NUREG/CR-4639
EGG-2458
Volume 5

Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR)

Data Manual

Part 1: Summary Description

Prepared by D.I. Gertman, B.G. Gilbert, W.E. Gilmore, W.J. Galyean

Idaho National Engineering Laboratory
EG&G Idaho, Inc.

Prepared for
U.S. Nuclear Regulatory
Commission

NUREG/CR-4639
EGG-2458
Volume 5
RX

Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR)

Data Manual

Part 1: Summary Description

Manuscript Completed: May 1988
Date Published: June 1988

Prepared by
D.I. Gertman, B.G. Gilbert, W.E. Gilmore, W.J. Galyean

Idaho National Engineering Laboratory
Managed by the U.S. Department of Energy

EG&G Idaho, Inc.
Idaho Falls, ID 83415

Prepared for
Division of Reactor and Plant Systems
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555
NRC FIN A6850
Under DOE Contract No. DE-AC07-76ID01570

ABSTRACT

This volume of a five-volume series summarizes those data currently resident in the first release of the Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR) data base. The raw human error probability (HEP) and hardware component failure data (HCFD) contained herein are accompanied by a glossary of terms and the HEP and hardware taxonomies used to structure the data. Instructions are presented on how the user may navigate through the NUCLARR data management system to find anchor values to assist in solving risk-related problems.

Volume V: Data Manual will be updated on a periodic basis so that risk analysts without access to a computer may have access to the latest NUCLARR data. Those users wishing to learn more regarding the computer-based interactive search and report-generation capabilities of the NUCLARR system are referred to the other volumes in the NUREG/CR-4639 series, e.g., Volume I: Summary Description or Volume IV: User's Guide.

FIN No. A6854--Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR)

EXECUTIVE SUMMARY

Volume V: Data Manual of NUREG/CR-4639, EGG-2458, is comprised of four individual parts. Part 1: Summary Description introduces aspects of the NUCLARR data base management system and prepares the reader for reviewing data presented in Parts 2, 3, and 4. Part 2: Human Error Probability (HEP) Estimates contains detailed information on the HEP data in the NUCLARR system on the task, cell, and functional group summary level. Part 3: Hardware Component Failure Data (HCFD) presents HCFD contained in NUCLARR; and Part 4: Summary Aggregations offers NUCLARR HEP and HCFD summary aggregations.

A human and hardware reliability analysis group (HHRAG) has been established for the purpose of preparing and processing HEP and HCFD. An external review committee meets at least three times per year to provide technical direction, quality assurance, and make recommendations for upgrades to the NUCLARR system.

The NUCLARR Data Clearinghouse, the primary interface for users of the system, is responsible for the distribution of Volume V and periodic updates of the data which are issued as change pages. The NUCLARR Data Clearinghouse also acts as a resource to answer questions, offer supplemental advice to users, and distribute NUCLARR software.

This report reviews NUCLARR coding systems and data processing procedures. It also highlights the manner in which users can employ the various parts of this volume directly or to establish anchor values for use in addressing generic safety issues. Parts 2, 3, and 4 each begin with an overview and are followed by a task flow and detailed examples on how to use NUCLARR data in order to identify HEP and HCFD rates.

ACKNOWLEDGMENTS

We wish to thank those persons without whom review and evaluation of human error probability and hardware component failure data would have been an arduous task. These include M. Groh and C. Gentillon who, in addition to the above-mentioned duties, had considerable input in deriving the hardware taxonomy and coding system. The software development, implementation, and test and evaluation were herculean efforts on the parts of G. Beers, T. Tucker, and O. Call. We also wish to thank D. Fink for her fine work on the first version of the NUCLARR system.

Thanks are also due H. S. Blackman, for his technical contributions to the NUCLARR system and management support throughout the year. Lastly, we are indebted to T. G. Ryan, our NRC Technical Monitor, for his technical input, attention, and continued support during design and implementation of the data base.

CONTENTS

FIGURES

TABLES

ACRONYMS

CLCS	consequence limiting control system
HEP	human error probability
HCFD	hardware component failure data
HHRAG	Human and Hardware Reliability Analysis Group
INEL	Idaho National Engineering Laboratory
IRRAS	Integrated Reliability and Risk Analysis System
LCB	lower confidence bound
NRC	U.S. Nuclear Regulatory Commission
NUCLARR	Nuclear Computerized Library for Assessing Reactor Reliability
PC	personal computer
PRA	probabilistic risk assessment
PSF	performance shaping factors
SARA	Systems Analysis and Risk Assessment System
UCB	upper confidence bound

NUCLEAR COMPUTERIZED LIBRARY FOR ASSESSING
REACTOR RELIABILITY (NUCLARR)
VOLUME V: DATA MANUAL
PART 1: SUMMARY DESCRIPTION

1. INTRODUCTION

The Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR) is a computer-based data management system used to process, store, and retrieve human error probability (HEP) and hardware component failure data (HCFD) in a ready-to-use format. The NUCLARR data management system was sponsored and developed by the U.S. Nuclear Regulatory Commission (NRC) to provide the risk analysis community a repository of reliability data that can be used to support a variety of existing and developing techniques for performing reactor risk assessment. A special function, the NUCLARR Data Clearinghouse, has been established at the Idaho National Engineering Laboratory (INEL) to assist in providing users of the data management system and data manual with adequate documentation, NUCLARR computer software, expert assistance, data processing, and quality assurance functions.

The NUCLARR system is documented in a series of five volumes (NUREG/CR-4639, EGG-2458).[1-6] Volume I: Summary and Description[1] presents a general introduction to the NUCLARR system. In this document, key information regarding the organization of the NUCLARR system, structural taxonomy for the HEP and HCFD side, and on-line search and retrieval capabilities of the NUCLARR system software are presented. Failure modes, actions, plant codes, document retrieval capability, data origin and survey period are also defined for the reader. In addition, specifications for the hardware and software configuration necessary to run the NUCLARR system are discussed in detail. Points of contact for problems encountered when attempting to use the data base or when attempting to forward new data to the NUCLARR Data Clearinghouse are also included.

Volume II: Programmer's Guide[2] provides information necessary for maintaining the software programs resident in the NUCLARR system. This includes modules for adding new equipment or actions to the taxonomy matrices and software for converting raw human and hardware performance data into processed failure rate estimates with the appropriate confidence bounds and error factors. Also included are procedures for maintaining and modifying help screens, equipment and plant codes, log plot programs, and computational aggregation algorithms contained in NUCLARR.

Volume III: Data Base Management Guide for Processing Data and Revising the Data Manual[3] provides the input procedures used by the NUCLARR Data Clearinghouse for extracting suitable data from candidate source documents and entering this information into the NUCLARR system.

Volume IV: User's Guide[4-6] provides users with step-by-step procedures for locating, reviewing, and combining data extracted from the NUCLARR system. This volume also provides ad-hoc search strategies and examples of where the analyst may or may not wish to use the aggregation routines offered by the NUCLARR system.

Volume V: Data Manual is the fifth volume of a five-volume set and is meant to serve the needs of and accommodate those who do not have access to personal computers; it provides those users the means to review all data available in the NUCLARR system. Volume V is divided into four parts. Part 1: Summary Description provides the user with a top-level review of the type of data, both HEP and HCFD, resident in the NUCLARR data management system. Readers may supplement the information contained in Part 1 of Volume V by addressing Parts 2, 3, and 4 in the series: Part 2: Human Error Probability (HEP) Data; Part 3: Hardware Component Failure Data (HCFD); and Part 4: Summary Aggregations. Volume V has been designed to be a stand-alone document. For analysts interested in HEP, Volume V, Part 2, provides 16 two-dimensional matrices used to determine equipment and human action codes. The analyst searches for data items by combining equipment characteristics and human actions. These codes are used to locate all related data in the data appendices associated with Part 2. Definitions for all equipment are also presented in Part 2. Similarly, the coding sequences presented in Part 3 for the HCFD taxonomy section of the Data Manual may be used to identify all relevant HCFD for a particular component. Part 4 presents summary aggregations across equipment groups for HEP and HCFD.

Subscribers to the NUCLARR data base management system will receive a series of diskettes, allowing them to use the system at their own location. Minimum utility specifications require the analyst to have an IBM-compatible[a] personal computer with math co-processor, 20-megabyte hard disk, 640K of random access memory, and no auto load, sys.cache file, or virtual disk commands which reduce the 640K needed to run NUCLARR.

Any reader desiring copies of the individual volumes listed in the NUC[illegible] series or a copy of NUCLARR software should contact the NUCLARR Clearinghouse at the address listed below:

David I. Gertman
NUCLARR Data Clearinghouse
Idaho National Engineering Laboratory
P. O. Box 1625
Idaho Falls, ID 83415 USA
Telephone: FTS 583-0652; commercial 208-526-0652

Questions regarding the NUCLARR program may be directed to the address listed above or to the NRC Technical Monitor:

Thomas G. Ryan
U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
5650 Nicholson Lane, NL/N-316
Rockville, MD 20852 USA
Telephone: FTS 492-3550; commercial 301-492-3550

---

a. Mention of specific products and/or manufacturers in this document implies neither endorsement or preference nor disapproval by the U.S. Government, any of its agencies, or EG&G Idaho, Inc., of the use of a specific product for any purpose.

2. ORGANIZATION

Part 1 of Volume V of NUREG/CR-4639 is organized to familiarize potential users with the NUCLARR data base management system, provide orientation for data base usage without the aid of a computer, inform users on how to identify and retrieve the data which will meet their needs, and instruct them on how to access the two types of data, HEP and HCFD, currently residing in the system. All the taxonomic information needed in order to understand how the NUCLARR system is organized has been provided in this overview.

HEP data are organized in matrices by human action; equipment being monitored, used, tested or calibrated; whether errors committed are errors of commission or omission; and whether or not the data source specifies if recovery actions have been considered in the calculation of the HEP point estimate.

HCFD are organized by equipment (component) type and failure mode. Additional coding exists, such as plant codes, normal operating state, and survey period.[a] Listings of all the HEP and HCFD sources for data currently entered in NUCLARR may be found in Section 3.3 of this report.

The appendices to Parts 2, 3, and 4 of Volume V present HEP, HCFD and summary aggregation data, respectively. As part of an ongoing effort, other data sources will be identified, processed, and, where appropriate, entered into the NUCLARR data base management system.

---

a. For readers wishing to broaden their understanding of HCFD, the following references are available from the NUCLARR Data Clearinghouse: EGG-REQ-7775, Aggregation Methods for Component Failure Data in the Nuclear Computerized Library for Assessing Reactor Reliability;[7] EGG-REQ-7742, Requirements for the Entry of Component Failure Data in NUCLARR,[8] and NUCLARR Volume IV: User's Guide.[4-6]

3. DATA QUALIFICATION

A number of parameters can be used to describe and define error probability and rate-based data. Popular examples for HEP include performance shaping factors (PSFs), task performance time, the quality of procedures, whether the errors committed where those of omission or commission, and whether there was opportunity for recovery from the error. Likewise, hardware failure rate descriptors may include such parameters as survey period, plant identification, component application, and distribution type (e.g., lognormal, gamma, Poisson). All events contained in the HCFD side of the NUCLARR system concern component failures, and all components are treated equally. The hierarchical structure merely serves to organize data.

Authors of documents reviewed to date tend to differ in what they select as descriptive characteristics of the task, equipment, and work environment and the method by which data were collected. In all cases, then, it is the user who must be the ultimate arbiter as to the quality of data and which documents should be included in a data search.

A series of stringent criteria have been introduced to ensure that data contained in the NUCLARR system are of the highest quality. Prior to the current implementation, detailed set(s) of screening procedures were developed which would allow all reasonable, quantified data a place within the NUCLARR system. The results of this effort are discussed below for both the HEP and HCFD sides of the NUCLARR data management system. Likewise, the aggregation methods and algorithms used in NUCLARR are sophisticated and have, over the past few years, undergone extensive review by outside consultants who were knowledgeable in probabilistic risk assessment (PRA) and human reliability analysis techniques.

3.1 The NUCLARR Data Clearinghouse and Quality Control

The NUCLARR Data Clearinghouse includes human factors, risk analysis, and software personnel who are responsible for all contact with users of the NUCLARR system and for providing documentation and support services for software maintenance. NUCLARR Data Clearinghouse personnel are further responsible for the distribution of user documentation, including training course documentation, and diskettes containing NUCLARR software. They also review updated versions and revised data pages for Volume V: Data Manual.

A library has been established at the Clearinghouse wherein copies of all five volumes of the NUCLARR series are maintained and kept up to date. Clearinghouse personnel also track requests for documents and ensure that requestors receive NUCLARR materials in a timely fashion. A small, personal-computer-based management system which keeps account of each new transaction has been implemented in dBaseIII+ software expressly for this purpose.

The human and hardware reliability analysis group (HHRAG) plays a major role in the NUCLARR data management process, distinct from the NUCLARR Data Clearinghouse function. The HHRAG reviews data sources for suitability and then processes those data which are qualified for inclusion in the NUCLARR system. The personnel who make up the HHRAG are experienced in one or more of the following disciplines: nuclear power plant operations, human reliability analysis, probabilistic risk analysis, system reliability, and generic safety issues. An external review committee, composed of members internal and external to the NUCLARR project team, meets three times per year to process and perform quality assurance checks of the data resident in the system. Review committee members are selected with approval of the NRC Technical Monitor, and members serve on a rotating basis. They make suggestions as to sources of new, meaningful HEP and HCFD. To assist the review members in their qualification of data, equipment and human actions have been operationally defined and are presented as Appendices A and B of this report.

The external review committee also takes under consideration recommendations for changes or upgrades to the NUCLARR data management system, including additions to data base taxonomies which will result in more efficient processing, coding, and retrieval of data. One such recommendation recently implemented in NUCLARR calls for the addition of a log plot capability for both HEP and HCFD sides of the data management system.

3.2 Plant (Utility) Identification Codes

Codes for all plants in the United States which are used to identify data for both HEP and HCFD are listed in Parts 2, 3, and 4 of Volume V.

3.3 Data Sources

A variety of sources are eligible for inclusion in NUCLARR. With the exception of PRA sources, most data sources (e.g., documents or data bases) present either HEP or HCFD. An example of an HEP data source would be NUREG CR-1278, Handbook of Human Reliability with Emphasis on Nuclear Power Plant Applications.[9] A HCFD source could be any raw, plant-specific data contained in a PRA. HCFD sources could also include generic data rates, such as those contained in IEEE STD 500, "Guide of the Collection and Presentation of Electrical, Electronic, Sensing Component, and Mechanical Equipment Reliability Data for Nuclear Power Generator Statistics,"[10] or WASH 1400, Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants.[11] The sections below list some of the sources and potential sources entered to date. Readers are encouraged to submit any raw or processed HEP or HCFD directly to the NUCLARR Data Clearinghouse by sending it to the address specified on page 3 of this report.

3.3.1 HEP Sources

Sources of HEP data entered to date are listed in Table 1. In addition, part of the HERAS data base, a collection of the HEP portion of 19 plant PRAs, has also been entered. Raw HEP data from these various sources are found in appendices to Part 2 of Volume V.

3.3.2 HCFD Sources

Sources of HCFD entered to date are listed in Table 2. Raw failure rate data from these various sources are found in appendices to Part 3 of Volume V.

TABLE 1. HUMAN ERROR PROBABILITY REFERENCES LISTED BY DOCUMENT NUMBER

Document Number	Reference
1-62	S. J. Munger, R. W. Smith, and D. Payne, An Index of Electronic Equipment Operability: Data Store, AIR-C43-1/62/RP(1), January 1962.
1/75	U.S. Nuclear Regulatory Commission, Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants, WASH-1400, NUREG-75/014, October 1975.
1-81	D. D. Carlson, Reactor Safety Study Methodolcgy Applications Program: Sequoyah #1 PWR Power Plant, NUREG/CR-1659, February 1981.
1-82	D. A. Topmiller et al., Human Reliability Data Bank for Nuclear Power Plant Operations Volume 1: A Review of Existing Human Reliability Data Banks, NUREG/CR-2744, December 1982.
1-83	A. D. Swain and H. E. Guttman, Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications, NUREG/CR-1278, August 1983.
1/84	A. N. Beare et al., A Simulator Based Study of Human Errors in Nuclear Power Plant Control Room Tasks, NUREG/CR-3309, January 1984.
2/84	K. Comer, D. Seaver, W. Stillwell, and C. Gaddy, Calculating Human Reliability Estimates Using Expert Judgement, NUREG/CR-3688, Vol. 2, November 1984.
3-84	W. R. Sugnet, G. J. Boyd, and S. R. Lewis, Oconee PRA, NSAC-60, Vol. 1, June 1984.
4/84	A. C. Payne et al., Interim Reliability Evaluation Program: Analysis of the Calvert Cliffs Unit 1 Nuclear Power Plant, NUREG/CR-3511, Vols. 1 and 2, August 1984.
1/85	Luckas, O'Brien, Perline, and Spettell, Operator Actions in Anticipated Transient Without Scram (ATWS-TC) Sequence for Peach Bottom Plant, October 1985.
2/85	J. N. O'Brien and Spettell, Uses of Human Reliability Analysis Probabilistic Risk Assessment Results to Resolve Personnel Performance Issues That Could Affect Safety, NUREG/CR-4103, March 1985.
2/86	R. C. Bertucio et al., Analysis of Core Damage Frequency from Internal Events: Surrey, Unit 1, NUREG/CR-4550, Vol. 3, 1986.

TABLE 1. (CONTINUED)

Document Number	Reference
3/86	Kolaczkowski et al., Analysis of Core Damage Frequency from Internal Events: Peach Bottom, Unit 2, NUREG/CR-4550, Vol. 4, October 1986.
1/87	M. T. Drouin et al., Analysis of Core Damage Frequency from Internal Events: Grand Gulf, Unit 1, NUREG/CR-4550, Vol. 6, April 1987.
2/87	R. C. Bertucio et al., Analysis of Core Damage Frequency from Internal Events: Sequoyah, Unit 1, NUREG/CR-4550, Vol. 5, February 1987.

TABLE 2. HARDWARE COMPONENT FAILURE DATA REFERENCES LISTED BY DOCUMENT NUMBER

Document Number	Reference
200-81	Big Rock Point Probabilistic Risk Assessment, Consumer Power Company, March 1981.
205-86	Connecticut Yankee Probabilistic Safety Study, NUSCO 149, February 1986.
209-82	Indian Point Probabilistic Risk Assessment, Pickard, Lowe, and Garrick, Inc., December 1982.
211-85	Millstone Probabilistic Risk Assessment, Northern Utilities, July 1985.
212-81	Electric Power Research Institute (Nuclear Safety Analysis Center), A Probabilistic Risk Assessment of Oconee Unit 3, NSAC-60, Vols. 1-4, June 1984.
213-81	Zion Probabilistic Risk Assessment, Pickard, Lowe, and Garrick, Inc., September 1981.
54-75	Reactor Safety Study, Appendix III--Failure Data, WASH-1400, NUREG-75/014, U.S. Nuclear Regulatory Commission, 1975 - data under review, some entry
53-83	IEEE Standard 500, Nuclear Power Engineering Committee, IEEE Power Engineering Society, 1984.
63-82	NUREG/CR-1205, Data Summaries of Pumps at U.S. Nuclear Power Plants, Rev. 1, January 1980.
36-85	NUREG/CR-3831, The In-Plant Reliability Data Base for Nuclear Plant Components: Interim Report for Diesel Generators, Batteries, Chargers and Inverters, January 1985.
133-86	Electric Power Research Institute, The Reliability of Emergency Diesel Generators at U.S. Nuclear Power Plants, NSAC 108, September 1986.

4. CRITERIA FOR DATA INCLUSION

The following sections describe the specific criteria used to qualify data sources for entry into the NUCLARR system. Only those data that have met the criteria specified in Sections 4.1 and 4.2 are included in the raw data appendices of Parts 2 and 3 of Volume V and summarized in Part 4.

4.1 HEP Side

Data entered in the HEP side of the NUCLARR system must meet three criteria:

1. They must specify a human action;

2. They must specify a piece of equipment or a system; and,

3. They must be quantitative in nature. The most preferable data are in the form of an HEP statement with upper and lower confidence bounds. Data presented as median values with errors, or simply as error observed over the number of opportunities for error, are also acceptable.

If data obtained from a study meet the criteria specified above but are lacking in scientific merit, they may be excluded from the data base by the HHRAG review group. Exclusion, although possible, is the exception rather than the rule. The NUCLARR user is expected to be relatively sophisticated and able to select those documents germane to the problem under investigation.

Data reported in one source which are simply repeated in a second source are also not included. For example, once data from WASH-1400[11] have been entered in NUCLARR, a review article which merely repeats those data would not be suitable for inclusion in NUCLARR. If the origin of data is other than in the document being reviewed and data have been modified by expert judgment or task analysis methods, the transformed data are available for the analyst's review and the original source is referenced. These data are not aggregated. This procedure helps prevent the possibility of over-representation of data within the data base.

4.2 HCFD Side

Data requirements for the HCFD side of the NUCLARR system are limited to time- and demand-based estimates and do not, at the present time include other types of data, such as unavailability or common-cause. Losses of function are not included, as they are confounded with function losses due to human intervention, i.e., error. What is included, then, are events where components were in need of repair, replacement, or adjustment.

Furthermore, components selected for inclusion in the NUCLARR system are those that are typically involved in basic events in fault-tree models of nuclear power plant systems. They also tend to be those types of components most often found in safety systems.

HCFD entries have been restricted to failures within specified component boundaries. Secondary failures have been excluded; i.e., failures due to conditions existing outside the boundary that produce conditions exceeding the design basis of the component. Thus, closely associated equipment that is physically coupled is included, and failures caused by common-support systems are not.

Ideal failure rate data, therefore, depend upon the component and its immediate environment and application.

In summary, HCFD accepted for inclusion into the NUCLARR system must have:

- A description of component and failure mode; and
- A probability value; i.e., number of failures and number of operating hours or demands, or the rate itself.

When available, an account of plant operating conditions or the state in which the failures occurred is also preserved in the data base. Finally, raw data are preferred over rates which have made use of Bayesian updates.

