PROGRAM PLAN REPORT
DETAILED CONTROL ROOM DESIGN REVIEW
KEWAUNEE NUCLEAR POWER PLANT
WISCONSIN PUBLIC SERVICE CORPORATION

APRIL 15, 1983

TABLE OF CONTENTS

Section	Title	Page
INTRODUCTION		v
1	REVIEW PLAN	1-1
1.1	OBJECTIVES	1-1
1.2	DETAILED CONTROL ROOM DESIGN REVIEW ACTIVITIES	1-2
1.3	IMPLEMENTATION OF CHANGES	1-3
2	MANAGEMENT AND STAFFING	2-1
2.1	UTILITY MANAGEMENT RESPONSIBILITY	2-1
2.2	REVIEW TEAM STRUCTURE AND QUALIFICATIONS	2-2
2.2.1	Structure	2-2
2.2.2	Qualifications	2-2
2.3	UTILIZATION OF SPECIALISTS	2-5
3	DOCUMENTATION AND DOCUMENT CONTROL	3-1
3.1	DOCUMENT CONTROL SYSTEM DESCRIPTION	3-1
3.2	INPUT DATA	3-1
3.3	OUTPUT DATA	3-1
3.3.1	Control Room Inventory	3-2
3.3.2	Control Room Survey Checklists	3-2
3.3.3	Human Engineering Observation (HEO) Record	3-2
3.3.4	HEO Report	3-3
3.4	CONFIDENTIALITY	3-3
3.5	DOCUMENTATION STORAGE	3-3
4	REVIEW PROCEDURES	4-1
4.1	OPERATING EXPERIENCE REVIEW	4-1
4.1.1	Examination of Available Documents	4-1
4.1.2	Control Room Operating Personnel Survey	4-3
	EXHIBIT 4-1	Follows page 4-5
4.2	SYSTEM REVIEW AND TASK ANALYSIS	4-6
4.2.1	Purpose	4-6

TABLE OF CONTENTS (CONT)

		Page
4.2.2	Approach	4-6
4.2.3	Procedure	4-7
4.2.4	Documentation	4-7
4.3	CONTROL ROOM INSTRUMENTATION AND EQUIPMENT INVENTORY	4-8
4.3.1	Purpose	4-8
4.3.2	Objectives	4-8
4.3.3	Procedure	4-9
4.3.4	Documentation	4-11
4.4	CONTROL ROOM SURVEY	4-13
4.4.1	Control Room Workspace Survey	4-15
4.4.2	Communications Survey	4-16
4.4.3	Annunciator Warning System Survey	4-18
4.4.4	Controls Survey	4-20
4.4.5	Visual Displays Survey	4-22
4.4.6	Labels and Location Aids Survey	4-24
4.4.7	Process Computer Survey	4-27
4.4.8	Panel Layout Survey	4-30
4.4.9	Control - Display Integration Survey	4-32
4.5	VERIFICATION OF TASK PERFORMANCE CAPABILITIES	4-34
4.5.1	Purpose	4-34
4.5.2	Scope	4-34
4.5.3	Approach	4-34
4.5.4	Procedure	4-35
4.6	CONTROL ROOM VALIDATION AS AN INTEGRATED SYSTEM	4-37
4.6.1	Purpose	4-37
4.6.2	Approach	4-39
4.6.3	Procedure	4-40
4.6.4	Results	4-48
4.6.5	References	4-48
5	HEO ASSESSMENT AND HED IMPROVEMENT	5-1
5.1	PURPOSE	5-1
5.2	APPROACH	5-2
5.3	PROCEDURES	5-3
5.3.1	HEO Significance Assessment	5-3
5.3.2	HEO Categorization	5-10
5.3.3	Selection of a Correction Method	5-14
5.3.4	Correction Analysis	5-16
5.3.5	Verification and Validation	5-20

TABLE OF CONTENTS (CONT)

Page

5.3.6 Documentation 5-20

5.4 RESULTS 5-21

5.5 FUTURE CHANGES TO THE BASELINE CONTROL ROOM 5-22

EXHIBIT 5-1 . . . . Follows page 5-23

6 APPENDICES

A INDEX OF DOCUMENTS FOR DCRDR
B PHOTOGRAPHY PROCEDURE
C CONTROL ROOM DESIGN CONVENTIONS SURVEY
D VIDEOTAPING PROCEDURE
E AID TO REVIEW TEAM FOR CONDUCTING OPERATING PERSONNEL SURVEYS

LIST OF FIGURES

Figure	Title	Follows Page
1-1	Activity Schedule	1-3
2-1	DCRDR Team Organization	2-2
3-1	HEO Record (Obverse Side)	3-2
3-2	HEO Record (Reverse Side)	3-2
3-3	Sample HEO Log	3-2
3-4	Sample Photo Log	3-2
3-5	HEO Report	3-3
3-6	HEO Index	3-3
4-1	Control Room Floor Plan	E4-16
4-2	Sample Task Element Table	4-7
4-3	Simulator Exercise Activity Sequence	4-43
4-4	Man-Machine System Control Feedback Loop	4-44
5-1	Assessment and Improvement Process	5-2
5-2	Significance Rating Statistical Evaluation Guide	5-7
5-3	HED Categorization and Prioritization Process	5-11
5-4	Category Level Definition	5-13
5-5	Selection of a Correction Method	5-14
B-1	Sample Photo Log - Control Panel Mosaic	B-2
B-2	Photograph Identification Stamp	B-2
D-1	Sample Videotape Log	D-2

INTRODUCTION

By letter of December 17, 1982, the NRC requested licensees to perform a detailed control room design review to provide evidence that the control room is designed in accordance with accepted human engineering principles, and as such, provides a vehicle by which the operator can carry out the functions necessary for routine and non-routine duties. This plan is submitted in response to Item I.D.1 of the above noted letter.

The control room of the Kewaunee Nuclear Power Plant was designed at a time when "human engineering" guidance and standards either did not exist or were not readily available. Nevertheless, great care was taken in the design of the control room, such that the intent of many of the current human engineering standards and guidelines have been met or exceeded. For example, prior to construction of the control room, a full-scale mock-up of the control room panels was built in order to test the adequacy of the layout. Engineers and operators were involved in this testing. The result was a well-designed and functionally efficient control room.

The control room has now been subjected to and endured over ten years of operation, including preoperational testing. The exceptional performance of the Kewaunee Plant (a capacity factor of 77.8 and an availability factor of 83.4, through December, 1982) is in part a tribute to the functionality of the control room design and a testimony to its acceptability from a human factors engineering perspective. In fact, the operation of the plant (from the control room) can be considered a de facto Control Room Design Review for routine operations. Inadequacies of the control room for normal operation may, therefore, be identified by the Operating Experience Review.

Emergency control room operations, however, have not received such extensive review, either explicitly or implicitly. Since the accident at Three Mile Island, certain aspects of emergency operations have received attention, i.e. training and qualifications of operators, accident analysis and certain hardware modifications, but the control room as a whole and emergency operations have not yet received this scrutiny.

Recognizing this and anticipating the NRC's request, WPSC has developed this plan for a Detailed Control Room Design Review. For the reasons noted above, the extensive analysis of emergency operations conducted by the Westinghouse Owners Group (the generic System Function Review and Task Analysis) as well as the Symptom Oriented Emergency Operating Procedures will be made plant specific and integrated with the DCRDR.

The guidance provided in NUREG-0700, Guidelines for Control Room Design Reviews, and draft NUREG-0801 of October, 1981, Evaluation Criteria for Detailed Control Room Design Review, was used in the preparation of this plan. It should be noted that this document has been prepared as a guide to the DCRDR team in performance of their work. While few changes are expected to occur in this plan, in certain instances it may be necessary to deviate from the guidance given, based on circumstances encountered during the review.

The scope of this review is limited to the Control Room and Dedicated Shutdown Panel. Specific review objectives are defined in Section 1.

There are three main purposes of this review: to identify Human Engineering Observations (HEO's), to evaluate and categorize those which are Human Engineering Discrepancies (HED's), and establish an implementation plan for corrective action.

Finally, it is important to keep in mind that it is the goal and the responsibility of WPSC to assure safe and reliable operation of the Kewaunee Nuclear Power Plant. Consequently, WPSC management must carefully review changes recommended to improve operations and ensure that the changes will not have adverse effects. This will be a key factor in determining final disposition of Human Engineering Deficiencies.

SECTION 1

REVIEW PLAN

1.1 OBJECTIVES

Specific objectives of the detailed control room design review (DCRDR) are as follows:

1. To verify that the control room provides the system status information, control capabilities, feedback, and analytic aids necessary for control room operators to accomplish their functions effectively.

2. To determine if any characteristics of the existing control room instrumentation, controls, other equipment, and physical arrangements may detract from operator performance.

3. To analyze and evaluate any problems that may arise from identified discrepancies, and to analyze means of correcting those discrepancies which could lead to substantial problems.

4. To establish a human factors baseline for the control room and put into effect a plan of action that applies human factors principles to future control room design changes.

5. To integrate the control room design review with other areas of human factors identified in the NRC Task Action Plan.

Accomplishment of these objectives is a major step toward minimizing the risk of human error in the control room.

1.2 DETAILED CONTROL ROOM DESIGN REVIEW ACTIVITIES

The review process activities described in this review plan are based on guidance given by the Nuclear Regulatory Commission in NUREG-0700, Guidelines for Control Room Design Review, draft NUREG-0801, October 1981, Evaluation Criteria for Detailed Control Room Design Review, references listed in Appendix A, and the specific needs of the Kewaunee Nuclear Power Plant.

The evaluation process will start with a detailed review of the existing control room design to (1) evaluate the completeness of the control room to allow operators to accomplish their functions and tasks effectively, and (2) provide human engineering observations (HEOs) which could lead, or have led, to control room operator performance errors. All HEOs will be identified, and emphasis will be placed on correcting those which are categorized as Human Engineering Discripancies (HEDs) and could compromise plant safety or plant operability.

Once HEOs are identified and documented, the process of HEO assessment can begin. HEOs will be assessed to determine if the effect, or potential effect, of the HEO is significant enough to warrant analysis for correction. HEOs warranting correction will be categorized as HEDs and will be analyzed to determine whether a correction can be made using relatively simple, surface treatment techniques, known as enhancements. Correction by enhancement may not always be possible or adequate. A more extensive design effort may be required. In such cases recommendations concerning engineering design efforts will be made. Where these correction methods are inadequate or inappropriate, recommendations for additional procedures or modifications to existing procedures may be made.

The specifics of the review process activities are described in greater detail in Section 4.

The primary review activities are listed below:

1. Operating Experience Review.

2. System Review and Task Analysis.

3. Control Room Surveys.

4. Verification of Task Performance Capabilities.

5. Validation of Control Room as an Integrated System.

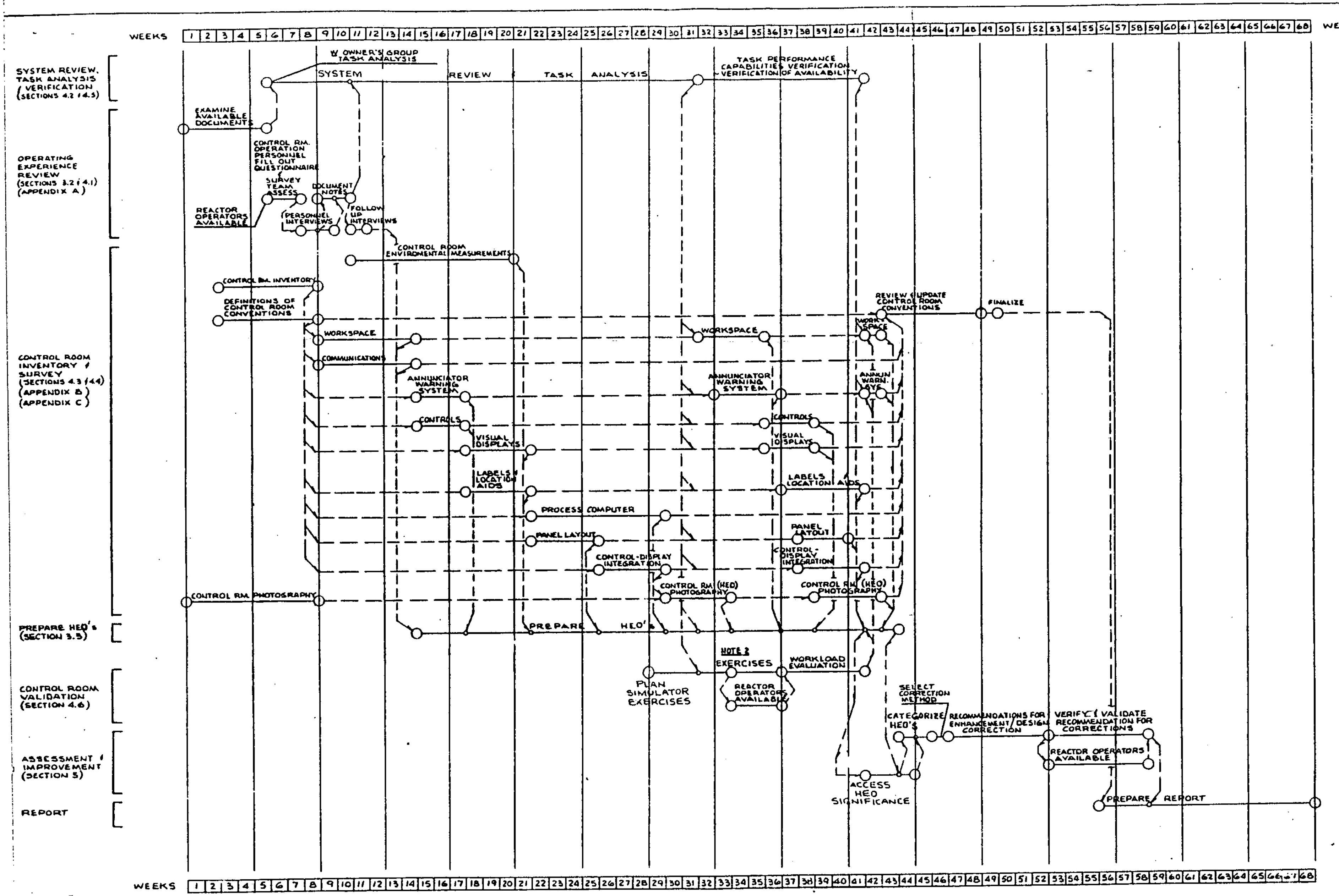
The sequencing, phasing, and durations of these activities are shown on a sample activity schedule (Figure 1-1). The schedule illustrates a plan to conduct the DCRDR over approximately a 68-week period. It should be noted that the Westinghouse Owners' Group (WOG) has performed extensive studies in the verification and validation of the WOG generic emergency response guidelines. This work includes a comprehensive system review and task analysis based on the ERG's. It is WPSC's intent to utilize this work as much as possible in the performance of the KNPP DCRDR. Validation of the KNPP specific emergency operating procedures, and the control room as a whole, will be accomplished through use of the KNPP Simulator.

1.3 IMPLEMENTATION OF CHANGES

Any modifications to the control room, be they enhancements or extensive redesign efforts, will be made in accordance with WPSC Engineering Control Directive 4.1 "Design Change Control." The Design Change

Engineers will schedule the modifications at the completion of the DCRDR. Changes to procedures will be made in accordance with WPSC Administrative Control Directive 2.6 "Plant Procedures".

The completed DCRDR plus validation and verification of all modifications resulting from the DCRDR, will determine the baseline control room. Any future changes to the control room will be evaluated according to the criteria and processes outlined in this report before implementation.



