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Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR) Volume I: Summary Description

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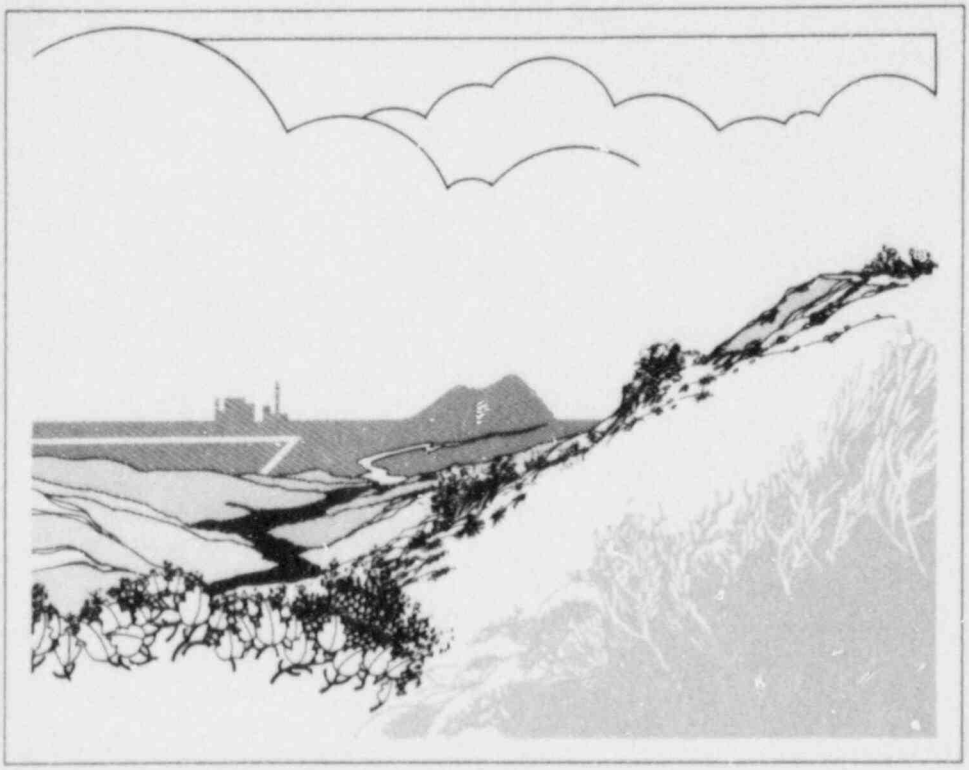

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NUCLEAR COMPUTERIZED LIBRARY FOR ASSESSING REACTOR RELIABILITY (NUCLARR) VOLUME I: SUMMARY DESCRIPTION

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ABSTRACT

A data management system has been implemented which supports a variety of risk-related analyses and provides a repository of hardware component failure and human error probability data to the risk analyst. The Nuclear Computerized Library for Assessing Reactor Reliability, NUCLARR, is an interactive, graphically oriented system which resides on a personal computer (PC) or PC-compatible environment. An overview of the data management system, including a description of data collection, specification, data structure, and taxonomies, is presented in Volume I of this report. Programming activities, procedures for processing data, user's guide, and hard copy data manual are presented in Volumes II through V.

EXECUTIVE SUMMARY

The Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR) is an automated data base management system used to process, store, and retrieve human and equipment reliability data in a ready-to-use format. NUCLARR was developed by the U.S. Nuclear Regulatory Commission (NRC) to provide the risk analysis community a repository of human error and hardware failure rate data that can be used to support a variety of analytical techniques for assessing risk. The human error component of the NUCLARR system complies with the specifications and procedures as described in NUREG/CR-4010, *Specification of a Human Reliability Data Bank for Conducting HRA Segments of PRAs for Nuclear Power Plants*. Specifications for the hardware failure rate features for NUCLARR were developed by the project team at the Idaho National Engineering Laboratory (INEL).

The Summary Description, which provides a general overview of the NUCLARR System, is Volume I of a five-volume set. Program background, system taxonomy, data structures, and capabilities of the NUCLARR System are included. Stated briefly, Human Error Probability (HEP) data are hierarchically organized by system, subsystem and component, and human action. Hardware component failure data are organized by equipment type, e.g., type of valve or pump, and failure mode. Both parts of the NUCLARR system make use of a matrix structure and independent aggregation methods appropriate for the data types. Additional, detailed information regarding programming, data processing, data management, and data retrieval is presented in the four accompanying NUREG/CR-4639 volumes in this series.

A clearinghouse function has been established at the INEL to maintain the NUCLARR data library, to distribute diskettes containing the data base, and to assist users of the NUCLARR System.

ACKNOWLEDGMENTS

We are grateful to Dr. T. G. Ryan, of the U.S. Nuclear Regulatory Commission (NRC), for his continued contributions as Technical Monitor for this program. In addition, we owe a special appreciation to Dr. G. R. Burdick, also of the NRC, for his assistance and support of the NUCLARR program.

The authors would like to thank Ms. M. K. Comer, from General Physics Corporation (GPC), and Mr. M. D. Donovan, Consultant, for their guidance and critical review of the NUCLARR program. Their insightful recommendations and contributions during this effort are greatly appreciated. In addition, we are deeply indebted to them for allowing us to use sections directly from NUREG/CR-4010, the technical specification for the HEP portion of this work, in the preparation of this report.

Other individuals who provided valuable input to this program from the Idaho National Engineering Laboratory (INEL) were D. Fink, G. Beers, P. M. McGuire, T. H. Tucker, and O. Call, for their efforts in software development and document preparation.

Finally, we would like to thank Dr. H. S. Blackman, from the Human Factors Research Unit at the INEL, for his technical direction, recommendations, and contributions in the area of program management.