5. AGGREGATION FEATURES

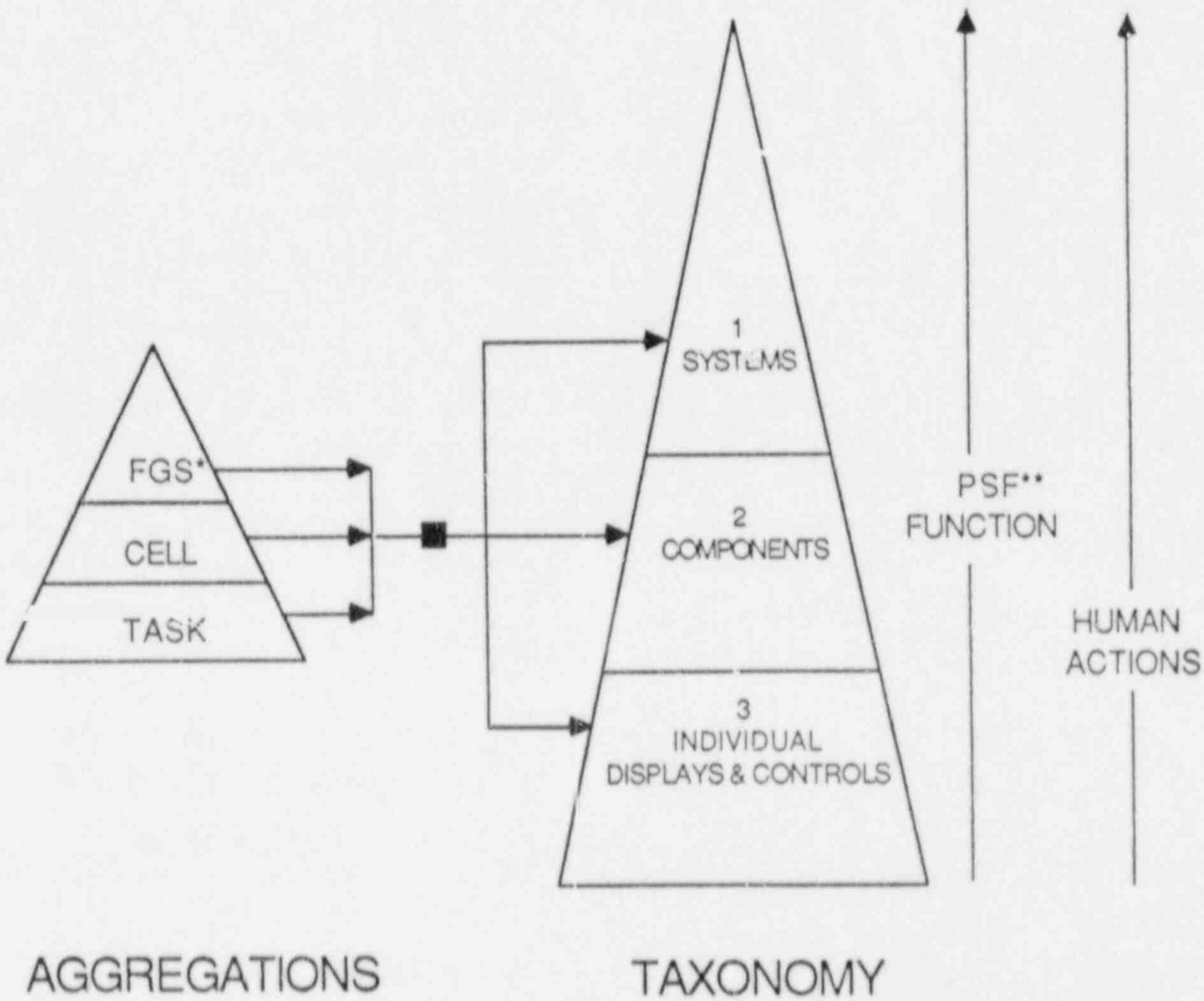
The sections which follow present the aggregation features of the NUCLARR system for both HEP and HCFD. For in-depth information regarding the aggregation features and corresponding algorithms resident in the NUCLARR system, the reader is referred to Section 3.3 of Volume IV: User's Guide, Part 3: NUCLARR System Description.[6]

5.1 HEP Data Treatment

The NUCLARR system automatically makes a number of calculations for each HEP source data point. Depending on the degree of detail available when data are first entered, the NUCLARR system will compute upper confidence bounds (UCBs), lower confidence bounds (LCBs), error factors, medians, means, errors, and opportunities for error. All of these data are present for the reader's review. Separate aggregation algorithms are applied to compute task statement HEPs, cell HEPs, and functional group HEPs. These aggregations are computed for each of the three levels of the the NUCLARR system taxonomy. Figure 1 presents this HEP configuration with each of the aggregations being nested in each of the equipment taxonomy levels. Aggregation values are derived in the following manner.

For computing task statement HEP aggregations, raw source data are compared for consistency using a homogeneity test based upon the binomial distribution. Statistically consistent HEPs are pooled; the task HEP is the total number of errors divided by the total number of opportunities. Based upon binomial distribution characteristics, the UCB and LCB limits are computed.

For computing cell HEP aggregations, HEPS from functionally related tasks are gathered together and are assumed to be lognormally distributed. Therefore, the sum of the logs of the HEPS for a given cell is divided by the number of HEPs, and the antilogarithm is calculated to determine the cell HEP. Calculation of the error factor for the cell HEP is based on taking the root mean square of the log ratios of task statement UCBs to LCBs.



* FUNCTIONAL GROUP SUMMARY
** PERFORMANCE SHAPING FACTORS

Figure 1. Relationship of NUCLARR HEP aggregations and taxonomy.

The functional group summary is the highest level of HEP data allowed in the NUCLARR system. For computing functional group HEP aggregations, calculations are based on task level HEPs, just as they are in the cell aggregation calculations. In this case, the aggregation employs task HEPs functionally grouped not for one cell but taken across a set of cells. This distribution of HEPs is assumed to be lognormal. Again, the sum of the logs of the HEPs for these tasks comprising the functional group is divided by the number of HEPs, and the antilogarithm is calculated to determine the functional group HEP. Calculation of the error factor for the functional group HEP is based on taking the root mean square of the log ratios of task statement UCBs to LCBs.

Those readers wishing to sample raw data from Part 2 of Volume V and manually compute task, cell, and functional group HEPs are referred to Volume IV in this series for procedures outlining manual calculation methods.

5.2 HCFD Treatment

There are two sets of aggregations within the HCFD side of the NUCLARR system. The first set is performed automatically when data are first entered. The second set is only applied when the user performs custom aggregations with the computer-based version of the NUCLARR system. Although time-consuming, it would be possible to perform these same aggregations manually. The methods used in the NUCLARR system recognize two types of data beside raw data--tolerance interval information and confidence intervals. Generic data are acceptable input; e.g., WASH 1400[11] data are available for review by the analyst using the NUCLARR system, but are not as preferred by the system as are raw data.

The automatically executed algorithms are driven by the nature of the data themselves. Acceptable combinations include homogeneous/raw; homogeneous/tolerance information available; homogeneous/no tolerance information available; preaggregated data/tolerance information available; and preaggregated data/no tolerance information available. Homogeneous data by definition are from equipment having a constant failure rate; raw data are the number of failures and the associated demand, or exposure time. Details regarding different Bayes procedures, raw data conversion, and weighted and unweighted fits to lognormal distributions are contained in Volume IV of this series.

The aggregation procedure computes failure probabilities at the following five separate event levels: (a) component/failure mode group; (b) component/failure mode; (c) component/design/failure mode group; (d) component/design/failure mode; and (e) component/design/failure mode/normal state. Basic NUCLARR system output is a point estimate and tolerance bound, with supporting information about the number of records or raw data points in the aggregation, normal operating condition (state), failure mode, component, and design. Supporting information is available regarding each raw data point contributing to the aggregated value. Aside from those categories cited above, this information includes component application, aggregation type, survey/period, origin of failure and exposure data, plant identification code, and systems and subsystem information.

Additionally, the NUCLARR system calculates median, mean, error factor, and upper tolerance bounds for each data point. The treatment of data in these calculations for raw data is described in more detail in Volume IV of this series.

6. DATA STRUCTURE

The sections which follow describe briefly the data structure for both the HEP and HCFD contained in the NUCLARR system.

6.1 Matrix Schema for HEP Data

A hierarchical approach is used in the HEP side of the NUCLARR system; this supports the level of detail appropriate to the needs of the risk analyst. Data are nested under equipment categories. For example, Level 1 refers to equipment systems, such as the emergency core cooling system and is further identified by nuclear steam supply system vendor. Level 2 refers to equipment components, such as pumps and valves. Level 3 refers to individual controls or displays, such as a meter or CRT. Action verbs keyed distinctly to each of the three levels are recorded as well. For Levels 1 and 2, these action verbs are specified for each of three types of personnel: control room operators, equipment or auxiliary operators, and maintenance technicians.

The reader is referred to Part 2, Appendix B, where equipment characteristics are listed by rows and human actions are listed by column for each matrix. The intersection of an equipment characteristic (identifier) with a human action characteristic (identifier) within a particular matrix constitutes a cell. There is a unique numeric identifier associated with each cell. In addition, there are functional group summary cells that contain data combined from lower cells. For example, the functional group summary cell for valves includes globe valves, needle valves, gate valves, etc. Each of the functional group summary cells also has a unique identifier.

Individual data records also contain a host of information not specified by the matrix. These are addressable on-line when using the ad-hoc search mode of the NUCLARR system and include plant code, performance shaping factors, time available to the operator or crew, mode (omission or commission), whether recovery was considered, plant/sequence, source document used, and data origin, e.g., expert judgment, laboratory, or field data.

6.2 Matrix Schema for HCFD

Contained within Volume V, Part 3, are failure data for components typically used at nuclear power plants. All plant codes, component codes, distribution codes, application codes, and failure mode codes defined in EGG-REQ-7742[8] have been implemented.

Data are structured first by event. There are five basic event levels:

1. Component category.

2. Component type (or just component).

3. Component design.

4. Failure mode.

5. Normal state.

In addition, data are organized by:

- Application (environment or other parameters);

- Plant identifier;

- Safety grade or not;

- Document ID;

- Reference ID;

- Whether or not control circuits are included;

- Severity of failure;

- Failure data origin (expert judgment, plant experience, etc.);

- Exposure data origin and data record type (log books, utility base records, cycle counters, and total operating hours); and

- Failure data themselves, where failure data may take the form of median failure rate or probability, mean failure rate or probability, units - demand or per hour, confidence interval, tolerance interval, error factor, variance, Bayesian update flag, and the data distribution.

7. HOW TO USE THE DATA MANUAL

Prior to attempting to extract meaningful data from the Data Manual, it is best to become acquainted with its various parts. Figure 2 presents a series of steps depicting the flow of actions related to use of the various parts of the Data Manual. Each part of Volume V contains within itself a task flow and example of how to use the data found therein.

In Figure 2, Step 1.0, calls for establishing PRA data requirements. In the case of obtaining HEP data requirements, this requires that the analyst construct a problem statement of sufficient detail to indicate the involvement of control room operators, auxiliary operators, or maintenance personnel and the equipment or systems they would use in meeting such a problem. In the case of obtaining HCFD, the analyst would want to determine the components of interest for a particular plant sequence, the normal operating conditions of that piece of equipment, and the failure mode(s) involved.

Step 2.0 requires that the analyst review Volume I: Summary Description (NUREG/CR-4639) to get an overview of the capabilities and types of data resident in the NUCLARR system. Users may review this volume to find out about other documents in the NUCLARR series or to find a point of contact at the NUCLARR Data Clearinghouse for assistance in determining whether or not the NUCLARR system is appropriate to their needs.

Step 3.0 calls for the analyst to review in-house resources. The NUCLARR system may be addressed by use of either computer facilities or by following procedures outlined in Volume V. If the user has access to a personal computer with the capability to accept the NUCLARR system, then the analyst should acquire the NUCLARR computerized data base (see Step 3.1). Volume IV: User's Guide should be consulted for the procedures involved in carrying out descriptive or ad-hoc searches.

Steps 3.2 and 3.2.1 indicate that the analyst who has no personal computer or copy of NUCLARR software should consult Part 1 of Volume V.

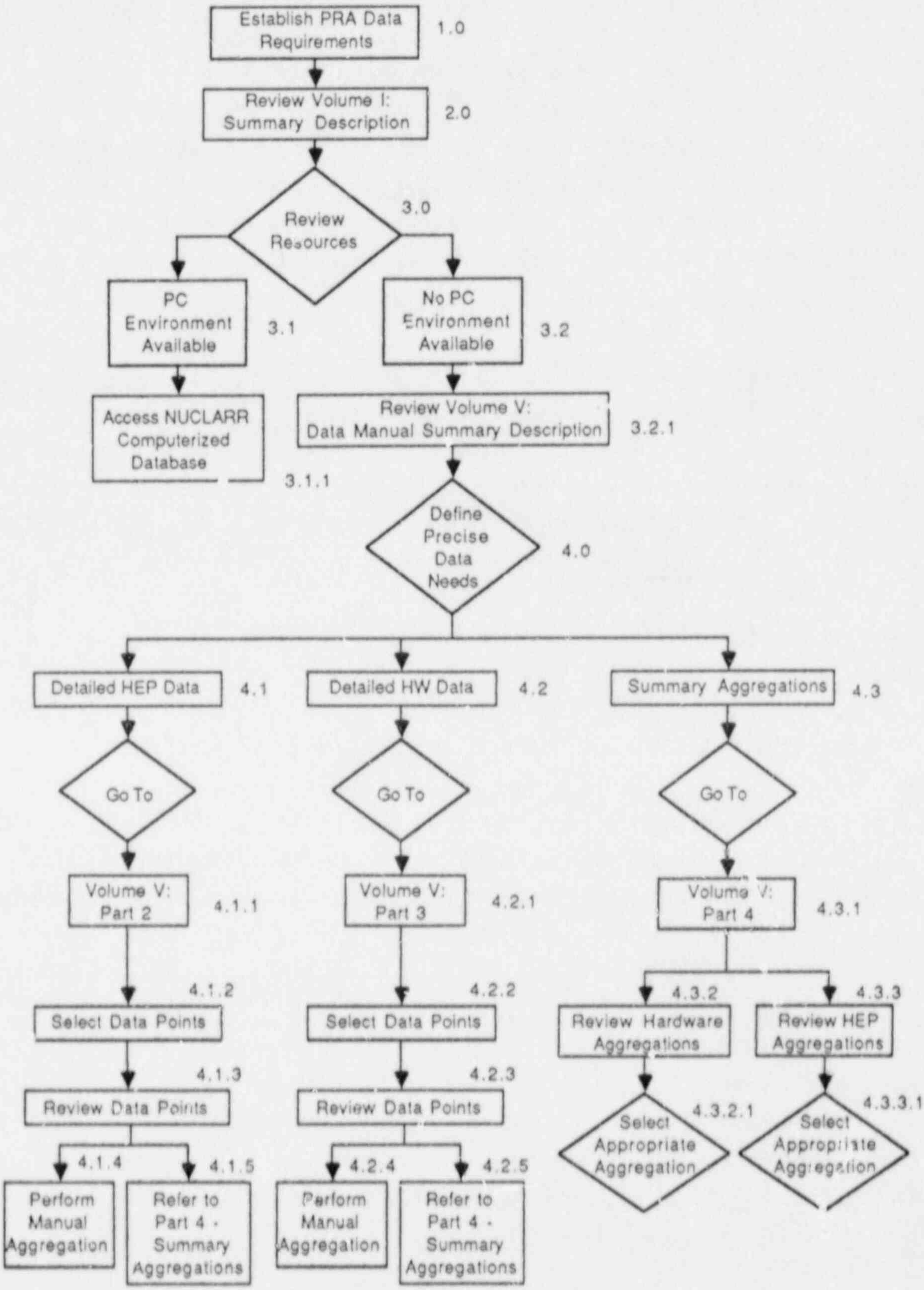


Figure 2. Task flow for Volume V of NUREG/CR-4639.

Step 4.0 requires that the analyst determine more precisely his or her data needs and whether these needs might be best met by going to detailed or summary HEP and/or HCFD information. For example, if detailed HEP data are desired (see Step 4.1), then the analyst may address data located in Part 2 such as "...Control room operator fails to manually activate the consequence limiting control system (CLCS) at Surry, Unit 1, data from NUREG CR-4550."

If Part 2: HEP Estimates has been selected (see Step 4.1.1), the analyst will use the procedures outlined in that document to go to the correct cells (Step 4.1.2), review data including factors which may limit the utility of particular data points to the analysis in question, and, finally, obtain data points appropriate to the data analysis at hand (Step 4.1.3).

If only a subset of rates in Part 2 are acceptable to the analyst, then he or she may wish to perform a manual aggregation (Step 4.1.4) or select the anchor value most appropriate to the problem at hand. Such might be the case if, for example, the analyst were only interested in rates for crew errors committed at Babcock & Wilcox plants during loss-of-offsite power sequences. If a broader scope of aggregation is desired due either to the nature of the problem at hand or to lack of specific data being available in the open literature, the user may wish to go to Part 4: Summary Aggregations (see Step 4.1.5). For example, the user may want to determine a median HEP estimate for all occasions where control room crews have attempted to initiate high pressure injection in the presence of various plant transients.

If detailed HCFD are desired (see Step 4.2), then the analyst may address data located in Part 3: Hardware Component Failure Data, such as "failure for diesel generator with diesel engine driver, normally in standby, fails to start, raw data = 6 failures over 1340 demands, data collection period 1974 through 1983, at Zion Station."

If Part 3 has been selected (see Step 4.2.1), the analyst will use the procedures outlined therein to go to the correct cells (Step 4.2.3); review data, including factors related to the component rates which may limit their utility to the analysis in question; and, finally, manually select those data points most appropriate (Step 4.2.4). Once these data points are selected, the user may wish to aggregate the data (4.2.4) or select the anchor value most appropriate to the problem at hand. If only a general screening value is needed or if a very large number of HCFD rates are observed, the analyst may wish to review Part 4: Summary Aggregations (see Step 4.2.5)

If a generic anchor value (e.g., HEP or HCFD rate) is all that is required, then the analyst may wish to access directly summary aggregation information contained in Part 4: Summary Aggregations (see Steps 4.3 and 4.3.1). Summary aggregations for the HCFD side of the NUCLARR system are addressed as part of Step 4.3.2 and include component failure rates in the form "check valves, fails to operate group, design equals all." Note that demand and hourly aggregations are listed separately. Furthermore, aggregations are collapsed across plant, survey period, and reference document. If a user requires data on the survey period and plant, then Part 3 should be used as a reference instead.

Representative data to be reviewed as part of Figure 2, Step 4.3.3, include detailed summary aggregations across HEP functional cells, such as those contained in cell 0429001, the summary of main steam systems, where rates and bounds are presented along with classification by error type (omission or commission) and by virtue of the extent to which recovery actions are represented in the calculations. Note that these aggregations are collapsed across performance shaping factors and nuclear power plant. Users requiring information on the time necessary for a crew to respond to plant/transient conditions should refer instead to Part 2.

8. SUMMARY

The NUCLARR data management system is an NRC-sponsored respository for probabilistic data that is currently dedicated to human error probability and hardware component failure rates. This report provides the means for the analyst who is without access to computer resources to use the appended raw data in investigating risk-related issues.

Volume V: Data Manual, Parts 1 through 4, of NUREG/CR-4639 is an important source of rate-based information for the analyst and is a living document which will be updated on a periodic basis. These updates will be available to all users in the form of change pages which can be added to Parts 2 and 3 in the Volume V series. Part 4: Summary Aggregations will also be updated in its entirety to reflect any addition of HEP and HCFD rate-based data to the NUCLARR data management system.

The effort at the INEL involving the NUCLARR system is complementary to other NRC-sponsored efforts in the area of risk management, including the System Analysis and Risk Assessment (SARA)[12] and Integrated Reactor Reliability Assessment System (IRRAS)[13] programs.

Users of this volume which complements the computerized NUCLARR data management system are encouraged to submit HEP and/or HCFD directly to the NUCLARR Data Clearinghouse at the INEL. These data may be sent to the address specified in Section 1 of this report. Instructions regarding the appropriate formatting of these data may be found in EGG-REQ-7732, Specification for the Submission of Raw Human Error Probability Data to the NUCLARR Clearinghouse,[14] and EGG-REQ-7742, Requirements for Entry of Component Failure Data in the NUCLARR System.[3]

9. REFERENCES

1. D. I. Gertman et al., Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR), Volume I: Summary Description, EGG-2458, NUREG/CR-4639, February 1988.

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

3. W. E. Gilmore, D. I. Gertman, B. 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).

4. W. E. Gilmore et al., Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR), Volume IV: User's Guide, Part 1: Overview of NUCLARR Data Retrieval, NUREG/CR-4639, EGG-2458, May 1988.

5. W. E. Gilmore et al., Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR), Volume IV: User's Guide, Part 2: Guide to Operations, NUREG/CR-4639, EGG-2458, May 1988.

6. W. E. Gilmore et al., Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR), Volume IV: User's Guide, Part 3: NUCLARR System Description, NUREG/CR-4639, EGG-2458, May 1988.

7. C. D. Gentillon, Aggregation Methods for Component Failure Data in the Nuclear Computerized Library for Assessing Reactor Reliability, EGG-REQ-7775 (draft), August 1987.

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

9. A. D. Swain and H. E. Guttman, Handbook of Human Reliability with Emphasis on Nuclear Power Plant Applications, NUREG/CR-1278, August 1983.

10. IEEE STD 500, "Guide of the Collection and Presentation of Electrical, Electronic, Sensing Component, and Mechanical Equipment Reliability Data for Nuclear Power Generator Statistics."

11. Reactor Safety Study, Appendix III--Failure Data, WASH-1400, NUREG-75/014, U.S. Nuclear Regulatory Commission, 1975.

12. K. D. Russell, D. M. Snider, M. B. Sattison, H. D. Stewart, S. D. Mathews, and K. L. Wagner, Integrated Reliability and Risk Analysis System (IRRAS) User's Guide - Version 1.0, EGG-2495, NUREG/CR-4844 (DRAFT), June 1987.

13. W. W. Tullock, M. B. Sattison, V. S. Van Siclen, System Analysis and Risk Assessment System (SARA) User's Manual, EGG-2522, NUREG/CR-5022 (DRAFT), September 1987.

14. D. I. Gertman, W. E. Gilmore, Specification for the Submission of Raw Human Error Probability Data to the NUCLARR Data Clearinghouse, EGG-REQ-7732, June 1987.

APPENDIX A

DEFINITIONS OF EQUIPMENT CHARACTERISTICS AND HUMAN ACTIONS FOR CLASSIFYING HUMAN ERROR PROBABILITY (HEP) DATA

CONTENTS

APPENDIX A

DEFINITIONS OF EQUIPMENT CHARACTERISTICS AND HUMAN ACTIONS FOR CLASSIFYING HUMAN ERROR PROBABILITY (HEP) DATA

DEFINITIONS OF EQUIPMENT CHARACTERISTICS

Equipment characteristics on all three levels of the HEP data taxonomy are defined in this appendix. The definitions are organized as follows:

- o Level 1 (systems)
  - General Electric systems
  - Westinghouse systems
  - Combustion Engineering systems
  - Babcock & Wilcox systems
- o Level 2 (components)
- o Level 3 (displays/instruments/controls)

Within each of the above categories, the definitions are listed in the order that the equipment characteristics appear on the matrices.

Level 1--General Electric Systems[a]

Air Systems

Air systems provide the proper type and pressure of air to operate necessary instrumentation and equipment in the plant. The air systems include service air and instrument air systems.

Instrument Air System--The instrument air system provides a continuous supply of clean, dry, oil-free compressed air for use by plant instrumentation, various air-operated valves, and control devices.

Service Air System--The service air system provides a continuous supply of compressed air, without drying or filtration, for such functions as backwashing, mixing, and agitation as well as general plant use. Some plants utilize service air as a backup to instrument air.

Annunciator Systems

Annunciator systems are hardwired systems that provide the operator with the audio and visual alarm information required for unit operation,

---

a. An asterisk indicates that this definition of a General Electric system is based on the Nuclear Plant Reliability Data System (NPRDS).

startup, and shutdown. These systems are independent of the plant computer system and include the controls necessary to acknowledge, silence, and reset alarms.

Communication Systems

Communications systems provide reliable and convenient communications among onsite personnel and between on-site and off-site locations. These systems include an intraplant public address system, a private telephone system to permit plant-to-off-site communication on a continuous basis, and a two-way radio communication system.

Compressed Gas Systems

Compressed gas systems store and distribute as required the necessary gases used to operate and maintain the plant. Typical gases are hydrogen, oxygen, CO_2, argon, and acetylene.