NOTES:

1. SECTION NUMBERS AND APPENDICES REFER TO PROGRAM PLAN REPORT
2. SIMULATOR EXERCISES ARE CONTINGENT UPON AVAILABILITY OF SIMULATOR.

FIGURE 1-1

ACTIVITY SCHEDULE

KEWAUNEE NUCLEAR POWER PLANT DETAILED CONTROL ROOM DESIGN REVIEW

SECTION 2

MANAGEMENT AND STAFFING

2.1 UTILITY MANAGEMENT RESPONSIBILITY

The WPSC Nuclear Technical Review Assistant will assume the role of Project Manager. Management responsibilities will include the following:

1. Analysis of objectives and constraints.

2. Commitment of WPSC resources.

3. Selection of review team personnel.

4. Assurance that the review team functions in accordance with all WPSC procedures, directives, and commitments applicable to the work being performed by the review team.

5. Integration of control room improvements with other design changes and improvement programs.

6. Interface between the review team and other WPSC groups, vendors, consultants, and state and federal agencies.

These management responsibilities will receive additional definition in the "Detailed Control Room Design Review - Project Interface Procedure." In addition to management responsibilities, the Project Interface Procedure will define the responsibilities of WPSC and contractor personnel associated with the review.

The DCRDR will be conducted in accordance with WPSC Engineering Control Directive 14.1, "Independent Technical Review."

Upon completion of the DCRDR, the review team will prepare a comprehensive report which will list all discrepancies found, recommendations for their correction, and reference appropriate supporting data. The report will then be presented to WPSC management.

2.2 REVIEW TEAM STRUCTURE AND QUALIFICATIONS

2.2.1 Structure

The review team will be organized as shown in Figure 2-1. The team will be under the direction of a project engineer who will report to the project manager. Additional personnel in the four disciplines shown will be assigned as required.

2.2.2 Qualifications

Minimum qualifications for the project engineer and lead engineers are described in the sections that follow.

Project Engineer

The project engineer have at least ten years experience in one of the four basic review team disciplines.

He shall have a bachelor's degree in engineering and shall be a professional engineer licensed in Wisconsin.

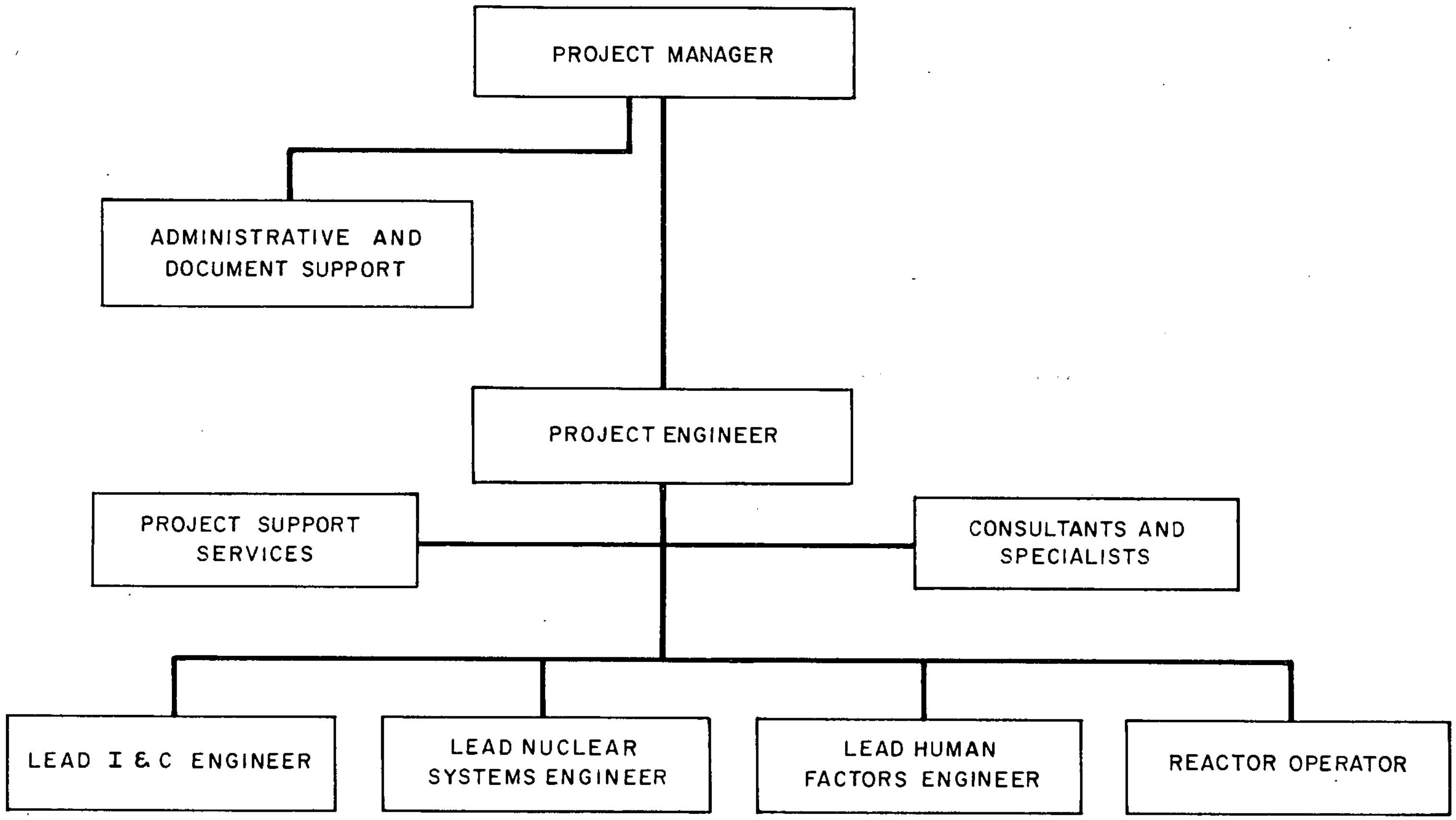


FIGURE 2-1
DCRDR TEAM ORGANIZATION
KEWAUNEE NUCLEAR POWER PLANT
DETAILED CONTROL ROOM DESIGN REVIEW

Lead Human Factors Engineer

Formal Education: Preferably the lead human factors engineer shall have a degree, at the graduate level, in human factors engineering or engineering psychology. However, qualified human factors specialists may have received their formal training in other disciplines ranging from the behavioral sciences to engineering; therefore, the pertinent formal training requirements for the lead human factors engineer will include course work in at least some of the following areas:

1. Human factors engineering.
2. Human performance theory.
3. Sensory/perceptual processes.
4. Experimental design.
5. Quantitative methods/statistics.
6. Anthropometry.
7. Survey design.
8. Industrial engineering/design.

Professional Experience: Since there is no single academic route, certification, or licensing requirement for qualifying as a human factors specialist, the past professional experience of the lead human factors engineer will be taken into account. As a guideline, five or more years of experience will be required.

HEO No. ______

PAGE 1 OF ______

HEO SOURCE:	☐ Operating Experience	☐ Guideline
	☐ Task Verification	☐ C.R. Validation

TITLE:

Panel Location –	Instr. No. –	System Code –	Service
–	–	–	
–	–	–	
–	–	–	
–	–	–	
–	–	–	
Photo Ref:	Total: ______ Items	Continued on Page ______	

OBSERVATION
Continued on Page ______

Preliminary Assessment:	Category ______ Level ______	☐ Significant ☐ Not Significant

Remarks:		
Reviewer:	Date / /	Checked:

FIGURE 3-1
HEO RECORD (OBVERSE SIDE)
KEWAUNEE NUCLEAR POWER PLANT
DETAILED CONTROL ROOM DESIGN REVIEW

HEO No. ________

Photo Instructions	Photo No.
POINT ARROW TOWARDS	Photo Taken ☐
POINT ARROW TOWARDS	Photo Taken ☐
POINT ARROW TOWARDS	Photo Taken ☐

Panel Location	Instr. No. —	System Code —	Service

FIGURE 3-2
HEO RECORD (REVERSE SIDE)
KEWAUNEE NUCLEAR POWER PLANT
DETAILED CONTROL ROOM DESIGN REVIEW

Previous experience in process control system design and operations is preferred. Demonstration of extensive hands-on experience in the application of human factors engineering and human factors psychology to other large, complex man-machine systems (e.g., command and control systems, submarine control-display layouts) will be an acceptable alternative.

Preferred specific experience will include the application of human factors to design and/or evaluation in the following areas:

1. Workspace layout.

2. Panel design (control and display layout).

3. Environmental conditions (e.g., lighting and acoustics).

4. Procedures and training.

Experience in systems analysis and task analysis will also be required within the complement of human factors professionals on the team.

Reactor Operator

A licensed reactor operator for the Kewaunee Nuclear Power Plant, with a minimum of two years control room experience, will be included in the DCRDR team.

Lead Instrumentation and Control Engineer

Formal Education: The lead instrumentation and control engineer will hold a bachelor's degree in engineering or its equivalent.

Professional Experience: The lead instrumentation and control engineer will have a minimum of five years of applied experience. Most, if not all, of this experience should have been gained in the nuclear field, preferably at a nuclear power plant similar to the one under review. The instrumentation and control engineer should be familiar with the regulations, standards, and design constraints that have an impact on nuclear power plant control room design.

Lead Nuclear Systems Engineer

Formal Education: The lead nuclear systems engineer will hold a bachelor's degree in engineering or its equivalent.

Professional Experience: The lead nuclear systems engineer will have a minimum of three years of applied design or operating technical experience. Professional licenses or certification and active participation in professional societies provide additional indication of competency in some fields. Previous experience in power plants or other process control applications is prefered. Alternatively, experience with other complex commercial, industrial, or military facilities and systems will be considered acceptable.

2.3 UTILIZATION OF SPECIALISTS

Specialists may be retained as follows in the areas indicated:

Specialty	Area of Participation
Acoustics	Control Room Workspace Survey (Section 4.4).
Photography	Control Room Instrumentation and Equipment Survey (Section 4.3).

Audio and Video Recording	Control Room Validation as an Integrated System (Section 4.6).
Lighting	Control Room Workspace Survey (Section 4.4).
HVAC	Control Room Workspace Survey (Section 4.4).
Failure Analysis	System Review and Task Analysis (Section 4.2).
Mental Workload Evaluation	Control Room Evaluation as an Integrated System (Section 4.6).

SECTION 3

DOCUMENTATION AND DOCUMENT CONTROL

3.1 DOCUMENT CONTROL SYSTEM DESCRIPTION

The DCRDR will involve the use and manipulation of a large number of forms and documents. In order to keep the documents well organized and easily accessible, a documentation control system will be implemented.

Data used by the review team are divided into two categories: input data and output data. These categories are described below along with specific means of organizing and controlling the system.

3.2 INPUT DATA

Input data to the review are existing documents which describe plant design, operation, and operating experience, or provide background information on human factors engineering. A list of references is included in Appendix A.

3.3 OUTPUT DATA

Output data from the review will consist of records of various review activities (including checklists, logs, and indexes) and identification and assessment forms for discrepancies. Each separate task, such as the control room survey and writing of HEO forms, will have its own log to account for and control activity.

Forms for individual activities such as verifying compliance with guidelines will be devised as required to ensure consistent review.

3.3.1 Control Room Inventory

The control room inventory printout will provide the review team with the results of the control room inventory as well as additional information developed during the course of the review.

3.3.2 Control Room Survey Checklists

The control room survey checklists will be generated by the review team. Sound human engineering criteria, selected for use in this review, will provide the basis for these checklists.

3.3.3 Human Engineering Observation (HEO) Record

The HEO Record (HEO Form) (Figures 3-1 and 3-2) is used to document an instance where some facet of the control room design deviates from the human engineering criteria used in this review. One HEO record will be used to document all instances of the particular observation. For example, if six control switches extend to the edge of a panel (a guideline deviance), all six would be documented on a single HEO record.

Objective of the HEO Log (Figure 3-3):

> The HEO log is a means to track HEOs sequentially. The HEO number will be preprinted, and entries are made for the reference and title.

Objective of the Photo Log (Figure 3-4):

> The Photo Log is a means to track photographs taken to support HEO evaluation. (Refer to Appendix B).

HEO No.	REFERENCE No.	REFERENCE TITLE
1	LER 305-77000	CHEMICAL DISCHARGE
2	6.6.3.2.F	SPELLING
3		
4		
5		
6		
7		
8		

FIGURE 3-3
SAMPLE HEO LOG
KEWAUNEE NUCLEAR POWER PLANT
DETAILED CONTROL ROOM DESIGN REVIEW

PHOTO No.	ROLL & FRAME No.	PHOTO CAPTION
1-A	16-6	pH RECORDER
2-A	22-14	FIRE PROTECTION ANN. 01 MISSPELLING
2-B	22-15	SERVICE WATER PUMP LABEL MISSPELLING

FIGURE 3-4
SAMPLE PHOTO LOG
KEWAUNEE NUCLEAR POWER PLANT
DETAILED CONTROL ROOM DESIGN REVIEW

3.3.4 HEO Report

The HEO report (Figure 3-5) is the form used to (1) evaluate the significance and type of HEO and to (2) track the status of the HEO. This form will be used with the HEO record. During the assessment phase of the review, an HEO report will be started for each HEO. Progress towards resolution of the HEO will be recorded on an index (Figure 3-6) which will summarize action taken to date.

3.4 CONFIDENTIALITY

Access to output documents will be limited to review team members and designated management personnel.

3.5 DOCUMENTATION STORAGE

Control Room Design Review documentation will be filed in a manner consistent with the sections outlined in the review plan. In addition, the Control Room Operating Personnel Questionnaire and Walkthrough Videotapes will be stored in a secure location with access limited to designated personnel.

HEO No. ______

PAGE 1 OF ______

HEO ASSESSMENT:

CATEGORY ______ ☐ SIGNIFICANT

LEVEL ______ ☐ NOT SIGNIFICANT

RESOLUTION:

Reviewer: Date / / Checked

DISPOSITION

DCR No. ______

OTHER ______

FIGURE 3-5

HEO REPORT

KEWAUNEE NUCLEAR POWER PLANT

DETAILED CONTROL ROOM DESIGN REVIEW

HEO INDEX

HEO No.	HED CAT	SIGNIFICANCE ASSESSMENT	SELECT CORRECTION	CORRECTION ANALYSIS	V & V	DOCUMENTATION	DISPOSITION
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

FIGURE 3-6
HEO INDEX
KEWAUNEE NUCLEAR POWER PLANT
DETAILED CONTROL ROOM DESIGN REVIEW

SECTION 4

REVIEW PROCEDURES

4.1 OPERATING EXPERIENCE REVIEW

The operating experience review will consist of two parts: an examination of available documents, and a control room operating personnel survey. Through these two procedures, the review team can identify conditions that may interfere with human performance and which may be alleviated by the application of human engineering principles.

4.1.1 Examination of Available Documents

Kewaunee Nuclear Power Plant Incident Reports will be reviewed by the review team. Events that have occurred during the operating history of the plant, will be analyzed to identify control room operator errors and/or control room design deficiencies associated with those events. Events will be considered to be plant or system transients or any other conditions which interfere with the operators proper performance. Information relative to events identified by the review team, may be found in the following documents:

Operating Procedures
Final Safety Analysis Report
Maintenance Procedures
Control Room Logs
Technical Specifications
I&E Report Findings

Licensee Event Reports with generic applicability will also be reviewed. This review will, however, be limited to LER's for similar Westinghouse two-loop plants. These plants will include Prairie Island 1 and 2, Ginna and Point Beach 1 and 2.

