DATA BASES FOR RAPID RESPONSE TO POWER REACTOR PROBLEMS *

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INTRODUCTION

On March 28, 1979 news was flashed around the world of an ongoing reactor accident in Unit 2 of the Three Mile Island (TMI-2) nuclear power plant in Pennsylvania, USA. Nuclear scientists and engineers rushed to the scene or were on standby to help in controlling and minimizing the adverse effects of the accident. Around the world R & D personnel of the nuclear power industry listened to reports of the accident, did calculations and ran computer simulations in an effort to understand and possibly advise the U.S. technologists. Radiation protection and safety were of concern to all.

Almost two years has passed since the TMI-2 accident first captured news headlines with threat of an impending nuclear disaster. The incident has been thoroughly studied (Andrews II, 1980) and both government and industry response has been positive and long term in nature. There has been a reorganization of priorities within government research and regulatory bodies and two major institutions have been formed, the Nuclear Safety Analysis Center (NSAC) (Zebroski, 1980) of the Electric Power Research Institute (EPRI) and the Institute of Nuclear Power Operations (INPO) an independent professional organization established by the U.S. electric utilities in Atlanta, Georgia, to deal specifically with the technical and operational aspects of nuclear safety.

Much of the confusion which added to the problems of dealing with the TMI-2 accident as it was happening and immediately afterwards was due to the inability of the staff to quickly access needed information and data. In its aftermath, the several commissions and study groups made strong recommendations for remedies. The nuclear industry is now making an assessment of its needs and of the availability of data bases for rapid response to questions about power reactor problems. An effort is being made to generate new data bases to fill voids in the available information base and also to improve data base management schemes for dynamic, rapid access to the data.

This paper reviews several planned and existing data bases established for both dynamic on-line access and more considered response to nuclear power reactor problems. The relationship of the data bases to specific problem areas of reactor licensing and regulation is not always clear but some are accessible as a national technology resource in the United States. Embedded in engineering physics research and development programs and managed by knowledgeable scientists and engineers, these data bases are an integral part of the related national programs. At least two of the data bases serve an international scientific community.

DATA BASES AND METHODS DEVELOPMENT

Engineers on duty during and after the TMI-2 accident expressed their data needs in simple terms, such as low energy buildup factors for noble gas, steel, water, lead, etc., current estimates of power history of the reactor core, and generic data normally available in handbooks, etc. Dynamic on-line access to computers with codes and associated data libraries would have been a tremendous asset in performing analyses at the scene of the accident (Hopkins, 1980). The U.S. Nuclear Regulatory Commission (NRC) and the nuclear power industry are studying both needs. New generic data bases and improvements to existing ones, as well as simplified methodology for use on-site are expected to result from these studies.

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TMI-2 has reemphasized the importance of reactor operators and the role they play in determining the level of safety associated with nuclear power. In addition to research in improving training programs, much thought is given to human factors and a body of associated information is being collected and analyzed.

A few specific data bases and associated management systems can be cited, e.g., SEE-IN, CREDO, and SACRD.

SEE-IN

One of the lessons taught by TMI-2 was that there had been visible prior warning of the possibility of such an accident in the form of less serious events at other plants and at TMI-2. Yet these warnings were not perceived for what they were by either NRC or the industry. Analyses that were done on the precursor events were not disseminated to the utilities until after the accident.

To remedy this situation, NSAC set up a mechanism for systematically searching plant operating experience for such early warning signs, and a new data base system, SEE-IN (Zebloski, 1980), came into being. A large, rapidly searchable data base of licensing information that is continually updated is an integral part of the SEE-IN system. Included is a body of data based on the examination of all Licensee Event Reports (LERs) from all U.S. nuclear utilities. The establishment and maintenance of the data bank is a cooperative effort of NSAC and INPO with the assistance of the Nuclear Safety Information Center (NSIC) (Cottrell, 1971, 1977) at the Oak Ridge National Laboratory (ORNL) and other contractors. The NSIC LER data base contains 22,000 events with computerized descriptions which are retrievable using keywords. An important element of SEE-IN is the computer information network and conferencing system (NOTEPAD) which permits rapid, comprehensive, user-selective transfer of urgently needed information to all interested parties.

CREDO

Safety studies usually involve an assessment of risk and the cost and benefit of reducing risk. Risk assessment is probabilistic in nature; one estimates the probability that an accident will occur and the damage that will result from it. The product, probability times damage, is the risk, in engineering terms. Essential to risk assessment is the availability of a large body of related data. Several efforts are underway to supply the needed data.