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ACRONYMS

AEOD	NRC Office for Analysis and Evaluation of Operational Data
B&W	Babcock & Wilcox
BWR	boiling water reactor
CRO	control room operator
DOS	disk operating system
EO	equipment operator
FY	fiscal year
GSI	generic safety issue
HEP	human error probability
HHRAG	Human and Hardware Reliability Analysis Group
HRA	human reliability analysis
IBM	International Business Machines
INEL	Idaho National Engineering Laboratory
IRADAP	Integrated Risk Assessment Data Acquisition Program
IRRAS	Integrated Reliability & Risk Analysis System
LCB	lower confidence bound
LER	licensee event report
MDP	motor-driven pump
MT	maintenance technician
NPP	nuclear power plant
NRC	United States Nuclear Regulatory Commission
NSSS	nuclear steam supply system
NUCLARR	Nuclear Computerized Library for Assessing Reactor Reliability
PC	personal computer
PMS	Performance Measurement System
PRA	probabilistic risk assessment

PWR	pressurized water reactor
PSF	performance shaping factor
RC	recovery considered
RCIC	reactor core isolation cooling system
RNC	recovery not considered
RO	reactor operator
SRV	safety relief valve
SS	shift supervisor
UCB	upper confidence bound

NUCLEAR COMPUTERIZED LIBRARY FOR ASSESSING REACTOR RELIABILITY (NUCLARR) VOLUME I: SUMMARY DESCRIPTION

INTRODUCTION

Background to Human Error Probability (HEP) Data

"Human error" is often defined as any member of a set of human actions that deviates from some range of acceptable performance. Human error probability (HEP) assessment is the codification and translation of these performance deviations into a coherent probability statement. Knowledge of the type and frequency of human errors that can occur in a given event is essential when reliability issues associated with the successful operation of complex systems are addressed. These human error probabilities are combined with probabilities for equipment/hardware failures to quantify overall estimates of risk. "Risk," in this context, can imply the likelihood of economic loss, as well as those events that affect the health and safety of the public. Probabilistic risk assessment (PRA) is the dominant technique, and the most commonly accepted practice in the nuclear industry, for a risk analysis. The results obtained from PRAs are crucial when decisions are made regarding the safety of nuclear power plants (NPPs).

A major portion of the PRA process consists of obtaining accurate and relevant HEP data. HEPs provide the basic inputs for performing human reliability assessment (HRA) segments of PRAs. A major source of HEP data is contained in NUREG/CR-1278, *Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Operations.*[1] In recent years, however, due to increased activities in determining HEP values, a variety of additional data sources have emerged (e.g., field data reports, training simulator data, consensus of expert judgment, laboratory experiments, simulator modeling data). These recently developed data sources present a problem to the PRA practitioner tasked with utilizing this information. The practitioner often does not have the time or resources to conduct detailed searches through these sources in order to locate appropriate HEP data. In some cases, the requestor of HEP data may not be familiar with, or aware of, all of the sources available. As a result, the PRA practitioner's ability to access the best data for a given application is constrained.

A need, therefore, exists to develop and implement a repository or library where human reliability data sources can be processed, stored, and retrieved in a timely fashion. To fulfill this need, a research program sponsored by the U.S. Nuclear Regulatory Commission (NRC) was initiated.

Background to Hardware Failure Data

Part of NUCLARR's mission is to better support the operational data use and collection activities conducted by the NRC through offering a central repository for failure rate data. NUCLARR contains both generic and plant-specific failure rate data and shortly will include unavailability, common cause, and root cause data. Selection of generic failure data was a recommendation from a study conducted by the INEL for the NRC in FY-1986. This recommendation was predicated upon availability, completeness, and cost of obtaining data. Efforts in the area of data collection, including an appropriate taxonomy, are coordinated with IRADAP (the Integrated Risk Assessment Data Acquisition Program), sponsored by NRC's Office for Analysis and Evaluation of Operational Data (AEOD).

The data sought for entry in NUCLARR consist of failure rates and probabilities for failure on demand for hardware that is used in commercial power plants.

Detailed hardware component failure data are structured in the NUCLARR system as a series of events (the equivalent of a cell in the HEP subsystem). An event is defined by the component, its design, its normal state, and the mode of failure. While the HEP subsystem treats its cell as a

two-dimensional matrix element, the hardware event is actually a four-dimensional entity. Each event may contain one or more sources of hardware failure data, each containing the following additional searchable information where applicable: (a) the component's application; (b) whether control circuitry is included; (c) the failure severity; (d) the failure degree for non-catastrophic failures; (e) data origin information, including the plant and the type of records used to extract the failure data and whether the data source is domestic, foreign, nuclear, or non-nuclear; (f) the component's system, subsystem, and train; (g) the data collection start and end dates; (h) a reference to the source documentation; and (i) a comment field. For nuclear plants, the reactor type and the nuclear steam supply system (NSSS) vendor are also searchable. Additional function or application information is stored when available. This additional information includes instrumentation, internal or external environment, relay applications, and voltage level applications.

Data emphasis is specifically on hardware failures, not general losses of function. The failure events of interest are those events in which the components required some type of repair, replacement, or adjustment.

Hardware failure data records are designed to supply information for failure rates (failures/hour) or probabilities of failure on demand (failures/demand). Maintaining the level of detail which the operational experience allows for distinguishing separate rates within a component type is another aspect of the scope. For example, if failures are counted separately for each pump in a plant, then a failure record unique to each individual pump would be available. However, NUCLARR possesses the capability to combine operating experience to form an overall pump failure rate for all pumps.

One goal of NUCLARR is to maintain the source data at a level of detail such that the failure rate can reasonably be assumed to be constant. Thus, data from a single source for components having the same design, function, application, and operating environment are combined. If there is any reason to expect differences in the rates (e.g., perhaps a particular component was used in a unique environment), the preferred approach is to separate the data into distinct records. In summary, the optimal data record for NUCLARR is a statement of the number of failures of a particular type and corresponding operating history (times or demands) for a set of identical, or at least similar, components.

If this desired level of detail is not available, the data describe a collection or population of components with failure rates that may vary. For such data, an important feature is the inclusion of tolerance intervals that describe this population variability. If no tolerance intervals are available, NUCLARR still maintains the data; and the variability is characterized through the combining of the data from several sources.

History of Prior Efforts

The first objective of the NUCLARR program was to develop a human reliability data bank that would satisfy the requirements for a single, integrated source of data that could be used as input to the HRA portion of PRAs. As part of this program, a survey of existing human reliability data banks from other industries was conducted; and a concept of a data bank for the nuclear industry was developed. The results of the survey and the data bank concept are documented in NUREG/CR-2744, *Human Reliability Data Bank for Nuclear Power Plant Operations, Volume 1: A Review of Existing Human Reliability Data Banks,*[2] and NUREG/CR-2744, *Human Reliability Data Bank for Nuclear Power Plant Operation, Volume 2: A Data Bank Concept and System Description,*[3] respectively.