Observations relative to these documents will be recorded on HEO forms. Supporting documentation may also be included for use during HEO Significance Assessment, HED Categorization and Correction Analysis.

Results

A written summary of the examination of available documents will include a complete list of the documents used and HEO forms as applicable.

4.1.2 Control Room Operating Personnel Survey

Objective

This survey is designed to document both problems and positive features of the Kewaunee Nuclear Power Plant control room by interviews of personnel from the operations staff of the power plant.

The questionnaire is designed to identify to the survey team perceived problem areas within the control room. During the interviews more detailed questioning will take place in problem areas identified from the questionnaire results.

Procedures

1. The survey will consist of two parts: Operating Personnel Questionnaire and Interviews.

   a. Operating Personnel Questionnaire

      (1) A sample questionnaire is provided in Exhibit 4-1. Each question has been designed to focus on designated subjects pertaining to the control room/operator interface.

      (2) A review team member will brief the personnel prior to distributing the questionnaire. The briefing will consist of the following:

         (a) Statement of confidentiality.

         (b) Identification of survey team members.

(c) Motivation of the respondent by assuring him that his views will be given serious attention.

(d) Request that respondents not confer with other respondents while completing the questionnaire.

(3) The questionnaires will be distributed to the following personnel:

(a) Control Operators.

(b) Shift Technical Advisors.

(c) Shift Supervisors.

(d) Reactor Technician.

(e) Reactor Engineer.

(f) Reactor Supervisor.

(g) Operations Engineer.

(h) Assistant Superintendent Operations.

(i) Operations Superintendent.

(j) Technical Supervisor.

(k) Operations Supervisor.

(4) Completed questionnaires will be sent to the review team leader.

(5) Responses to the questionnaire will be examined both individually and in aggregate to identify responses which are of value as HEOs. The individual or aggregate identification of troublesome areas will be the subject of more detailed questioning during the interviews.

b. Operating Personnel Interview

(1) Each interview will consist of the interviewee and two or three review team members.

(2) Instructions will be provided to the interviewers prior to the interviews, and interviewers will be familiar with guidance provided in Appendix E.

(3) One hour should be the maximum time allotted for each interview. Longer interviews could cause a decrease of interest in the interview process by the respondent and the interviewers. However, follow-up interviews will be scheduled if the need arises.

(4) At the conclusion of the interviews, the notes taken by the review team members will be compared. To assure the accuracy of the information received during the interview, a final copy of notes will be reviewed by the interviewee.

(5) Observations having the potential to cause a human error in the control room will be documented on HEO forms.

EXHIBIT 4-1

Sample Control Room Operating Personnel Questionnaire

Kewaunee Nuclear Power Plant

Name of Operator:__________________________ Date:______________

Position Title:_________________Time at this Title:_____________

Total Time as an Operator (Nuclear Plants):_____________________

Education/Degrees:______________________Shift:__________________

____

INTRODUCTION

The NRC has recently directed all utilities with an operating nuclear power plant to conduct a detailed control room design review, from which this survey evolves.

This questionnaire is not designed to review your proficiency as an operator but to draw out your special knowledge of control room operations and document the problems and positive system features that you have noted in the course of operations or preparation for operations.

Your answers will be considered strictly confidential and will be seen only by the review team members. After the review team examines all questionnaire responses, you will be interviewed. This interview will allow you the opportunity to expand on any issues brought up in this questionnaire.

Work Space and Environment

1. Can the plant be monitored from a primary operating area in the control room during the following plant operations?

   (Circle Yes or No.)

Startup Operations	Yes	No
Shutdown Operations	Yes	No
Abnormal Operations	Yes	No
Emergency Operations	Yes	No
Steady State Operations	Yes	No

2. Do tasks performed by other control room personnel interfere with your assigned tasks during the following plant operations?

   (Circle Yes or No.)

Startup Operations	Yes	No
Shutdown Operations	Yes	No
Abnormal Operations	Yes	No
Emergency Operations	Yes	No
Steady State Operations	Yes	No

3. Have you ever experienced difficulty locating a specific control or display? (Circle Yes or No.)

   Yes No

4. Do any routine tasks take you out of the control room? (Circle One.)

Never Rarely Sometimes Often

5. Personnel are injured in the control room during plant operations: (Circle one.)

Never Rarely Sometimes Often

6. Rate the following control room parameters: (Check one.)

	Poor	Fair	Good
Ventilation	____	____	____
Temperature/Humidity	____	____	____
Normal lighting	____	____	____
Emergency lighting	____	____	____
Noise Level	____	____	____
Control Room Layout	____	____	____
Desk/Counter Space	____	____	____

7. Is adequate seating available for operators assigned to the control room? (Circle one.)

Never   Rarely   Sometimes   Usually   Always

8. Do any of the following aspects of the control room environment interfere with your alertness? (Circle Yes or No.)

Physical Features (color scheme, noise, temp, lighting, etc)	Yes	No
Personnel	Yes	No
Operational Tasks	Yes	No

Panels

9. Fill in the matrix below using the following rate scale. A control room floor plan drawing (Figure 4-1) showing all panels can be found at the end of this questionnaire. Complete the matrix column-by-column for comparative rating purpose.

1 = Poor
2 = Fair
3 = Good
4 = Very Good
5 = Excellent

N/A = Not Applicable

	Acces-sibility	Logical Or-ganization	Labeling	Illumination from Room Lighting	Color Coding
Mechanical Console A					
Mechanical Console B					
Mechanical Console C					
Mechanical Vertical Panel A					
Mechanical Vertical Panel B					
Mechanical Vertical Panel C					
Electrical Vertical Panel A					
Electrical Console A					
Dispatch Deck					
SER Printer					
Aux. Feedwater Panel					

10. The space allocation for controls and displays on each of the following panels is: (Check one.)

	Inadequate	Adequate	Excessive
Mechanical Console A	_____	_____	_____
Mechanical Console B	_____	_____	_____
Mechanical Console C	_____	_____	_____
Mechanical Vertical Panel A	_____	_____	_____
Mechanical Vertical Panel B	_____	_____	_____
Mechanical Vertical Panel C	_____	_____	_____
Electrical Vertical Panel A	_____	_____	_____
Electrical Console A	_____	_____	_____
Aux. Feedwater Panel	_____	_____	_____

11 Rate the following systems (Check one.)

	Learning to Operate			Operating		
	Diff.	Avg.	Easy	Diff.	Avg.	Easy
Station & Instrument Air	_____	_____	_____	_____	_____	_____
Service Water	_____	_____	_____	_____	_____	_____
Condensate	_____	_____	_____	_____	_____	_____
Feedwater	_____	_____	_____	_____	_____	_____
Aux. Feedwater	_____	_____	_____	_____	_____	_____
Main Steam & Steam Dump	_____	_____	_____	_____	_____	_____
Steam Generator Blowdown	_____	_____	_____	_____	_____	_____
Heater & Moisture Sep. Drains	_____	_____	_____	_____	_____	_____
Bleed Steam	_____	_____	_____	_____	_____	_____

	Learning to Operate			Operating		
	Diff.	Avg.	Easy	Diff.	Avg.	Easy
Aux. Bldg. Special Vent.						
Aux. Bldg. Air Conditioning						
Aux. Bldg. Vent.						
Spent Fuel Pool Cooling						
Containment Spray						
Shield Bldg. Vent System						
Control Room Air Cond.						
Component Cooling						
Waste Disposal System						
Safety Injection						
Residual Heat Removal						
Chemical & Volume Control						
Reactor Coolant						
D.C. Supply & Distribution						
4160V Supply & Distribution						
480V Supply & Distribution						
Diesel Generator Electrical						
Electrical Generation						
Reactor Control & Protection						
Nuclear Instrumentation						
Circulating Water						
SER-Annunciator						
Fire Protection						

	Learning to Operate			Operating		
	Diff.	Avg.	Easy	Diff.	Avg.	Easy
Diesel Generator, Mechanical	____	____	____	____	____	____
Control Rod Drive	____	____	____	____	____	____
Turbine	____	____	____	____	____	____
Containment & Containment Isolation	____	____	____	____	____	____

12. Do you find the mimics helpful in performing your job?

(Circle Yes or No.)

Yes No

Annunciator Warning Systems

13. Rate the detection of incoming alarms during the following plant operations: (Check one.)

	Diff.	Avg.	Easy
Startup Operations	____	____	____
Shutdown Operations	____	____	____
Abnormal Operations	____	____	____
Emergency Operations	____	____	____
Steady State Operations	____	____	____
Shutdown Operations from Aux. Feedwater Panel	____	____	____

14. Do the annunciators provide an adequate status of normal operation?

(Circle Yes or No.)

Yes No

15. Does the alarm system provide adequate assistance during normal and abnormal operation? (Circle Yes or No)

Yes No

16. Rate the number of annunciator windows on each panel: (Check one)

	Inadequate	Adequate	Excessive
Mechanical Vertical Panel A	_____	_____	_____
Mechancial Vertical Panel B	_____	_____	_____
Mechanical Vertical Panel C	_____	_____	_____
Electrical Vertical Panel A	_____	_____	_____

17. Is printing legible on control room annunciator windows? (Circle Yes or No.)

Yes No

18. Are annunciators in proximity to the controls necessary to respond to alarms? (Circle Yes or No.)

Yes No

19. Do false or nuisance alarms ever interfere with the performance of your job? (Circle Yes or No.)

Yes No

20. The following questions pertain to annunciator Test-Acknowledge-Reset controls. (Circle Yes or No.)

Are these controls easily accessible during all operations?

Yes No

Are they in proximity to the annunciator windows involved?

Yes No

Are they of sufficient numbers in relation to the annunciator windows?

Yes No

Communications

21. Are there adequate communications between the following? (Circle Yes or No.)

CR and Auxiliary Operator	Yes	No
CR and Shift Supervisor	Yes	No
CR and Technical Support Center	Yes	No
CR and Emergency Operating Facility	Yes	No
CR and Radiological Analysis Facility	Yes	No
CR and Operational Support Facility	Yes	No
CR and Other Plant Facilities	Yes	No

22. Have you ever experienced any of the following problems regarding plant communication equipment? (Circle Yes or No.)

Equipment not Accessible	Yes	No
Lack of Equipment	Yes	No
Equipment Malfunctions	Yes	No
Operator Error in Equipment Usage	Yes	No
Excessive Background Noise	Yes	No

23. Does communications equipment interfere with control room instrumentation or controls? (Circle Yes or No.)

Yes No

Process Computer

24. Rate the information supplied by computer displays and/or printers to perform the following plant operations: (Check one.)

	Adequacy			Legibility		
	Inade-quate	Ade-quate	Exces-sive	Poor	Fair	Good
Startup Operations	____	____	____	____	____	____
Shutdown Operations	____	____	____	____	____	____
Abnormal Operations	____	____	____	____	____	____
Emergency Operations	____	____	____	____	____	____
Steady State Operations	____	____	____	____	____	____

25. Do you find the computer useful in your job? (Circle Yes or No.)

Yes No

Procedures

26. Indicate whether you have problems using any control room procedures due to reasons listed below: (Circle Yes or No.)

Labeling	Yes	No
Indexing	Yes	No
Storage location	Yes	No
Set not complete	Yes	No
Incorrect references to other procedures or control room devices	Yes	No
Formatting of Procedures	Yes	No

27. Do references and terms in the procedures agree with the labels on the control room panels and consoles? (Circle Yes or No.)

Yes No

28. Are there procedures which you find difficult to follow? (Circle Yes or No.)

Yes No

29. When using procedures, is there sufficient space to lay out the procedures so they do not interfere with controls or displays? (Circle Yes or No.)

Yes No

30. For the following operations, do applicable procedures adequately describe the required operator actions? (Circle Yes or No.)

Startup Operations	Yes	No
Shutdown Operations	Yes	No
Steady State Operations	Yes	No
Abnormal Operations	Yes	No
Emergency Operations	Yes	No
Shutdown from Aux. Feedwater Panel	Yes	No

Staffing and Job Design

31. In your opinion, what is the optimal number of control room operators needed to operate the plant during the following conditions: (Fill in all spaces.)

	Super.	Control Oper.	Aux. Oper.	Equip. Oper.
Startup Operations	____	____	____	____
Shutdown Operations	____	____	____	____
Abnormal Operations	____	____	____	____
Emergency Operations	____	____	____	____
Steady State Operations	____	____	____	____

32. Describe any aspects of your recordkeeping duties that either enhance or detract from your job performance.

33. Do you feel that overtime or extended shifts degrade your job performance? (Circle Yes or No.)

Yes No

34. Do you feel that too many functions are performed automatically during: (Circle Yes or No.)

Startup Operations Yes No

Shutdown Operations	Yes	No
Abnormal Operations	Yes	No
Emergency Operations	Yes	No
Steady State Operations	Yes	No
Shutdown Operations from Aux. Feedwater Panel	Yes	No

35. Do you feel that too many functions are performed manually during: (Circle Yes or No.)

Startup Operations	Yes	No
Shutdown Operations	Yes	No
Abnormal Operations	Yes	No
Emergency Operations	Yes	No
Steady State Operations	Yes	No
Shutdown Operations from Aux. Feedwater Panel	Yes	No

Workload Analysis

36. In your opinion do any systems operated from the control room require too much attention during the following operations? (Circle Yes or No.)