The Centralized Reliability Data Organization (CREDO) (Knee, 1980) is a DOE-sponsored program at the Oak Ridge National Laboratory (ORNL) as a part of the National Advanced Reactor Reliability Data System. It disseminates advanced reactor reliability/availability data and provides limited specialized analysis services for requesting users. Interface and cooperative data exchange with other US and international data banks is an integral part of the program plan.

A working system for data collection, management and distribution is in operation and expected to move from a development stage to routine operation in the next two years. The organization includes a nationally recognized steering committee of experts, and working groups on 1) input data, formats and procedures, 2) data evaluation, and 3) output data, formats and procedures, and the ORNL principals and support staff.

Three types of data are collected:

- (1) Engineering Data which contain a complete engineering description of a component and uniquely identify it so that its specific operating and failure history can be tracked. In general, engineering data on a component is collected once, preferably before initial operation.
- (2) Operating Data, i.e., operating hours and/or number of cycles of a component. In CREDO, an estimate of operating hours (or cycles) for a component is obtained by reporting (quarterly) the operating hours for the unit, and then multiplying that by "operating factors" or "duty factors" which are specified on the component engineering form. Therefore, the CREDO operating file contains information on unit operating hours.
- (3) Event Data is a complete description of an occurrence (failure), its cause and effects, corrective action taken and time required for various elements of total repair time. Event data are reported as soon after the event as possible.

All of the data management functions - cataloging, storage, searching, retrieval, routine statistical analysis, and routine output - are under control of a versatile data base management system (DBMS) which has been constructed primarily from systems existing at ORNL. The DBMS uses techniques developed for the Oak Ridge Computerized Hierarchical Information System (ORCHIS) (Brooks, 1974) combined with the data management facilities of JOSHUA, a modular system developed (Honeck, 1975) at the Savannah River Laboratory. Additional software has been developed for tasks specific to CREDO needs, e.g. failure-rate estimation. The JOSHUA-ORCHIS combination provides a flexible and efficient data management system to perform the varied tasks of a reliability data center.

Both raw and reduced data are available to users through a variety of routine and specialized outputs. Currently available routine output forms, issued either periodically or on demand, include quarterly failure data summaries, component quantitative failure data summaries, and engineering and event inventories. Because of the flexibility of the computerized system, specialized output can be prepared to accommodate specific user requests, or outputs can be generated manually by CREDO staff.

Routine services planned, in addition to systems information in newsletter form, include an early alert system (CAUTION) which provides rapid dissemination of information on occurrences with potentially serious safety or operational impact, and an urgent data request service (PLEA) in which all participants are queried for rapid response to a special urgent data request from a particular user.

SACRD

The TMI-2 incident highlighted the need for quick access to generic and other data to be used in computer codes for reactor safety analyses. More than one effort is underway, such as the Safety Analysis Computerized Reactor Data (SACRD) (Forsberg, 1980; Greene, 1977). A data bank system sponsored by DOE at ORNL, SACRD includes nondesign-related information used in computer codes for fast reactor safety analyses.

The organizational structure of SACRD is similar to that associated with several other successful data banks, in particular, the Evaluated Nuclear Data File (ENDF) (Garber, 1975) and the Nuclear Systems Materials Handbook (NSMH). As with these data banks, the direction of SACRD is guided by a central committee of experts and interested persons from governmental agencies, universities, national laboratories, and industry. This committee of approximately 25 members is called the Safety Analysis Data Coordinating Group. It coordinates the activities of a number of subcommittees, whose primary responsibilities are in the data evaluation area. Present subcommittees exist for Thermophysical Properties, Structural Mechanical Properties, Fuel Mechanical Properties, Aerosol Transport Properties, Radiological Data, Neutronic Data, and External Code Interfaces and Formats.

To avoid duplication, the SACRD subcommittees include individuals who are also members of similar committees for other evaluation efforts. This ensures that SACRD evaluation work will focus on extending and augmenting existing data to cover the "extreme" ranges needed by the reactor safety analyst which are not provided by other sources.

The data in SACRD, with the exception of some meteorology- and dosimetry-related parameters, are managed by the JOSHUA system (Honeck, 1975), a modular programming system developed at Savannah River Laboratory. The hard-copy services presently available include data catalogs, graphical output, abstracts, tabular data, and parametric fits.

Interactive facilities are provided for the user with a teletype-compatible terminal and fast response is emphasized.

DATA BASES IN INFORMATION ANALYSIS CENTERS

Two information analysis centers (IACs) which collect, organize, evaluate, package and disseminate information (including bibliographic citations and abstracts, numeric data and scientific computer codes) are included in this survey. These and other centers not reviewed for this paper supply an important information and technology base which can be accessed for fast response to power reactor problems.