Following the concept development, a technical specification containing detailed procedures for receiving, treating, storing, and retrieving data was prepared. The human reliability data bank was designed and developed to be responsive to the varied requirements for human reliability data use in the HRA portion of a PRA. The data bank also has the flexibility to provide data input to many other types of modeling techniques.

An evaluation was conducted to determine the practicality, acceptability, and usefulness of the technical specification. The evaluation consisted of an operability demonstration and evaluation of the data processing procedures, a data retrieval demonstration and evaluation of the data retrieval procedures, a retrospective analysis of information related to the operation of existing data banks, and an internal analysis of information gathered during the preparation of the technical specification. The results of the evaluation are documented in NUREG/CR-4009, *Human Reliability Data Bank Evaluation Results.*[4]

The technical specification was modified based on the results of the evaluation. Revised procedures for receiving, treating, storing, and retrieving data are contained in NUREG/CR-4010, *Specification of a Human Reliability Data Bank for Conducting HRA Segments of PRAs for Nuclear Power Plants.*[5] The objective of this document is to provide all detailed procedures and specifications to initiate, operate, and maintain the human reliability data bank system. Information is also supplied in the document for assembling the personnel and materials needed for initiating and subsequently operating the data bank.

Current Efforts

The data bank specification and system description presented in NUREG/CR-4010[5] became the requirements for implementing the NUCLARR system.

The primary goal of NUCLARR is to establish and operate computerized data base management tools for HEP and hardware component failure data. It was recognized by the NRC and the developers of the human reliability data bank concept that a fully functional library would not be feasible, or practical, to implement without the aid of computerized tools for management and manipulation of its data sources. Many of the advantages for computer-aided features were revealed during the field evaluation of the human reliability data bank. Specific features identified during the evaluation period included programs for modifying, locating, and storing HEP data and supporting information. Additional features consisted of provisions for performing on-line calculations of HEPs and confidence bounds. The flexible capability for revising the data bank taxonomy and updating the data bank were also noted as desirable features. NUREG/CR-4010,[5] developed for manual paper and pencil applications, furnished INEL with the guidelines and system specifications for software implementation, making NUCLARR, as a finished product, an on-line computerized adaptation of this document. Enhancements, such as additional performance shaping factors (PSFs) and search retrieval capabilities, have been added in response to user surveys and reviews.

Likewise, it was realized that a user-friendly, menu-driven system would be of great benefit to the PRA and risk analyst concerned with hardware failure rates. This work was initiated in early FY-1987.

Scope of NUCLARR

The NUCLARR data management system was designed specifically for use in performing nuclear power plant PRAs. Therefore, the taxonomies, or classification schemes, reflect both human errors and hardware failure rates pertaining to the nuclear power industry. The NUCLARR system in its entirety consists of a computerized hardware and software tool which is supported, maintained, and administered by personnel within the Data Clearinghouse, Human and Hardware Reliability Analysis Group (HHRAG), Review Committee, and administrative staff. The purpose of these organizations is to coordinate and perform all the various activities associated with system management and implementation. The necessary information for assembling the personnel and materials needed for initiating and subsequently operating the NUCLARR system are also specified within the scope of this program.

Questions and further information regarding data collection, submission, or use of the NUCLARR System should be directed toward:

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NUCLARR Data Clearinghouse
Idaho National Engineering Laboratory
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FTS-583-0652, commercial 208-526-0652

All of the hardware, software, and documentation are available to process, store, and retrieve HEP and hardware reliability data using the NUCLARR system. This document, *Volume I: Summary Description*, presents a general introduction to the NUCLARR system. In this document, the background and history of the program are described. Information regarding the organization, structural taxonomies, and key features of the NUCLARR system are also summarized. This report is intended to be used by individuals who are interested in obtaining a top-level overview of the system's functions and capabilities. Detailed procedures, system specifications, and supporting information for operating and using the NUCLARR

system are provided in the following series of companion reports.

- *Volume II: Programmer's Guide*—provides information necessary for maintaining the software of the NUCLARR system. Descriptions of the data base structure, system taxonomies, programs, support libraries, main menus, computer environment, and structural rebuild instructions are provided. This report is intended for use by the software engineer maintaining and modifying the NUCLARR programs.[6]
- *Volume III: Data Base Management Guide*—provides the input procedures for extracting suitable data from candidate source documents and entering this information into the NUCLARR system. In addition, procedures are also provided for revising the data base taxonomies and structure. This guide is intended primarily for use by members of the HHRAG who are responsible for screening and entering the data. Its contents also serves as a resource for data entry clerks who may be tasked with loading data items and document information into the NUCLARR system.[7]
- *Volume IV: Data Retrieval Manual*—provides the output procedures for locating and retrieving data from the NUCLARR system. In addition to directions for use of the software, guidance is provided for determining the degree to which selected data can be applied to a specific application. If data are not available, the manual contains instructions for locating alternative sources of data in the NUCLARR system. This report and a PC diskette of the NUCLARR programs and data will be used by the requestor (e.g., PRA practitioner) in order to perform a risk analysis.[8]
- *Volume V: Data Manual*—Parts 1 and 2 provide data requestors with a hard-copy version of all data and supporting information residing on the NUCLARR system computerized data base. The manual is a stand-alone document enabling the data requestor and the HHRAG to access HEP and hardware component failure data without use of the on-line data base. This report is updated periodically to provide ready reference material to the data requestor (e.g., PRA practitioner).[9]

Document Organization

The next section of this document provides a detailed internal description of the NUCLARR data management system. The system requirements (e.g., personnel, hardware and software, facilities), taxonomy, data structures, and cell contents for both HEP and hardware modules are presented. This is followed in each case by an overview of the procedures for retrieval of data (data output), processing the data (data input), and revising the taxonomy and cell structure. An overview of the procedures for interfacing with the data suppliers and data requestors is also included. The report concludes with a section summarizing the current status of the NUCLARR program.