Condensate Systems*

Condensate systems deliver condensate from the main condenser hotwell to the suction of the reactor feed pumps (feedwater system) that supply the water to the reactor vessel for conversion into steam. The hotwell pumps, arrange in parallel, take condensate from the condenser hotwell and pump it through an offgas condenser, a gland steam condenser, and two steam jet air ejector intercondensers in which the condensate can gain additional energy prior to entering the feedwater system. The condensate booster pumps drive the condensate through parallel component arrangements, each consisting of a feedwater heater drain cooler and feedwater heaters. After exiting the feedwater heaters, the condensate enters the feedwater system by way of the reactor feed pumps.

The boundary of the systems is at the outlet of the condenser; however, the condensate storage tank is considered part of these systems because of its safety functions.

Condensate Cleanup System--The condensate cleanup system removes dissolved and suspended impurities from the condensate. The system consists of parallel operating demineralizers. External resin regeneration facilities are considered part of this system.

Condenser Air Removal System--The condenser air removal system maintains a vacuum in the main condenser sections during normal plant operation by removing noncondensible gases with steam jet air ejectors. This system, utilizing mechanical vacuum pumps, will also establish the initial vacuum when steam pressure is inadequate to operate the steam jet air ejector units. The condenser air removal system exhausts to the offgas system.

Containment Systems

Containment systems serve as a pressure boundary and shielding for the reactor if there is release of radioactivity from the reactor. The containment systems include the containment atmosphere cooling, containment combustible gas control, containment penetration/isolation, containment spray, standby gas treatment, and suppression pool support systems.

Containment Atmosphere Cooling System*--The containment atmosphere cooling system removes heat energy from the drywell atmosphere in order to maintain the containment atmospheric pressure below design pressure. The containment atmosphere cooling system consists of one or more cooling fans and cooling coils. Heat is usually via the reactor building closed cooling water system, but other cooling methods may be used.

Containment Combustible Gas Control System*--The containment combustible gas control system is one of two types: the dilution type or the recombiner type. The dilution subsystem provides the means by which the containment atmosphere is diluted with clean air and vented to the atmosphere. The hydrogen recombiner system maintains the hydrogen concentration below 4% by volume in the containment following a design-basis LOCA without reliance on purging. The system basically consists of a skid-mounted thermal recombiner unit with associated valves, piping, instrumentation, and controls.

Containment Penetration/Isolation System*--The containment penetration/isolation system comprises all primary containment penetrations and all accesses regardless of size. Equipment and personnel access hatches and fuel transfer tubes are considered components. All associated instruments, monitors, etc., are considered piece parts of the access or penetration. This system includes maintenance hatches and all electrical, mechanical, piping, and instrumentation penetrations.

Containment Spray System*--The containment spray system, a subsystem of the residual heat removal (RHR) system, aids in reducing drywell pressure following a LOCA. With the RHR system in the containment spray mode of operation, the RHR pumps transfer water from the suppression pool through the residual heat exchangers, where heat is removed by the RHR service water. The cooled water is diverted to two redundant spray headers embedded in and protected by the primary shield wall located in the drywell. Some of this water may be diverted to a header suspended above the suppression pool, as well as to a line that directs flow to the lower portion of the suppression chamber.

Standby Gas Treatment System*--The standby gas treatment system maintains a small negative pressure in the reactor building under isolation conditions and prevents ground level escape of airborne radioactivity. Filters are provided in the system to remove radioactive particulates, and charcoal absorbers are provided to remove radioactive halogens that may be present in concentrations significant with respect to environmental dose.

The system is sized to provide one air change per day in the reactor building. Two separate filter absorber/fan units are provided, and both fan units automatically start on a standby gas treatment system initiate signal. Both units receive power from emergency electrical supply.

Suppression Pool Support System*--The suppression pool support system consists of three subsystems: the makeup subsystem, the temperature-monitoring subsystem, and the cleanup subsystem. The cleanup subsystem removes sludge, corrosion products, and iodine remaining in the pool after blowdown from the reactor vessel. The temperature-monitoring subsystem consists of a number of temperature detectors located around the suppression pool that monitor the water temperature and initiate alarms if the technical specification limit is approached or exceeded. The makeup subsystem provides additional water to the suppression pool to maintain the minimum top vent coverage while the emergency core coolant pumps are operating during the initial phase of a LOCA.

Control Rod Drive Systems

Control rod drive systems comprise the hydraulic supply subsystem, the hydraulic control units, the scram discharge volume, the control rod drive housing, and the control rods. These systems provide shaping of the neutron flux across the fuel and scram the reactor. The redundant supply pumps develop pressure over the nitrogen accumulators located in the individual rod drive hydraulic control units. A reactor scram signal releases pressurized water in the lines charged by these accumulators to drive the control rods into the reactor. The water that is displaced by this action is exhausted into the scram discharge volume.

Although hydraulic control units are not control rod drive mechanisms, they are considered to be in the same category.

Electrical Distribution Systems

Electrical distribution systems provide a means of receiving off-site power and a means of transmitting site-generated power. These systems supply power to those auxiliaries needed for power generation by the plant. The electrical distribution systems include the ac instrument power, dc power, and plant ac distribution systems.

ac Instrument Power System*--The ac instrument power system provides an uninterruptible source of power for instruments and control circuits under all plant conditions. Any load circuit breakers that may supply several loads are considered part of the ac instrument power system. Breakers that supply a single system are considered part of the system supplied. All ac power that feeds instruments or supports a safety function is considered part of this system.

dc Power System*--The dc power system supplies electric power to both safety-related and non-safety-related dc loads under any plant conditions.

The dc power can be supplied by either a battery or battery charger. Any dc circuit breakers that may supply several loads (to different systems), such as several solenoid valve controls or control power for an ac switchgear, are considered part of the dc power system. The three dc distribut on systems used in GE plants are all considered part of this system.

Plant ac Distribution System*--The plant distribution system provides electric power to both safety-related and non-safety-related loads during normal plant operation. Electric power is supplied at various voltage levels that are connected in a hierarchical fashion.

Emergency Core Cooling Systems

Emergency core cooling systems are designed to mitigate the consequences of postulated emergency situations that could otherwise lead to core damage and release of fission products to the environment. The emergency core cooling systems include the high-pressure coolant injection, high-pressure core spray, low-pressure core spray, and residual heat removal/pressure coolant injection systems.

High-Pressure Coolant Injection System*--The high-pressure coolant injection system is used in Marks 1-5 to ensure that the reactor is adequately cooled, limiting the fuel cladding temperature. It is initiated in the event of a small break in the nuclear steam system and loss of coolant that does not result in rapid depressurization of the reactor vessel. The high-pressure coolant injection system permits the plant to be shut down while maintaining sufficient reactor vessel water inventory until the reactor vessel is depressurized. The high-pressure coolant injection system continues to operate until the reactor vessel pressure is below the pressure at which low-pressure coolant injection operation or core spray system operation can maintain core cooling.

High-Pressure Core Spray System*--The high-pressure core spray system is typical of Mark 6 design. It operates in the event of a LOCA by spraying makeup water on the reactor core, thus depressurizing the reactor vessel and preventing fuel damage. In the event of a low water level in the reactor vessel, makeup water is pumped to the reactor vessel and discharged through spray nozzles onto the reactor core. The primary source of makeup water to the system is the condensate storage tank, with the suppression pool serving as a secondary source.

The high-pressure core spray actuation controls are considered a part of the system. Some plants may use a keep-fill system.

Low-Pressure Core Spray System*--The low-pressure core spray system helps prevent nuclear fuel damage in the event a LOCA occurs that might uncover the reactor core. Water is sprayed on the core to maintain the temperature at a safe level. The system goes into operation after the reactor vessel pressure has been reduced and only if other safety systems prove inadequate in maintaining the necessary water level in the reactor vessel.

The low-pressure core spray actuation controls are considered a part of the system. The number of pumps and loops will vary with design. Some plants may use a keep-fill system instead of a head tank.

Residual Heat Removal/Low Pressure Coolant Injection System*--The residual heat removal system is a closed-loop system of piping, water pumps, and heat exchangers for decay heat removal under both operational and accident conditions. This removal is accomplished by several related but independent modes of operation:

Low-Pressure Coolant Injection--The low-pressure coolant injection mode of the residual heat removal system operates to restore and maintain, if necessary, the water level in the reactor vessel after a LOCA. Low-pressure coolant injection also provides protection for small breaks in which the control rod drive water pumps, reactor core isolation cooling, and high-pressure coolant injection are unable to maintain water level and the automatic depressurization system has operated to lower reactor pressure. The low-pressure coolant injection actuation controls are also a part of the residual heat removal system.

Suppression Pool Cooling--This mode of residual heat removal is initiated manually as soon as possible after isolation of the primary system from the condenser. Its function is to cool the suppression pool so that pool temperatures do not exceed 170°F after a blowdown.

Shutdown Cooling: The shutdown cooling mode of the residual heat removal system provides for the removal of decay heat and sensible heat from the primary system during shutdowns for refueling or servicing.

Fire Protection Systems

Fire protection systems furnish water or fire extinguishing chemicals to areas throughout the station to minimize the adverse effects of fire on station structures, equipment, and personnel.

Generator Systems

Generator systems convert the rotating mechanical energy of the turbines into electrical energy. Generator systems include the generator excitation system, generator H_2 cooling/CO_2 purge system, generator seal oil system, and generator stator water cooling system.

Generator Excitation System--The generator excitation system provides a regulated, controllable source of magnetizing power to the rotating generator field winding, which controls generator output voltage. The generator excitation system consists of the alternator exciter, exciter field breaker and rectifier, voltage regulators, and all associated controls and instrumentation.

Generator H_2 Cooling/CO_2 Purge System--The generator H_2 cooling/CO_2 purge system keeps the generator adequately cooled by maintaining proper generator hydrogen pressure, temperature, and purity. The system consists of hydrogen coolers, storage cylinders, regulatory valves, a hydrogen control panel, and associated piping and instruments. The carbon dioxide supply used to purge the generator comes from a CO_2 storage tank. The generator gas monitoring subsystem is included in this system.

Generator Seal Oil System--The generator seal oil system contains the hydrogen within the generator casing, preventing leakage of hydrogen out of the generator and leakage of air into the generator. This system supplies seal oil under pressure to the generator hydrogen shaft seals. This system consists of various seal oil pumps, vacuum tank, oil filters, pressure regulators, and associated instruments. Seal oil is supplied by the turbine lube oil system.

Generator Stator Water Cooling System--The generator stator water cooling system cools generator stator bars, the generator terminal box in the lower frame extension, and the exciter rectifiers. This is a closed system that consists of cooling pumps, water coolers, deionizer and filter regulatory valves, and assorted piping and instruments.

Heating, Ventilation, and Air Conditioning (HVAC) Systems

Heating, ventilation, and air conditioning systems provide an environment with controlled temperatures, humidities, and air flow patterns to maintain an atmosphere that ensures the comfort and safety of personnel and the operability of equipment located in the containment, drywell, and other small areas.

High-Pressure Core Spray (HPCS) Diesel Generator Systems*

High-pressure core spray diesel generator systems supply electric power to the HPCS during abnormal plant conditions such as a plant blackout or LOCA. Diesel start and generator breaker closing control circuits are considered a part of HPCS diesel generator systems. The ground fault breakers and exciter are considered piece parts of the diesel. The sequencer and load-shedding relays and the starting circuit breaker are considered part of the systems.

High-Pressure Core Spray (HPCS) Cooling Water Systems--The HPCS cooling water system provides adequate water flow to remove heat from the diesel engine during operation. A jacket heating loop also is provided to prevent thermal shock when the diesel is started.

High-Pressure Core Spray (HPCS) Fuel Oil Storage and Transfer System*--The HPCS fuel oil storage and transfer system supplies fuel to run the diesel engine in the HPCS diesel generator system and stores enough fuel for several days' continuous operation. Fuel supplied from the day tank may be pumped into the diesel, or a gravity feed may be used.

High-Pressure Core Spray (HPCS) Lube Oil System*--The HPCS lube oil system provides oil to lubricate the moving parts of the diesel engine in the HPCS diesel generator system, thus protecting it from excessive wear and overheating. Adequate lube oil pressure is usually a permissive signal in the diesel generator starting circuit. During diesel operation, the lube oil is normally circulated by engine-driven oil pumps that are considered piece parts of the diesel engine. Prior to the diesel start, a motor-driven oil pump supplies oil pressure.

High-Pressure Core Spray (HPCS) Starting Air System*--The HPCS starting air system is designed to provide compressed air to assist in the rapid starting of the diesel engine in the HPCS diesel generator system.

Instrumentation and Control Systems

Instrumentation and control systems provide timely operation of equipment needed for proper plant operation and the necessary indication of plant parameters and equipment conditions.

Area Radiation Monitoring System--The area radiation monitoring system indicates alarms and records abnormal radiation levels in areas where radioactive material may be present, stored, handled, or inadvertently introduced. The system consists of a number of radiation monitors and the associated instrumentation.

Automatic Depressurization System--The automatic depressurization system, in the event of a small break in the reactor coolant pressure boundary concurrent with a failure of the high-pressure emergency core cooling system to adequately cool the reactor core, depressurizes the reactor vessel and thus allows the low pressure emergency core cooling systems to flood the core and prevent fuel cladding damage.

The automatic depressurization system consists of redundant signal logics arranged in two separate channels that control separate valves on each safety relief valve that has been assigned the automatic depressurization system function.

Containment Atmosphere Monitoring System--The containment atmosphere monitoring system provides a means of measuring the drywell and containment hydrogen gas concentrations and radiation levels following a LOCA.

Electrohydraulic Control (Turbine Control) System--The electrohydraulic control (turbine control) system controls the speed and acceleration of the main turbine, operates the steam bypass system to keep reactor pressure within limits and avoid pressure/power transients, and controls main turbine inlet pressure. The electrohydraulic control (turbine control) system also matches nuclear steam supply to turbine steam requirements during automatic load following operation.

Feedwater Control System--The feedwater control system maintains the water level in the reactor vessel within a programmed range during all modes of plant operation by regulating the flow of feedwater as a function of vessel water level and steam flow from the vessel.

Leak Detection System--The leak detection system detects and annunciates the escape of potentially radioactive material from the reactor coolant pressure boundary. In addition, the leak detection system is capable of determining the rate of leakage and initiating action to isolate systems that are leaking at a substantial rate in order to protect the nuclear fuel from damage that may be caused by the loss of coolant.

Main Steam Isolation Valve (MSIV) Leakage Control System--The MSIV leakage control system controls and minimizes the release of fission products that could leak through the closed MSIVs following a LOCA by directing the leakage through bleed lines into an area served by the standby gas treatment system for processing prior to release to the atmosphere.

Neutron Monitoring system--The neutron monitoring systems provide neutron flux level monitoring of the reactor by utilizing three instrument ranges: source, intermediate, and power. These instruments perform continuous monitoring and provide automatic safety protection and interlock features.

Nuclear Steam Supply Shutoff System*--The nuclear steam supply shutoff system establishes the requirements that are necessary to maintain the leaktightness of the reactor containment. It provides the means by which the various fluid systems that penetrate the reactor containment can be isolated reliably. Isolation is generally accomplished by utilization of the penetrating systems' isolation valves. Components in this system are considered to be any isolation valves that are part of another system (e.g., waste gas or liquid waste isolation valves) and the nuclear steam supply shutoff system actuation logic.

Process Radiation Monitoring System*--The process radiation monitoring system monitors radiation levels of certain liquid and gaseous processes throughout the nuclear power plant. The process radiation monitoring system assists in controlling the release of radioactive byproducts within legally prescribed limits and provides for personnel safety by warning of abnormal radiation levels.

The process radiation monitoring system also includes main steam line radiation monitoring, which detects significant increases in the gross gamma radiation level and initiates control action. Such increases in radiation level are caused by fission products in the main steam lines.

Reactor Protection System*--The reactor protection system detects conditions that threaten the fuel or reactor coolant pressure boundary and initiates an automatic reactor shutdown (scram) when monitored system parameters exceed predetermined limits. This action prevents fuel damage and damage to the reactor coolant pressure boundary and limits uncontrolled releases of radioactive material.

Remote-mounted instrumentation and interfaces with selected systems feed information to the reactor protection system logic circuitry. When threshold values are exceeded, actuator logic generates a signal that deenergizes the scram pilot valves, which in turn open the inlet and outlet air-operated scram valves, allowing the primary control rod drive hydraulic pressure or accumulator pressure to scram the control rods. Once the system is actuated, the scram goes to completion unless a deliberate action is taken by the plant operator. In addition to automatic operation, a manual mode is provided.

Any instrumentation is considered part of the reactor protection system if it provides input into the reactor protection system.

Remote Shutdown System--The remote shutdown system provides a reactor plant shutdown capability located outside the control room for situations when the control room may have to be evacuated. The remote shutdown system provides all the controls and indication necessary to shut down the reactor as well as to provide subsequent reactor plant stabilization and cooldown.

Rod Control and Information System--The rod control and information system (RCIS) provides a means of making changes in the reactor core reactivity so that reactor power level and power (neutron flux) distribution can be controlled. This function is performed by providing the controls necessary to permit operator execution of control rod movements in the reactor core. The RCIS also functions to limit the worth of any control rod to reduce the effects from a rod drop accident or a rod withdrawal error by enforcing adherence to predetermined control rod patterns through the use of control rod blocks. The RCIS consists of the electronic circuitry, switches, indicators, and alarm devices necessary for the manipulation of control rods. Some GE plants refer to this system as the reactor manual control system or rod sequence control system.

Traversing In-core Probe System--The traversing in-core probe system serves as a calibration device for the local power range monitoring (LPRM) system. The traversing in-core probe system is capable of sensing neutron flux in the immediate vicinity of the permanently installed LPRM fission chambers. The flux signal is used to perform LPRM channel calibrations, compensate for changes in detector sensitivity, and provide line plots of the actual flux distribution.

Process Sampling Systems

Process sampling systems monitor the operation of plant equipment and provide information needed to make operational decisions. These systems provide remote sampling facilities and the capability for sampling fluids of various process systems during normal plant power operation and shutdown conditions.

Radwaste Systems

Radwaste systems collect, process, monitor, store, and dispose of all radioactive wastes. The radwaste systems include the liquid radwaste, offgas, and solid radwaste systems.

Liquid Radwaste System--The liquid radwaste system collects, processes, stores, and monitors, for reuse or disposal, all potentially radioactive liquid wastes. The liquid radwaste system consists of one or more subsystems designed to handle specific types of liquid wastes, such as water, chemical solutions from the demineralizer resin regeneration process, and evaporator distillate.

Offgas System--The offgas system receives air and noncondensible gases from the condenser air removal system and processes the effluent for decay and/or removal of gaseous and particulate radioactive isotopes before release to the environment.

Solid Radwaste System--The solid radwaste system collects, processes, packages, and temporarily stores, prior to off-site shipping, such wastes as spent resins, evaporator concentrates, and chemical drain tank effluents. Liquid-bearing wastes are dewatered and solidified. Contaminated solids such as filters, rags, paper, clothing, and tools are compacted.

Reactor Coolant System and Connected Systems

The reactor coolant system includes the reactor pressure vessel, the reactor recirculation system, and the main feedwater system extending to and including the outermost containment isolation valves.

Systems are connected to the reactor coolant system to perform the following functions: (a) provide makeup water to the reactor, (b) remove solids and dissolved impurities from the reactor coolant, and (c) provide emergency reactivity control. Functions such as residual heat removal and emergency core cooling are not considered part of these systems.

Feedwater System*--The feedwater system provides feedwater to the reactor to maintain a constant reactor water level. It takes suction from the condensate system and delivers water to the reactor vessel at an elevated pressure and temperature.

Isolation Condenser System*--The isolation condenser system provides a heat sink for the reactor if the reactor is isolated from its main condenser or if all feedwater is lost. The isolation condenser system operates by natural circulation without the need to place the system in operation. The condenser consists of two tube bundles immersed in a large water storage tank. When the isolation condenser is in operation, steam flows from the reactor through the tubes of the heat exchanger; after condensing, it returns by gravity to the reactor. The isolation condenser is located high in the reactor building to facilitate natural circulation.

Reactor Core Isolation Cooling (RCIC) System*--The RCIC system provides makeup water to the reactor vessel during shutdown and isolation of the reactor vessel from the main condenser. The RCIC system consists of a steam-driven turbine pump unit and associated valves and piping capable of delivering makeup water to the reactor vessel.

The steam supply to the RCIC pump turbine comes from the main steam system. The steam exhausted from the turbine dumps to the suppression pool. The pump can take suction from the demineralized water in either the condensate storage tank or from the suppression pool. The pump discharges either to the feedwater line or to a full-flow return test line running to the condensate storage tanks via the high-pressure coolant injection test line. A minimum flow bypass line to the suppression pool via the residual heat removal test line provides pump protection. The makeup water is delivered into the reactor vessel through a connection to the feedwater line, where it is distributed within the reactor vessel through the feedwater sparger.

Reactor Recirculation System*--The reactor recirculation system consists of two loops external to the reactor vessel, each loop containing a recirculation pump and motor, suction and discharge valves, a discharge bypass valve, and connecting piping to the reactor vessel.

Flow Path (BWR 3 through 6)--The jet pump recirculation system provides forced circulation flow through the BWR core. The recirculation pumps take suction from the downward flow in the annulus between the core and the vessel wall, and the pressure is increased to provide the driving force for the jet pump. This driving flow is discharged in the jet pump nozzle, inducing the remainder of the downcomer flow. In the jet pumps, these flows mix, diffuse, and discharge into the lower core plenum.

Flow Control (BWR 3 and 4)--A variable-speed pump motor is supplied from a variable-frequency motor-generator set. The motor-generator set is located outside the drywell.

Flow Control (BWR 5 and 6)--The flow control valve is a ball type with electrohydraulic activator. The bypass valve is used for plant startup (low-flow) conditions.

Reactor Water Cleanup System--The reactor water cleanup (RWCU) system maintains reactor water quality by removing fission products, corrosion products, and other soluble and insoluble impurities.

The flow path of the RWCU system includes high-pressure flow through RWCU pumps, regenerative and nonregenerative heat exchangers with lines provided for system water sampling, and the required instrumentation for effluent operation.

Flow can be routed through the RWCU demineralizer subsystem, which consists of filter/demineralizers and support equipment such as pumps and tanks.

Standby Liquid Control System*--The standby liquid control system is a redundant, independent control system for use in the unlikely event that the control rod system becomes inoperable. The system will shut down and hold the reactor subcritical as the reactor cools and xenon decays.

Refueling Systems

Refueling systems provide a safe and effective means for transporting and handling fuel from the time it reaches the plant until it leaves the plant. The refueling systems include the fuel handling and fuel pool cooling and cleanup systems.

Fuel Handling System--The fuel handling system consists of the mechanical and electrical components required to manipulate nuclear fuel through the various movements and operations undergone while in the reactor building. Reactor vessel servicing equipment is provided to support fuel handling as well as the nonroutine removal of reactor vessel equipment.

Fuel Pool Cooling and Cleanup System--The fuel pool cooling and cleanup system removes decay heat from the fuel and maintains acceptable pool water level, water quality, and radiation levels. The fuel pool cooling and cleanup demineralizer subsystem removes dissolved and suspended solids from the water.

Standby Diesel Generator Systems*

Standby diesel generator systems supply electric power to vital safety-related loads during abnormal plant conditions, such as a plant blackout or LOCA. These systems typically have two to four diesel generator units. The diesel start, load-shedding, generator breaker closing, and sequencing control circuits are considered part of the standby diesel generator systems.