EPIC

The Engineering Physics Information Centers (EPIC) at the Oak Ridge National Laboratory (ORNL) vary in complexity from a technical institute to a data repository. Included are: the Radiation Shielding Information Center (RSIC) (Maskewitz, 1972; Roussin, 1975; Trubey, 1977) founded in 1962 and sponsored by the U.S. Department of Energy (DOE), the Defense Nuclear Agency (DNA), and the Nuclear Regulatory Commission (NRC); the NRC-sponsored Reactor Safety Research Data Repository (RSRDR); the NRC Technical Data Management Center (TDMC); and a newly established Center of Model Validation Technology (COMET), sponsored by the DOE Energy Information Administration. Each IAC creates and manages data bases, and excepting for COMET which is concerned with energy economy models and data, each responds to inquiries for information related to power reactor problems.

The Reactor Safety Research Data Repository (RSRDR) serves as the archival repository and response center of the NRC/RSR Data Bank System, which also includes Data Base Managers, and a Data Bank Processing System located at the Idaho National Engineering Laboratory (INEL). Several Data Base Managers collect and evaluate data to be included in the Data Bank System. The INEL Data Bank Processing System processes the data into a standard format, sends it to RSRDR and makes it directly available to NRC and INEL researchers via on-line interaction with the INEL computer.

The NRC/ASR Data Bank System is designed to manage data pertinent to research investigating the loss of coolant accident for both pressurized water reactors and boiling water reactors. The data is in the form of raw measured data that has not been processed with the exception of conversion to engineering units and application of calibration factors. Data sources include experimental programs sponsored by NRC, other government agencies, private industry, and foreign governments.

The TDMC gives assistance as required to NRC's many data management problems. It includes a dynamic treatment of safety-related computing technology and data bases, the enhancement and standardization of computing technology for use in licensing and regulating nuclear power plants, and the building of safety-related data bases for dynamic on-line access and for rapid response as needed. As an aftermath of the TMI-2 accident, TDMC staff members became involved in a survey of NRC data needs and making recommendations for the establishment of new, improved, easily accessed data bases. At the same time, efforts are underway to generate data which was not available when needed by engineers at the TMI-2 site.

NSIC

The ORNL Nuclear Safety Information Center (NSIC) (Cottrell, 1971, 1977) is a national center for collecting, storing, evaluating, and disseminating nuclear-safety information generated throughout the world. Established in 1963, NSIC is sponsored by DOE and NRC to analyze current information, produce state-of-the-art reports, and answer technical inquiries. The scope encompasses all types of nuclear facilities and reactors from water-cooled to liquid-metal fast breeders, along with associated considerations such as siting and operating experience. Its products include the bimonthly technical progress review, Nuclear Safety, which is sold on a subscription basis by the U.S. Government Printing Office, Washington, D.C.

A quick measure of the impact of TMI-2 on NSIC is the change in the Center's overall budget over the past year - an increase of about 80%, primarily in studies and evaluations. Immediate impacts were (1) support of the industry advisory group at the TMI site, (2) assistance to EPRI in the formation of NSAC Safety Analysis Center (NSAC), (3) preparation of a report on reactor accidents for the Kemeny Commission, and (4) a greatly expanded use of NSIC resources.

The Center has seen the use of its data base of Licensee Event Reports (LERs) expanded dramatically, both in the response to technical inquiries and as one of the most important resources used in performing special studies. As an example, the Accident Sequence Precursor Study has screened 22,000 LERs and selected about 0.7% as potential precursors to severe core damage accidents. Event "trees" are being constructed for the selected events, and the accidents are being analyzed for lessons to be learned.

NSIC and its sponsors plan new and expanded data bases with dynamic on-line access a standard feature.

CONCLUSION

The urgency of the TMI-2 incident demanded prompt answers to an imperious situation. In responding to these challenging circumstances, both government and industry recognized deficiencies in both availability of essential retrievable data and calculational capabilities designed to respond immediately to actual abnormal events. Each responded by initiating new programs to provide a remedy for the deficiencies and to generally improve all safety measures in the nuclear power industry.

Many data bases and information centers offer generic data and other technology resources which are generally useful in support of nuclear safety programs. A few centers can offer rapid access to calculational methods and associated data and more will make an effort to do so.

As a beneficial spin-off from the lessons learned from TMI-2, more technical effort and financial resources will be devoted to the prevention of accidents, and to improvement of safety measures in the immediate future and for long term R & D programs by both government and the nuclear power industry.

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