DESCRIPTION OF NUCLARR

NUCLARR System Overview

The NUCLARR system's major components are:

- *NUCLARR Clearinghouse*—functions as the primary interface and point of contact and interacts with data suppliers and users. Besides personnel management and responsibility for all interactions between the data requestors (e.g., PRA practitioners) and the NUCLARR system, this group is also responsible for developing and administering a quality control program for the processing of data by the HHRAG (see below). Data Clearinghouse personnel distribute the Data Manual and accompanying PC diskettes, provide data source material when requested, and respond to questions regarding uses of the data.
- *Human and Hardware Reliability Analysis Group (HHRAG)*—primarily tasked with all data input and data base maintenance functions. The HHRAG reviews data in source documents for suitability, and if accepted, prepares them for entry into NUCLARR. Many of the activities required of the HHRAG will be supported by data entry technicians. The HHRAG also develops recommendations for improving NUCLARR procedures, taxonomy, or format if necessary to provide a more efficient treatment of data.
- *HHRAG Review Committee*—provides technical direction to the HHRAG, data entry clerks, and software engineers to integrate any approved changes into the NUCLARR system. This committee, consisting of members from both inside and external to the NUCLARR project team, will meet on a periodic basis to review recommendations for changes to the NUCLARR system taxonomy. Additional duties involve quality assessment of the data stored in NUCLARR, and review of the Data Manual prior to distribution.
- *NUCLARR Computer*—encompasses all the software/hardware for the automated data base management functions of storing, processing, and retrieving human error and hardware failure rate data. This includes the applications software, computational algorithms, and housekeeping functions necessary for maintaining and handling the computer-aided features for the NUCLARR system.

Personnel Qualifications for Operating and Maintaining the NUCLARR System

The NUCLARR data management system is administered and operated by the Administrative Staff, HHRAG, Review Committee, and Data Clearinghouse personnel. These personnel are experienced in one or more of the following disciplines:

1. Nuclear power plant operations and maintenance
2. Human factors engineering, with particular emphasis on evaluating human performance in nuclear power plant facilities
3. Human reliability analysis (HRA), with familiarity in conducting PRAs
4. Probabilistic risk analysis and generic safety issues.

This core group of individuals is supported by data entry technicians and software engineers.

Sources of Data and Collection Procedures

Any individual or organization may submit data to the Clearinghouse for consideration for entry into the NUCLARR system. Data sources received from data suppliers will be screened for suitability by the HHRAG.

Data Submission—HEP. Data that are accepted for inclusion in the HEP side of the NUCLARR system must meet the following general criteria:

- The data must involve a *human action* that was performed or was supposed to be performed.
- The data must describe the *equipment* that was the object of the human action.

- The data must provide quantitative values of error probability in the form of an HEP point value, HEP probability distribution, or a ratio of errors to estimated opportunities.

The data base management features of the NUCLARR system will provide for immediate update capabilities as new data are entered. Periodically, a revision to the entire Data Manual and accompanying PC diskettes will be published that incorporates the new data as well as any changes to the taxonomy or cell structure.

Data Submission—Hardware. Data submitted for inclusion in the hardware side must meet those criteria outlined in EGG-REQ-7742, *Requirements for Entry of Hardware Failure Data.*[10] Briefly stated, they include: data source, description of component and failure mode, description of operating conditions, safety grade status, probability data (number of failures and number of operating hours or demands), tolerance or confidence intervals, and assumed distribution.

Hardware and Software Specifications

Routine processing and data base management functions are performed by the system software and hardware. The minimum hardware needed for the NUCLARR system and the preferred configuration are shown in Table 1. IBM equipment was selected because of its portability, industry-wide acceptance, and conformity to NRC standards. Data requestors receive an updated copy of the software and data files from the Data Clearinghouse that can be operated on their individual IBM PC or IBM-compatible workstation. Later, if a need exists, direct on-line access from a central computer facility can be made available.

The software was written in the Modula-2 programming language with the aid of SAGE programming tools. SAGE is a reusable set of prepackaged subroutines and program modules developed "in house" at the INEL. The software is menu-driven and supplemented with an ad hoc command structure. Help forms are integrated into the menu hierarchy for easy reference as needed. The HHRAG is responsible for maintenance and entry of HEP data. Data retrieval and output functions are performed by the data requestor (e.g., PRA practitioner).

File Conversion Routines

On the HEP side, NUCLARR currently produces ASCII data files which are directly readable by software packages such as SPSS, SAS and dBIII. These file conversion routines were developed in FY-1987 and are to be fully operational in early FY-1988. On the hardware side, NUCLARR both accepts and creates ASCII data files.

Table 1. Minimum and preferred computer system configuration

Minimum	Preferred
IBM PC:	IBM PC - AT:
640 kB of memory	Maximum allowable memory
Graphics card	Enhanced graphics card
Math 8087 co-processor card	Math 8087 co-processor card
Monochrome, 80-column monitor	Color monitor
20-MB fixed disk	30- to 60-MB of fixed disk
Floppy disk drive	Floppy disk drive
80-column line printer	Printer with IBM graphics font
DOS operating system	DOS 3.2 operating system
	Logi-mouse and software
	Communications port for mouse

DATA CLASSIFICATION SCHEME AND TAXONOMY—HEP

General—Background to HEP Classification

The HEP data collected for the NUCLARR system are organized and classified in a three-level hierarchy, as follows:

- *Level 1:* Actions are classified by nuclear power plant system and by duty areas that summarize the objective of the human interaction with the system. Examples of Level 1 tasks are:
  - Control room operator (CRO) monitors the reactor recirculation system.
  - Maintenance technician (MT) tests the leak detector system.
- *Level 2:* The task involves one or more actions that change or determine the state of a plant component. Actions have an effect on the plant component(s). Examples of Level 2 tasks are:
  - MT repairs a centrifugal pump.
  - Equipment operator (EO) starts a motor-driven pump.
- *Level 3:* The task is a single action directed at a specific control, instrument, or display device used to operate or maintain equipment in the plant or to communicate with other plant personnel. Actions specify interactions with controls or display devices. Examples of Level 3 tasks are:
  - Operator reads a meter.
  - Operator positions a J-handle switch.

The objectives for developing the classification scheme were to:

1. Classify data useful for HRA;
2. Simplify filing, storage, and retrieval of the data;
3. Enable data from different sources to be combined; and
4. Keep track of the data collected.

The taxonomy permits a hierarchical approach to the data so that the NUCLARR user can choose the appropriate level of detail for the analysis. For example, the equipment reliability analyst can choose whether or not the analysis should end at the diesel generator level, should include the subsystems such as lube oil, or should extend to the individual parts level (bearings, fuel injection pump) of the diesel generator. The NUCLARR classification scheme or taxonomy presents the same kind of choices to the human reliability analyst by combining equipment characteristics and human actions on three separate levels.