Preventive Maintenance	Yes	No
Startup Operations	Yes	No
Shutdown Operations	Yes	No
Abnormal Operations	Yes	No
Emergency Operations	Yes	No
Steady State Operations	Yes	No

37. Describe how you would respond to an excessive number of annunciator alarms?

38. Do you experience physical fatigue while performing any control room task? (Circle Yes or No.)

Yes No

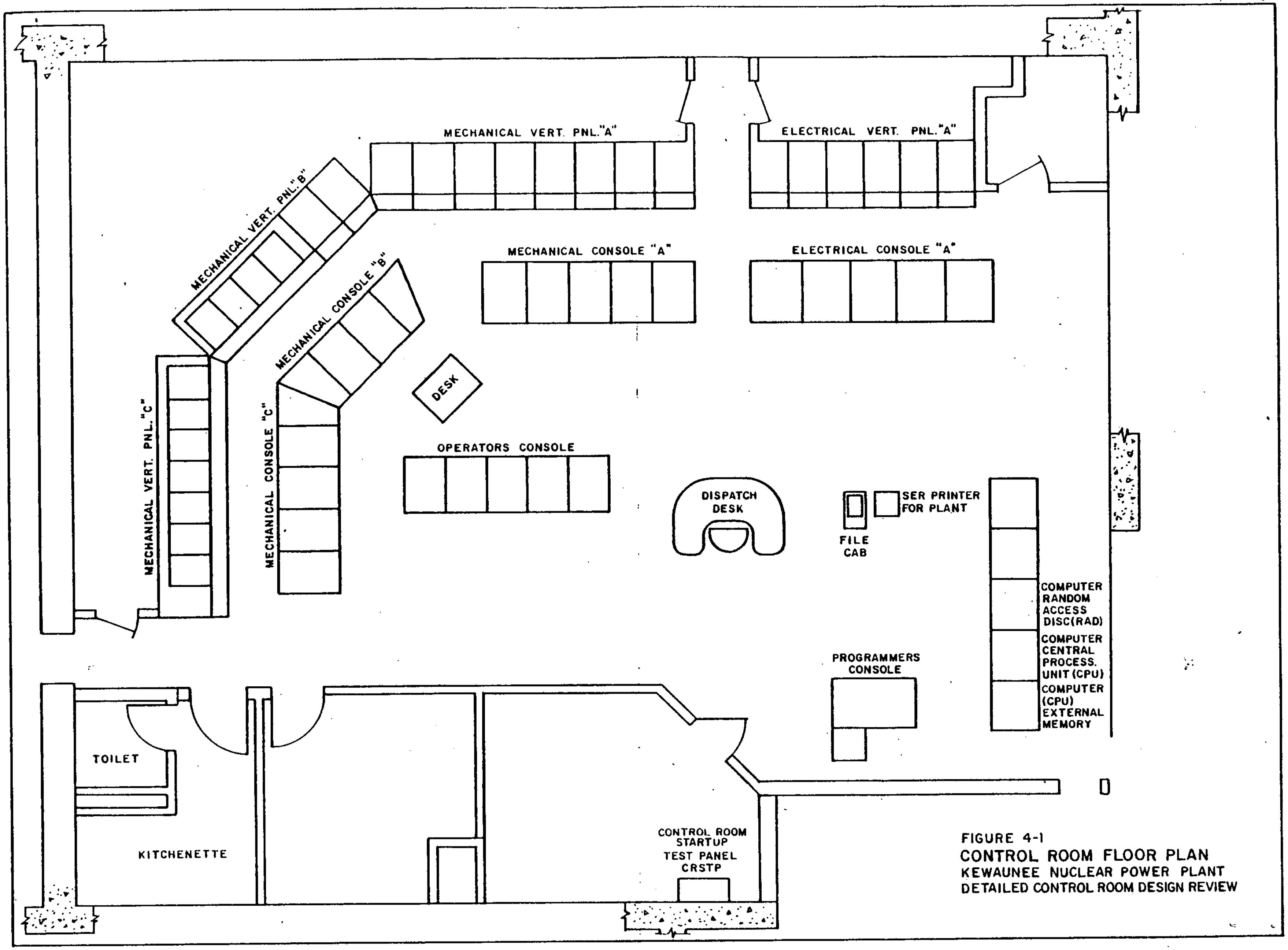


FIGURE 4-1
CONTROL ROOM FLOOR PLAN
KEWAUNEE NUCLEAR POWER PLANT
DETAILED CONTROL ROOM DESIGN REVIEW

4.2 SYSTEM REVIEW AND TASK ANALYSIS

4.2.1 Purpose

The primary purpose of the system review and task analysis (SRTA) is to systematically identify and assess operator task and instrumentation and control requirements. A secondary objective of the SRTA is to develop documentation that supports procedure development and operator training. Although tasks may be performed by equipment or personnel, the task analysis described in this effort includes only control room operator tasks.

4.2.2 Approach

In accordance with NUREG-0737, Item I.C.1, the Westinghouse Owners Group (WOG) performed a re-analysis of transients and accidents and prepared a set of Generic Emergency Response Guidelines (ERG's). A program to develop plant specific procedures, based on these guidelines, will be established.

In addition to the ERG's, the Westinghouse Owners Group developed System Review and Task Analysis (SRTA) documentation. The SRTA project provides generic system review and task analysis documentation based on the Emergency Response Guidelines. This data base of operator task requirements and the supporting documentation is a generic product that will be adapted and augmented by the review team to develop plant specific documentation.

The task analysis identifies the event sequences, plant systems, operator functions and the operator tasks required to implement the emergency procedures. The individual tasks and subtasks are analyzed to identify their constituent elements. The following list summarizes the basic elements for which each task and subtask has been analyzed:

- Task Objective

- Task Decision Requirements
- Task Knowledge Requirements
- Task Instrumentation Requirements
- Task Action Requirements
- Task Control Capability Requirements
- Consequences of Task Error/Omission

A sample task element table is shown in figure 4-2.

4.2.3 Procedure

The review team will develop a set of plant specific technical guidelines to be used in converting the generic task analysis to a KNPP specific task analysis. The following major items should be considered:

- mechanics of conversion
- documentation requirements

Conversion of the generic task analysis should be accomplished concurrently with development of the plant specific emergency procedures. As each procedure is completed, a copy should be given to the review team. Those tasks identified in the procedure may then undergo conversion. It is anticipated that the plant specific documentation will be completed soon after completion of the plant specific emergency operating procedures.

4.2.4 Documentation

The documentation produced during this phase of the review will include plant specific Task/System Sequency Matrices, Task Element Tables and Instrumentation Requirements Tables and Control Requirements Tables.

ELEMENT TABLE — TASK E00.1

Function - Verify Automatic Actuations

Task - E00.1 Verify Reactor Trip

Task Objective

- To ensure that the reactor is tripped

Task Decision (Criteria) Requirements

- To determine if the reactor is tripped (control rods inserted and neutron flux decreasing)

Task Knowledge Requirements

- Relationship of rod position and neutron flux in indicating a reactor trip

Task Instrumentation (Criteria) Requirements

- Control rod position indication (rods inserted):
  - Rod bottom lights
  - Rod position indication

- Reactor core neutron flux indication (flux decreasing):
  - Power range neutron flux indication
  - Intermediate range neutron flux indication

Task Action (Criteria) Requirements

- If reactor is tripped, go to next task
- If reactor is not tripped, perform subsequent actions:
  - Manually trip reactor
  - If reactor is manually tripped, go to next task
  - If reactor cannot be manually tripped, go to Task C10.1 and monitor CSF status trees

Task Control Capability (Criteria) Requirements

- Switches to manually trip reactor

Consequences of Task Error/Omission

- If the reactor is not tripped, task error/omission will result in continued power generation with potential severe consequences.
- The consequences of task error/omission are minimized by the CSF status trees. Failure of the reactor to trip will be detected via operator monitoring of the CSF status trees (Subcriticality). The subject failure is the highest priority challenge to a CSF.

FIGURE 4-2
SAMPLE TASK ELEMENT TABLE
KEWANEE NUCLEAR POWER PLANT
DETAILED CONTROL ROOM DESIGN REVIEW

4.3 CONTROL ROOM INSTRUMENTATION AND EQUIPMENT INVENTORY

4.3.1 Purpose

The control room inventory will establish a reference set of data which identifies all instrumentation, controls, and equipment within the control room, for comparison with the requirements identified through the analysis of operator tasks (Section 4.2). This will be accomplished by itemizing and cataloging all devices in the control room used by operators to control and monitor plant conditions. The inventory will also include those additional systems (Dedicated Shutdown Panel, the plant computer, and safety parameter display system (SPDS) which are scheduled for installation. It will not include the present plant computer.

4.3.2 Objectives

The objectives of the inventory are to gather or produce:

1. A detailed list of all controls, indicators, annunciators, communications devices, computer input/output (I/O) devices, and other devices located in the control room.

2. A list similar to that produced in number 1 for the Dedicated Shutdown Panel.

3. Identification of manufacturers' drawings for devices listed in numbers 1 and 2 above.

4. A list of all nameplate and annunciator window engravings in the control room and Dedicated Shutdown Panel.

5. Software specifications, keyboard and work station arrangement drawings, computer printouts, and graphic display drawings to be used in the plant computer system and the SPDS.

6. Photographs of the control room and of each panel in the control room to produce a photo-mosaic.

7. A list of all procedures, checklists, drawings, and other documentation required in the control room and Dedicated Shutdown Panel.

8. A list of abbreviations, color coding, and layout conventions used in the control room, dedicated Shutdown Panel, and in computer displays (refer to Appendix C).

9. Verification of all of the above by comparison with control room panels and the Dedicated Shutdown Panel.

4.3.3 Procedure

The detailed list of control room devices will be derived from the existing instrument list. It will be checked and updated from control board layout drawings. Annunciators will be treated as separate sub-panels and annunciator windows as individual control room devices.

The following information will be gathered for each control room device:

1. System number and equipment identification number of each device controlled.

2. Valve type and number (if available).

3. Service description/function.

4. Instrument number.

5. Panel and sub-panel location.

6. Description of device (manufacturer's model number).

7. Range.

8. LER number associated with device (if applicable).

9. Incident report number (if applicable).

The following additional information will be gathered for each control room device as it becomes available:

1. Emergency operating procedure (EOP) reference.

2. Task reference.

3. HED number (if applicable).

4. HED type.

5. Photo reference number.

6. Remarks.

The communications system will be treated as a panel and each communications device as a separate control room device. Each computer system will be treated as a separate panel. Each I/O device will be treated as a sub-panel. Information will be gathered to facilitate panel-to-panel comparison.

The same procedure will be used to gather information for the Dedicated Shutdown Panel.

As various types of devices are identified in the inventory, the applicable manufacturer's drawings (outline and internal) will be listed.

A list of nameplates and annunciator window engravings will be produced from panel layout drawings, engraving listings, and existing control room photographs or existing computer files.

Photographs of the control room and control boards will be taken and be combined into a photo-mosaic. Additional photographs will be taken as required to produce the necessary clarity for close-up examination. An authorized list of abbreviations and color coding conventions, along with other preferred control room conventions, will be prepared and included in the project library. The adequacy of the above information will be verified by a review of the control room and Dedicated Shutdown Panel.

4.3.4 Documentation

The control room and Dedicated Shutdown Panel inventory will be maintained for each device and entered into the document management system. It will be possible to sort the information in the following ways:

1. System code
2. Instrument number (shown as "Mark Number" on layout drawings).
3. Panel location number.
4. Device description.

5. LER number.

6. EOP reference.

7. Task identification number.

8. HED number.

9. HED type.

10. Photo reference number.

11. Incident report number.

4.4 CONTROL ROOM SURVEY

Purpose

The purpose of the control room survey is to determine whether components installed in the control room are well designed for use by humans and whether the control room environment provides acceptable working conditions for operators. Further, the control room survey will examine the consistency of control room conventions, as well as the adequacy of the control room to fulfill some requirements determined from both the system review and task analysis (Section 4.2), and the verification of task performance capabilities (Section 4.5). To do this, the survey will be divided into the nine sections indicated below.

1. Control Room Workspace.
2. Communications.
3. Annunciator Warning Systems.
4. Controls.
5. Visual Displays.
6. Labels and Location Aids.
7. Process Computers.
8. Panel Layout.
9. Control - Display Integration.

Objective

The objective of the control room survey is to evaluate the control room against established human factors guidelines. The term "established guidelines" as used in this report refers to human factors standards established for the nuclear industry by various agencies such as the Nuclear Regulatory Commission (NRC), the Electric Power Research Institute (EPRI), and the Institute of Nuclear Power Operations (INPO).

Procedure

Compliance checklists will be developed using sound human engineering criteria established for the nuclear industry. The review team will extract the necessary information from the referenced documents and reformat that information for the control room survey. The checklists will organize guidelines under the broad categories listed in this section under "Purpose." The checklists will then be used to evaluate each plant system and component represented in the control room.

While most of the checklist items are applicable at the component level, some guidelines apply to the specific use of instruments and equipment, task sequence requirements, communications requirements or other aspects of dynamic operation. These dynamically oriented guidelines are most appropriately addressed from the task or function perspective as described in section 4.6.

Documentation

The documentation produced during the survey will consist of evaluation sheets for each device or group of devices, compliance checklists for all guidelines, and HEO forms and supporting documentation for all HEOs. All documents will be filed by guideline number.

4.4.1 Control Room Workspace Survey

Purpose

The purpose of the control room workspace survey is to assess the adequacy of the control room as a workplace.

Objectives

The control room workspace survey will:

1. Evaluate whether adequate instrumentation and controls, sufficient to meet the requirements of normal operation and to detect and mitigate abnormal conditions, are located in the control room.

2. Evaluate whether the control room manning is suited to the layout.

3. Evaluate furniture and panel dimensions and layout for their suitability as operator workspaces.

4. Evaluate the control room environment.

Procedure

1. The function review and task analysis (Section 4.2) will provide a list of required controls and displays. This list will be compared to the control room inventory list. Items which are missing from the control room will be documented as HEOs.

2. The task analysis and simulator exercises (Section 4.6) will be used to evaluate the adequacy of control room manning for the control room layout. Interferences in the traffic pattern, time or space conflicts, and lack of proper coverage of controls and displays will constitute HEOs and will be documented as such.

3. The furniture and panel dimensions and layout will be evaluated for suitability of use by operators.

4. The control room environment will be evaluated in accordance with established guidelines using appropriate instrumentation for ambient noise, lighting, and HVAC.

<u>Documentation</u>

All panel, furniture, and environmental measurements will be recorded. HEO forms will be completed for measurements which exceed guideline recommendations.

4.4.2 Communications Survey

<u>Purpose</u>

The purpose of the communications survey is to assess the adequacy of the various communications systems used in the control room. The survey will also include assessment of the intelligibility of signals in various plant locations.

The following communications systems will be evaluated:

1. Gai-Tronics.

2. Walkie-Talkies.

3. Bell Telephone.

4. Ring Down (Blue) Telephone.

5. Auditory Signals (such as the evacuation alarm).

6. NAWAS.

7. Red Phones.

8. Yellow Phones.

9. Paging System.

10. Sheriff Radio.

11. Dedicated Shutdown Panel Communications System.

Objective

The objective of this portion of the survey is to evaluate the adequacy of each communications system. Hardware evaluation will be conducted for appropriate equipment in the control room as well as in selected high noise areas in the plant where information would have to be communicated to the control room. For inclusion in the control room inventory, each communications system will be treated as a separate panel.

Procedure

All communications systems will be evaluated using compliance checklists developed by the review team.

Documentation

The results of all measurements and inspections will be recorded. HEO forms will be completed (with supporting photographs or other data attached) for each aspect of the hardware or system capability which does not meet guideline standards.

4.4.3 Annunciator Warning System Survey

Purpose

The purpose of the annunciator warning system survey is to evaluate the functional adequacy of the annunciator warning system. This evaluation will cover the appropriateness of variable selection, the suitability of the hardware to support the operator, and the ease of operation.

In addition, the system operating procedures will be examined. Evaluation of the adequacy of set points will be limited to:

1. Nuisance alarms identified in the operating experience review.

2. Time needed by operators to respond to alarms which initiate task sequences chosen for the system review and task analysis.

Objective

The annunciator warning system survey will:

1. Define the requirements for alarms needed to initiate event sequences evaluated in the system review and task analysis and compare them with the actual alarms provided.

2. Compare alarm set points for those alarms defined above with actual alarm set points. Determine the cause and extent of nuisance alarms.

3. Compare system capabilities with established guidelines.

4. Evaluate the viewing field and positioning of each annunciator.

5. Compare annunciator engraving, color coding, and controls with established control room conventions (Appendix C).

6. Evaluate the procedures and controls used to operate the annunciator warning system.

Procedure

1. The system review and task analysis will evaluate a series of event sequences. Alarms necessary to initiate operator response to the individual event sequences will be defined. The listing of those alarms will be an input to the verification of task performance capability (Section 4.5). The control room inventory data base will provide a listing of the actual alarms provided. Differences in the provision of necessary alarms will be documented on an HEO form. Unnecessary alarms identified by the function review and task analysis will be noted for later evaluation as HEOs.

2. Alarm set points (required and actual) will be compared for those alarms listed above. The operating personnel survey will serve as the primary means of identifying nuisance alarms. Variances in set points and alarms will be listed as HEOs.

3. Hardware capabilities will be evaluated for all annunciators and annunciator controls, using the guidelines.

4. Using the guidelines for viewing distance and viewing angle, a sketch will be made showing the acceptable viewing field for each annunciator. These sketches will be used to evaluate the size and angle to the operator's line of sight of all annunciators. The viewing field limits will be marked on mosaics (Diazo prints) of control board and control room drawings.