Sequencer and load-shedding relays and the starting circuit breaker are considered part of these systems. Some units may use gas or hydraulic turbines to supply emergency power. These components are considered part of these systems.

The high-pressure core spray diesel generator system is considered a separate system.

Standby Diesel Generator Cooling Water System*--The standby diesel generator cooling water system provides adequate water flow to remove heat from the diesel engine during operation. A jacket heating loop is also provided to prevent thermal shock when the diesel is started.

Standby Diesel Generator Fuel Oil Storage and Transfer System*--The standby diesel generator fuel oil storage and transfer system supplies fuel to run the diesel engine and stores enough fuel for several days' continuous operation. Fuel supplied from the day tank may be pumped to the diesel.

Standby Diesel Generator Lube Oil System*--The standby diesel generator lube oil system provides oil to lubricate the moving parts of the diesel engines, thus protecting them from excessive wear and overheating. Adequate lube oil pressure is usually a permissive signal in the diesel generator starting circuit. During diesel operation, the lube oil is normally circulated by engine-driven oil pumps that are considered piece parts of the diesel engine. Prior to the diesel start, a motor-driven oil pump supplies oil pressure.

Standby Diesel Generator Starting Air System*--The standby diesel generator starting air system is designed to provide compressed air to assist in the rapid starting of the diesel engines in the standby diesel generator system.

Steam Systems

The steam systems are used to generate and/or transfer steam to the main turbine and other auxiliaries during various modes of plant operation.

Auxiliary Steam System--The auxiliary steam system provides a reliable source of clean steam to various plant components when the main steam system is not available.

Main Steam System*--The main steam system transports steam from the reactor vessel to the turbine-generator. The scope of the main steam system includes the four main steam lines and their components from the interface with the reactor pressure vessel to the main turbine stop valves. Also included is the automatic depressurization system comprised of safety relief valves, lines, and quencher/diffusers located in the suppression pool and the turbine steam bypass equipment.

Turbine Systems

Turbine systems convert the thermodynamic energy of steam to drive the main generator for the production of electricity. Turbine systems are composed of turbines, the extraction steam system, turbine lube oil system, and turbine seal steam system.

Extraction Steam System--The extraction steam system provides heating steam to such components as feedwater heaters for condensate and feedwater heating, seal steam evaporators, and radwaste steam generators. The extraction steam system takes steam from the high-pressure turbine and low-pressure turbine extraction points and from the moisture separators.

Turbine Lube Oil System--The turbine lube oil system continuously supplies cool, clean lubricating oil to the turbine-generator and exciter bearings. The turbine lube oil system comprises lube oil reservoirs, lube oil pumps and coolers, and associated strainers, piping, and instrumentation.

Turbine Seal Steam System--The turbine seal steam system prevents the entrance of air and noncondensible gases into the main condenser and the leakage of radioactive steam to the atmosphere. Clean sealing steam is supplied to the turbine shaft glands and valve stems. Condensed sealing steam is returned to the main condenser.

Water Systems

Water systems provide the needed cooling and makeup water throughout the plant for safe and efficient operation of water-cooled components. The water systems include the circulating water, emergency (RHR) service water, essential service water, reactor building closed cooling water, turbine building closed cooling water, and station service water systems.

Circulating Water System--The circulating water system is a closed-loop system that removes the excess heat from the turbine exhaust steam and turbine bypass steam by continuously supplying cooling water from the cooling tower basin to the main condenser and returning the heated water to the cooling tower for cooling.

Emergency (RHR) Service Water System--The emergency (RHR) service water system removes heat from safety-related coolers and heat exchangers that are required for a safe reactor shutdown or for mitigation of the consequences of postulated accidents. It also serves those nonsafety-related cooling coils and heat exchangers that, because of plant reliability considerations, are serviced when the normally operating station service water is unavailable. This system may provide the capability to flood the reactor vessel, drywell, and containment during the post-LOCA period and to provide makeup water to the spent fuel pool under emergency conditions.

Essential Service Water System*--The essential service water system provides the final heat sink for waste heat loads. Water from the ultimate heat sink (river, ocean, bay, lake, etc.) is pumped through various heat exchangers and provides cooling both directly to heat loads, such as the residual heat removal system, and to intermediate, closed water systems, such as the reactor building closed cooling water system. Only piping and valves associated with essential loads (e.g., reactor building closed cooling water heat exchangers, emergency service water system heat exchangers, motor-generator oil coolers) are considered part of the system. Nonessential loads are not considered part of the system, except for the valves that isolate these loads. If dedicated cooling pumps for systems such as diesel cooling are used, they are considered part of the essential service water system.

Reactor Building Closed Cooling Water System*--The reactor building closed cooling water system removes waste heat from components of various systems that may contain potentially radioactive material. Heat is absorbed by the system's circulating water at various coolers and heat exchangers of reactor-associated systems and then rejected to the essential service water system at the closed cooling water heat exchangers. The system thus provides a closed cooling water loop between the possibly contaminated (radioactive) systems and the essential service water system.

The system consists primarily of circulating pumps, heat exchangers, circuit breakers, expansion tank, air separator, piping, valves, instrumentation, and controls.

Turbine Building Closed Cooling Water (TBCCW) System--The TBCCW system is a closed-loop system that provides cooling water to nonessential systems that are potentially radioactive. The system consists of pumps, heat exchangers, tanks, piping, valves, controls, and instrumentation. The TBCCW pumps are used to evaluate the cooling water through the TBCCW heat exchangers and the components cooled by the TBCCW system. Heat is rejected from the TBCCW heat exchangers to the final heat sink for waste heat loads.

Station Service Water System--The station service water system provides a continuous supply of cooling water to the auxiliary mechanical equipment associated with the power conversion systems and other auxiliary systems. This system also supplies cooling water to numerous emergency service water heat loads during normal plant operation.

Level 1--Westinghouse Systems[a]

Air Systems

Air systems provide the proper type and pressure of air to operate necessary instrumentation and equipment in the plant. The air systems include the instrument air and service air systems.

Instrument Air System--The instrument air system provides a continuous supply of clean, dry, oil-free compressed air for use by plant instrumentation, various air-operated valves, and control devices.

---

a. An asterisk indicates that this definition of a Westinghouse system is based n the NPRDS.

Service Air System--The service air system provides a continuous supply of compressed air, without drying or filtration, for such functions as backwashing, mixing, and agitation as well as general plant use. Some plants utilize service air as a backup to instrument air.

Annunciator Systems

Annunciator systems are hardwired systems that provide the operator with the audio and visual alarm information required for unit operation, startup, and shutdown. These systems are independent of the plant computer system and include the controls necessary to acknowledge, silence, and reset alarms.

Communication Systems

Communication systems provide reliable and convenient communications among on-site personnel and between on-site and off-site locations. These systems include an intraplant public address system, a private telephone system to permit plant-to-off-site communication on a continuous basis, and a two-way radio communication system.

Compressed Gas Systems

Compressed gas systems store and distribute as required the necessary gases used to operate and maintain the plant. Typical gases are hydrogen, oxygen, CO_2, argon, and acetylene.

Condensate Systems*

Condensate systems provide continuous condensate flow from the condenser hotwells to the main feedwater pumps, which in turn provide feedwater to the steam generators at the required pressures and temperatures under all anticipated steady-state and transient conditions. Condensate systems consist of two or more parallel, interconnected trains. These take condensate from the condenser hotwells and discharge it into the low-pressure feedwater heaters, which in turn supply the feedwater pumps.

Condensate Cleanup System--The condensate demineralizer system maintains the required purity of the condensate and feedwater by using precoat filters and demineralizers.

Containment Systems

Containment systems serve as a pressure boundary and shielding for the reactor in the event there is release of radioactivity from the reactor. Containment systems include the annulus ventilation, combustible gas control, containment/reactor building penetration, containment fan cooling, containment isolation, containment spray, containment ventilation, and ice condenser systems.

Annulus Ventilation System*--The annulus ventilation system is designed to: (a) produce and maintain a negative pressure in the containment annulus following a LOCA; (b) minimize the release of radioactivity following a LOCA by recirculating a large volume of air compared to the amount discharged for pressure control; and (c) provide long-term fission product removal by filtration.

Combustible Gas Control System*--The combustible gas control system is one of three types: the dilution type, the igniter type, and the recombiner type. Any of the types may be used to control the concentration of hydrogen in the containment atmosphere. Hydrogen must be kept below 4.1% by volume, which is the lower explosive limit of hydrogen in air. The dilution system bleeds containment air out through a filtering system, replacing it with outside air. The igniter system burns the hydrogen to water, and the recombiner system uses a skid-mounted thermal recombiner unit, usually a catalytic type.

Containment/Reactor Building Penetration System*--The containment/reactor building penetration system comprises all primary containment accesses and penetrations regardless of size. Penetrations should not be considered part of any other system. Equipment and personnel access hatches and fuel transfer tubes are components of this system. All associated components are considered piece parts of the penetration.

Containment Fan Cooling System*--The functions of the containment fan cooling system are to: (a) reduce the pressure in containment following a LOCA or a steam line break inside containment; (b) remove fission products from the containment atmosphere should they be released during a LOCA; and (c) provide containment cooling during both normal plant operation and accident conditions.

The containment fan cooling units are used to cool the containment building atmosphere following a LOCA. Heat removed by the units is rejected to the ultimate heat sink via the service water system through an air-water heat exchanger. There are several variations to the design of the system.

Containment Isolation System*--The containment isolation system establishes the requirements that are necessary to maintain the leaktightness of the reactor containment. The containment isolation system provides the means by which the various fluid systems that penetrate the reactor containment can be isolated reliably. Isolation generally is accomplished by utilization of the penetrating systems' isolation valves. Any isolation valves not considered part of another system are to be included in this system.

Containment Spray System*--The containment spray system also includes systems, such as quench spray, that perform essentially the same function as containment spray. The containment spray system depressurizes and cools the containment to subatmospheric pressure and removes iodine from the containment atmosphere following a LOCA by spraying cool, treated water into the containment. Initially, water is taken from the refueling water storage tank. When this water source is depleted to a certain predetermined level, cooling is continued by recirculation from the reactor building sump. Spray additives such as NaOH may be used to scavenge the iodine.

Containment Ventilation System--The containment ventilation system consists of several subsystems, each of which has separate design objectives. The systems are designed around objectives relating to normal operation, personnel access, containment protection and accident conditions.

The containment air cooling subsystem is designed to maintain an acceptable temperature within the containment upper and lower compartments, reactor well, control rod drive mechanism shroud, and instrument room for the protection of equipment and controls during normal reactor operation and normal shutdown.

The containment purge subsystem is designed to maintain the environment in the primary and secondary containment within acceptable limits for equipment operation and personnel access and to limit the release of radioactivity to the environment.

The vacuum relief subsystem protects the containment vessel from an excessive external force.

The air return fan subsystem enhances the ice condenser and containment spray heat removal operation by circulating air from the upper compartment to the lower compartment, through the ice condenser, and back to the upper compartment. This subsystem limits the hydrogen concentration in potentially stagnant regions by ensuring a flow of air from these regions.

Ice Condenser System--The ice condenser system is a static system that rapidly absorbs the energy release resulting from a pipe rupture. The ice condenser is a completely enclosed, refrigerated, annular compartment formed between the crane wall and the containment shell. The refrigeration system that prevents melting and sublimation and the instrumentation that monitors and controls the refrigeration system are considered part of the ice condenser system.

Control Rod Drive Systems*

Control rod drive systems position the shutdown and control rod cluster control assemblies upon commands from the operator or the automatic rod control system, thus controlling reactor temperature and power distribution within the core. Power to control rod drive mechanisms is supplied by two motor-generator sets operating from two separate 480-V, three-phase buses. The generators, driven by motors, are paralleled through circuit breakers.

The power is distributed to the power cabinets through the two series-connected reactor trip breakers. Bypass breakers can be connected in parallel with the reactor trip breakers to facilitate on-line testing of the protective system. The power cabinets contain the solid-state electronics necessary to control power to the control rod drive mechanisms. The control rod drive mechanism is a magnetic, jacking-type device that moves the rod control cluster assemblies within the core.

Electrical Distribution Systems

Electrical distribution systems provide a means of receiving off-site power and a means of transmitting site-generated power. These systems supply power to those auxiliaries needed for power generation by the plant. The electrical distribution systems include the ac instrument power, dc power, and plant ac power systems.

ac Instrument Power System*--The AC instrument power system provides an uninterruptible source of power for instruments and control circuits under all plant conditions. Any load circuit breakers that supply several components are considered part of the ac instrument power system. Circuit breakers that supply a single system or component are considered part of the system supplied. The unique breaker and controls supplying the load to a component are considered part of the system that contains the component. Not all plants have inverters. Other components that provide this function are considered part of the ac instrument power system.

dc Power System*--The dc power system supplies electric power to both safety- and nonsafety-related dc loads under any plant condition. The dc power can be supplied by either a battery or battery charger. Any dc circuit breakers that may supply several loads, such as several solenoid valve controls or control power for an ac switchgear, are considered part of the dc power system. Those that supply a single component are considered part of the system that contains the component.

Plant ac Power System*--The plant ac power system provides electric power to both safety- and nonsafety-related loads during normal plant operation. Electric power is supplied at various voltage levels in a hierarchical fashion.

Emergency Core Cooling Systems

Emergency core cooling systems are designed to mitigate the consequences of postulated emergency situations that could otherwise lead to core damage and release of fission products to the environment. The emergency core cooling systems include the high-pressure safety injection, residual heat removal/low-pressure safety injection, and upper head injection systems.

High-Pressure Safety Injection System*--The high-pressure safety injection system ensures that the reactor is cooled adequately to limit fuel cladding temperature in the event of a small break in the nuclear system and loss of coolant that does not result in rapid depressurization of the reactor vessel. The high-pressure safety injection system permits the plant to be shut down while maintaining reactor vessel coolant level until the reactor vessel is depressurized. High-pressure safety injection operates until reactor vessel pressure is below the pressure at which low-pressure safety injection operation maintains core cooling.

The boron injection subsystem is a subsystem of high-pressure safety injection used under emergency conditions. Under such circumstances, the chemical and volume control system charging pumps are used to pump concentrated boric acid into the reactor coolant system. The boric acid solution compensates for control rods not fully inserted into the reactor core when negative reactivity is needed to bring and keep the reactor subcritical.

Residual Heat Removal/Low-Pressure Safety Injection System*--The residual heat removal (RHR) mode provides for the removal of decay heat and sensible heat from the primary system during shutdowns for refueling or servicing.

The low-pressure safety injection mode of the residual heat removal system uses the RHR pumps and heat exchangers to restore and maintain water level in the reactor vessel after a LOCA. This system also provides suction to the high-pressure safety injection system and the charging pumps during the recirculation phase and provides cooling to the recirculation sump water.

The safety injection accumulator tanks are included in this system.

Upper Head Injection System*--The upper head injection system is a passive injection system designed to provide additional coolant to the reactor core during the blowdown phase of a large cold leg LOCA. The upper head injection system actuates at a relatively high reactor coolant pressure. Water from the upper head injection accumulator is driven by nitrogen pressure and is injected directly into the upper portion of the reactor vessel.

Emergency Power Systems*

Emergency power systems supply electric power to vital safety-related loads during abnormal plant conditions such as plant blackouts or LOCAs. Emergency power systems are typically a diesel generator-powered system with two to four diesel generator units. The diesel start, load-shedding, generator breaker closing, and sequencing control circuits are considered a part of emergency power systems. Some units may use other emergency power sources, such as gas or hydroelectric turbines, to supply emergency power. These components are considered part of the emergency power systems.

Diesel Generator Cooling Water System*--The diesel generator cooling water system provides adequate water flow to remove heat from the diesel engine during operation. A jacket heating loop is also provided to prevent thermal shock when the diesel is started.

Diesel Generator Fuel Oil Storage and Transfer System*--The diesel generator fuel oil storage and transfer system supplies fuel to run the diesel engine and stores enough fuel for several days' continuous operation. Fuel supplied from the day tank may be either pumped or gravity fed to the diesel.

Diesel Generator Lube Oil System*--The diesel generator lube oil system provides oil to lubricate the moving parts of the diesel engines, thus protecting them from excessive wear and overheating. Adequate lube oil pressure is usually a permissive signal in the diesel generator starting circuit. During diesel operation, the lube oil is normally circulated by engine-driven oil pumps that are considered piece parts of the diesel engine. Prior to the diesel start, a motor-driven oil pump supplies oil pressure.

Diesel Generator Starting Air System*--The diesel generator starting air system provides compressed air to assist in the rapid starting of the diesel engine.

Feedwater Systems

Feedwater systems provide a continuous supply of preheated water to the steam generators through all power operation modes of the plant.

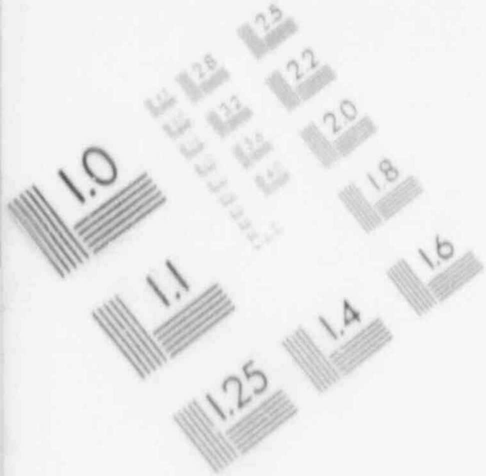
Auxiliary Feedwater System*--The auxiliary feedwater system supplies feedwater to the steam generators following transient or accident conditions when the main feedwater system is not available. The system is also used during normal plant startup, shutdown, and hot standby conditions. The most common arrangement is the three-pump arrangement. Other arrangements contain similar components. When the auxiliary feedwater actuation logic is uniquely identifiable, it is considered part of the auxiliary feedwater system. Emergency feedwater pump(s) may be driven by a diesel engine, which is considered part of the auxiliary feedwater system.

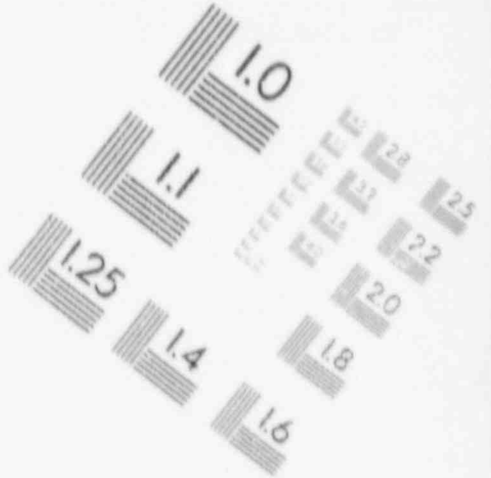
Main Feedwater System*--The main feedwater system provides feedwater to the steam generators at the required pressures and temperatures under all anticipated steady-state and transient conditions.

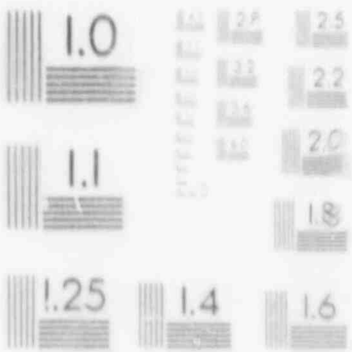
Fire Protection Systems

Fire protection systems furnish water or fire extinguishing chemicals to areas throughout the station to minimize the adverse effects of fire on station structures, equipment, and personnel.

IMAGE EVALUATION TEST TARGET (MT-3)

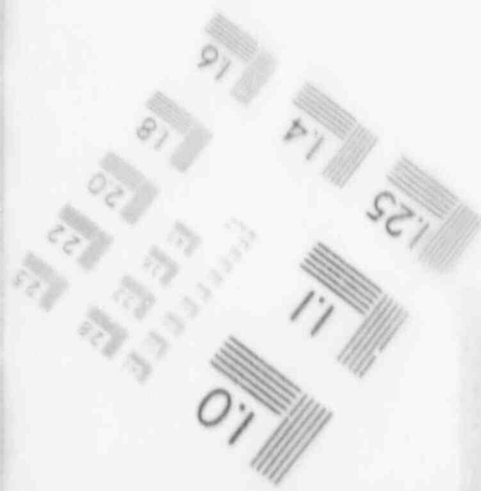


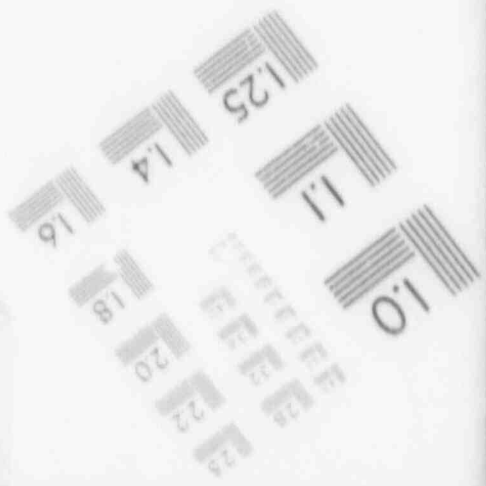




150mm

6"





Generator Systems

Generator systems convert the rotating mechanical energy of the turbines into electrical energy. Generator systems include the generator, generator excitation system, generator H_2 cooling/CO_2 purge system, generator seal oil system, and generator stator water cooling system.

Generator Excitation System--The generator excitation system provides a regulated, controllable source of magnetizing power to the rotating generator field winding. This winding controls generator output voltage. The generator excitation system consists of the alternator exciter, exciter field breaker and rectifier, voltage regulators, and all associated controls and instrumentation.

Generator H_2 Cooling/CO_2 Purge System--The generator H_2 cooling/CO_2 purge system keeps the generator adequately cool by maintaining proper generator hydrogen pressure, temperature, and purity. The system consists of hydrogen coolers, storage cylinders, regulating valves, a hydrogen control panel, and associated piping and instruments. The carbon dioxide supply used to purge the generator comes from a CO_2 storage tank. The generator gas monitoring subsystem is included in this system.

Generator Seal Oil System--The generator seal oil system contains the hydrogen within the generator casing, preventing leakage of hydrogen out of the generator and leakage of air into the generator. This system supplies seal oil under pressure to the generator hydrogen shaft seals. This system consists of various seal oil pumps, a vacuum tank, oil filters, pressure regulators, and associated instruments. Seal oil is supplied by the turbine lube oil system.

Generator Stator Water Cooling System--The generator stator water cooling system cools the generator stator bars, the generator terminal box in the lower frame extension, and the exciter rectifiers. This is a closed system that consists of cooling pumps, water coolers, deionizer and filter regulating valves, and assorted piping and instruments.

Heating, Ventilation, and Air Conditioning Systems

Heating, ventilation, and air conditioning systems provide an environment with controlled temperatures, humidities, and air flow patterns to maintain an atmosphere that ensures the comfort and safety of personnel and the operability of equipment located in the containment, drywell, and other small areas.

Penetration Room Ventilation System*--The penetration room ventilation system collects and filters any gases that may leak through containment penetrations during accident conditions. For this reason, the system is used to keep the penetration room at slightly negative pressure. The penetration room ventilation system is designed to be used only under accident conditions. This system concept has a number of variations and nomenclature. At some stations, the penetration room ventilation system function is performed by the auxiliary building standby gas treatment system or the auxiliary building emergency exhaust system. Such systems would also be included in this system.

Instrumentation and Control Systems

Instrumentation and control systems provide timely operation of equipment needed for proper plant operation and the necessary indication of plant parameters and equipment conditions.

Electrohydraulic Control (Turbine Control) System--The electrohydraulic control (turbine control) system controls the speed and acceleration of the main turbine and turbine load by controlling steam flow to the turbine.