Under equipment characteristics associated with human actions, the system category (Level 1) has been divided according to the major nuclear steam supply system (NSSS) vendors. This differentiation was incorporated into the taxonomy because of the differences in system configuration, nomenclature, and operation among NSSS vendors. These differences are substantial enough to preclude the broad combining of human error data across all NSSS vendors. Therefore, the data are separate in the NUCLARR system, allowing the analyst the flexibility of combining data appropriate to the analyst's application. Classification by NSSS vendor was not performed for the component level (Level 2) or the displays/instruments/ controls level (Level 3) because the differences among NSSS vendors at these levels do not significantly affect the interface between the equipment and the human action.

Under Level 1, human actions are divided into:

- CRO duty area
- EO duty area
- MT duty area.

This division was incorporated into the taxonomy structure because of the differences in responsibilities and functions of the three positions, as well as the differences in the primary workstations of each (for example, control room versus general plant areas). These differences are also significant at the task level (Level 2). However, at the task element level (Level 3), the human actions associated with the equipment characteristics are similar for the three positions, so no differentiation is required.

Data and Cell Structure

The structure of the NUCLARR system is a series of two-dimensional matrices combining the

different levels of the equipment characteristics category with the specific levels of the human actions category. Complete descriptions of equipment characteristics and human actions are located in the Data Manual.[9] A total of 16 separate and distinct matrices are utilized. Equipment characteristics are listed by rows, and human actions are listed by columns for each matrix. The intersection of an equipment characteristic and a human action on a matrix constitutes a *cell*.

Cell Type. Within each of the three levels, there are three different types of cells: basic equipment cells, general equipment classification cells, and functional group summary cells. The differentiation among the types of cells is:

1. Data pertaining to a specific type of equipment are stored in a *basic equipment cell*. For example, data on all single push buttons except those with illuminated legends are stored in the cell corresponding to push button (other).
2. The *general equipment classification cell* contains data that are reported on general equipment types. For example, data may be reported on two-position switches in general, without specifying whether it is a push button or a rocker switch. Only data describing the equipment characteristics in general terms are stored in *general equipment classification cells*.
3. The *functional group summary cell* contains data that have been combined from the *basic equipment cells* and from the *general equipment classification cells*. The *functional group summary cell* contains data that are recommended as the best overall data to use for a specific functional group.

Cell Page Numbering Scheme. HEP data, confidence bounds, and supporting information (e.g., task statements, PSFs, data sources) are displayed in each individual cell. Cells are organized in the data structure by taxonomy level, equipment characteristic, and human action. Each cell is identified by a unique seven-digit cell page number code.

Cell Validity. Cells selected by the data requestor are automatically checked for validity for both equipment and human action by the NUCLARR system. For example, the system will not enter data such as the "control room operator vents the diesel generator."

Data and Contents. Individual entries typically contain the following items:

- Task statement
- Failure mode (omission, commission)
- Data type (recovery considered, recovery not considered)
- Human error probability
  - Mean HEP point value
  - E, number of errors
  - N, number of opportunities for error
  - UCB (upper confidence bound)
  - LCB (lower confidence bound)
  - Median HEP point value
  - Error factor
  - Aggregated HEP (calculated on user-demand)
- Plant code
- Performance time to complete task
- Time available to complete task
- Scaled values for performance shaping factors (PSFs)
  - Stress
  - Experience
  - Procedure
  - Tagging
  - Feedback
  - Staffing
  - Training
  - Supervision
- Data source
  - Data identification number
  - Reference citation (if applicable)
  - Origin of data
  - Page number, paragraph and line number
- Event type (procedural sequence where the operator error occurred)
  - Pre-initiating event
  - Planned operator action
  - Recovery action outside of procedures.

Data are displayed in the matrix cells by task statements, failure mode, and data type. The failure modes in the NUCLARR system are errors of omission and errors of commission. An omission error is defined as a failure to perform the task or a step within a task. A commission error occurs when a task is attempted but is not successfully accomplished for any reason. In addition, for each failure mode, omission and commission, the HEPs and confidence bounds for recovery considered (RC) and recovery not considered (RNC) are presented. Within the context of the NUCLARR system, errors with recovery considered include cases where recovery factors or corrective actions were considered in the estimation of the HEP value. Errors with recovery not considered are HEP estimates of an initial error and are not based on recovery factors or corrective action.

Data Origin

The data entered in the NUCLARR system are identified in all cases according to their sources. The data source information provided on the cell page is:

- *Data Identification Number* - This number consists of three digits followed by the last two digits of the calendar year in which the data were processed (XXX-YR). Each source of data is assigned a number when it enters the system.
- *Origin of Data Source* - The data origin is classified as one of the following:

  — Field data
  — Training simulator data
  — Laboratory data
  — Consensus expert judgment
  — Subjective data
  — Simulation modeling data
  — Analytic data.

- *Data Item* - This is the page, table, and line number of the data source containing the information that was used to obtain the HEP.
- *Reference Citation* - This field is used for HEPs identified from the data source that have been "referenced" from another document.

Source documents, from which the HEPs were obtained, are stored and maintained in the on-line NUCLARR system document file. This feature gives the data requestor immediate access to the title, authors, publisher, and other information identifying where the HEP values were derived. The document identification number from the cell pages is cross-referenced with the citations from the document file.

Data Combination and Treatment

A description of the types of data combinations performed by the NUCLARR system follows.

- *Task Statement HEP* - an estimate of the unrecovered or basic HEP for commission or omission errors in performing a task described by a task statement (may be combined over multiple sources).
- *Cell HEP* - an estimate of the unrecovered or basic HEP for commission or omission errors in performing all tasks identified in a cell.
- *Functional Group Summary HEP* - an estimate of the unrecovered or basic HEP for commission or omission errors in performing all tasks with a common human action verb on any equipment in a functional group.

At the highest level of HEP data are the functional group summary HEPs based on related task statement HEPs. For example, a functional group summary HEP would be provided for "open/close valves" based on task statement HEPs involving opening or closing numerous types of valves in numerous situations. A cell HEP would provide a probability for "open/close gate valve" across numerous situations. A task statement HEP would provide a probability for opening or closing a gate valve in similar situations. Finally, source statement HEPs would provide the probabilities presented in the original data source that were used to develop the task statement HEP. In all cases, data on commission errors are not combined with data on omission errors, and data on recoverable errors are not combined with data on errors where recovery has not been considered or where recovery is not possible.

