-defined situations, computers can be programmed to do evaluations. No computer, however, is going to prepare a state-of-the-art report, and this is where the information center scientist is at his best. Thus it is obvious that a "balanced" center will use a computer to do what it does best and will use technical personnel not only to prime the computer but also in comprehensive ad hoc evaluations.

The sizes of the "compression ratios" we have attained in both our state-of-the-art report and our Journal are astounding, even when allowance is made for the fact that these ratios do not tell the full story. However, from these ratios it is easy to appreciate the need for such literature. With it technical personnel with peripheral interest can keep up with a technology,

and personnel with a direct interest are informed of the sources they need. Without it most technical personnel would go uninformed, see only a very small fraction of the information, or spend so much time locating and digesting the information as to otherwise seriously compromise their effectiveness.

Unfortunately, I know of no absolute way to determine the effectiveness or monetary value of such scientific information compression and evaluation. Nevertheless I am convinced that it is not only of real value but of substantial value and with that assertion I guess I had better close. We have attempted to measure or establish criteria to measure our effectiveness but that will have to be the subject for another paper.

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