5. All annunciator windows will be evaluated for conformance to written control room conventions and examined to determine whether any other conventions apply.

6. The annunciator operating procedures will be examined for clarity and ease of use. Troublesome areas will be identified from the operating experience review (Section 4.1).

<u>Documentation</u>

The results of all inspections and evaluations will be recorded. A list of HEOs will be produced from the set point evaluation. HEO forms will be completed for all other instances in which the actual installation does not conform to the guidelines.

4.4.4 Controls Survey

<u>Purpose</u>

The purpose of the controls survey is to evaluate all control devices in the main control board, Dedicated Shutdown Panel, and communications and computer panels with regard to the physical design of the component, its suitablity to its application, and its consistency of application.

Objectives

The controls survey will:

1. Verify that controls meet human factors guidelines for dimensions and operability.

2. Verify that the controls can fulfill the range and accuracy requirements demanded of them.

3. Verify that control room conventions are consistently applied.

Procedure

1. Established guidelines will be used to assess the dimensional and operability requirements. Typical examples of each control will be examined in detail, and all other similar controls will be examined by inspection. In cases where distances appear to vary from the typical values that were measured, additional measurements will be made.

2. The functional requirements for range and accuracy will be defined from the system review and task analysis (Section 4.2). A comparison will be made between these functional requirements and actual range and accuracy. (Refer also to Section 4.5.)

3. Control room conventions will be included in the Control Room inventory. All controls will be examined to determine their con-

formance with established control room conventions. In addition, controls will be examined to determine wehther any patterns or "unwritten" conventions exist.

Documentation

All measurements (force, angle of control movement, etc.) will be recorded. Measurements which exceed limits established in the guidelines will provide the backup information to support citing an HEO. The control room inventory will be amended with additional information (such as range) as it becomes available.

4.4.5 Visual Displays Survey

Purpose

The purpose of the visual displays survey is to evaluate all analog, digital, and status display devices for consistency of application with control room conventions and suitability to fulfill their application in the control room. This portion of the control room survey will include:

1. Indicators.
2. Meters.
3. Recorders
4. Status Lights.
5. Legend Lights.
6. Drum Counters.
7. Digital Counters.
8. Indicator Portion of Hand Indicating Controllers.

Objectives

The visual displays survey will:

1. Analyze visual display design for suitability to its intended use.

2. Evaluate physical characteristics of displays for suitability of use by operators.

3. Evaluate the ease of maintaining and servicing the displays.

4. Evaluate consistency of display design/application with other control room conventions.

Procedure

1. The system review and task analysis (Section 4.2) will define what information is required to be displayed for each task sequence analyzed. Comparison will be made between actual range and required range as defined by the function review (refer also to Section 4.5). The display design should reflect direct measurement of the variable. Failure of the display should be detectable by the operator.

2. The physical characteristics of all visual display devices will be evaluated against the guidelines and for consistency.

3. Maintenance and servicing actions will be reviewed for compliance with guidelines. In addition, consistency with spare parts and tools will be verified.

4. Conventions applied to visual display devices will be documented as they are identified and compared to existing control room conventions.

Documentation

All evaluations and inspections will be recorded. As additional unwritten conventions are discovered, they will be added to the list of control room conventions. Deviation beyond guideline limits and lack of consistency will be documented and included on HEO forms.

4.4.6 Labels and Location Aids Survey

Purpose

The purpose of the labels and location aids survey is to assess the adequacy and consistency of use of these aids in supporting the operator. All labels and location aids, as well as the administrative procedures used to control their design and installation, will be evaluated.

Objectives

The labels and location aids survey will:

1. List all control room and Dedicated Shutdown Panel devices which are not labeled.

2. Define the convention used for hierarchical labeling in the control room.

3. Evaluate all labels for adequacy of character font, style, color, orientation, and location.

4. Evaluate control room labels for adequacy and appropriateness of information as well as for consistency in use of abbreviations or acronymns.

5. Examine location aids installed in the control room for consistency of application and define additional areas where location aids should be used.

6. Evaluate the Administrative Control Directives or Engineering Control Directives used to design and control the addition of labels, annunciator window engraving, and location aids (both temporary and permanent).

7. Evaluate the consistency of terminology between control room devices and operating procedures or other written aids.

Procedure

1. Control panels will be examined to determine whether all devices are labeled. Devices not labeled will be documented as HEOs.

2. Existing labels will be examined to determine the extent of hierarchical labeling used.

3. All labels will be examined for conformance with lettering and location guidelines.

4. Labels on control room devices will be examined for the adequacy on the information presented. Results of the system function

review and task analysis (Section 4.2) will also be used as a guide for evaluating the label's appropriateness to its particular application.

5. Some location aids (mimics and demarcation lines) are installed in the control room. Conventions used in their application will be verified and conformance to guidelines verified. Areas which do not use location aids will be examined for the possibility of incorporating some or all aids to assist operator performance.

6. Administrative Control Directives and Engineering Control Directives covering the design and control of location aids will be evaluated for conformance with guidelines. Labels produced according to the procedures should meet appropriate human factors standards.

7. The consistency of terminology between operating procedures and alarms/controls will be evaluated for consistency and ease of use. Procedures will be evaluated to determine whether alarms and controls can be easily located. This evaluation will be performed in both directions: from alarm to procedure and from procedure to alarm/control.

Documentation

All inspections and evaluations will be recorded. Deviations from the guidelines will be documented on HEO forms with appropriate supporting material (i.e., drawing reference, picture reference, measurements, etc). The location aids conventions used in the control room will be documented and the administrative procedures for the design and control of location aids will be updated to reflect recommended changes and additions. Changes or additions to the cross-indexing methods used will be recommended as appropriate.

4.4.7 Process Computer Survey

Purpose

The purpose of the process computer survey is to verify that the hardware, documentation, display, and operator interaction will meet acceptable human engineering standards.

Scope

The survey will be limited to the new Plant Process Computer System and the Safety Assessment System (SAS) which are currently being designed. Thus, this portion of the detailed control room design review will serve to ensure that adequate human engineering, which is consistent with the present control room design, is incorporated into the design of the new computer systems.

The existing plant process computer system will be removed and will not be covered by this review.

Objectives

The process computer survey will:

1. Evaluate the organization and layout of operator work stations and other hardware devices.

2. Evaluate the operator interaction required by both computer systems.

3. Examine proposed operating procedures and data indices.

4. Evaluate cathode ray tube (CRT) graphic displays for adequacy of size, color, and style, etc, used.

5. Evaluate the methods used to display information and messages, both on the CRTs and on the printers.

Procedure

The following procedure will be performed using engineering drawings, specifications, and other design documents. In all cases, consistency between the control room conventions, the plant process computer system, and the SAS will be checked.

1. The hardware design drawings will be checked against the guidelines for adequacy of space and appropriate layout.

2. Planned interaction between man and machine (including security requirements) will be checked. This check will consist of a review of design documents or a request for information from the computer vendor.

3. Proposed operating procedures and data indices (such as a set point list) will be reviewed for their consistency with

operating procedures and for their conformance to the guidelines.

4. Proposed graphic displays will be examined for conformance with the guidelines. If all graphic displays are not designed, then the design conventions to be used in their designs will be evaluated for conformance to the guidelines and control room conventions.

5. Methods used to display information, such as piping and instrumentation diagrams (P&IDs), menus, and lists will be evaluated with reference to the particular function being served.

Documentation

All evaluation activities will be recorded and will show the applicable page or drawing reference.

Deviations from the guidelines will be documented as HEOs, as will instances where the existing control room conventions for color, motion, etc, are not properly applied to the design of the computer systems.

4.4.8 Panel Layout Survey

Purpose

The purpose of the panel layout survey is to verify that panel devices are properly organized to support operations and emergency procedures.

Objectives

The panel layout survey will:

1. Evaluate panel layout for its ability to satisfy functional requirements and support task sequences.

2. Evaluate existing demarcation and grouping methods and identify any unwritten conventions.

3. Identify those areas where additional demarcation of controls and displays is needed.

4. Examine the panels to determine whether control and display spacing meets guideline minimums.

Procedure

1. The system ~~function~~ review and task analysis (Section 4.2) will provide all the input required. Each area analyzed will be examined to determine whether the control/display arrangement supports the operations. High priority and high frequency of use controls will also be identified and their locations checked.

2. All existing demarcation lines and other means of identifying device grouping will be identified and compared with the written control room conventions.

3. Areas which do not use some means to show functional grouping will be identified as HEOs. These areas will be shown on a set of control board layout drawings.

4. Panel layout drawings will be examined along with the manufacturer's drawings of control room devices to determine actual spacing between devices. These spacings will be compared with guideline minimums. Devices with marginal spacing will be measured in the control room to determine suitability.

Documentation

All evaluations and inspections will be recorded. Inconsistencies in the panel layout supporting task sequences will be documented as HEOs, as will all other instances where the guideline standards are not met. Any undocumented conventions for grouping or demarcation will be added to the list of control room conventions.

4.4.9 Control - Display Integration Survey

Purpose

The purpose of the control-display integration survey is to identify all relationships between controls and displays and to verify that the installation and design support these relationships.

Objectives

The controls-display integrating survey will:

1. Identify all control-display pairs and groups.

2. Evaluate the installation of control-display pairs and groups in control room panels.

3. Evaluate both the physical characteristics and system design of control-display pairs and groups against guidelines.

Procedure

1. The system review and task analysis (Section 4.2) will identify control-display relationships. These will be listed for use in the following step.

2. The arrangement used in the installation of all control-display pairs and groupings will be checked.

3. The physical characteristics of control devices and the system response characteristics will be evaluated against guidelines. HEO forms will be completed for those instances where guidelines are not met.

Documentation

Displays without associated controls will be documented as HEOs. Those controls and displays which do not meet guidelines, as well as those which depart from established control room conventions, will be listed as HEOs. Conventions which are not documented will be added to the list of control room conventions.

4.5 VERIFICATION OF TASK PERFORMANCE CAPABILITIES

4.5.1 Purpose

The task performance capabilities verification will assess the adequacy of control room instrumentation to support execution of operator tasks and will identify problems that may affect task performance.

4.5.2 Scope

The verification process will be based on the system review and task analysis (Section 4.2). Since the events analyzed reflect the spectrum of plant operations, and the systems are the key plant systems, this assessment will be comprehensive.

4.5.3 Approach

The verification process will consist of two parts. In the first part, the display/control requirements resulting from the system review and task analysis will be compared with the inventory of control room devices (Section 4.3). This comparison will be made to determine the availability of instruments in the control room which meet these display/control requirements and also to assess the adequacy of the instrument design specifications. This part is called the "verification of availability."

In the second part, a determination will be made as to whether the control room displays/controls are effectively designed from a human engineering standpoint to support task accomplishment. This part is called "verification of human engineering suitability" and will consist of a followup survey of all applicable guidelines using the results of the system review and task analysis (Section 4.2).

4.5.4 Procedure

<u>Verification of Availability</u>

The display/control requirements resulting from the system review and task analysis (Section 4.2) will be compared with the listing of control room devices developed from the control room inventory (Section 4.3). This listing will be obtained from a computer sort of control room devices contained in the control room inventory using such key parameters as panel category, panel location, applicable system code, and/or device controlled. A comparison will be made between the control room inventory printout of the devices and the display/control requirement to identify the applicable devices. In addition, a comparison between the specifications associated with the required display/control in the task element table and the actual specifications for the applicable control room device will be made.

The following information will be added to the task element table:

1. Instrument number of the device which meets the display/control requirement.

2. Code, which indicates the degree to which the device meets the specification requirement.

    S - Device satisfactorily meets all specification requirements

P - Device meets specification requirements only partially, e.g., display range of parameter X is from A to B, whereas display specification requires a range from A to C.

For each control room device which is found to meet a display/control requirement, the following information will be added to the control room inventory: applicable task identifier from the task element table and applicable code (S or P). Following completion of the comparison process, evaluation of the results will be performed and HEOs identified.

HEOs will be prepared for task display/control requirements for which no control room device was located and/or for which the applicable device meets the specification requirements only partially.

Verification of Human Engineering Suitability

Using the results of the system review and task analysis, a followup survey of all applicable guidelines will be conducted. This will be done to identify those guidelines which require consideration of the analysis results and to evaluate or re-evaluate the findings of applicable guidelines based on the analysis results. Checklists to support the control room survey (Section 4.4) will be used. HEO forms will be prepared for all cases of partial compliance or non-compliance with applicable guidelines.

4.6 CONTROL ROOM VALIDATION AS AN INTEGRATED SYSTEM

4.6.1 Purpose

The purpose of validating control room functions and overall system integration is to determine whether the control room's physical and organizational designs have been integrated so that the functions allocated to the control room operating personnel can be accomplished effectively. Validation of functions should demonstrate that adequate manual controls, automatic controls, monitoring systems, and trained operators are provided to ensure that plant parameters do not exceed acceptable predefined operating boundaries, such as those defined by the technical specifications for operations.

The process of validation will provide an opportunity to identify HEOs which may not have become evident in other processes of the system review. Validation also will provide the opportunity to see how HEOs from earlier processes come into play during interactive plant operations. The process of verification of task performance capabilities will be conducted to assure that operator tasks can be performed in the existing control room with a minimum potential for error. This process will analyze availability of equipment to perform specific tasks and will evaluate the man-machine interfaces of individual work stations and operators. The task of validating system integration is distinct from verification of task performance capabilities because it places the emphasis on function execution and the interrelationship of the work stations and operating personnel.

This process will assess the ability of plant operators to ascertain and evaluate overall system status during normal and emergency plant operations and to respond properly according to set procedures. The collective ability of the existing display and control systems to support proper operator functions is the key concern.

For example, the number and format of plant parameters displayed, the number and types of controls provided, and the dynamic response of instruments/displays/indicators have a major effect on operator workload (physical and mental). Integrated display of a small number of plant parameters may impose a manageable mental workload so that an operator may correctly ascertain plant status. Conversely, the display of too many parameters, poor display integration or dispersion, inconsistency or slow response time of displays may necessitate division of human responsibility; this may result in confusion and prolong the time required before the correct state of the plant process, and the safety implications of that state, can be determined. Under these conditions, the operators may not be able to correctly ascertain plant process status required to perform the proper actions to maintain safe and effective plant operation.

In addition to man-machine interface studies, studies of the interaction of operating personnel will be conducted. The purpose of these studies will be to determine whether the size, composition, and integrated functions of the operating crew are appropriate. The performance of the control room operating crew as a unit may be assessed during power plant operations on the Kewaunee Simulator. Any deficiencies in traffic patterns, communications, and operation task performance related to personnel interaction will be identified.

4.6.2 Approach

Observation and evaluation of operating personnel performance dynamics will be conducted in part by having operating personnel conduct a series of events on the Kewaunee Simulator. Operator workload, effects of the arrangement of functionally related instrumentation, and feasibility of task completion can then be assessed. This phase of the CRDR will be scheduled around the delivery of the Kewaunee Nuclear Power Plant Simulator. The Kewaunee Simulator is currently scheduled to be released for use in January of 1984.

Event sequences which reflect the spectrum of normal and emergency plant operations will be selected for simulation. The event sequences will be developed based on events identified in Section 4.2.

Operations on the simulator will be tape recorded (audio and video) for later analysis as required. Debriefing and tape review sessions will be scheduled to follow the simulator sessions. Participants should aid the investigators in the analysis of the recorded performances.