DATA CLASSIFICATION SCHEME AND TAXONOMY—HARDWARE

General—Background to Hardware Failure Data Classification

Several types of hardware data are needed for assessing the safety of and risk related to commercial nuclear power plants. These include component failure rate data, data on corrective and preventive maintenance, equipment outages, common cause data, and data on internal and external initiating events. Additionally, data on root causes, common cause, and the effects of plant aging are needed if one wishes to address lifetime extension issues and prevent the recurrence of problems that impact reactor safety.

Currently, the capability to process component failure data is fully functional in NUCLARR. The addition of modules to support some of the other data types listed above is an FY-1988 task. In the remainder of this section, the component failure data processing capabilities of NUCLARR are described.

Data Structure

The component failure data portion of NUCLARR contains failure data for components typically used at nuclear power plants. The system is configured to include all the component codes and failure mode codes currently defined in *Requirements for Entry of Component Failure Data* (EGG-REQ-7742).[10] The taxonomy and descriptive search are hierarchically configured as shown below:

Basic Event Levels

1. Component category
2. Component type
3. Component design
4. Failure mode
5. Normal state

Event Source Data

Applications
Data origin information
Data record log
Failure data

Basic event Levels 1 through 5 are listed and described in more detail in the following sections.

Basic Event Levels

Component category (e.g., mechanical versus electrical)

Component type (general categories)

Component design (keyed specifically, e.g., *centrifugal* pump)

Failure mode (four major groups: fails to operate, spurious operation, leakage, and blockage; also, more specific failure mode, such as fails to start and transfers open)

Normal state (eight possibilities: open, closed, energized, de-energized, running, standby, alternating, locked-out)

Source Record Level

Applications 1, 2, and 3

(Specific applications are associated with each component type; they describe use-related attributes such as internal environment, voltage level, and the parameters that instruments monitor).

Data origin information

Plant identifier (FID, four character code)
Domestic or foreign data
Nuclear or non-nuclear data
Safety grade or non-safety grade
Quality data (IRADAP applicable, yes/no)
Source document ID (This field is similar to the HEP "data item" fields.)
Reference document ID (This field shows the root source of the data.)
Control circuit inclusion
Secondary failures inclusion
Severity of failure (three types: catastrophic, degraded, incipient)

Type of non-catastropic failure (eight types: output high/low, setpoint high/low, leakage small/large, operates early/late)
Failure data origin type (five types: expert judgment, plant experience, laboratory testing, other, unknown)
Failure data origin record type (As many as 10 values from a list that includes such records as administrative logs, control room log books, deviation reports, incident reports, limiting conditions for operation records, licensee event reports, plant maintenance logs, plant maintenance test records, plant maintenance work requests, test reports, shift supervisor log books, surveillance tests, and utility data base records)
Exposure data origin type (six types: expert judgment, plant experience, total calendar hours, total operating hours, other, and unknown)
Exposure data origin record type (As many as 10 values from a list that includes such records as administrative logs, control room log books, dedicated cycle counters, run hour logs, shift supervisor log books, and utility data base records)
System identifier
Sub-system/train identifiers
Data collection dates

Data record log

Notes (comment field of up to 254 characters of text)
Data input date
Data input person

Failure Data

Median failure rate or probability (scientific notation)
Mean failure rate or probability
Failure probability units (per hour or per demand)
Number of failures (F, 1 to 99,999)
Number of components (C, 1 to 9,999)
Number of demands on exposure time (N or T, 1 to 999,999)
Confidence interval (upper limit, lower limit, and confidence)
Tolerance interval (upper value, lower value, and coverage)
Error factor, type (one- or two-sided) and coverage (1% to 99%)
Variance (scientific notation) and/or standard deviation
Bayesian update flag
Data distribution (several types are possible, such as lognormal, Poisson, gamma, and binomial).

Additionally, a way to identify and freeze the original failure data obtained from the source document versus data calculated by the NUCLARR software is maintained. The "frozen" data are those data originally input into NUCLARR and may consist of any of the available data fields. Codes and further information for most of these fields are contained in EGG-REQ-7742.[10]

Data Input Requirements

The inputting of data is accomplished either manually, through a "quick edit" type of screen, or electronically by reading a dBase III + file. When manually inputting data, the procedure for creating a single data record requires only a minimum number of screens. Defaults are defined for the fields, initially with "unknown" for alpha fields and the SAGE default of "——" for numeric fields, and subsequently with the entries from the previous record. The software prevents the record from being saved until all the required fields (as specified by the minimum data requirements set forth in EGG-REQ-7742[10]) have been filled. The software also performs validity checks to verify that the entries are legal and compatible codes. This validity checking can be performed in either a batch process (i.e., when a particular inputting session is finished) or an interactive process (i.e., when a particular record is saved). Also, the capability to edit existing records and to update the aggregations is provided. The list below identifies the checks which are made.

1. Are the application types valid for the component type listed? (see EEG-REQ-7742[10] for the valid combinations)
2. Does only the degraded and incipient failure severity contain an entry in the failure degree field?
3. Is the failure mode applicable to the normal state of the component?

Checks are not performed on the failure mode to component combinations or the failure mode to failure severity combinations. All failure modes are

valid for all components, and all failure severities are valid for all failure modes.

When a record is to be saved, the software within responds with a message indicating that the record was successfully saved or with a specific error message as to the reason it was not. If the record was not saved, the software displays the input screen and highlights the field or fields which are in error. When all data points have been entered, the automatic aggregation procedure computes failure probabilities at the following five separate event levels: (1) component/failure mode group; (2) component/failure mode; (3) component design/failure mode group; (4) component/design/failure mode; and (5) component/design/failure mode/normal state.

Overview of Procedures for Processing and Entry of HEP Data into the NUCLARR System: Data Input

The processing of data (which is performed by the HHRAG) involves the extraction of human reliability information from a data source for entry as HEPs in the appropriate locations in the NUCLARR system. Each step corresponds to the performance of one of the procedures in Volume III.[7] A brief description of each procedure is provided below.