Engineered Safeguards Actuation and Logic System*--The engineered safeguards actuation and logic system senses plant parameters to determine the need for engineered safety features actuation and operation. This system may comprise either relays or solid-state logic. The system includes the elements in the signal path from sensors or from the output of the reactor protection system isolation amplifiers through the engineered safeguards actuation and logic system signal processors, logic circuits, relay circuits, and output controller circuits that are directly involved in the that system's functions. Outputs from the engineered safeguards actuation and logic system that are used to trip the reactor are part of the reactor protection system.

Ex-core Nuclear Instrumentation System--The ex-core nuclear instrumentation system protects the reactor by monitoring the neutron flux and generating appropriate trips and alarm signals for various phases of reactor operating and shutdown conditions. The ex-core nuclear instrumentation system consists of eight independent channels: two source range, two intermediate range, and four power range. In addition, there are four auxiliary channels: the audiovisual count rate channel, the comparator channel, the startup rate channel, and the flux deviation channel.

In-core Instrumentation System--The in-core instrumentation system provides information on the neutron flux distribution and fuel assembly outlet temperatures at selected core locations. The system consists of thermocouples, in-core flux thimbles to permit insertion of movable fission detectors, detector drive units and associated components, gas purge and leak detection components, and control and readout equipment.

Leak Detection System--The leak detection system detects and annunciates the escape of potentially radioactive material from the reactor coolant pressure boundary. In addition, the leak detection system is capable of determining the rate of leakage and initiating action to isolate systems that are leaking at a substantial rate in order to protect the nuclear fuel from damage that may be caused by the loss of coolant.

Pressurizer Level Control System--The pressurizer level control system maintains pressurizer level during expansion and contraction of the reactor coolant volume due to temperature changes. Reactor coolant average temperature is used to develop a programmed level setpoint. Water inventory is maintained by controlling the balance between water leaving the system, via the letdown flow to the chemical and volume control system, and water entering the system from the charging pumps.

Pressurizer Pressure Control System--The pressurizer pressure control system controls the pressure of the reactor coolant system at or near a fixed setpoint during both steady-state and design transient conditions. The system consists of a combination of heater banks, spray valves, and relief valves actuated at the proper times by a pressure controller with proportional, rate, and reset adjustments. The system components operate at various fixed pressure deviation points from the controller setpoint.

Radiation Monitoring System--The radiation monitoring system indicates, alarms and records abnormal radiation levels in areas where radioactive material may be present, stored, handled, or inadvertently introduced.

Reactor Protection System--The reactor protection system prevents damage to the fuel and to the reactor coolant pressure boundary. The system monitors the plant for abnormal conditions that might be indicative of an approaching unsafe operating state. When such deviations in operating conditions are detected, the reactor protection system's redundant actuator logic generates signals that deenergize a dc undervoltage coil on each reactor trip breaker. The circuit breakers open, power is interrupted to the control rod drive power supply, and the control rods fall into the core under gravity, causing reactor shutdown. The signal that deenergizes the dc undervoltage coils also initiates a primary coolant trip. In addition to automatic operation, manual initiation is also provided. The elements in the signal path from the sensor through signal processor circuits, relay circuits, and output controller circuits that are part of the reactor protection functions are considered part of the reactor protection system. Any outputs from an isolation amplifier or isolation circuit that feeds the engineered safeguards actuation and logic system are part of that system. The reactor trip breakers are considered part of the control rod drive system.

Remote Shutdown System--The remote shutdown system provides a reactor plant shutdown capability located outside the control room for situations when the control room may have to be evacuated. The remote shutdown system provides all the controls and indication necessary to shut down the reactor as well as to provide subsequent reactor plant stabilization and cooldown.

Rod Control System--The rod control system maintains a programmed average temperature in the reactor coolant system by regulating the reactivity in the core and shapes the axial flux profile of the core. The rod control system consists of the electronic circuitry, switches, indicators, and alarm devices necessary for the manipulation of the control rods.

Rod Position Indication System--The rod position indication system, composed of two subsystems, continuously senses and displays rod position information for each control rod. The individual rod position indication subsystem measures the actual rod position and displays it on the main control board. The demand position subsystem counts the number of steps demanded by the rod control system to move the rods up or down. This information is displayed by step counters located on the main control board.

The system consists of field-mounted detectors, rack-mounted electronic equipment, and control-board-mounted equipment.

Steam Dump Control System--The steam dump control system reduces the magnitude of nuclear system transients following a large turbine load reduction or reactor trip by dumping throttle steam directly to the main condenser, thereby creating an artificial load on the reactor and preventing the lifting of steam generator safety valves. The system comprises several banks of valves located downstream of the main steam stop valves and all associated circuitry and controls.

Steam Generator Water Level Control System--The steam generator water level control system provides each steam generator with a three-element feedwater controller (feedwater flow, steam flow, and water level) that maintains a programmed water level on the secondary side of the steam generator during normal plant operation. This controller, continuously compares measured feedwater flow with steam flow, and a compensated steam generator downcomer water level signal with a water level setpoint to regulate the main feedwater valve position.

Main Steam Systems*

Main steam systems contain and transport the saturated steam to the turbines, where it is utilized in the production of electricity. Main steam systems also provide the means of removing heat when the turbines are not available through the use of steam dumps and atmospheric relief valves.

Process Sampling Systems

Process sampling systems monitor the operation of plant equipment and provide information needed to make operational decisions. These systems provide remote sampling facilities and the capability for sampling fluids of various process systems during normal plant operation and shutdown conditions.

Radwaste Systems

Radwaste systems collect, process, monitor, store, and dispose of all radioactive wastes. Radwaste systems include the gaseous radwaste, the liquid radwaste, and solid radwaste systems.

Gaseous Radwaste System--The gaseous radwaste system processes and controls the release of gaseous radioactive wastes to the site environs. The gaseous radwaste system typically consists of waste gas compressor packages, gas decay tanks, and associated piping, valves, and instrumentation.

Liquid Radwaste System--The liquid radwaste system collects, processes, stores, and monitors, for reuse or disposal, all potentially radioactive liquid wastes. The liquid radwaste system consists of one or more subsystems designed to handle specific types of liquid wastes such as water, chemical solutions from the demineralizer resin regeneration process, and evaporator distillate.

Solid Radwaste System--The solid radwaste system collects, processes, packages, and temporarily stores, prior to off-site shipping, such wastes as spent resins, evaporator concentrates, and chemical drain tank effluents. Liquid-bearing wastes are dewatered and solidified. Contaminated solids such as filters, rags, paper, clothing, and tools are compacted.

Reactor Coolant Systems*

Reactor coolant systems transfer heat from the reactor core to the steam generators. They are closed piping systems consisting of two, three, or four parallel loops. Any instruments that provide a signal to the reactor protection system are considered part of the reactor protection systems.

Boron Thermal Regeneration System--The boron thermal regeneration system is designed to allow treatment of all or part of the reactor coolant system letdown flow when boron concentration changes are desired for load following. Storage and release of boron during load-following operation is determined by the temperature of the fluid entering the thermal regeneration demineralizers. A chiller unit and a group of heat exchangers are employed to provide the desired fluid temperatures at the demineralizer inlets.

Chemical and Volume Control System*--The functions of the chemical and volume control system are to:

- o Adjust the concentration of chemical neutron absorber (boric acid) in the reactor coolant for chemical reactivity control.
- o Maintain the proper water inventory in the reactor coolant system.

- o Provide seal water flow for the reactor coolant pump shaft seals.

- o Maintain the proper concentration of corrosion-inhibiting chemicals in the reactor coolant.

- o Reduce the quantity of fission and corrosion products and maintain the reactor coolant chemistry to within design limits.

- o Provide cooling to limit fuel cladding temperature in the event of a small break and during LOCAs that do not result in rapid depressurization of the reactor vessel.

Refueling Systems

Refueling systems provide a safe and effective means for transporting and handling fuel from the time it reaches the plant until it leaves the plant. The refueling systems include the fuel handling and spent fuel pit cooling systems.

Fuel Handling System--The fuel handling system consists of the mechanical and electrical components required to manipulate nuclear fuel through the various movements and operations undergone while in the reactor building. Reactor vessel servicing equipment is provided to support fuel handling as well as the nonroutine removal of reactor vessel equipment.

Spent Fuel Pit Cooling System--The spent fuel pit cooling system consists of two cooling trains, a purification loop, and a skimmer loop. It removes decay heat from the spent fuel pit water, provides adequate purification to permit unrestricted access to the spent fuel storage area, and maintains optical clarity of the spent fuel pit water.

Turbine Systems

Turbine systems convert the thermodynamic energy of the steam to drive the main generator for the production of electricity. Turbine systems include the turbines, extraction steam system, turbine lube oil system, and turbine seal steam system.

Extraction Steam System--The extraction steam system provides heating steam to such components as feedwater heaters for condensate and feedwater heating, seal steam evaporators, and radwaste steam generators. The extraction steam system takes steam from the high-pressure turbine and low-pressure turbine extraction points and from the moisture separators.

Turbine Lube Oil System--The turbine lube oil system continuously supplies cool, clean lubricating oil to the turbine-generator and exciter bearings. The turbine lube oil system comprises lube oil reservoirs, lube oil pumps and coolers, and associated strainers, piping, and instrumentation.

Turbine Seal Steam System--The turbine seal steam system prevents the entrance of air and noncondensible gases into the main condenser and prevents the leakage of radioactive steam to the atmosphere. Clean sealing steam is supplied to the turbine shaft glands and valve stems. Condensed.sealing steam is returned to the main condenser.

Water Systems

Water systems provide the needed cooling and makeup throughout the plant for safe and efficient operation of water-cooled components. The water systems include the circulating water, component cooling water, essential raw cooling water, and nuclear service water systems.

Circulating Water System--The circulating water system is a closed-loop system that removes the excess heat from the turbine exhaust steam and turbine bypass steam by continuously supplying cooling water from the cooling tower basin to the main condenser and returning the heat water to the cooling tower for cooling.

Component Cooling Water System*--The component cooling water system is a closed system that supplies cooling water to various plant components during normal operations, removes residual heat from the reactor coolant system during the second phase of plant cooldown, and supplies coolant to safeguard equipment loads during and after an accident.

Essential Raw Cooling Water--The essential raw cooling water system is designed to supply cooling water directly from the main river channel (lake) to various primary and secondary systems and components necessary for plant safety during normal and accident conditions.

Nuclear Service Water System*--The nuclear service water system acts as the final heat sink for waste heat loads. Typically, it uses the same water and sink as the turbine condenser (river, lake, etc.). It supplies cooling water to equipment essential to the safe shutdown of the reactor under both normal and emergency conditions.

Level 1--Combustion Engineering Systems[a]

Air Systems

Air systems provide the proper type and pressure of air to operate necessary instrumentation and equipment in the plant. The air systems include the instrument air and service air systems.

---

a. An asterisk indicates that this definition of a Combustion Engineering system is based on the NPRDS (Ref. 23).

Instrument Air System--The instrument air system provides a continuous supply of clean, dry, oil-free compressed air for use by plant instrumentation, various air-operated valves, and control devices.

Service Air System--The service air system provides a continuous supply of compressed air, without drying or filtration, for such functions as backwashing, mixing, and agitation, as well as general plant use. Some plants utilize service air as a backup to instrument air.

Annunciator Systems

Annunciator systems are hardwired systems that provide the operator with the audio and visual alarm information required for unit operation, startup, and shutdown. These systems are independent of the plant computer system and include the controls necessary to acknowledge, silence, and reset alarms.

Communication Systems

Communication systems provide reliable and convenient communications among on-site personnel and between on-site and off-site locations. These systems include an intraplant public address system, a private telephone system to permit plant-to-off-site communication on a continuous basis, and a two-way radio communication system.

Compressed Gas Systems

Compressed gas systems store and distribute as required the necessary gases used to operate and maintain the plant. Typical gases are hydrogen, oxygen, CO_2, argon, and acetylene.

Condensate Systems.

Condensate systems provide continuous condensate flow from the condenser hotwells to the main feedwater pumps, which in turn provide feedwater to the steam generators at the required pressures and temperatures under all anticipated steady-state and transient conditions. Condensate systems consist of parallel, interconnected trains. These take condensate from the condenser hotwells and discharge it into the low-pressure feedwater heaters, which in turn supply the feedwater pumps.

The demineralizers and their inlet, outlet, relief valves, and valve operators are considered part of the demineralizer beds. The remainder of the items associated with demineralizer beds (pumps, blowers, etc.) are considered piece parts of the demineralizers.

Condensate Storage System--The condensate storage system provides the primary supply of water for the maintenance of condenser water level in the condenser hotwell, the control rod drive system, and the reactor core isolation cooling system. It also supplies makeup for other plant systems as required.

Containment Systems

Containment systems serve as a pressure boundary and shielding for the reactor in the event there is release of radioactivity from the reactor. The containment systems include the containment/reactor building penetration system, containment cooling system, combustible gas control system, containment isolation system, containment spray system, and containment ventilation system.

Containment/Reactor Building Penetration System*--The containment/reactor building penetration system comprises all primary containment penetrations and all accesses. All penetrations are considered part of this system. Equipment and personnel access hatches and fuel transfer tubes are components of the system. All associated instruments, monitors, etc., are considered piece parts of the access penetration. The system includes maintenance hatches and all electrical, mechanical, piping, and instrumentation penetrations.

Containment Cooling System*--The containment cooling system removes sufficient heat energy from the containment atmosphere following a LOCA or a main steam line break in order to maintain the containment atmospheric pressure below design pressure. The containment cooling system typically consists of cooling units with a vane axial type fan and two sets of cooling coils. There are several variations to the design of this system.

Combustible Gas Control System--The combustible gas control system is one of two types: the dilution type or the hydrogen recombiner type. The dilution system maintains the hydrogen concentration in the containment at an acceptable level by introduction of atmospheric air. The hydrogen recombiner system maintains the hydrogen concentration below 4% by volume in the containment following a design-basis LOCA without reliance on purging and without release of radioactive material to the environment. The system basically consists of a skid-mounted thermal recombiner unit with associated valves, piping, instrumentation, and controls. Designs will vary.

Containment Isolation System*--The containment isolation system provides a double barrier to the escape of radioactive material at each fluid penetration through the containment liner plate. This system consists of any isolation valves (both inside and outside containment) not already included in other systems. Examples of valves in this system are isolation valves in the waste systems and check isolation valves in the nitrogen system.

Containment Spray System*--The containment spray system reduces the pressure and temperature within the containment building following a LOCA and maintains them at acceptable levels. The containment spray system has two independent loops, each consisting of a containment spray pump and a heat exchanger. During the injection phase, the pumps take suction from the refueling water tank. During the recirculation phase, the pumps take suction from the containment recirculation sump. If the heat exchangers are shared with the shutdown cooling system, they are considered part of the shutdown cooling system.

Containment Ventilation System--The containment ventilation system comprises several subsystems, each of which has separate design objectives. The systems are designed around objectives relating to normal operation, personnel access, containment protection, and accident conditions.

The containment air cooling subsystem is designed to maintain an acceptable temperature within the containment upper and lower compartments, reactor well, control rod drive mechanism shroud, and instrument room for the protection of equipment and controls during normal reactor operation and normal shutdown.

The containment purge subsystem is designed to maintain the environment in the primary and secondary containment within acceptable limits for equipment operation and for personnel access, and to limit release of radioactivity to the environment.

The vacuum relief subsystem protects the containment vessel from an excessive external force.

The air return fan subsystem enhances the ice condenser and containment spray heat removal operation by circulating air from the upper compartment to the lower compartment, through the ice condenser, and back to the upper compartment. This subsystem limits the hydrogen concentration in potentially stagnant regions by ensuring a flow of air from these regions.

Control Element Assembly Systems*

Control element assembly systems control the reactivity of the reactor core and consist of the redundant reactor regulating system, the control element drive system, the control element assemblies, and their control element drive mechanisms. There are typically 12 groups of control element assemblies, divided as follows:

- Shutdown - two groups
- Regulating - eight groups
- Part-length - two groups

The control rod drive mechanisms are magnetic-operation drives. Each control element drive mechanism is capable of withdrawing, inserting, holding, or tripping the control element assembly; however, components in these systems used only for reactor regulation are not considered part of the system. The control signal is provided by the control element drive system. Electrical power to the control element drive mechanism is provided by two motor-generator sets through the reactor protection system trip breakers.

Electrical Distribution Systems

Electrical distribution systems provide a means of receiving off-site power and a means of transmitting site generated power. These systems supply power to those auxiliaries needed for power generation by the plant. The electrical distribution systems include the ac instrument power, dc power, and plant ac power systems.

ac Instrument Power System*--The ac instrument power system provides an uninterruptible source of power for instruments and control circuits under all plant conditions. Any load circuit breakers that may supply several loads are considered part of the AC instrument power system.

dc Power Systems--The DC power system supplies electric power to both safety- and non-safety-related dc loads under any plant condition. The dc power can be supplied by either a battery or battery charger. Any dc circuit breakers that may supply several loads, such as several solenoid valve controls or control power for ac switchgear, are considered part of the dc power system.

Plant ac Power System*--The plant ac power system provides electric power to both safety- and nonsafety-related loads during normal plant operations. Electric power is supplied at various voltage levels that are connected in a hierarchical fashion.

Emergency Core Cooling Systems

Emergency core cooling systems are designed to mitigate the consequences of postulated emergency situations that could otherwise lead to core damage and release of fission products to the environment. The emergency core cooling systems include the high-pressure safety injection and the low-pressure safety injection/shutdown cooling systems.

High-Pressure Safety Injection System*--The high-pressure safety injection system must function to supply core cooling during a LOCA. The safety injection system is treated as an integrated system consisting of three complementary systems: high-pressure safety injection, low-pressure safety injection, and safety injection tanks.

The high-pressure system is capable of delivering emergency coolant at discharge pressures of up to 1205 psig. Two high-pressure injection pumps take suction from two independent suction headers. These headers are initially supplied with borated water from the refueling water tank and after exhaustion are supplied from the recirculation sump of the containment. If the high-pressure safety injection pumps are shared with the chemical and volume control system, these pumps and associated valves and piping are considered part of the high-pressure safety injection system.

Low-Pressure Safety Injection/Shutdown Cooling System*--The low-pressure safety injection/shutdown cooling system is actually two systems that share common piping. The shutdown cooling portion is used to provide core cooling during cold shutdown. Piping connections draw from the reactor coolant system piping and return to four inlet nozzles on the reactor coolant system cold legs. The low-pressure injection portion operates during accident conditions. It has two modes of operation. The first mode is the injection mode. During this mode, borated water is drawn from the refueling water tank (RWT) and injected into the reactor coolant system piping through the inlet nozzles. When the water level on the RWT falls to a predetermined level, low-pressure injection suction is transferred to the emergency sump inside the reactor building. This mode of operation is called the recirculation mode.

Emergency Power Systems*

Emergency power systems supply electric power to vital safety-related loads during abnormal plant conditions such as plant blackouts or LOCAs. Emergency power systems are typically a diesel generator-powered system with two to four diesel generator units. The diesel start, load-shedding, generator breaker closing, and sequencing control circuits are considered a part of the emergency power system. Some units may use gas or hydroelectric turbines to supply emergency power.

Diesel Generator Cooling Water System*--The diesel generator cooling water system provides adequate water flow to remove heat from the diesel engine during operation. A jacket heating loop is also provided to prevent thermal shock when the diesel is started.

Diesel Generator Fuel Oil Storage and Transfer System*--The diesel generator fuel oil storage and transfer system supplies fuel to run the diesel engine and stores enough fuel for several days' continuous operation. Fuel supplied from the day tank may be either pumped or gravity fed to the diesel.

Diesel Generator Lube Oil System*--The diesel generator lube oil system provides oil to lubricate the moving part of the diesel engines. Adequate lube oil pressure is usually a permissive signal in the diesel generator starting circuit. During diesel operation, the lube oil is normally circulated by engine-driven oil pumps that are considered piece parts of the diesel engine. Prior to the diesel start, a motor-driven oil pump supplies oil pressure.

Diesel Generator Starting Air System*--The diesel generator starting air system provides compressed air to assist in the rapid starting of the diesel engines.

Feedwater Systems

Feedwater systems provide a continuous supply of preheated water to the steam generators through all power operation modes of the plant.

Auxiliary/Emergency Feedwater System*--The auxiliary/emergency feedwater system is designed to provide steam generator makeup for the removal of decay heat from the reactor coolant system during both normal and emergency cooldowns. The auxiliary emergency feedwater system consists primarily of the following: emergency feedwater pumps, valves, and instrumentation.

Main Feedwater System*--The main feedwater system provides feedwater to the steam generators at the required pressures and temperatures under all anticipated steady-state and transient conditions.

Fire Protection Systems

Fire protection systems furnish water or fire extinguishing chemicals to areas throughout the station to minimize the adverse effects of fire on station structures, equipment, and personnel.

Generator Systems

Generator systems convert the rotating mechanical energy of the turbines into electrical energy. Generator systems include the generator, generator excitation system, generator H_2 cooling/CO_2 purge system, generator seal oil system, and generator stator water cooling system.

Generator Excitation System--The generator excitation system provides a regulated, controllable source of magnetizing power to the rotating generator field winding. This winding controls generator output voltage. The generator excitation system consists of the alternator exciter, exciter field breaker and rectifier, voltage regulators, and all associated controls and instrumentation.

Generator H_2 Cooling/CO_2 Purge System--The generator H_2 cooling/CO_2 purge system keeps the generator adequately cool by maintaining proper generator hydrogen pressure, temperature, and purity. The system consists of hydrogen coolers storage cylinders, regulating valves, a hydrogen control panel, and associated piping and instruments. The carbon dioxide supply used to purge the generator comes from a CO_2 storage tank. The generator gas monitoring subsystem is included in this system.

Generator Seal Oil System--The generator seal oil system contains the hydrogen within the generator casing, preventing leakage of hydrogen out of the generator and leakage of air into the generator. This system supplies seal oil under pressure to the generator hydrogen shaft seals. This system consists of various seal oil pumps, a vacuum tank, oil filters, pressure regulators, and associated instruments. Seal oil is supplied by the turbine lube oil system.

Generator Stator Water Cooling System--The generator stator water cooling system cools the generator stator bars, the generator terminal box in the lower frame extension, and the exciter rectifiers. This is a closed system that consists of cooling pumps, water coolers, deionizer and filter regulating valves, and assorted piping and instruments.

Heating, Ventilation, and Air Conditioning (HVAC) Systems

HVAC systems provide an environment with controlled temperatures, humidities, and air flow patterns to maintain an atmosphere that ensures the comfort and safety of personnel and the operability of equipment located in the containment, drywell, and other small areas.

Penetration Room Ventilation Systems--The penetration room ventilation system consists of fans, filter trains, and duct work. The system minimizes environmental activity levels by collecting and processing post-LOCA containment leakage.

Instrumentation and Control Systems

Instrumentation and control systems provide timely operation of equipment needed for proper plant operation and the necessary indication of plant parameters and equipment conditions.

Control Element Assembly Position Monitoring System--Control element assembly position monitoring is provided by two diverse and independent indication systems. One system consists of reed switch assemblies attached to the control element drive mechanisms. The reed switches are operated by a magnet providing a signal proportional to position for display. The second system uses the plant computer to count raise-lower pulses to the control element drive mechanism power programmers. Position is displayed for group or individual control element assemblies.

Electrohydraulic Control (Turbine Control) System--The electrohydraulic control system controls the speed and acceleration of the main turbine and turbine load by controlling steam flow to the turbine.