4.6.3 Procedure

Planning of Simulator Operations

As stated previously, alternative event sequences for walkthroughs will be developed from operating procedures and from system review and task analysis (Section 4.2) results. The following event sequences will be conducted because of their importance to plant operation and safety:

1. Small break loss-of-coolant accident (LOCA).

2. Inadequate core cooling (ICC).

3. Anticipated transient without scram, following loss of offsite power (ATWS).

4. Multiple failures of tubes in a single steam generator and tube ruptures in both steam generators.

5. Reactor startup.

6. Reactor shutdown or refueling.

This list of events contains generic transients and accident conditions. The results of the operating experience review (Section 4.1) may indicate additional events in which operator performance is significant and should be included in the simulator operations phase.

The following information from the system review and task analysis (Section 4.2) will be compiled for each scheduled event:

1. Systems and system functions incorporated into event sequences.

2. Control room operator tasks related to each sequence.

This information will be reviewed to determine whether the following criteria have been met:

1. The set of event sequences involves all work stations.

2. The set of event sequences tests the operator's ability to monitor for component failures while executing operational tasks under acceptable operating crew workload levels.

If the set of event sequences will not satisfy both criteria, event sequences will be added or modified until the criteria are met. Additional event sequences will be selected from other events analyzed in the system review and task analysis (Section 4.2) or from Section 14 (Accident Analyses) of the FSAR.

Once a complete set of event sequences is selected, the following tasks will be performed:

1. Timelines will be prepared for each event sequence showing sequencing, frequency, and duration of task actions. A sample timeline is shown in Reference 1.

2. Traffic diagrams will be prepared for each event sequence. A color-coded or line-coded composite of all operator traffic patterns will be prepared. A sample traffic diagram is shown in Reference 2.

3. Methods and measures for evaluating operator workload and performance will be selected.

4. Methods and formats for documenting simulator exercises will be established. The same formats for timelines and traffic diagrams developed during exercise planning will also be used for documenting actual simulator exercises.

To prepare for the simulator exercises, the following steps will be performed:

1. Identify, select, and schedule times for the simulator exercises.

2. Identify, select, schedule, and notify operating personnel for simulator exercise participation. Exercises will be conducted using an entire or partial normal operating shift depending on the specific event sequence being studied. Operating personnel should be selected so that the range of experience is as broad as possible. Each event sequence simulation will be performed twice by each of two separate shifts, when possible.

3. Make arrangements to carry out the exercise preparations (i.e., videotaping equipment setup, work station modification, observer station setup, etc).

    a. Prepare a briefing for participants to communicate the purpose and specific objectives of the exercise. The briefing will include a description of the operating situation/scenario along with initial conditions. Care should be taken to not include information which would bias the thoughts and actions of the participants.

b. Prepare a checklist of observations to be made, measurements to be taken and questions to ask participants before, during, and after the exercise. Questions should be designed not to interfere with the timing of the event sequence when real-time measurements are important.

c. Prepare schedule to conduct the simulator exercises.

<u>Simulator Exercise Procedure</u>

Generic activities to perform during the simulator exercises are given below and are subject to change upon the actual design of the exercises. Figure 4-3 illustrates a sample sequence of simulator activities.

Time Study

Only time limits for each action/activities for time critical event sequences will be determined. Timelines will be produced showing the sequence, frequency, and duration of actions/activities. The same formats will be used as those prepared for the exercise. This activity may be performed during the review of the videotapes.

Traffic Analysis

The traffic patterns of each operator will be drawn on a floor plan of the control room using a color or line code to differentiate operators. This activity may also be performed during the review of the videotapes. The floor plan shown in Figure 4-1 will be used for this purpose.

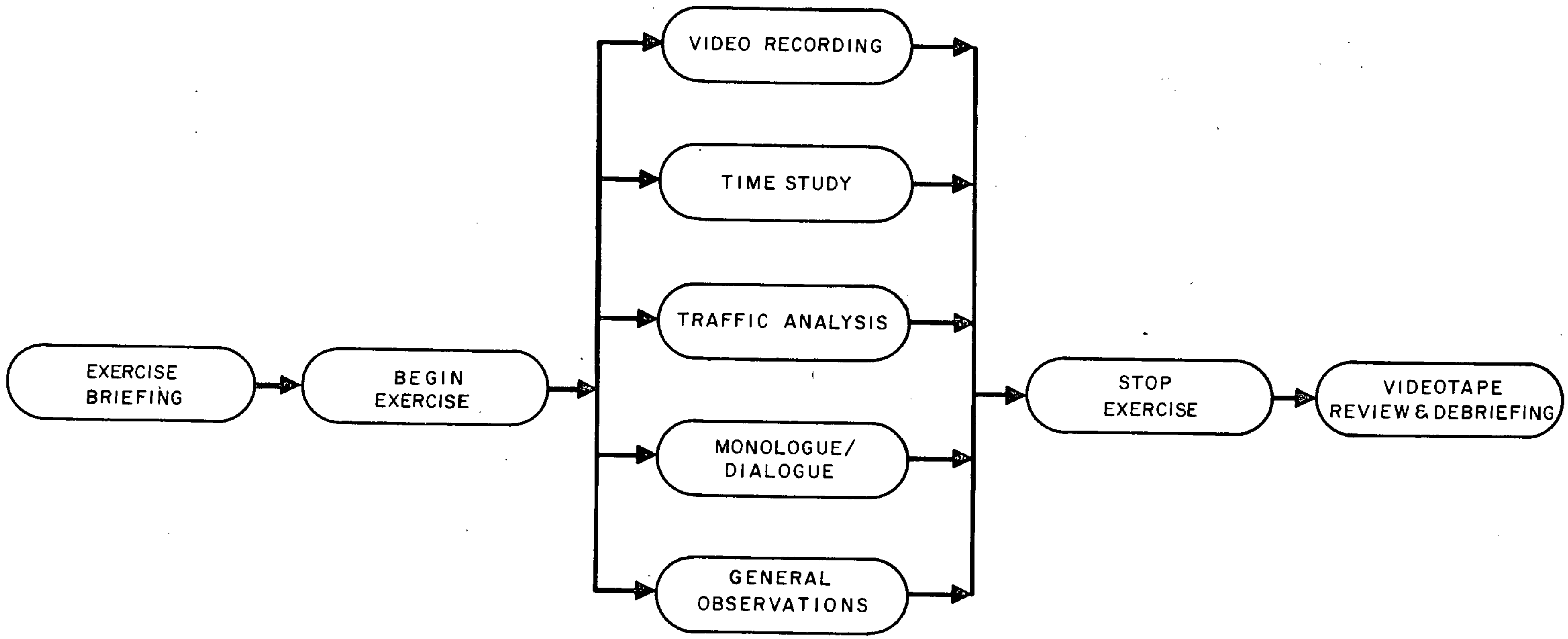


FIGURE 4-3
SIMULATOR EXERCISE ACTIVITY SEQUENCE
KEWAUNEE NUCLEAR POWER PLANT
DETAILED CONTROL ROOM DESIGN REVIEW

Monologue/Dialogue/General Observations

During the simulator exercise, and as time permits, the participants will describe their thoughts and actions while performing tasks. The purpose of obtaining the description is to gain insight into the operator's cognitive, sensory, and motor processes as they interact with the man-machine system shown in a generalized form in Figure 4-4. Important detailed information which will be observed or elicited during the exercises includes descriptions of the following processes:

1. Signal/Information Detection.

2. Signal/Information Source Identification.

3. Information Application Identification.

4. Information Processing.

    a. Information/Data Conversions.

    b. Uncertainty Resolution.

    c. Output Option Development.

    d. Output Decision-Making Criteria Development.

    e. Decision-Making (Reasoning).

5. Action-Taking.

6. Control System Feedback.

7. Expectation Response.

8. Actions to Take Given Unexpected Response.

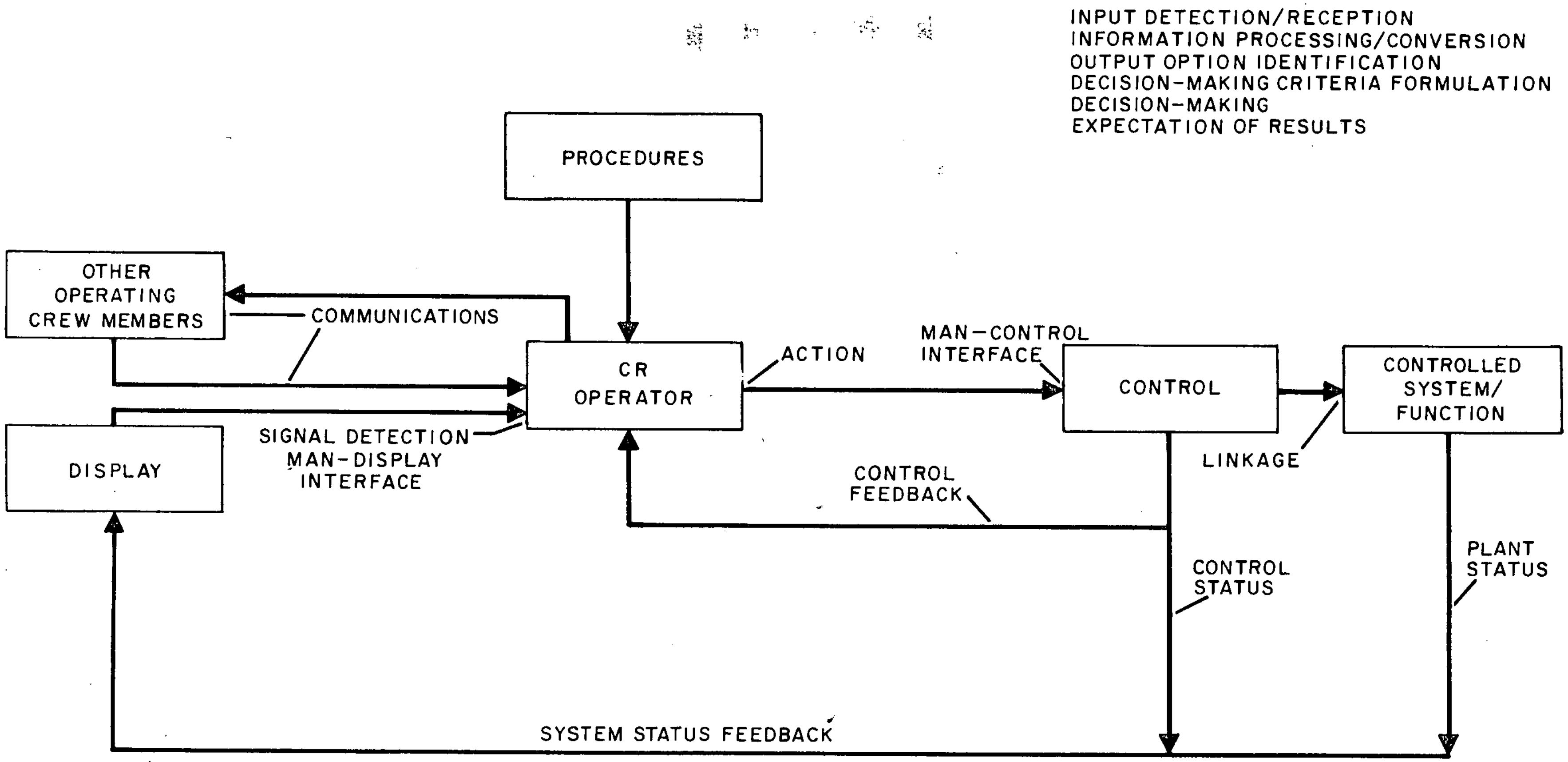


FIGURE 4-4
MAN-MACHINE SYSTEM CONTROL FEEDBACK LOOP
KEWAUNEE NUCLEAR POWER PLANT
DETAILED CONTROL ROOM DESIGN REVIEW

9. System Status Feedback (Response Verification).

Workload Evaluation

An analysis of the control room operational crew's workload will be conducted. Two broad categories of operator workload exist. These categories are physical workload and mental or cognitive workload.

Physical Workload Evaluation

a. Traffic Analysis

A traffic analysis will be used to study the traffic patterns of the operators. The technique is used to assess the frequency and sequence of traffic for given event sequences. The traffic patterns will be depicted in a traffic diagram. This diagram will show a composite of the movements of the operators on a KNPP control room floor plan. This type of diagram will be used to assess overall layout of work station, consoles, and panels; and the mobility or physical workload requirements of operators.

The following steps will be conducted when performing a traffic analysis:

1. Identify traffic sequence requirements for each operator and draw traffic patterns on control room floor plan.

2. Draw actual traffic sequence on control room floor plan followed by each operator during simulator exercises.

3. Assess traffic link length, frequency and crossing with other links.

The traffic diagram prepared prior to the exercise will be compared to traffic diagrams tracking the motion of operators during the exercise. This comparison may indicate traffic problems related to control room design versus operator habit or training, and event sequence dynamics.

b. Timeline Analysis

A timeline analysis will be used to analyze temporal aspects of operator performance and/or the performance of an operating crew as a unit. The analysis will produce estimates of physical workload by plotting the observed or estimated time to perform each particular task in an event sequence.

The timeline will indicate at any point along the time dimension axis the following information:

1. Number of concurrent functions/tasks.

2. Frequency of function/task performance.

3. Operator work overload and underload.

Timelines can show times where a single operator may be expected to perform two separate tasks concurrently, suggesting a work overload, especially if both tasks require constant use of the same sensory modality.

The level of detail of the timeline functions/tasks will be a matter of the review team's judgement and the requirements of the specific analysis. The level of detail may range from gross task description such as manually trip all reactor coolant pumps to more refined tasks such as place key in control keylock. The procedure for conducting a timeline analysis will be:

1. Identify function/task sequence requirements for each operator.

2. Estimate time requirements of each task and determine operator task assignments.

3. Draw timeline showing functions/tasks, time dimension, operator assignments, and duration and sequencing of function/task performance.

4. Draw a timeline using the same format as above for function/task performance observed during the simulator exercises.

Mental Workload Evaluation

The evaluation of mental workload will be directed by the lead human factors engineer. Since some aspects of this process are subjective and difficult to quantify, an outside specialist in the field of mental workload may be used to augment the DCRDR team's activity in this area.

4.6.4 Results

The primary results of the validation process will include observational and analytical findings concerning the following areas:

1. Operator difficulties in responding to events.

2. Effects of previously identified HEOs (from the operating experience review (Section 4.1), the control room survey (Section 4.4), and the task capabilities verification (Section 4.5).

Conclusions will be drawn regarding the adequacy of the existing control room functions, operator tasks, workspace configuration, work station interfaces, and shift composition on an integrated basis. These conclusions will be inputs to the HEO assessment and improvement process (Section 5).

4.6.5 References

1. EPRI Report NP-1637, Draft, Integrating Human Factors Engineering Into Nuclear Power Plant Design, Vol. III, p. 111-2-16, June 1982.

2. EPRI Report NP-1637, Draft, Integrating Human Factors Engineering Into Nuclear Power Plant Design, Vol. III, p. 111-2-14, June 1982.

SECTION 5

HEO ASSESSMENT AND HED IMPROVEMENT

5.1 PURPOSE

Disposition for each HEO identified in the review, will be determined during the HEO Assessment and HED Improvement process. Those HEOs assessed and determined to be important or significant will be reclassified as HEDs, categorized and analyzed for correction.

The result of this process will be a set of recommendations for corrections using enhancement techniques, design changes or procedure changes. Where possible, design corrections will be verified and validated using the review techniques employed in Sections 4.5 and 4.6.