- A-0 Prior to running NUCLARR, a series of steps should be performed to ensure proper operation of the NUCLARR system. This procedure provides the HHRAG with the necessary information for booting up the system and backing up the NUCLARR system files.
- A-1 The data source document is reviewed to identify human performance reliability data suitable for entry into the NUCLARR system. If the source document does not contain suitable data items, the document is returned to the administrative staff. This process includes a review to make sure that the same data have not already been entered in NUCLARR.
- A-2 If the data source document passes the screening procedure (A-1), a data package is started for each suitable data item. Each data item is analyzed to determine the appropriate matrix, cell page, and functional group summary page for storage.
- A-3 One or more task statements are developed, summarizing the conditions representing the HEP data.
- A-4 A data source statement (e.g., document ID, data item location, reference information, data origin, data type, failure mode) is drafted for each data item.
- A-5 The data source document is reviewed to scale the PSFs (stress, procedures, experience, and tagging) relevant to the task statement.
- A-6 The HEP and associated confidence bounds for the source statement are noted.
- A-7 If the cell contains task statements from previously processed data, the new task statement is compared to those in the cell for human factors equivalency. If the new task statement is found to be different from those in the cell, it will be added as a new task statement to the cell. If the new task statement is equivalent to a task statement currently in the cell, the new source data will be entered in the cell under the existing task statement.
- A-8 The data packages developed in Procedures A-1, A-2, A-3, A-4, A-5, and A-6 are entered into the NUCLARR system.
- A-9 Revised task statement HEPs and the confidence bounds for each task statement are computed.
- A-10 Cell HEPs and confidence bounds are computed across all the revised task statements.
- A-11 Functional group summary HEPs and confidence bounds are computed across all the revised cell pages.
- A-12 New copies of the cell page and functional group summary pages are printed to include the overall HEP data computed in Procedures A-9, A-10, and A-11. The revised pages are reviewed and entered in the Data Manual.

Overview of Procedures for Processing and Entry of Hardware Data into the NUCLARR System: Data Input

The processing of data (which is performed by the HHRAG) involves the extraction of hardware component reliability information from a data source for entry into the appropriate locations in the NUCLARR system. A brief description of each procedural step is provided below. Volume III may be consulted if greater detail is desired.

- B-0 Prior to running NUCLARR, a series of steps should be performed to ensure proper operation of the NUCLARR system. This procedure provides the HHRAG with the necessary information for booting up the system and backing up the NUCLARR system files.
- B-1 The data source document is reviewed to identify component reliability data suitable for entry into the NUCLARR system. If the source document does not contain suitable data items, the document is returned to the administrative staff.
- B-2 If the data source document passes the screening procedure (A-1), a data package is started for each suitable data item. Each data item is analyzed to determine the appropriate component and failure mode page for storage.
- B-3 A data source statement (e.g., document ID, data item location, reference information, data origin, data type) is drafted for each data item.
- B-4 The component failure statistics for the associated component are entered on the data entry form.
- B-5 If the data are for a component different than previously processed data, a new data cell will be added to the software data structure in order to accommodate the new component.
- B-6 The data packages developed in Procedures B-1, B-2, B-3, B-4, and B-5 are entered into the NUCLARR system.
- B-7 Revised component aggregations and confidence bounds for each component are computed.
- B-8 New copies of the component/failure mode pages are printed to include the overall HEP data computed in Procedure B-7. The revised pages are reviewed and entered in the Data Manual.

Overview of Procedures for Revising the NUCLARR System: Taxonomy and Cell Structure

It is anticipated that during the processing of the initial data sources, the HHRAG may recommend changes to the taxonomy or cell structure of the NUCLARR system. The Review Committee will review these recommendations in accordance with Procedures B-1 and B-2. Following the review cycle, the NUCLARR System Software and Data Manual will be updated in accordance with Procedure B-3. Finally, a revision of the Data Manual will be produced to reflect these changes in accordance with Procedure B-4. Full descriptions of these procedures are presented in Volume III.[7]

Overview of Procedures for Retrieving Data from the NUCLARR System: HEP Side

In the NUCLARR system, the data, including HEPs, PSFs, and references to data source documents, are presented in a format that is easily accessible using the retrieval procedures described in Volume IV.[8]

A brief description of the steps and procedures is provided below in the order in which they are performed.

- Step 1: The menu-driven system requests that the user identify the cell page containing the HEP data for a particular task.
- Step 2: The task statements on the cell page are analyzed to determine whether one is similar to the HRA task. If a similar task statement exists, the data for that task statement are supplied for the HRA problem.

- Step 3: If no data are on the cell page or none of the task statements are judged to be similar to the HRA task, guidance for locating data under alternative categories is provided in the Data Retrieval Manual.
- Step 4: The data requestors may want more information than is presented in the NUCLARR system or Data Manual, or may require assistance in choosing the data most applicable to a specific problem. In these instances, the data requestors can refer all questions to the Data Clearinghouse.

Ad hoc searches of the NUCLARR system have a slightly different procedural flow. Once the specialized ad hoc search screen is selected, the experienced user can rapidly access sets of data by specifying such features as taxonomy level, NSSS vendor, data area, PSFs, failure modes, and recovery factors. Additionally, data may be searched by equipment and action codes.

Overview of Procedures for Retrieving Data from the NUCLARR System: Hardware Side

Descriptive Searches and Displays. Descriptive and ad hoc searches using aggregations modeled in NUCLARR can be performed at all levels of the hardware taxonomy. The aggregation procedure used is that specified in the report titled *Aggregation Methods for Component Failure Data in the Nuclear Computerized Library for Assessing Reactor Reliability*, (EGG-REQ-7775).[11]

A tailored, standard automatic aggregation is included which goes through the data base, as above, but includes only certain records based on user-specified characteristics for the following fields:

Failure data origin type

Exposure data origin type

Domestic or foreign

Nuclear or non-nuclear

Safety-grade or non-safety grade

Quality data code (yes/no).

The descriptive search procedure is menu-driven and mimics the hierarchical structure of the taxonomy. For example, the first selection is either mechanical component list or electrical component list. Selecting mechanical produces a list of all the Level 2 entries under mechanical. Selecting one of the Level 2 component types produces a list of the associated Level 3 component designs. ("All" would be a valid selection at this level.) The next menu displays the failure mode choices (a maximum of 20 valid possibilities shown on one screen). The fifth menu lists the normal states. The sixth menu lists the valid application types and specific entries based on the previous menu selections.

Ad Hoc Searches. The ad hoc search includes all the information requested in the standard search and includes one last menu which covers all the remaining data attributes except for the comment field. This allows the user to pick and choose those aspects of the data he/she feels are most important or appropriate to use. In specifying values for these attributes, the user has the option to either list values to be excluded or list entries.

At any time during the search process, it is possible to "escape" or to "back out" through the menus to change some search parameters (for example, re-select Level 3, component designs). When a search has been completed, the software allows the user to easily return to the last menu which was selected from, complete with all the entries used in the last search. This allows the user to "tweak" the search entries in order to generate an optimal amount of data for aggregation.