Engineered Safety Features Actuation System*--The engineered safety features actuation system (ESFAS) consists of the sensors, logic, and actuation circuits that monitor selected plant parameters. It also provides an actuation signal to each actuated component in the engineered safety features (ESF) system if the selected plant parameters reach predetermined setpoints. There is one actuation system for each of the ESF systems.

The ESFAS includes the sensors that monitor selected plant variables. When the monitored variables reach levels indicative of conditions that require protective action, the ESFAS generates the following signals: containment isolation actuation; containment spray actuation; main steam isolation; safety injection actuation; recirculation actuation; and emergency feedwater actuation. This system includes the elements in the signal path from sensors or from the output of the reactor protection system isolation amplifiers through the ESFAS signal processors, logic circuits, relay circuits, and output controller circuits that are directly involved in ESFAS functions. Outputs from the ESFAS that are used to trip the reactor are part of the reactor protection system. The control circuitry for the components provides the sequencing necessary to provide proper ESF system operation.

Ex-core Nuclear Instrumentation System--The ex-core nuclear instrumentation system protects the reactor by monitoring the neutron flux and generating appropriate trips and alarm signals for various phases of reactor operating and shutdown conditions. The ex-core nuclear instrumentation system consists of eight independent channels: two startup channels, two control channels, and four safety channels. This system also provides readout and audio count information and rate of change of power information.

In-core Instrumentation System--The in-core instrumentation system provides information on the neutron flux distribution and fuel assembly outlet temperatures at selected core locations. The system consists of thermocouples, in-core flux thimbles to permit insertion of movable fission detectors, detector drive units and associated components, gas purge and leak detection components, and control and readout equipment.

Leak Detection System--The leak detection system detects and annunciates the escape of potentially radioactive material from the reactor coolant pressure boundary. In addition, the leak detection system is capable of determining the rate of leakage and initiating action to isolate systems that are leaking at a substantial rate in order to protect the nuclear fuel from damage that may be caused by the loss of coolant.

Pressurizer Level Control System--The pressurizer level control system maintains pressurizer level during expansion and contraction of the reactor coolant volume due to temperature changes. Reactor coolant average temperature is used to develop a programmed level setpoint, generated in the reactor regulating system. Water inventory is maintained by controlling the balance between water leaving the system, via the letdown flow to the chemical and volume control system, and water entering the system from the charging pumps.

Pressurizer Pressure Control System--The pressurizer pressure control system controls the pressure of the reactor coolant system at or near a fixed setpoint during both steady-state and design transient conditions. The system consists of a combination of heater banks, spray valves, and relief valves actuated at the proper times by a pressure controller with proportional, rate, and reset adjustments. The system components operate at various fixed pressure deviation points from the controller setpoint.

Process Monitoring System--The process monitoring system monitors the radiation levels in selected liquid and gaseous process streams in order to provide the required readouts and records of these levels. When radiation levels exceed predetermined setpoints, alarms and isolation signals are activated to control the release of radioactivity to the environment.

Radiation Monitoring System--The radiation monitoring system indicates, alarms, and records abnormal radiation levels in areas where radioactive material may be present, stored, handled, or inadvertently introduced.

Reactor Protection System*--The reactor protection system consists of sensors, calculators, logic, and other equipment necessary to monitor selected nuclear steam supply system conditions and to effect rapid reactor shutdown (reactor trip) if any one or a combination of the monitored conditions approaches specified safety system settings. Four measurement channels with electrical and physical separation are provided for each parameter used in the direct generation of trip signals, with the exception of control element assembly position. A coincidence of two like trip signals is required to generate a reactor trip signal. The fourth channel is provided as a spare and allows bypassing of one channel while maintaining a two-out-of-three system. The reactor trip signal deenergizes the control element drive mechanism coils, allowing all control element assemblies to drop into the core.

The elements in the signal path from the sensor through signal processor circuits, logic circuits, relay circuits, and output controller circuits that are part of the reactor protection functions are included in the reactor protection system. Any output from an isolation amplifier or isolation circuit that feeds the engineered safety features actuation system is part of that system.

Reactor Regulator System--The reactor regulator system automatically controls reactor temperature, and thus secondary pressure, by positioning regulating control element assemblies. This system keeps average coolant temperature within a programmed band to maintain design steam conditions. This system also operates in conjunction with the steam bypass control system and the pressurizer level control system. The reactor regulator system consists of the electronic circuitry, switches, indicators, and alarm devices necessary for the manipulation of control element assemblies.

Remote Shutdown System--The remote shutdown system provides a reactor plant shutdown capability located outside the control room for situations when the control room may have to be evacuated. The remote shutdown system provides all the controls and indication necessary to shut down the reactor as well as to provide subsequent reactor plant stabilization and cooldown.

Steam Bypass Control System--The steam bypass control system reduces the magnitude of nuclear system transients following a large turbine load reduction or reactor trip by dumping throttle steam directly to the main condenser, thereby creating an artificial load on the reactor and preventing the lifting of steam generator safety valves. The system comprises several banks of valves, located downstream of the main steam stop valves, and all associated circuitry and controls.

Steam Generator Water Level Control System--The steam generator water level control system provides each steam generator with a three-element feedwater controller (feedwater flow, steam flow, and water level) that maintains a programmed water level on the secondary side of the steam generator during normal plant operation. This controller continuously compares measured feedwater flow with steam flow and a compensated steam generator downcomer water level signal with a water level setpoint to regulate the main feedwater valve position.

Main Steam Systems*

Main steam systems consist of: main steam isolation valves, main steam safety valves, power-operated atmospheric dump valves, condenser dump valves, and associated piping. Main steam systems deliver steam from the steam generators to the turbine-generator, dissipate heat from the nuclear steam supply system when the turbine-generator is not available, and provide steam for various auxiliary systems.

Process Sampling Systems

The process sampling systems monitor the operation of plant equipment and provide information needed to make operational decisions. These systems provide remote sampling facilities and the capability for sampling fluids of various process systems during normal plant power operation and shutdown conditions.

Radwaste Systems

Radwaste systems collect, process, monitor, store, and dispose of all radioactive wastes. The radwaste systems include the gaseous radwaste, liquid radwaste, and solid radwaste systems.

Gaseous Radwaste System--The gaseous radwaste system processes and controls the release of gaseous radioactive wastes to the site environs. The gaseous radwaste system typically consists of waste gas compressor packages, gas decay tanks, and associated piping, valves, and instrumentation.

Liquid Radwaste System--The liquid radwaste system collects, processes, stores, and monitors, for reuse or disposal, all potentially radioactive liquid wastes. The liquid radwaste system consists of one or more subsystems desired to handle specific types of liquid wastes, such as water, chemical solutions from the demineralizer resin regeneration process, and evaporator distillate.

Solid Radwaste System--The solid radwaste system collects, processes, packages, and temporarily stores, prior to off-site shipping, such wastes as spent resins, evaporator concentrates, and chemical drain tank effluents. Liquid-bearing wastes are dewatered and solidified. Contaminated solids such as filters, rags, paper, clothing, and tools are compacted.

Reactor Coolant Systems*

Reactor coolant systems remove heat from the reactor core and internals and transfer it to the secondary (steam) system. These systems consist of two loops connected to the reactor vessel. Each loop contains one steam generator, two reactor coolant pumps, and connecting piping. Coolant system pressure is maintained by a pressurizer connected to one of the loops. All temperature, pressure, and flow transducers that provide signals to the reactor protection system are considered part of the reactor protection systems.

Chemical and Volume Control System*--The functions of the chemical and volume control system are to:

- o Maintain the chemistry and purity of the reactor coolant;
- o Maintain the required volume of water in the reactor;
- o Provide a controlled path for water discharge;
- o Control boron concentration;
- o Provide auxiliary spray;
- o Inject boric acid into the reactor coolant system upon a safety injection actuation signal; and
- o Control reactor coolant pump seal injection flow.

The system consists of charging pumps, heat exchangers, purification subsystem, boric acid makeup capability, volume control tank, chemical addition subsystem, and a process radiation system. If the high-pressure safety injection pumps are shared with the chemical and volume control system, these pumps and directly associated valves and piping are considered part of the high-pressure safety injection system.

Refueling Systems

Refueling systems provide a safe and effective means for transporting and handling fuel from the time it reaches the plant until it leaves the plant. The refueling systems include the fuel handling and spent fuel pool cooling and purification systems.

Fuel Handling System--The fuel handling system consists of the mechanical and electrical components required to manipulate nuclear fuel through the various movements and operations undergone while in the reactor building. Reactor vessel servicing equipment is provided to support fuel handling as well as the nonroutine removal of reactor vessel equipment.

Spent Fuel Pool Cooling and Purification System--The spent fuel pool cooling and purification system removes the decay heat from spent fuel stored in the spent fuel pool. It also maintains the clarity and purity of the water in the spent fuel pool, fuel transfer canal, refueling water pool, and refueling water tank.

Turbine Systems

Turbine systems convert the thermodynamic energy of the steam to drive the main generator for the production of electricity. Turbine systems include the turbines, extraction steam system, turbine lube oil system, and turbine seal steam system.

Extraction Steam System--The extraction steam system provides heating steam to such components as feedwater heaters for condensate and feedwater heating, seal steam evaporators, and radwaste steam generators. The extraction steam system takes steam from the high-pressure turbine and low-pressure turbine extraction points and from the moisture separators.

Turbine Lube Oil System--The turbine lube oil system continuously supplies cool, clean, lubricating oil to the turbine-generator and exciter bearings. The turbine lube oil system comprises lube oil reservoirs, lube oil pumps and coolers, and associated strainers, piping, and instrumentation.

Turbine Seal Steam System--The turbine seal steam system prevents the entrance of air and noncondensible gases into the main condenser and the leakage of radioactive steam to the atmosphere. Clean sealing steam is supplied to the turbine shaft glands and valve stems. Condensed sealing steam is returned to the main condenser.

Water Systems

Water systems provide the needed cooling and makeup throughout the plant for safe and efficient operation of water-cooled components. The water systems include the circulating water, component cooling water, and nuclear service water systems.

Circulating Water System--The circulating water system is a closed-loop system that removes the excess heat from the turbine exhaust steam and turbine bypass steam by continuously supplying cooling water from the cooling tower basin to the main condenser and returning the heated water to the cooling tower for cooling.

Component Cooling Water System--The component cooling water system is a closed system that removes waste heat from essential and nonessential equipment during normal plant operation. The component cooling water system provides a barrier between equipment containing potentially radioactive fluid and the nuclear service water system.

Nuclear Service Water System*--The nuclear service water system acts as the final heat sink for waste heat loads. The heat loads are usually transferred from the point of heat generation to the nuclear service water system by a closed loop (via heat exchangers and air handling units). The nuclear service water system typically uses the same water and heat sink as the turbine condenser (river, lake, ocean, etc.).

Level 1 Definitions--Babcock & Wilcox Systems[a]

Air Systems

Air systems provide the proper type and pressure of air to operate necessary instrumentation and equipment in the plant. The air systems include the instrument air and service air systems.

Instrument Air System--The instrument air system provides a continuous supply of clean, dry, oil-free compressed air for use by plant instrumentation, various air-operated valves, and control devices.

Service Air System--The service air system provides a continuous supply of compressed air, without drying or filtration, for such functions as backwashing, mixing, and agitation as well as general plant use. Some plants utilize service air as a backup to instrument air.

Annunciator Systems

Annunciator systems are hardwired systems that provide the operator with the audio and visual alarm information required for unit operation, startup, and shutdown. These systems are independent of the plant computer system and include the controls necessary to acknowledge, silence, and reset alarms.

Communication Systems

Communication systems provide reliable and convenient communications among on-site personnel and between on-site and off-site locations. These systems include an intraplant public address system, a private telephone system to permit plant-to-off-site communication on a continuous basis, and a two-way radio communication system.

Compressed Gas Systems

Compressed gas systems store and distribute as required the necessary gases used to operate and maintain the plant. Typical gases are hydrogen, oxygen, CO_2, argon, and acetylene.

---

a. An asterisk indicates that this definition of a Babcock & Wilcox system is based on the NPRDS.

Condensate Systems*

Condensate systems collect water from the hotwell in the condenser, use it to cool other loads, purify it, and then raise its pressure before discharging it to the feedwater system. There are many configurations of condensate systems. The number and type of cooling loads may vary greatly. The particular configurations and numbers of demineralizers, pumps, and heaters also may vary considerably.

Condensate Demineralizer System--The condensate demineralizer system maintains the required purity of the condensate and feedwater by using precoat filters and demineralizers.

Containment Systems

Containment systems serve as a pressure boundary and shielding for the reactor in the event there is release of radioactivity from the reactor. The containment systems include the combustible gas control, containment/reactor building penetration, containment isolation, containment ventilation, reactor building cooling, and reactor building spray systems.

Combustible Gas Control System*--The combustible gas control system is of two types: the dilution type and the hydrogen recombiner type. The dilution system maintains the hydrogen concentration in containment at an acceptable level by introduction of atmospheric air. The hydrogen recombiner system maintains the hydrogen concentration below 4% by volume in the containment (during a LOCA) without reliance on purging. The system basically consists of a skid-mounted thermal recombiner unit with associated valves, piping, instrumentation, and controls.

Containment/Reactor Building Penetration System*--The containment/reactor building penetration system is made up of all the penetrations of the reactor building pressure boundary. All penetrations are considered part of this system, regardless of size. One penetration can have several pipes passing through it.

Equipment and personnel access hatches and fuel transfer tubes are components of the system. All associated instruments, monitors, etc., are considered piece parts of the access or penetration. The system includes maintenance hatches and all electrical, mechanical, piping, and instrumentation penetrations.

Containment Isolation System*--The containment isolation system consists of those valves that have not been included in one of the other systems and are used to isolate the reactor building in the event of an accident. The valves may be active (motor-operated) or passive (check valves or manually closed valves). The operation of the motor-operated valves is initiated by the safety features actuation system. Isolation valves in the liquid and gaseous waste systems are examples of valves considered part of this system.

Containment Ventilation System--The containment ventilation system comprises several subsystems, each of which has separate design objectives. The systems are designed around objectives relating to normal operation, personnel access, containment protection, and accident conditions.

The containment air cooling subsystem is designed to maintain an acceptable temperature within the containment upper and lower compartments, reactor well, control rod drive mechanism shroud, and instrument room for the protection of equipment and controls during normal reactor operation and normal shutdown.

The containment purge subsystem is designed to maintain the environment in the primary and secondary containment within acceptable limits for equipment operation and for personnel access, and to limit the release of radioactivity to the environment.

The vacuum relief subsystem protects the containment vessel from an excessive external force.

The air return fan subsystem enhances the ice condenser and containment spray heat removal operation by circulating air from the upper compartment to the lower compartment, through the ice condenser, and back to the upper compartment. This subsystem limits the hydrogen concentration in potentially stagnant regions by ensuring a flow of air from these regions.

Reactor Building Cooling System*--The reactor building cooling system reduces pressure inside the reactor building by cooling and condensing the steam created by an accident. During normal operation, the system can be used to cool the reactor building atmosphere, thus making the working environment more comfortable. The emergency operation of the reactor building cooling system is actuated by the safety features actuation system.

Reactor Building Spray System*--The reactor building spray system reduces pressure inside the reactor building by spraying water to condense steam that might be released in an accident. Chemicals are added to the spray to help reduce the iodine concentration of the containment air. This system is used only during an accident situation.

Control Rod Drive Systems*

Control rod drive systems control the reactivity of the reactor core. There are eight groupings of control rods. Groups 1-4 are safety rods and are used to scram the reactor, if necessary. Groups 5-8 are used for reactor regulation and power shaping. There are 69 control rods in control rod drive systems. Group 8 has eight control rods. The number of rods in all other groups will vary with core configuration. The average number is eight rods for groups 1-4 and eight to twelve rods for groups 5-7. Reactor trip breakers are considered part of control rod drive systems.

Electrical Distribution Systems

Electrical distribution systems provide a means of receiving off-site power and a means of transmitting site-generated power. These systems supply power to those auxiliaries needed for power generation by the plant. The electrical distribution systems include the ac instrument power, dc power, and plant ac power systems.

ac Instrument Power System*--The ac instrument power system provides an uninterruptible source of power for instruments and control circuits under all plant conditions. Any load circuit breakers that may supply several loads are considered part of the ac instrument power system. Circuit breakers that supply a single system are considered part of the system supplied.

dc Power System--The dc power system supplies electric power to both safety- and non-safety-related dc loads under any plant condition. The dc power can be supplied by either a battery or battery charger. Any dc circuit breakers that may supply several loads, such as several solenoid valve controls or control power for ac switchgear, are considered part of the dc power system. Those that supply a single component are considered part of the system that contains the component.

Plant ac Power System*--The plant ac power system provides electric power to both safety- and non-safety-related loads during normal plant operation. Electric power is supplied at various voltage levels in a hierarchical fashion.

Emergency Core Cooling Systems

Emergency core cooling systems are designed to mitigate the consequences of postulated emergency situations that would otherwise lead to core damage and release of fission products to the environment. The emergency core cooling systems include the decay heat removal/core flooding system, decay heat removal/low-pressure safety injection system, and high-pressure safety injection systems.

Decay Heat Removal/Core Flooding System*--The decay heat removal/core flooding system is a passive deluge system that maintains a sufficient water inventory to keep the reactor core covered during the period between high-pressure injection system actuation and low-pressure injection system actuation following a LOCA. The system injects borated water into the reactor vessel through the low-pressure injection inlet nozzles.

Decay Heat Removal/Low-Pressure Safety Injection System*--The decay heat removal/low-pressure injection system is actually two systems that share common piping. The decay heat removal portion is used to provide core cooling during cold shutdown. Piping connections draw from the reactor coolant system piping and return to two inlet nozzles on the reactor vessel. The low-pressure injection portion operates during accident conditions and has two modes of operation. The first mode is the injection mode. During this mode, borated water is drawn from the borated water storage tank and injected into the vessel through the inlet nozzles. When the water level on the borated water storage tank falls to a predetermined level, low-pressure injection suction is transferred to the emergency sump inside the reactor building. This mode of operation is called the recirculation mode.

High-Pressure Safety Injection System*--The high-pressure safety injection system injects high-pressure, borated, reactor-quality water into the reactor coolant system during small LOCAs to flood and cool the reactor core. This system consists of at least two redundant, full-capacity injection trains and associated valves, piping, and instrumentation. For those cases in which the high-pressure safety injection pump function is performed by the letdown, purification, and makeup charging pumps, the components common to both systems are considered part of the high-pressure injection system.

Emergency Power Systems*

Emergency power systems supply electric power to vital safety-related loads during abnormal plant conditions such as loss of off-site power or LOCAs. Emergency power systems are typically diesel generator-powered systems with two to four diesel generator units. The diesel start, load-shedding, generator breaker closing, and sequencing control circuits are considered part of emergency power systems.

Diesel Generator Cooling Water System*--The diesel generator cooling water system provides adequate water flow to remove heat from the diesel engine during operation. A jacket heating loop is also provided to prevent thermal shock when the diesel is started.

Diesel Generator Fuel Oil Storage and Transfer System*--The diesel generator fuel oil storage and transfer system supplies fuel to run the diesel engine and stores enough fuel for several days' continuous operation. Fuel supplied from the day tank may be either pumped or gravity fed to the diesel.

Diesel Generator Lube Oil System*--The diesel generator lube oil system provides oil to lubricate the moving parts of diesel engines, thus protecting them from excessive wear and overheating. Adequate lube oil pressure is usually a permissive signal in the diesel generator starting circuit. During diesel operation, the lube oil is normally circulated by engine-driven oil pumps that are considered piece parts of the diesel engine. Prior to the diesel start, a motor-driven oil pump supplies oil pressure.

Diesel Generator Starting Air System*--The diesel generator starting air system provides compressed air to assist in the rapid starting of the diesel engines.

Feedwater Systems

Feedwater systems provide a continuous supply of preheated water to the steam generators through all power operation modes of the plant.

Emergency Feedwater System*--The emergency feedwater system supplies cooling water to the steam generators in the event of any of several transient conditions in which main feedwater is lost. The emergency feedwater system usually draws from two to four water sources and uses both motor-driven and steam turbine-driven pumps. Steam lines leading to the pump turbines are considered part of the emergency feedwater system.

Main Feedwater System*--The main feedwater system supplies high-quality water to the shell side of the steam generators. Feedwater suction is taken from the condensate system. Feedwater pumps are typically turbine driven, although electric motors occasionally are used as drivers. The startup regulating valve is used until the unit reaches about 15% power.

Fire Protection Systems

Fire protection systems furnish water or fire-extinguishing chemicals to areas throughout the station to minimize the adverse effects of fire on station structures, equipment, and personnel.

Generator Systems

Generator systems convert the rotating mechanical energy of the turbines into electrical energy. Generator systems include the generator, generator excitation system, generator H_2 cooling/CO_2 purge system, generator seal oil system, and generator stator water cooling system.

Generator Excitation System--The generator excitation system provides a regulated, controllable source of magnetizing power to the rotating generator field winding, which controls generator output voltage. The generator excitation system consists of the alternator exciter, exciter field breaker and rectifier, voltage regulators, and all associated controls and instrumentation.

Generator H_2 Cooling/CO_2 Purge System--The generator H_2 cooling/CO_2 purge system keeps the generator adequately cool by maintaining proper generator hydrogen pressure, temperature, and purity. The system consists of hydrogen coolers, storage cylinders, regulatory valves, a hydrogen control panel, and associate piping and instruments. The carbon dioxide supply used to purge the generator comes from a CO_2 storage tank. The generator gas monitoring subsystem is included in this system.

Generator Seal Oil System--The generator seal oil system contains the hydrogen within the generator casing, preventing leakage of hydrogen out of the generator and leakage of air into the generator. This system supplies seal oil under pressure to the generator hydrogen shaft seals. This system consists of various seal oil pumps, a vacuum tank, oil filters, pressure regulators, and associated instruments. Seal oil is supplied by the turbine lube oil system.

Generator Stator Water Cooling System--The generator stator water cooling system cools the generator stator bars, the generator terminal box in the lower frame extension, and the exciter rectifier. This is a closed system that consists of cooling pumps, water coolers, deionizer and filter regulating valves, and assorted piping and instruments.

Heating, Ventilation, and Air Conditioning Systems

Heating, ventilation, and air conditioning systems provide an environment with controlled temperatures, humidities, and air flow patterns to maintain an atmosphere that ensures the comfort and safety of personnel and the operability of equipment located in the containment, drywell, and other small areas.

Penetration Room Ventilation System*--The penetration room ventilation system collects and filters any gases that may leak through containment penetrations during accident conditions. For this reason, the system is used to keep the penetration room at slightly negative pressure. The penetration room ventilation system is designed to be used only under accident conditions. This system also includes pressurization and penetration cooling components.

Instrumentation and Control Systems

Instrumentation and control systems provide timely operation of equipment needed for proper plant operation and the necessary indication of plant parameters and equipment conditions.

Electrohydraulic Control (Turbine Control) System --The electrohydraulic control (turbine control) system controls the speed and acceleration of the main turbine and turbine load by controlling steam flow to the turbine.

Ex-core Nuclear Instrumentation System--The ex-core nuclear instrumentation system protects the reactor by monitoring the neutron flux and generating appropriate trips and alarm signals for various phases of reactor operating and shutdown conditions. The ex-core nuclear instrumentation system consists of eight independent channels: two source range, two intermediate range, and four power range. In addition, there are four auxiliary channels: the audiovisual count rate channel, the comparator channel, the startup rate channel, and the flux deviation channel.