In some cases, an extensive design effort, conducted separately from the DCRDR over an extended period of time, may be necessary to correct an HED. Verification and validation of these design corrections, therefore, will not be within the scope of the DCRDR, but will have to wait until completion of the design effort.

The assessment and improvement process will provide an organized approach for identifying control room modifications suitable for correcting or mitigating the effects of HEDs.

5.2 APPROACH

The approach to the assessment and improvement process includes six major steps as diagramed in Figure 5-1.

The first step in this process, HEO significance assessment, will determine which HEOs, identified during the review, are significant and warrant correction.

Those HEOs determined to be significant will be reclassified as Human Engineering Deficiencies (HEDs) and categorized based on their significance. This categorization process will also prioritize HEDs for correction as outlined in Figure 5-3.

Once HEDs have been categorized, the review team must select an appropriate correction method. Each correction method available to the review team, enhancement techniques, design changes or procedure changes, will be considered for each HED. This will help to ensure that the most appropriate and cost effective correction method is applied.

During correction analysis, detailed design recommendations will be developed based on the correction method selected by the review team. These recommendations will include:

1) a problem statement
2) recommendations for correction
3) objectives of the recommendations
4) a scope of work.

The verification and validation step includes two processes. Verification is an engineering anlysis conducted to verify that the recommended corrections will correct or mitigate the HED. After the

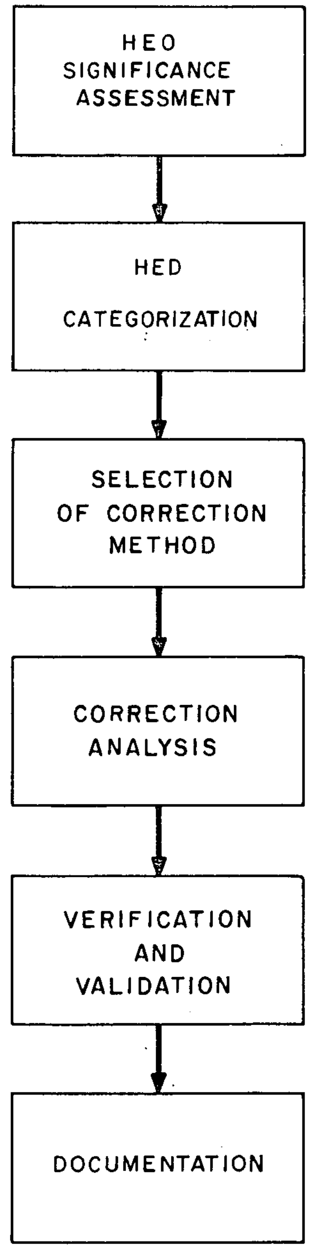


FIGURE 5-1
ASSESSMENT AND IMPROVEMENT PROCESS
KEWAUNEE NUCLEAR POWER PLANT
DETAILED CONTROL ROOM DESIGN REVIEW

recommendations have been implemented, and control room modifications have been completed, validation, a dynamic test of the system, will be conducted.

Documentation of the assessment and improvement process must be maintained for historical purposes. Additionally, documentation from the significance assessment and categorization steps will be required for subsequent steps in the assessment and improvement process; particulary Correction Method Selection. Special emphasis will be placed on documenting justifications for not correcting an HED.

5.3 PROCEDURES

5.3.1 HEO Significance Assessment

The purpose of this step is to determine which HEOs among those identified during the review process are significant. An HEO, by definition, represents a potential source of operator error with subsequent plant operation consequences; safety-related and nonsafety related. The term significant has two applications. It is applied to HEOs which have the potential to compromise plant safety, and to HEOs which affect plant operability/availability in a manner unacceptable to plant management. Accordingly, all HEOs of safety importance will be considered significant and categorized as HEDs. Some nonsafety-related HEOs of concern to plant management will also be considered significant and categorized as HEDs. Significant HEDs must be analyzed for correction while nonsignificant HEOs need not be.

Before an individual, nonsafety-related HEO may be discounted as nonsignificant, a second stage assessment will be performed in which the interrelationships or cumulative effects of non-significant HEOs will be studied to identify any unacceptable safety- or nonsafety-related effects on plant operation. If unacceptable effects are identified, the HEOs originally classified as non-significant are redefined as HEDs and will be analyzed for correction.

Specialized techniques have been developed to aid the assessment of HED significance. These techniques will be used to support decision-making but will not supersede the judgment of the review team. If the review team is divided over the judgment of an HEO's significance, the HEO will be defined as significant and categorized as an HED.

The techniques presented for assessing HEO significance will be reviewed by the review team and applied as an aid to decision-making as necessary. An HEO may be found to be significant on the basis of results of any one of three assessment techniques:

Technique 1 - Assessment by HEO Significance Rating.

Technique 2 - Assessment by HEO Mockup Mapping and Computer Sorting of HEOs.

Technique 3 - Assessment by Review Team Judgement.

Technique 1 - Assessment by HEO Significance Rating

The HEO Significance Rating Sheet (Exhibit 5-1) and human performance criteria listed below will be used for HEO assessment. The rating sheet addresses the following human performance criteria:

1. Physical Performance

   a. Fatigue (Physical Overload).

   b. Discomfort.

   c. Injury.

   d. Control Suitability.

2. Sensory/Perceptual Performance

   a. Distraction.

   b. Visibility.

   c. Readability.

   d. Audibility.

   e. Noise.

   f. Display adequacy.

   g. Inconsistency with stereotypes and conventions.

3. Cognitive Performance

   a. Mental overload.

   b. Confusion.

   c. Stress.

   d. Sequential or compound errors.

The rating sheet will be used to assess the comparative significance of related and unrelated HEOs. HEO significance will be quantified to aid in distinguishing between significant HEDs and non-significant HEOs and to aid the assessment of correction prioritization. The rating sheet is designed to rate qualitatively the level of performance degradation caused by an HEO, using a numerical scale. It is an imperfect measure of HEO significance, but will provide some basis of comparison. Some of the statements on the rating sheet will not be applicable to certain HEOs. In these cases, an "N/A" response will be entered.

The two statistics calculated for each HEO using the rating sheet will be the cumulative total and the average rating (cumulative total divided by the number of applicable responses). The cumulative total will indicate the scope of HEO caused performance degradation. The average can be used to compare the intensities of similar HEOs. Averages and cumulative totals for sets of HEOs will be summed for comparison of HEO significance for given control room functions or panels. Additional statistical techniques described in this procedure may be used to aid in significance assessment.

The significance rating sheet will also be used to assess the significance of individual HEOs by examining the results of the rating process. Judgment of the review team members will be used to formulate the ratings and then to formulate decisions regarding what rating frequency and magnitude indicate significance. When the rating sheet is used on an individual HEO basis, final assessments will be based largely on judgment, and the sheet will be used simply to organize the judgment-making process.

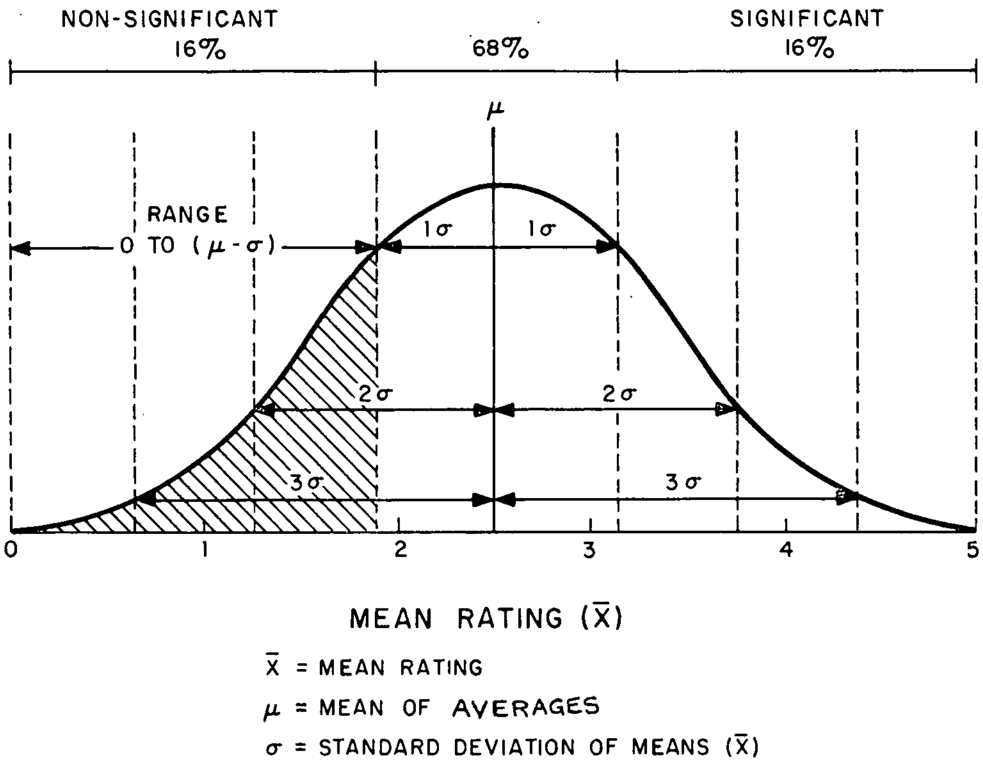


FIGURE 5-2
SIGNIFICANCE RATING STATISTICAL EVALUATION GUIDE
KEWAUNEE NUCLEAR POWER PLANT
DETAILED CONTROL ROOM DESIGN REVIEW

A possible method of using the rating sheet is to follow the steps of the statistical analysis given below:

1. Calculate the average ($\overline{X}$) rating for each HED (cumulative total divided by number rated).

2. Calculate the mean (μ) and standard deviation (σ) of the mean ($\overline{X}$) of the set of HEO's.

3. Calculate the range: $\mu \pm \sigma$

A normal probability distribution must be assumed for the average ratings ($\overline{X}$). Given this assumption, the mean μ ± 1 σ includes 68 percent of the mean ratings ($\overline{X}$), $\pm$ 2 σ includes 95 percent, and $\pm$ 3 σ includes 99.7 percent. Figure 5-2 illustrates these ranges for a sample normal distribution.

HEOs with a rating mean ($\overline{X}$) which falls in the range less than $\mu - \sigma$ or "minus 1 sigma" will be non-significant. Assuming a normal distribution of means ($\overline{X}$), approximately 16 percent of the HEOs can be defined as non-significant in this manner.

Before applying the above statistical analysis, it is recommended that one or more of the following three tests be used to verify the application of normal distribution statical methods.

Test #1 Calculate the third moment, or skewness, of the ratings. The expected result is zero for a perfectly normal distribution.

Test #2 Calculate the fourth moment, or kurtosis, of the ratings.

The expected result is three for a perfectly normal distribution.

Test #3 Apply the chi-squared test to the ratings data, using standard tables.

As an added guide, the first two tests are easiest to apply, but provide the least amount of information as to the degree or normality of the ratings. Although the chi-squared test will involve the most work, it will provide a reliable and accurate measure of the normality of the data.

Technique 2 - Assessment by HEO Mockup Mapping and Computer Sorting of HEDS

In many cases, a graphic display of HEOs, showing HEO patterns and concentrations on certain panel locations will aid in assessing HEO significance. This is especially true in identifying areas where there exists the possibility of cumulative effects. Therefore, mock-ups of the control panels will be constructed as required, at a location convenient to the review team. The necessary mock-ups will be full scale, with control board equipment being represented by two-dimensional pictorials.

The review team may map HEOs on the surface of the mock-ups using color-coded mapping symbols. It is recommended that the number of color codes be limited to eleven (11). HEO color codes may represent a variety of classification schemes including:

1. Review Process HEO Source:

a. Control Room Inventory (Section 4.3).

b. Control Room Survey (Section 4.4).

c. Operating Experience Review (Section 4.1).

d. System Function Review (Section 4.2).

e. Task Analysis (Section 4.2).

f. Task Performance Verification (Section 4.5).

g. Control Room Validation (Section 4.6).

2. HEO Effect on Human Performance:

a. Physical performance.

b. Sensory/perceptual performance.

c. Cognitive performance.

3. HEO Significance Rating.

HEO mapping symbols will be removable symbols, such as flags with pins. Each symbol will be a single, solid color and should be large enough to accommodate the HEO number.

The review team may analyze the mockup mapped with HEOs to identify HEO patterns and high density areas of HEOs related to individual panels. Patterns identified and dense groupings of HEOs will be documented and considered for assessment as significant.

Computer sorting of HEOs may yield information valuable in identifying HEO patterns among control room panels and areas of high HEO density. Computer sorting can also aid in identifying cumulative effects.

Sorting classes available to aid significance assessment as well as other processes will be:

1. Effect on Human Performance.

2. Functional Title.

3. Emergency Operating Procedure.

4. Task Reference.

5. Device Type.

6. Panel Location Number.

The review team will specify what computer sorts are required to assess HEO significance.

Technique 3 - Assessment By Review Team Judgement

Final decisions will be the consensus of the review team with all members participating in the decision process.

5.3.2 HEO Categorization

The purpose of this step of the assessment and improvement process is to place HEOs in detailed categories and category levels. HEOs will be categorized systematically so that decisions to classify them as HEDs and to fully or partially correct them may be made rationally.

Prior to HEO categorization, compilation of the following information is required:

1. Technical Specification Safety Limits.
2. Operating Limits.
3. Limiting Conditions for Operations.
4. LERs.

This information will be used to distinguish between potential and documented consequences of operator error and associated categories. The categorization process details the logical steps to determine category.

The HEO categorization process is diagramed in Figure 5-3. The steps shown in the figure are designed to place HEOs into one of four categories (1,2,3,4). Those HEOs placed into categories one through three will no longer be considered Human Engineering Observations, but Human Engineering Deficiencies (HEDs). Once HEOs are re-classified as HEDs, they must be included in the Improvement process.

Figure 5-3 includes a branch where HEOs may be recategorized due to the cumulative or interactive effects of multiple HEOs. The purpose of considering these effects is that HEOs would otherwise be discounted as non-significant and dropped out of the assessment and improvement process. Clearly, there can be significant cumulative effects of combined Category 1, 2 and 3 HEDs as well. However, these effects will be considered during the selection of a correction method discussed in Section 5.3.3.