The software provides the capability to allow the user to interactively page through the result of a NUCLARR search and to review located data records before performing an aggregation.

Help screens are provided for each field identifying the valid entries for that field.

Output Forms. The options for output forms offer the same basic choices as those presented by the HEP side of NUCLARR (i.e. a report file, a dBase III + file, and the statistical software files). In addition, a data manual mode is included which produces a hard copy of all data records in NUCLARR.

Two types of report files are provided. The first is a listing of each record located in a search. This output includes all fields and is similar to the output for the Data Manual and data checking discussed above.

The aggregation report file is the second type of report offered and contains two parts. The first part displays the results of each individual aggregation, complete with all the selected and not selected attributes. The selected fields contain the specific entries used in the search, while the non-selected fields either are left blank or contain an entry such as "all." The hard copy of this section of the output is limited to one aggregation per page. The second part of the report output contains a tabular listing of the results from all the aggregations performed in the output file. The output option to produce dBase III + and statistical software compatible files saves records identified in ad hoc searches for further processing by these packages in a manner similar to the files produced by the HEP side of NUCLARR.

FUTURE ENHANCEMENTS

A new aggregation capability is under review which allows a user to perform a Bayesian update analysis using the results of a NUCLARR search to establish a prior distribution. The user then inputs his own, limited, plant-specific data to perform the actual update of the distribution.

A macro capability (i.e. values used in an ad hoc search) is also being studied which allows the same search to be repeated and updated over time. This is of particular value in those instances when a number of searches need to be conducted, but not during the same session, or for when NUCLARR itself is updated with better or more data.

A capability to interface with the IRRAS software package is also being pursued. After selecting the IRRAS option, the software prompts the user for an output filename (prefix only, with the software adding the extension). In the next step, and before each subsequent aggregation, the user is prompted to identify the IRRAS basic event ID. The software then displays the standard NUCLARR search menu. After the desired records are located and the aggregation completed, the user is again prompted for another event ID. At a minimum, the failure rate file needs only the event ID and the point estimate failure probability.

SUMMARY AND CONCLUSIONS

The first-generation NUCLARR data management system is now fully implemented for handling human error probability and hardware component failure data. The system was developed in compliance with the specifications described in NUREG/CR-4010[5] and has been enhanced at the INEL to include hardware component failure data. At present, the following computer-aided features for the NUCLARR system are fully operational:

1. Applications software and supporting programs for modifying, locating, and storing data and cell information.
2. Capability for on-line calculation of HEPs and failure rates.
3. Capabilities for revising the system taxonomy and cell structure,
4. Computerized generation of the Data Manual (NUREG/CR-4639, Volume V).[9]
5. Applications software and supporting programs for retrieval of data and cell information (NUREG/CR-4639, Volume IV).[8]
6. Implementation of user-friendly quick-edit and ad hoc search capabilities.

The present version of NUCLARR provides the data requestor with an important computer-based support capability for conducting risk analysis with a simple means of accessing HEP and hardware component failure data.

Future tasks involve determining and developing retrieval enhancements that would increase usability of the NUCLARR system. These enhancements will be determined by direct survey of potential users of the system. It is assumed that some of these enhancements will include capability for graphical representation of time response data; interfacing the NUCLARR system with other programming applications, such as other NRC and industry available data bases; and consideration of additional NUCLARR software modules for processing common-cause failure data.

The NUCLARR system, with its existing capabilities and future enhancements, provides the risk and reliability analysis communities with a user-friendly, menu-driven, computer-based tool for performing a variety of nuclear power plant risk assessment activities.

REFERENCES

1. A. D. Swain and H. E. Guttman, Sandia National Laboratories, *Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications*, NUREG/CR-1278, August 1983.

2. D. A. Topmiiler, J. S. Eckel, and E. J. Kozinsky, General Physics Corporation, *Human Reliability Data Bank for Nuclear Power Plant Operations, Volume 1: A Review of Existing Human Reliability Data Banks*, NUREG/CR-2744, December 1982.

3. M. K. Comer, E. J. Kozinsky, J. S. Eckel, General Physics Corporation, and D. P. Miller, Sandia National Laboratories, *Human Reliability Data Bank for Nuclear Power Plant Operations, Volume 2: A Data Bank Concept and System Description*, NUREG/CR-2744, February 1983.

4. M. K. Comer, M. D. Donovan, and C. D. Gaddy, General Physics Corporation, *Human Reliability Data Bank Evaluation Results*, NUREG/CR-4009, January 1985.

5. M. K. Comer and M. D. Donovan, *Specification of a Human Reliability Data Bank for Conducting HRA Segments of PRAs for Nuclear Power Plants*, NUREG/CR-4010, January 1985.

6. G. Beers et al., *Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR) Volume II: Programmer's Guide*, NUREG/CR-4639, EGG-2458 (to be published).

7. W. E. Gilmore, D. I. Gertman, G. Gilbert, and W. J. Galyean, *Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR) Volume III: Data Base Management Guide for Processing Data and Revising the Data Manual*, NUREG/CR-4639, EGG-2458, (to be published).

8. W. E. Gilmore, G. Beers, G. Gilbert, and D. I. Gertman, *Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR) Volume IV: Data Retrieval Guide*, NUREG/CR-4639, EGG-2458, (to be published).

9. D. I. Gertman, B. G. Gilbert, W. E. Gilmore, and W. J. Galyean, *Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR) Volume V: Data Manual, Parts 1 and 2*, NUREG/CR-4639, EGG-2458, (to be published).

10. M. R. Groh, W. J. Galyean, and C. D. Gentillon, *Requirements for Entry of Hardware Failure Data in NUCLARR*, EGG-REQ-7742, October 1987.

11. C. D. Gentillon, *Aggregation Methods for Component Failure Data in the Nuclear Computerized Library for Assessing Reactor Reliability*, EGG-REQ-7775, September 1987.

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A data management system has been implemented which supports a variety of risk-related analyses and provides a repository of hardware component failure and human error probability data to the risk analyst. The Nuclear Computerized Library for Assessing Reactor Reliability, NUCLARR, is an interactive, graphically oriented system which resides on a personal computer (PC) or PC-compatible environment. An overview of the data management system, including a description of data collection, specification, data structure, and taxonomies, is presented in Volume I of this report. Programming activities, procedures for processing data, user's guide, and hard copy data manual are presented in Volumes II through V.

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