In-core Instrumentation System--The in-core instrumentation system provides information on the neutron flux distribution and fuel assembly outlet temperatures at selected core locations. The system consists of thermocouples, in-core flux thimbles to permit insertion of movable fission detectors, detector drive units and associated components, gas purge and leak detection components, and control and readout equipment.

Integrated Control System*--The integrated control system monitors various plant parameters and actuates equipment to keep unit demand, feedwater flow, and reactor power in the proper relationship. The integrated control system is made up of four subsystems: the unit load demand subsystem, the integrated master control subsystem, the feedwater control subsystem, and the reactor control subsystem. Under turbine trip conditions, the integrated control system controls steam generator water level to help establish conditions conducive to natural circulation.

Leak Detection System--The leak detection system detects and annunciates the escape of potentially radioactive material from the reactor coolant pressure boundary. In addition, the leak detection system is capable of determining the rate of leakage and initiating action to isolate systems that are leaking at a substantial rate in order to protect the nuclear fuel from damage that may be caused by the loss of coolant.

Main Steam System Steam Line Break Control System--The main steam system steam line break control system minimizes the release of steam to the containment following a breach of the main steam piping or the steam generator. This system performs its function by monitoring main steam line pressure and/or steam generator pressure. When these parameters reach predetermined setpoints, the logic circuitry automatically closes the main steam stop valves and isolates the feedwater supply to the steam generator. Some plants also monitor steam generator water level and feedwater system status to effect this function.

Pressurizer Level Control System--The pressurizer level control system maintains pressurizer level during expansion and contraction of the reactor coolant volume due to temperature changes. Reactor coolant average temperature is used to develop a programmed level setpoint, generated in the reactor regulating system. Water inventory is maintained by controlling the balance between water leaving the system, via the letdown flow to the chemical and volume control system, and water entering the system from the charging pumps.

Pressurizer Pressure Control System--The pressurizer pressure control system controls the pressure of the reactor coolant system at or near a fixed setpoint during both steady-state and design transient conditions. The system consists of a combination of heater banks, spray valves, and relief valves actuated at the proper times by a pressure controller with proportional, rate, and reset adjustments. The system components operate at various fixed pressure deviation points from the controller setpoint.

Process Monitoring System--The process monitoring system monitors the radiation levels in selected liquid and gaseous process steams in order to provide the required readouts and records of these levels. When radiation levels exceed predetermined setpoints, alarms and isolation signals are activated to control the release of radioactivity to the environment.

Radiation Monitoring System--The radiation monitoring system indicates, alarms, and records abnormal radiation levels in areas where radioactive material may be present, stored, handled, or inadvertently introduced.

Reactor Protection System*--The reactor protection system (RPS) monitors several plant parameters (core flux; reactor coolant flow, pressure, and temperature; reactor coolant pump operation; and reactor building pressure) and initiates a reactor shutdown if any of the parameters are out of limits. The RPS is made up of four electrically independent redundant channels. Two-out-of-four (2/4) coincident logic is required to initiate a reactor shutdown. A manual shutdown (trip) switch is also provided.

Any instrumentation that performs a safety or control function related to reactor coolant pump operation is considered part of the RPS. Reactor trip breakers are considered part of the rod drive system. Transmitters used in the engineered safeguards actuation and logic system or in control circuits are considered part of the RPS if they perform an RPS function.

Remote Shutdown System--The remote shutdown system provides a reactor plant shutdown capability located outside the control room for situations in which the control room may have to be evacuated. The remote shutdown system provides all the controls and indication necessary to shut down the reactor as well as to provide subsequent reactor plant stabilization and cooldown.

Rod Control System--The rod control system maintains a programmed average temperature in the reactor coolant system by regulating the reactivity in the core and shapes the axial flux profile of the core. The rod control system consists of the electronic circuitry, switches, indicators, and alarm devices necessary for the manipulation of the control rods.

Rod Position Indication System--The rod position indication system continuously senses and displays rod position information for each control rod. This system consists of two subsystems: the absolute position indication subsystem and the relative position indication subsystem. The absolute position indication subsystem consists of reed switch assemblies. The reed switches are operated by a magnet mechanically connected to the rod. The relative position indication subsystem utilizes a stepping motor to control the output of a potentiometer, which provides a voltage analogous to the control rod position.

Safety Features Actuation System*--The safety features actuation system senses plant parameters (e.g., reactor coolant pressure, both steam generator pressures, and reactor building pressure) to determine the need for engineered safety systems operation. Three analog subsystems monitor the parameters and feed into a 2/3 digital logic subsystem. When 2/3 of the analog subsystems indicate a parameter is above or below its threshold, the appropriate 2/3 digital subsystems are activated, which in turn activate one or more of the following:

- High-pressure injection
- Low-pressure injection
- Building spray
- Reactor building cooling and isolation
- Emergency power
- Main steam isolation valves
- Auxiliary feedwater

All components from the sensors through the logic to the operated device are considered part of the safety features actuation system. Steam generator level and auxiliary feedwater controls should be considered part of this system if they are not in the integrated control system. Any switches or instrumentation in auxiliary shutdown panels, from sensors to indicators, are considered control circuits in this system.

Steam Dump Control System--The steam dump control system reduces the magnitude of nuclear system transients following a large turbine load reduction or reactor trip by dumping throttle steam directly to the main condenser, thereby creating an artificial load on the reactor and preventing the lifting of steam generator safety valves. The system comprises several banks of valves located downstream of the main steam stop valves, and all associated circuitry and controls.

Process Sampling Systems

Process sampling systems monitor the operation of plant equipment and provide information needed to make operational decisions. These systems provide remote sampling facilities and the capability for sampling fluids of various process systems during normal plant power operation and shutdown conditions.

Radwaste Systems

Radwaste systems collect, process, monitor, store, and dispose of all radioactive wastes. The radwaste systems include the gaseous radwaste, liquid radwaste, and solid radwaste systems.

Gaseous Radwaste System--The gaseous radwaste system processes and controls the release of gaseous radioactive wastes to the site environs. The gaseous radwaste system typically consists of waste gas compressor packages, gas decay tanks, and the associated piping, valves, and instrumentation.

Liquid Radwaste System--The liquid radwaste system collects, processes, stores, and monitors, for reuse or disposal, all potentially radioactive liquid wastes. The liquid radwaste system consists of one or more subsystems designed to handle specific types of liquid wastes, such as water, chemical solutions from the demineralizer resin regeneration process, and evaporator distillate.

Solid Radwaste System--The solid radwaste system collects, processes, packages, and temporarily stores, prior to off-site shipping, such wastes as spent resins, evaporator concentrates, and chemical drain tank effluents. Liquid-bearing wastes are dewatered and solidified. Contaminated solids, such as filters, rags, paper, clothing, and tools, are compacted.

Reactor Coolant Systems*

Reactor coolant systems transport heat from the reactor core to the steam generators, where it produces the steam that drives the turbine generators. Reactor coolant systems also define the primary pressure boundary.

Boron Thermal Regeneration System--The boron thermal regeneration system is designed to allow treatment of all or part of the reactor coolant system letdown flow when boron concentration changes are desired for load following. Storage and release of boron during load-following operation is determined by the temperature of the fluid entering the thermal regeneration demineralizers. A chiller unit and a group of heat exchangers are employed to provide the desired fluid temperature at the demineralizer inlets.

Chemical and Volume Control System--The chemical and volume control system regulates reactor coolant chemistry for reactivity and corrosion control and maintains the water level in the pressurizer of the reactor coolant system.

Letdown, Purification, and Makeup System*--The letdown, purification, and makeup system performs the following major functions:

- Maintains the required water inventory in the reactor coolant system during normal operations through a feed-and-bleed process.
- Controls reactor coolant system water chemistry conditions through chemical addition, removal, and coolant purification.

- Provides for seal water injection flow and discharge from the reactor coolant pump seals.

- Interfaces with and, in some cases, provides common component support for the high-pressure safety injection system functions.

- Provides water for the pressurizer spray line.

If the charging pumps also supply the high-pressure injection system (no separate safety injection pumps), then the charging pumps and directly associated valves and piping are considered part of the high-pressure injection system.

Refueling Systems

Refueling systems provide a safe and effective means for transporting and handling fuel from the time it reaches the plant until it leaves the plant. The refueling systems are composed of the fuel handling and fuel pool cooling and cleanup systems.

Fuel Handling System--The fuel handling system consists of the mechanical and electrical components required to manipulate nuclear fuel through the various movements and operations undergone while in the reactor building. Reactor vessel servicing equipment is provided to support fuel handling as well as the nonroutine removal of reactor vessel equipment.

Spent Fuel Pool Cooling System--The spent fuel pool cooling system circulates spent fuel pool water to remove the decay heat from spent fuel stored in the pools. This system also purifies the spent fuel pool water, the fuel transfer canal water, and the borated water storage tank water. It maintains clarity for fuel handling operations and fills and drains the fuel transfer canal and cast loading pit.

Steam Systems

The steam systems are used to generate and/or transfer steam to the main turbine and other auxiliaries during various modes of plant operation.

Auxiliary Boiler/Steam System--The auxiliary boiler/steam system provides steam to various components within the plant. These components cannot use main steam because either non-radioactive steam is required by the component or the component operation is required when main steam is not available.

Main Steam System*--The main steam system transports the steam created in the steam generators to the main turbine. The boundary is up to, but not including, the turbine stop valve.

Turbine Systems

Turbine systems convert the thermodynamic energy of the steam to drive the main generator for the production of electricity. Turbine systems include the turbines, extraction steam system, turbine lube oil system, and turbine seal steam system.

Extraction Steam System--The extraction steam system provides heating steam to such components as feedwater heaters for condensate and feedwater heating, seal steam evaporators, and radwaste steam generators. The extraction steam system takes steam from the high-pressure turbine and low-pressure turbine extraction points and from the moisture separators.

Turbine Lube Oil System--The turbine lube oil system continuously supplies cool, clean lubricating oil to the turbine-generator and exciter bearings. The turbine lube oil system comprises lube oil reservoirs, lube oil pumps and coolers, and associated strainers, piping, and instrumentation.

Turbine Seal Steam System--The turbine seal steam system prevents the entrance of air and noncondensible gases into the main condenser and the leakage of radioactive steam to the atmosphere. Clean sealing steam is supplied to the turbine shaft glands and valve stems. Condensed sealing steam is returned to the main condenser.

Water Systems

Water systems provide the needed cooling and makeup throughout the plant for safe and efficient operation of water-cooled components. The water systems include the circulating water, component cooling water, and low-pressure service water systems.

Circulating Water System--The circulating water system is a closed-loop system that removes the excess heat from the turbine exhaust steam and turbine bypass steam by continuously supplying cooling water from the cooling tower basin to the main condenser and returning the heated water to the tower for cooling.

Component Cooling Water System*--The component cooling water system is an intermediate, closed-loop system that provides cooling for various loads inside the reactor building. Designs will vary.

Low-Pressure Service Water System*--The low-pressure service water system supplies raw cooling water to a number of loads in both the reactor and auxiliary buildings. Pump suction is normally taken from a service water pond or the condenser circulating water system and then returned to the same source after providing cooling to the loads. The number of loads and their piping configurations will vary with design.

Level 2 Definitions--Components[a]

Accumulators--devices in which pressurized fluid is stored and used later to drive an actuator, converting fluid pressure energy into mechanical energy.

Gas Accumulator--a device that stores potential energy by accumulating a quantity of pressurized gas in a suitable enclosed vessel. Pressurized liquid or gas acting against an actuator converts gas pressure energy into mechanical energy.

Liquid Accumulator--a device that stores potential energy by accumulating a quantity of pressurized liquid in a suitable enclosed vessel. Pressurized liquid or gas acting against an actuator converts liquid pressure energy into mechanical energy.

Air/Gas Dryers--devices that remove water or moisture from an air or gas system to ensure proper operation of supplied components.

Batteries--devices for producing an electromotive force (emf) by chemical means. When such a source of emf is connected to a closed electric circuit, chemical energy is transformed into electrical energy.

Battery Chargers--devices with sufficient capacity to restore a battery from its design minimum charge to its fully charged state while supplying normal and postaccident loads.

Circuit Closures/Interrupters--switching devices capable of making, carrying, and/or breaking current.

Circuit Breaker--a switching device designed to open a current-carrying circuit under abnormal conditions without injury to itself. It is adjusted to interrupt the current upon the occurrence of an overload of specified magnitude and must be capable of interrupting short-circuit currents.

Contactor--a device for repeatedly establishing and interrupting an electric power circuit.*

Disconnect--a manually operated device that provides positive isolation of associated circuit breakers.

---

a. Level 2 definitions marked with an asterisk (*) are taken from the IEEE Standard Dictionary of Electrical and Electronics Terms. Level 2 definitions marked with a double asterisk (**) are taken from the McGraw-Hill Dictionary of Scientific and Technical Terms.

Motor/Load Controller--a device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the motor or groups of motors to which it is connected.*

Switch--a device for making, breaking, or changing connections in an electric circuit under conditions of load for which it is rated. It is not designed for interruption of a circuit under short-circuit conditions.

Switchgear--a type of design in which all the equipment required to control an individual circuit, including bus, circuit breaker, disconnecting devices, current and voltage transformers, controls, instruments, and relays, is assembled in a single, compartmented structure with the circuit breaker provided with means for ready removal.

Computers--programmable electronic devices used to store, retrieve, process, and display data.

Control Instruments--components that monitor, display information about, and automatically control a process.

Flow Control Instrument--an instrument that controls flow rate.

Flux Control Instrument--an instrument used to control the neutron population or reactions in a nuclear reactor.

Level Control Instrument--an instrument that controls liquid levels.

Position Control Instrument - an instrument used to determine and control position (e.g., of valves or control rods).

Pressure Control Instrument--an instrument that controls the difference between atmospheric pressure and the pressure in a pipe or vessel.

RPM Control Instrument--instrument used to control the revolutions per minute of a rotating piece of machinery, such as a turbine.

Temperature Control Instrument--an instrument used to control temperature and temperature differences.

Voltage Control Instrument--an instrument used to control the voltage from a generator, both ac and dc.

Control Rods--rods used to control the reactivity of a nuclear reactor; may be a fuel rod or part of the moderator; in a thermal reactor, commonly a neutron absorber.**

Control Rod Drive Mechanisms--mechanisms normally located above or below the reactor vessel that serve to position a control rod assembly within the core.

Demineralizers--vessels containing anion and cation resin beads that are used to clarify impure water.

Eductors--ejectorlike devices for mixing two fluids.**

Jet Pump--a pump in which an accelerating jet entrains a second fluid to deliver it at elevated pressure.**

Steam Jet Air Ejector--a device like a jet pump that removes air and noncondensible gases from a condenser or low-pressure area.

Electrical Conductors--materials, usually in the form of wire, cable, or bus bar, suitable for carrying an electric current.*

Insulated Cable--a cable enclosed in a sheath or suitable jacket to prevent the infiltration of moisture and the loss of oil, gas, or impregnate, and to provide protection against corrosion and electrolysis.

Shielded Cable--a cable in which the insulated conductor or conductors are enclosed in a conducting envelope(s), so constructed that substantially every point on the surface of the insulation is at ground potential or at some predetermined potential with respect to ground.

Electrical Equipment--any component that amplifies, modulates, converts, changes the voltage of, or regulates electric current.

Amplifier--a component used to change the amplitude of an electric signal.

Converter--a machine or device for changing alternating-current power to direct-current power or vice versa, or from one frequency to another.*

Inverter--a machine, device, or system that provides an uninterruptible source of ac power by converting plant dc voltage into an ac source of power.*

Rectifier--a device for converting alternating current to direct current.*

Transformer--an apparatus for converting electric power in an ac system at one voltage and current into electric power at some other voltage and current without the use of rotating parts.

Voltage Regulator--a device used to adjust the voltage output from the generator for varying load conditions.

Electric Generators--machines that transform mechanical power into electric power.*

Alternator--a mechanical, electrical, or electromechanical device that supplies alternating current.**

Amplidyne--a rotating magnetic amplifier having special windings and brush connections so that small changes in power input to the field coils produce large changes in power output.**

Generator--turbine-driven device used to transform rotating mechanical energy into electric energy.

Electric Heaters--components that convert electric energy into sensible heat to maintain or increase the temperature of a system.

Equipment-Nonspecific--a component in use in commercial nuclear power plants that cannot be classified in any other category.

Fans/Ventilators--devices for producing and regulating currents to circulate, exhaust, or deliver large volumes of air or gas.**

Filters/Strainers--porous or screen mediums used to filter out harmful solid objects and particles from a fluid stream.**

Heat Exchangers--devices that transfer heat from one fluid to another or to the environment.**

Boiler--a water heater for generating steam.**

Condenser--a device used for one or more of the following functions: (a) to produce a vacuum of desired backpressure in a system by condensation of a vapor; (b) to condense a vapor for reuse in a closed cycle.

Cooler--a device within which a substance or process stream is cooled when its heat is transferred, via a temperature drop, to solid, liquid, or gaseous media that are naturally or artificially colder, their lower temperature stemming from radiative, sensible, or latent heat physical effects or endothermic chemical or thermoelectric effects.

Motors--machines that transform input power into mechanical power.**

Electric AC Motor--a machine that transforms alternating-current power into mechanical power.

Electric DC Motor--a machine that transforms direct-current power into mechanical power.

Hydraulic Motor--a motor activated by water or other liquid under pressure.**

Pneumatic Motor--a motor activated by air under pressure.

Pipes--tubes made of metal, plastic, or concrete used to conduct a fluid, gas, or finely divided solid.**

Elbow--a fitting that connects two pipes at an angle, often 90°.**

Nozzle--a tubelike device, usually streamlined, for accelerating and directing a fluid, the pressure of which decreases as it leaves the nozzle.**

Reducer/Orifice--device placed in a pipe arrangement to reduce flow or pressure.

Rupture Diaphragm--a device that relieves pressure in condensers or turbine casings by rupturing at preset pressures.

Tee--a fitting that connects pipes at right angles, forming a T.*.

Pumps--a machine that draws a fluid into itself through an entrance port and forces the fluid through an exhaust port.**

Centrifugal Pump--positive displacement machine in which the liquid is forced, by atmospheric or other pressure, into a set of rotating vanes that constitute an impeller discharging the liquid at a higher pressure and a higher velocity at its periphery. Velocity energy is converted to pressure energy by means of a volute or by a set of stationary diffuser vanes surrounding the impeller periphery.

Reciprocating Pump--positive displacement machine that, at constant speed, delivers essentially the same capacity at any pressure within the capability of the driver and the strength of the pump. This pump provides pulsating flow.

Rotary Pump--positive displacement machine consisting of a fixed casing containing gears, vanes, pistons, cams, screws, etc., operating with minimum clearance. Instead of "throwing" the liquid as in a centrifugal pump, a rotary pump traps it, pushing it around the closed casing much like the piston of a reciprocating pump but discharging a smooth flow.

Vacuum Pump--any pump operated to reduce the pressure of gas in a chamber. Vacuum pumps typically entrain air and noncondensible gas, compress the gas, and discharge it.

Recombiners--devices that reduce the hydrogen concentration in the containment atmosphere by combining free hydrogen and oxygen to form water.

Catalytic Recombiner--a device that reduces the hydrogen concentration in the containment atmosphere by combining free hydrogen and oxygen to form water and that uses a noble metal catalyst bed to promote recombination at relatively low temperatures.

Flame Recombiner--a device that reduces the hydrogen concentration in the containment atmosphere by combining free hydrogen and oxygen to form water and that depends on a self-maintaining, exothermic combustion process to initiate the recombination reaction.

Thermal Recombiner--a device that reduces the hydrogen concentration in the containment atmosphere by combining free hydrogen and oxygen to form water and that uses radiant heat to bring about recombination.

Sensors--devices that respond to a stimulus and transmit a signal for measurement, recording, or operating a control, etc.

Conductivity Sensor--a device used to measure the resistance of a fluid in microohm/cm.

Current Sensor--a device used to measure the current output from a generator or input into a motor.

Flow Sensor--a device that measures the flow rate of a fluid through a system or component.

Frequency Sensor--a device used to measure the frequency output from a generator or input into a component or system.

Flux Sensor--a device used to measure the flux or neutron population in a reactor.

Humidity Sensor--a device used to measure the humidity of a room or area in a power plant.

Level Sensor--a device used to measure the liquid level of a container, tank, or system.

Position Sensor--a device used to measure the position of a piece of equipment, e.g., valve or control rod.

Pressure Sensor--a device used to measure the pressure of a system or component.

Radiation Sensor--a device used to measure radiation levels within systems and areas in a power plant.

RPM Sensor--a device used to measure the revolutions per minute of a rotating piece of equipment.

Temperature Sensor--a device used to measure the temperature of a piece of equipment or area in the plant.

Velocity Sensor--a device used to measure the velocity of a component or fluid within a system.

Vibration Sensor--a device used to measure the vibration of a piece of rotating equipment, e.g., turbine, pump, or motor.

Voltage Sensor--a device used to measure the voltage out of a generator or into an electrical motor.

Steam Generators--components that take the energy from primary coolant water at high temperature and pressure and convert that energy to secondary coolant to generate nonradioactive steam.

Turbines--fluid acceleration machines for generating rotary mechanical power from energy in a stream of fluid.**

Valves--devices used to regulate the flow of fluids in piping systems and machinery.**

Angle Valve--a manually operated valve with its outlet opening oriented at right angles to its inlet opening.**

Ball Valve--A valve in which the fluid flow is regulated by a ball moving relative to a spherical socket as a result of fluid pressure and the weight of the ball.**

Check Valve--automatic valve that opens with forward flow and closes with reverse flow.

Diaphragm Valve--a valve in which body flexibility is provided by a diaphragm.

Four-Way Valve--a multiport plug valve.

Gate Valve--a valve in which a gatelike closure member is moved across the flow passage.

Globe Valve--a closing-down valve in which the closure member is moved squarely on and off the seat.

Needle Valve--a slender, pointed rod fitting in a hole or circular or conical seat.**

Plug Valve--a rotary valve in which a plug-shaped closure member is rotated through increments of 90° to engage or disengage a port hole or holes in the plug with the parts in the valve body.

Relief Valve--pressure-relieving device that automatically relieves a pressure system of excess pressure when abnormal operating conditions cause the pressure to exceed a set limit and recloses when the abnormal pressure recedes below the set limit.

Three-Way Valve--a multiport plug valve.

Valve Operators--devices that are used to position a valve either open or closed in a controlled manner.

Electric Motor - AC Valve Operator--an ac-driven valve operator.

Electric Motor - DC Valve Operator--a dc-driven valve operator.

Explosive Squib Valve Operator--a valve operator that has an explosive charge that causes the valve to reposition. This valve operator is used in the standby liquid control system.

Hydraulic Valve Operator--a valve operator that is operated by water or some other liquid under pressure.

Pneumatic Valve Operator--a valve operator that is operated by air pressure.

Solenoid - DC Valve Operator--a valve operator that has an electric dc solenoid valve that allows air pressure to reposition the valve.

Vessels/Tanks--containers or structural envelopes in which materials are processed, treated, or stored.**

Pressure Vessel--metal container, generally cylindrical or spheroid, capable of withstanding bursting pressure.**

Tank--a large container used for holding, storing, or transporting a fluid.**

Level 3--Displays/Instruments/Controls

Qualitative Displays--devices used to present information without the use of numbers.

Annunciator--a signaling apparatus that operates electromagnetically and serves to indicate visually, or visually and audibly, the existence or termination of an abnormal condition.

Computer Alarm Printer--device used to display computer output in a paper format (versus a CRT format); programmed to produce an audible sound under specific conditions.

CRT Text--written words displayed on a fluorescent screen, usually a computer monitor.

Indicator Light--a light the on-off condition of which is used to convey information.

Legend Light--a lighted tile or panel containing printed words or symbols and the on-off condition of which is used to convey information.

Quantitative Displays--arrangements of devices that produce information of an exact or specified amount or measure.

Chart Recorder--a recorder in which a dependent variable is plotted against an independent variable by an ink-filled pen moving on plain paper, a heated stylus on heat-sensitive paper, a light beam or electron beam on photosensitive paper, or an electrode on electrosensitive paper. The plot may be linear or curvilinear on a strip chart recorder, or polar on a circular chart recorder.

Computer Printer--a computer output mechanism that prints characters one at a time or one line at a time.*

Counter - Digital Readout--a device capable of changing from one to the next of a sequence of distinguishable states upon receipt of an input signal. It produces one output pulse each time it receives some predetermined number of input pulses.**

---

a. Level 3 definitions marked with an asterisk (*) are taken from the McGraw-Hill Dictionary of Scientific and Technical Terms. Level 3 definitions marked with a double asterisk (**) are taken from the IEEE Standard Dictionary of Electrical and Electronics Terms.

CRT Alphanumeric Display--an electron tube in which a beam of electrons can be focused to a small area and varied in position and intensity on a surface. The display uses all characters used by a computer, including letters, numerals, punctuation marks, etc.*

CRT Graphic Display--an electron tube in which a beam of electrons can be focused to a small area and varied in position and intensity on a surface. The display has the form of charts, drawings, or appropriate pictorial representation.*

Meter--a device for measuring the value of a quantity under observation; the term is usually applied to an indicating instrument alone.*

Printing Recorder--an electromechanical recording device that accepts electric signal impulses from transmitting circuits and converts them to a printed record of the signal received.**

Two-Position Switches--switches having two discrete positions, usually "ON" and "OFF."

Keylock--a switch that can be operated only by inserting and turning a key such as that used in ordinary locks.*

Knob--a component that is placed on a control shaft to facilitate manual rotation of the shaft; it sometimes has a pointer or markings to indicate shaft position.* A knob has only two possible positions.

Multifunction Push-button Matrix--a unit assembly of one or more externally operable push-button switches in which the function of the switches may be changed.

Push-button (Illuminated Legend)--a switch that is operated by finger pressure at the end of an operating button.* The switch title or explanation is printed on the button and is illuminated by an internal lamp when the switch is activated.

Push-button (Other)--a switch that is operated by finger pressure at the end of an operating button.* The associated title or explanation is not lighted.

Rocker--a rocking or oscillating arm or lever rotating with a moving shaft or pivoted on a stationary shaft.

Toggle Switch/Two-Position--a small switch that is operated by manipulation of a projecting lever that is combined with a spring to provide a snap action for opening or closing a circuit quickly. The circuit holds either of two states until changed.*

Multiposition Selectors--devices for making connections to any one of a number of circuits.

J-Handle Switch--a multiposition switch having a pistol-grip handle.

Rotary Switch--a multiposition switch that is operated by rotating its shaft with a knob.

Stepping Push-button--a push-button that produces incremental changes to the function being controlled with each activation.

Toggle Switch--a small switch that is operated by manipulation of a projecting lever, which is combined with a spring to provide snap action for opening or closing a circuit quickly.* The switch usually has three positions.

Continuously Variable Controls--controls that can be operated to achieve any setting within a prescribed range.

Knob--a control operated by a knob that is placed on a shaft to facilitate manual rotation of the shaft; sometimes the knob has a pointer or markings to indicate shaft position.

Lever--a control operated by a lever for making continuous adjustments.

Thumb Wheel--a control operated by the application of tangential force to the edge of a small wheel.

Keyboards--sets of keys or control levers having a systematic arrangement and used to operate a machine or other piece of equipment.*

Calculator--a device that performs logic and arithmetic digital operations based on numerical data that are entered by pressing numerical and control keys.*

Computer Terminal--a keyboard used to input data or instructions to a computer.

Teletype--a special electric typewriter that produces coded electric signals corresponding to manually typed characters and automatically types messages when fed with similarly coded signals produced by another machine.*

Typewriter--a machine that produces printed copy, character by character, as the typewriter is operated; essential parts are an input keyboard, a set of raised characters, inking means, a platen, and a mechanism for advancing the position at which successive characters are imprinted.*

Tools--devices or instruments for the performance of a manual operation.

Clippers--mechanical or electrical tools that are used for clipping or cutting; commonly referred to as shears.

Fuse Puller--tongs provided with an insulating handle and jaws; used to insert a fuse unit into a fuse support or to remove it from the support.**

Impact Wrench--a compressed air or electrically operated wrench that gives a rapid succession of sudden torques.*

Pliers--a small instrument witn two handles and two grasping jaws, usually long and roughened, working on a pivot; used for holding small objects and cutting, bending, and shaping wire..

Ratchet and Pocket--a wrench with a socket to fit the head of a bolt or a nut that consists of a wheel, usually toothed, operating with a catch or a pawl so as to rotate in only a single direction.*

Screwdriver--a tool for turning and driving screws in place; a thin wedge-shaped or fluted end enters the slot or recess in the head of the screw.*

Shorting Probe--a probe with an insulated handle and cable used to remove electric potential from a circuit.

Torch--a gas burner used for brazing, cutting, or welding.*

Torque Wrench--a hand or power tool used to turn a nut on a bolt that can be adjusted to deliver a predetermined amount of force to the bolt when tightening the nut.

Welding Rod--filler metal in the form of a rod or heavy wire.*

Wrench--a manual or power tool with fixed or adjustable jaws or sockets, either at the end or between the ends of a lever, for holding or turning a bolt, pipe, or other object.*

Lifting/Moving Devices--devices used to raise something upward or to some other position at the same level.

Crane--a hoisting machine with a power-operated inclined or horizontal boom and lifting tackle for moving loads vertically and horizontally.*

Come-along--a lever-operated chain or wire-rope hoist for lifting or pulling at any angle which has a reversible ratchet mechanism in the lever, permitting short-stroke operation for both tensioning and relaxing, and which holds the loads with a Weston-type friction brake or a releasable ratchet.*

Hoist--a power unit for a hoisting machine, designed to lift from a position directly above the load and therefore mounted to facilitate mobile service.*

Jack--a portable device for lifting heavy loads through a short distance, operated by a lever, screw, or hydraulic press.*

Sling--a length of rope, wire rope, or chain used for attaching a load to a crane hook.*

Wire Rope--a rope formed of twisted strands of wire.*

Electrical Test Equipment--equipment used to assess or evaluate the performance, capabilities, or present status of any system involving electricity.

Amprobe--a device for measuring the flow of current through a conductor by means of inductance, e.g., a clamp-on ammeter.

Decade Box--an assembly of precision resistors, coils, or capacitors, the individual values of which vary in submultiples and multiples of 10; the decade box can be set to any desired value within its range by appropriately setting a 10-position selector switch for each section.

Digital Meter--a device for measuring the value of electrical quantities; the result is indicated in directly readable numerals.

Frequency Counter--an electronic counter used to measure frequency by counting the number of cycles in an electric signal during a preselected time interval.*

Multimeter--a test instrument having a number of different ranges for measuring voltage, current, and resistance.*

Oscilloscope--a test instrument that uses a cathode-ray tube to make visible on a fluorescent screen the instantaneous values and wave forms of electrical quantities that are rapidly varying as a function of time or another quantity.*

Resistance/Impedance Bridge--a resistance bridge (also known as Wheatstone bridge) is a four-arm bridge circuit, all arms of which are predominantly resistive; used to measure the electrical resistance of an unknown resistor by comparing it with a known standard resistance. An impedance bridge is a device similar to a Wheatstone bridge that is used to compare impedances that may contain inductance, capacitance, and resistance.

Signal Generator--an electronic test instrument that delivers a sinusoidal output at an accurately calibrated frequency that may be anywhere from the audio to the microwave range: the frequency and amplitude are adjustable over a wide range, and the output is usually amplitude-modulated or frequency-modulated.*

Voltage Test Lamp--a set of probes with leads attached to an incandescent lamp; used to determine whether a voltage difference exists between two points.

Measurement Test Equipment--equipment used to ascertain the extent, dimensions, or quantity of some parameter of an object or system.

Gas Detector--a device that indicates the existence of combustible or noxious gas.*

Hydrometer--a direct-reading instrument for indicating the density, specific gravity, or some other characteristic of liquids.*

Micrometer--a caliper for making precise measurements; a spindle is moved by a screw thread so that it touches the object to be measured; the dimension can then be read on a scale.*

Pyrometer and Thermometer--any of a broad class of temperature-measuring devices; pyrometers were originally designed to measure high temperatures, but some are now used in any temperature range; includes radiation pyrometers, thermocouples, resistance pyrometers, and thermistors.*

Scale--a balance or other device used for weighing.*

Stroboscope--an instrument for making bodies visible intermittently, either by illuminating the object with brilliant flashes of light or by imposing an intermittent shutter between the viewer and the object; a high-speed vibration can be made visible by adjusting the strobe frequency close to the vibration frequency.*

Test Gauge--a pressure-measuring instrument used for hydrostatic tightness tests or other tests of systems or components.

Vibration Detector--an apparatus or system used to detect the presence of vibration.*

Printed Communications--a method of imparting knowledge or providing information expressed in a written form.

Administrative Procedure--a document describing a plant policy or other instructions for managing the conduct of operations in the plant.

Graph--a presentation of data in a diagram that represents the variation of a variable in comparison with one or more other variables.

Label--a small sign affixed on or in the vicinity of a piece of equipment for identification or description.

Log Book--a bound volume in which operating data are recorded.

Maintenance Procedure--a written procedure to assist personnel in performing corrective or preventive maintenance on plant equipment.

Operating Procedure--a written procedure to assist operating personnel in controlling plant systems or responding to abnormal events.

Table--a presentation of data in a systematic arrangement of rows and columns for ready reference.

Tag--a temporary label, marker, or sign used to indicate that a component is in an abnormal or protected condition.

Test or Calibration Procedure--a written procedure used by operations or maintenance personnel in testing equipment or calibrating instruments.

Verbal Communications--a method of imparting knowledge or providing information expressed in spoken words.

Face-to-Face Communication--verbal communications between people over relatively short distances without the aid of voice amplification or transmission devices.

Page-Party System (PA) Communication--verbal communications using an electronic system for amplification and broadcasting to several remote locations.

Sound-Powered Phone Communication--verbal communication using a telephone operating entirely on current generated by speaker's voice, with no external power supply; sound waves cause a diaphragm to move a coil back and forth between the poles of a powerful but small magnet, generating the required audio-frequency voltage in the coil.*

Telephone Communication--verbal communication using an electric device for transmitting signals to a distant point via conducting wire.

Two-Way Radio Communication--a compact, combination radio transmitter-receiver that can be carried or strapped on the belt; popularly known as a walkie-talkie.*

Equipment - Nonspecific--a display, control, communications device, tool, or piece of test equipment that cannot be classified in any other category.

DEFINITIONS OF HUMAN ACTIONS

The human action verbs used in the data bank taxonomy are defined in this appendix. They are organized as follows:

- Level 1

  Control Room Operator duties
  Equipment Operator duties
  Maintenance Technician duties

- Level 2

  Control Room Operator tasks
  Equipment Operator tasks
  Maintenance Technician tasks

- Level 3 (task elements)

The definitions are listed in the order in which the human actions appear on the matrices.

Level 1

Control Room Operator

Diagnose--to use information derived from plant systems to determine the nature or cause of a condition.

Operate--to cause to function or to sustain and regulate the ongoing functioning of a system.

Monitor--to observe the status of a system and its components over extended periods.

Test--to execute a procedure or routine that will provide evidence as to the functioning of a system or component.

Equipment Operator

Diagnose--to use information derived from plant systems to determine the nature or cause of a condition.

Inspect--to examine for the purpose of detecting an abnormal condition.

Maintain--to keep a system or component in an operational state or potentially operational.

Operate--to cause to function or to sustain and regulate the ongoing functioning of a system.

Test--to execute a procedure or routine that will provide evidence as to the functioning of a system or component.

Maintenance Technician

Check--to examine for the purpose of verifying the satisfactory condition, safety, or performance of a system.

Diagnose--to use information derived from plant systems or components to determine the nature or cause of a malfunction.

Maintain--to work on a system or component to repair it or to protect it against failure or decline.

Test--to execute a procedure or routine that will provide evidence as to the functioning of a system or component.

Level 2

Control Room Operator

Diagnose--to use information derived from plant components to determine the nature or cause of a condition.

Fill/Drain--to raise or deplete the level of a substance (operated from control room).

Monitor--to observe the status of plant components over extended periods.

Open/Close--to position a mechanical component to allow or to block the passage of fluid or electricity (operated from control room).

Operate--to sustain and regulate the ongoing functioning of plant components from the control room.

Start/Stop--to initiate or terminate the action of a component (operated from control room).

Equipment Operator

Diagnose--to use information derived from plant components to determine the nature or cause of a condition.

Fill/Drain--to raise or deplete the level of a substance.

Monitor--to observe the status of components from plant areas outside the control room.

Open/Close--to position a mechanical component to allow or to block the passage of fluid or energy.

Operate--to sustain and regulate the ongoing functioning of plant components not operated from the control room.

Start/Stop--to initiate or terminate the action of a component.

Maintenance Technician

Calibrate--to determine, check, or correct the graduation of any component providing quantitative measurements.

Diagnose--to use information derived from plant components to determine the nature or cause of a malfunction.

Maintain--to perform work on a component to protect it against failure or decline.

Repair--to restore a component to a functional state by the replacement or mending of worn or damaged parts.

Test--to execute a procedure or routine that will provide evidence as to the functioning of a component.

Level 3

Adjust--to operate a continuous control.

Calculate--to determine by mathematical processes.

Calibrate--to determine, check, or correct the graduation of any instrument providing quantitative measurements.

Diagnose--to use information derived from plant instruments to determine the nature or cause of a condition.

Identify--to detect and classify objects or indications according to implicit or predetermined characteristics.

Maintain--to keep an instrument or control in an operational state or a potentially operational state.

Monitor--to observe characteristics of instruments and/or displays over extended periods.

Position--to operate a control that has discrete states.

Read--to visually examine symbolic information.

Receive--to be given written or verbal information.

Remember--to retain information or retrieve information from memory.

Select--to choose equipment, tools, or job performance aids after consideration of alternatives.

Use--to employ equipment, tools, or job performance aids (other than discrete or continuous controls).

Verify--to confirm information concerning the condition or state of equipment. Includes check reading.

Write--to reproduce symbolic information manually.

APPENDIX B

TASK STATEMENT STRUCTURE

APPENDIX B
TASK STATEMENT STRUCTURE

INTRODUCTION

The task statement is a sentence describing the activity for which human error probability (HEP) data are provided. To ensure consistency and allow for systematic data categorization and retrieval, the task statement consists of a series of standardized terms or phrases. The structure and format of the task statement for each taxonomy level are described below. Note that words rather than codes are used in the task statements.

TASK STATEMENT STRUCTURE LEVEL 1

Level 1 Task Statement: [1]Job classification [2]verb the [3]system [4]state given: [5]standard, [6]condition, [6]condition...

Job Classification

Job classification refers to the individual performing the task. The classifications of Control Room Operator (CRO), Equipment Operator (EO), or Maintenance Technician (MT) may be specified.

Verb

This is the verb that best describes the duty area involved in performing the task. The verbs applicable to each job classification are defined in Appendix A.

System

Refers to the system involved (see Appendix A).

State

Refers to the operating mode or condition of a system during or resulting from the human action. The state entry is <u>optional</u> and is used to specify a system configuration that makes the steps necessary to accomplish the task different than those for other similar tasks involving the same system. In the case where a system has several modes of operation that are not procedurally defined, the purpose of the system operation may be entered as its state (e.g., operate the chemical and volume control system to control coolant inventory).

Standard

The standard is the criterion for successful task performance that was not achieved. The standard entry is used to identify different types or degrees of task errors. Based on the information provided in the data source document, a short phrase that describes the criterion used to identify errors is entered (e.g., level not maintained within limits, test not performed).

Conditions

Conditions include the initiating cu[illegible] lant conditions, and abnormal environmental or system constraints that may affect the difficulty of the human action or the probability of error. The condition entries are in the form of phrases that specify performance shaping factors (PSFs) affecting the human action that differ from the eight PSFs tracked separately for each source data item. If available, information is provided on whether the action was local or remote, what nuclear power plant probabilistic risk assessment (PRA) sequence (e.g., TP, loss of offsite power) relates to the event, and what human reliability analysis (HRA) method (e.g., SLIM) was used to derive the HEP. There is no limit to the number of condition entries that may be used. However, each condition entry must apply to all the error opportunities as well as the error events.

TASK STATEMENT STRUCTURE LEVEL 2

<u>Level 2 Task Statement</u>: ^{1}<u>Job classification</u> ^{2}<u>verb</u> the ^{3}<u>component</u> ^{4}<u>state</u> given: ^{5}<u>standard</u>, ^{6}<u>condition</u>, ^{6}<u>condition</u>, ^{6}<u>condition</u> ...

<u>Job Classification</u>

Refers to the individual performing the task. The classifications of Control Room Operator (CRO), Equipment Operator (EO), or Maintenance Technician (MT) may be specified.

<u>Verb</u>

This is the verb that best describes the effects of the human action on the component. Definitions of verbs used in Level 2 tasks for each job classification are provided in Appendix A.

<u>Component</u>

Refers to the piece of equipment involved in the task (see Appendix A).

<u>State</u>

Refers to the condition of the component at the completion of the task. The state entry is optional and is used to specify the component status if it affects the type of human action required to accomplish the task (e.g., EO operates the valve <u>throttled</u> ...).

Standard

The standard is the criterion for successful task performance that was not achieved. The standard entry is used to identify different types or degrees of task errors. Based on the information provided in the data source document, a short phrase describing the criterion used to identify errors is entered (e.g., not completely closed, wrong component, deviant condition not detected).

Conditions

Conditions include the initiating cue, plant conditions, and abnormal environmental or system constraints that may affect the difficulty of the human action or the probability of error. The condition entries are in the form of phrases that specify performance shaping factors (PSFs) affecting the human action that differ from the eight PSFs tracked separately for each source data item. There is no limit to the number of condition entries that may be used. However, each condition entry must apply to all the error opportunities as well as the error events.

In addition to the listing of PSFs, a number of key factors related to plant conditions and the use of procedures have been coded into the NUCLARR system. By convention, the following plant transients have been designated:

Anticipated transient without scram	ATWS
Transient initiated sequence with a loss of feedwater and emergency coolant injection (BWR)	TQUV/TQUX
Transient initiated sequence with a loss of feedwater and emergency coolant injection (PWR)	TML-D
Loss of offsite power	LOSP or TP
Small LOCAs	S2 or S3
Large LOCA	A
Long-term failure of containment heat removal	TW

Operator actions are also defined in terms of their proximity to the control room and are designated as either local or remote. Events are classified as either initiating, preinitiating, or post-initiating. Operators actions are classified as planned (poa), e.g., those actions specified by procedure, or as recovery (rop) actions taken outside of procedures.

TASK STATEMENT STRUCTURE LEVEL 3

Level 3 Task Statement: The personnel [1]verb the [2]means given: [3]standard, [4]condition, [4]condition, [4]condition ...

Verb

This is the verb that best describes the human action of the personnel. Definitions of verbs used in Level 3 tasks are listed in Appendix A.

Means

Refers to the display, instrument, or control device with which the subject interfaces (see Appendix A).

Standard

This is the criterion for successful task performance that was not achieved. The standard entry is used to identify different types or degrees of task errors. Based on the information provided in the data source document, a short phrase describing the criterion used to identify errors is entered (e.g., operated in wrong direction, wrong control, incorrect reading, deviant condition not detected).

Conditions

Conditions include the initiating cue, plant conditions, and abnormal environmental or system constraints that may affect the difficulty of the human action or the probability of error. The condition entries are in the form of phrases that specify performance shaping factors (PSFs) affecting the human action that differ from the eight PSFs tracked separately for each source data item. There is no limit to the number of condition entries that may be used. However, each condition entry must apply to all the error opportunities as well as the error events.

In addition to the listing of PSFs, a number of key factors related to plant conditions and the use of procedures have been coded into the NUCLARR system. By convention, the following plant transients have been designated:

Anticipated transient without scram	ATWS
Transient initiated sequence with a loss of feedwater and emergency coolant injection (BWR)	TQUV/TQUX
Transient initiated sequence with a loss of feedwater and emergency coolant injection (PWR)	TML-D
Loss of offsite power	LOSP or TP
Small LOCAs	S2 or S3
Large LOCA	A
Long-term failure of containment heat removal	TW

Operator actions are also defined in terms of their proximity to the control room and are designated as either local or remote. Events are classified as either initiating, preinitiating, or post-initiating. Operators actions are classified as planned (poa), e.g., those actions specified by procedure, or as recovery (rop) actions taken outside of procedures.

NRC FORM 335 (2-84) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

SEE INSTRUCTIONS ON THE REVERSE

1. REPORT NUMBER (Assigned by TIDC, add Vol. No., if any)

NUREG/CR-4639
EGG-2458
Volume 5

2. TITLE AND SUBTITLE

Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR)
Data Manual
Part 1: Summary Description

3. LEAVE BLANK

4. DATE REPORT COMPLETED

MONTH	YEAR
May	1988

5. AUTHOR(S)

David I. Gertman
B. Gay Gilbert
Walter E. Gilmore
William J. Galyean

6. DATE REPORT ISSUED

MONTH	YEAR
June	1988

7. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)

EG&G Idaho, Inc.
Idaho Falls, ID 83415

8. PROJECT/TASK/WORK UNIT NUMBER

9. FIN OR GRANT NUMBER

A6854

10. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)

Division of Reactor and Plant Systems
Office of Nuclear Regulatory Research
U.S. Nuclear Energy Commission
Washington, D. C. 20555

11a. TYPE OF REPORT

Technical

b. PERIOD COVERED (Inclusive dates)

12. SUPPLEMENTARY NOTES

13. ABSTRACT (200 words or less)

This volume of a five-volume series summarizes those data currently resident in the first release of the Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR) data base. The raw human error probability (HEP) and hardware component failure data (HCFD) contained herein are accompanied by a glossary of terms and the HEP and hardware taxonomies used to structure the data. Instructions are presented on how the user may navigate through the NUCLARR data management system to find anchor values to assist in solving risk-related problems.

Volume V: Data Manual will be updated on a periodic basis so that risk analysts without access to a computer may have access to the latest NUCLARR data. Those users wishing to learn more regarding the computer-based interactive search and report-generation capabilities of the NUCLARR system are referred to the other volumes in the NUREG/CR-4639 series, e.g., Volume I: Summary Description or Volume IV: User's Guide.

14. DOCUMENT ANALYSIS - a. KEYWORDS/DESCRIPTORS

NUCLARR
Computer Code
human error probability (HEP)
hardware component failure data (HCFD)

b. IDENTIFIERS/OPEN-ENDED TERMS

15. AVAILABILITY STATEMENT

Unlimited

16. SECURITY CLASSIFICATION

(This page)
Unclassified

(This report)
Unclassified

17. NUMBER OF PAGES

18. PRICE