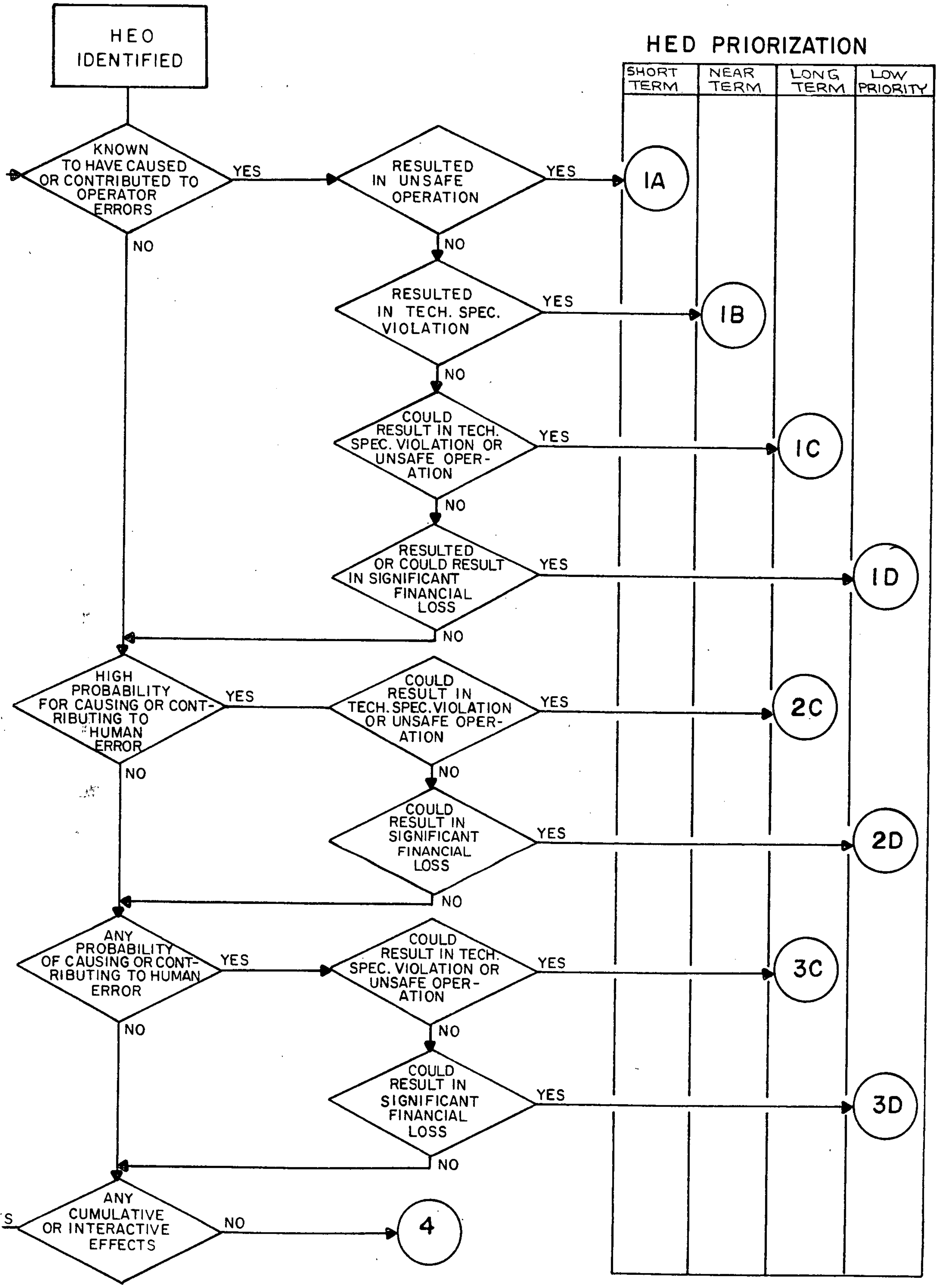


FIGURE 5-3
HED CATEGORIZATION AND PRIORITIZATION PROCESS
KEWAUNEE NUCLEAR POWER PLANT

The four categories used in the categorization process are defined below:

1. Category 1 -- HEDs Associated with Documented Errors

   Category 1 includes HEDs which are known to have previously caused or contributed to an operating error as documented in an LER or other historical record, or as established by the interview (or questionnaire) responses of operating personnel.

2. Category 2 -- HEDs Associated with Potential Errors

   Category 2 includes all HEDs which have been assessed and determined to have a high probability of causing or contributing to a human error, but for which there is no previous documentation.

3. Category 3 -- HEDs Associated with Low Probability Errors

   Category 3 includes HEDs which have been assessed and determined to have minimal potential for causing or contributing to a human error.

4. Category 4 -- HEOs not Associated with Errors

   Category 4 includes any observation that has been evaluated and determined neither to increase the potential for causing or contributing to a human error, nor to have adverse safety consequences.

Those HEOs re-categorized as HEDs will be further defined by level. Levels are based on an HED's actual or potential adverse affect on plant safety and operability. Each of the four levels (A, B, C and D) are defined below and graphically portrayed in Figure 5-4.

Level A - Includes those HEDs for which the related documented error:

1. Was associated with a safety function, and

2. Resulted in unsafe operation.

Note: The term "safety function" includes identified interactions of nonsafety-related systems with safety-related systems.

Level B - Includes those HEDs for which the related documented error:

1. Was associated with a safety function, and

2. Resulted in violation of a technical specification.

Level C - Includes those HEDs for which the related potential error:

1. Is associated with a safety function, and

2. Could result in unsafe operation or the violation of a technical specification.

Level D - Includes those HEDs for which the related potential error:

1. Is associated with a non-safety function, and

2. Could result in a plant outage or significant financial loss.

CATEGORIES \ LEVELS	RESULTED IN UNSAFE OPERATION	RESULTED IN TECH. SPEC. VIOLATION	COULD RESULT IN UNSAFE OPERATION OR TECH. SPEC. VIOLATION	RESULTED OR COULD RESULT IN SIGNIFICANT FINANCIAL LOSS
1. HED's KNOWN TO HAVE CAUSED OR CONTRIBUTED TO AN OPERATING ERROR AS DOCUMENTED IN AN "LER" OR OTHER HISTORICAL RECORD, OR AS ESTABLISHED BY THE INTERVIEW RESPONSES OF OPERATING PERSONNEL.	A	B	C	D
2. HED's WHICH HAVE BEEN ASSESSED AND DETERMINED TO HAVE A HIGH PROBABILITY FOR CAUSING OR CONTRIBUTING TO A HUMAN ERROR BUT FOR WHICH THERE IS NO PREVIOUS DOCUMENTATION.			C	D
3. HED's WHICH HAVE BEEN ASSESSED AND DETERMINED TO HAVE A LOW PROBABILTY FOR CAUSING OR CONTRIBUTING TO A HUMAN ERROR, AND FOR WHICH THERE IS NO PREVIOUS DOCUMENTATION.			C	D
4. HEO's THAT HAVE BEEN EVALUATED AND DETERMINED NEITHER TO INCREASE THE POTENTIAL FOR CAUSING OR CONTRIBUTING TO A HUMAN ERROR, NOR TO HAVE ADVERSE SAFETY CONSEQUENCES.				

FIGURE 5-4
CATEGORY LEVEL DEFINITION
KEWAUNEE NUCLEAR POWER PLANT
DETAILED CONTROL ROOM DESIGN REVIEW

Note: Not all levels are applicable to all HED categories by definition.

An HED may be placed into the following categories only:

1. Category 1 (A, B, C and D).

2. Category 2 (C and D).

3. Category 3 (C and D).

5.3.3 SELECTION OF A CORRECTION METHOD

Once HEDs have been placed in the proper HED categories and levels, the review team must determine the most appropriate method of correction. Figure 5-5 is a flow diagram depicting this review process.

There are three possible correction methods available to the review team: enhancement, design changes and procedure changes. All HED's will first be screened for correction by enhancement. For this purpose a checklist is provided in Figure 5-6, to aid in the review of possible enhancement techniques which may be applied. To select an enhancement approach, when a design approach is more appropriate, will be not be critical. All HEDs selected for correction by enhancement, will also be reviewed for correction using a design approach. The merits of each approach may then be weighed by the review team and the proper correction method applied.

Should both enhancement and design, or a combination of the two correction methods prove inadequate or inappropriate, the review team may choose to use procedure changes as a third method of correcting or mitigating HEDs.

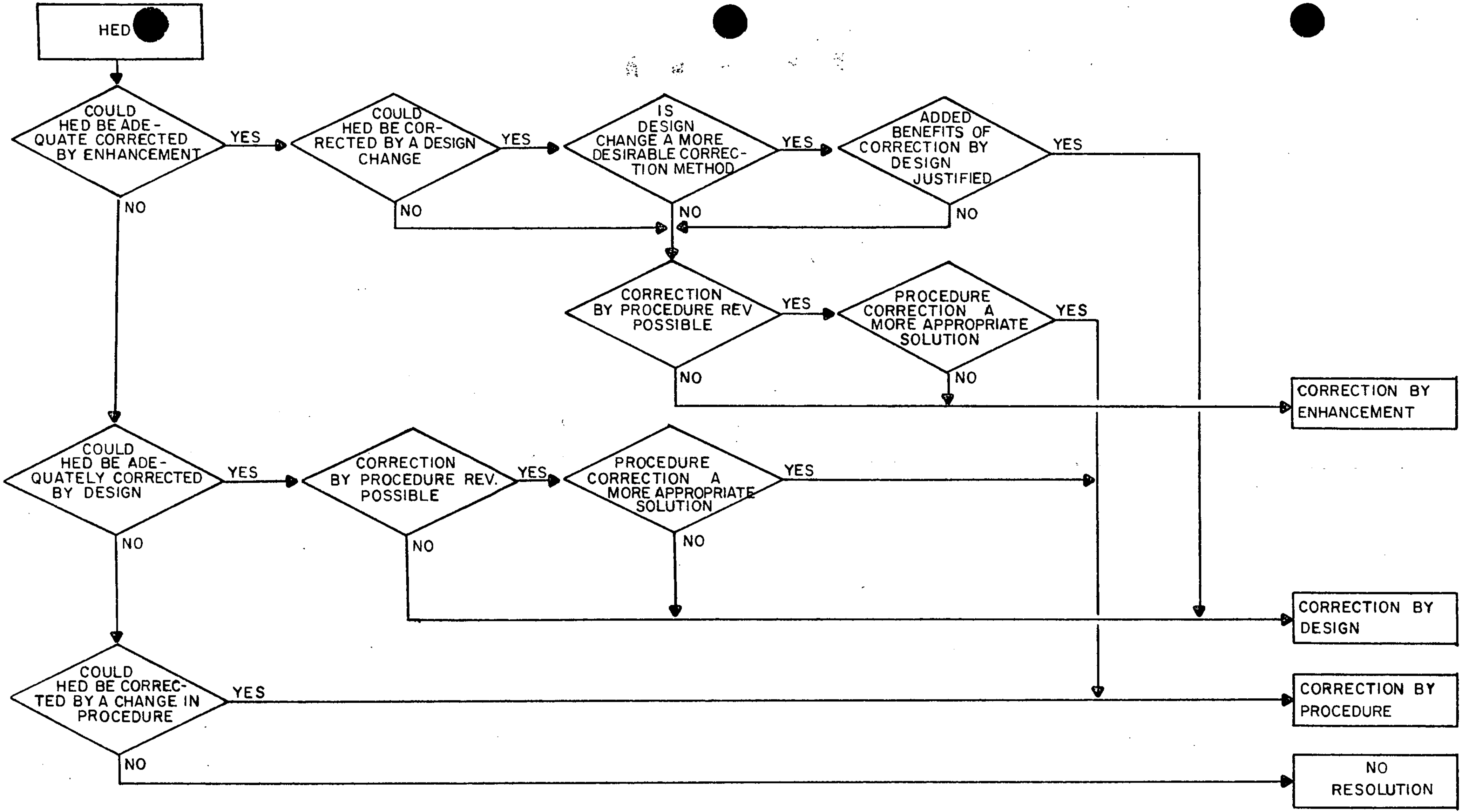


FIGURE 5-5
SELECTION OF A CORRECTION METHOD
KEWAUNEE NUCLEAR POWER PLANT
DETAILED CONTROL ROOM DESIGN REVIEW

ENHANCEMENT:

DEFINITION -CONTROL ROOM IMPROVEMENT BY SURFACE TREATMENT TECHNIQUES.

ACTION WORDS - ADD, REMOVE, REPLACE, RE-LOCATE, MODIFY, ADJUST, ORGANIZE.

EXAMPLES:

- LABELS:
  - CONTROLS
  - DISPLAYS
  - SYSTEMS
  - FUNCTIONS
  - ANNUNCIATOR TITLES

- DEMARCATION & MIMICS:
  - LINES
  - SYMBOLS
  - ZONES
  - CODING (COLOR, SHAPE, ETC)

- ENVIRONMENT:
  - FURNISHINGS
  - ROOM COLOR(S)
  - CABINET COLOR(S)
  - TEMPERATURE
  - VENTILATION
  - LIGHTING
  - NOISE LEVEL
  - TRAFFIC PATTERN(S)
  - FURNITURE LOCATION

- DISPLAYS:
  - RECORDER PAPER & SCALE
  - INDICATOR SCALES

- PROCEDURES VOLUMES:
  - ORGANIZATION
  - LABELING
  - COLOR CODING

- HARDWARE:
  - HANDLES
  - KNOBS
  - METER FACES

FIGURE 5-6
ENHANCEMENT SUITABILITY CHECKLIST
KEWAUNEE NUCLEAR POWER PLANT
DETAILED CONTROL ROOM DESIGN REVIEW

Procedure changes may be a very effective way of correcting HEDs in some instances. Particular care should be taken when making changes to the symptom-oriented emergency operating procedures. Before recommending changes to operating procedures, the review team shall conduct a thorough review of the consequences of such an action.

During the process of selecting a correction method, the reveiw team will consider all correction methods for each HED as shown in Figure 5.5. For each correction method deemed inappropriate by the review team, the decision not to use this correction method will be justified and documented. Likewise, the recommendations for final disposition of each HED will be justified and documented. This will be especially important when the review team recommends not correcting an HED.

While a particular correction method for an individual HED may appear to be appropriate, an alternative correction method may be more appropriate when the HEDs are taken as a group. After all HEDs have been analyzed for correction, it will be necessary for the review team to re-evaluate all similar HEDs selected for a particular correction method, to ensure that the method chosen is appropriate.

The approaches to HED correction by enhancement, design or procedure changes are described separately in the following section. In each case, analysis will be weighed towards using the judgment of the review team members in developing recommendations. Any special analyses employed in the development of recommendations will be identified by the review team at the time of correction analysis and, therefore, cannot be described here.

5.3.4 CORRECTION ANALYSIS

Enhancement Corrections

Development of enhancements will proceed soon after the design improvement approach selection, since an enhancement typically provides a significant improvement quickly and at low cost. In some cases, the enhancement may be implemented as an interim improvement while a long-term design solution is developed. In this way, the dilemma of providing a near-term solution as well as an integrated control room design in the long-term will be resolved.

All HEDs recommended for improvement through enhancement will be placed in one or more of the following enhancement categories:

1. Labels.
2. Demarcation and Mimics.
3. Environment.
4. Displays.
5. Procedures.
6. Hardware.
7. Miscellaneous.

Listing of HEDs in these categories will aid in the development of comprehensive, consistent, and integrated enhancement solutions. Once HEDs are categorized, the need for a concentrated demarcation design effort, for example, may become apparent. In such a case, the appropriate course of action will be to consolidate the set of HEDs for correction.

If consolidation of HEDs is not appropriate and/or the enhancement correction is still within the scope of the review team's responsibilities, enhancement analyses and design will commence. Analysis and design will be based on standards for human engineering design and will conform to the objectives of an integrated control room design.

Enhancements will be verified and validated by following the review processes detailed in Sections 4.5 and 4.6. It may be necessary to reiterate the enhancement design, verification, and validation cycle before reaching a final design. The final design may comprise a complete or partial correction of the given HED. A decision not to correct an HED will be a possible product of this analysis process. Recommendation for either the partial correction or no-correction will be justified and documented. The basis of justification will be benefit/cost or other appropriate analysis.

Enhancements of significant value in improving plant operability and safety will be recommended for prompt implementation. Recommendations for enhancements not requiring prompt implementation will be made by means of design recommendations. The recommendations will include a Problem Statement, an Enhancement Description and Verification and Validation documentation.

Design Corrections

Design corrections, by definition, are corrections which are developed through planned design efforts, and are beyond the scope of the DCRDR. The review team's responsibilities will, therefore, be limited to producing preliminary conceptual design recommendations. The specificity of a recommendation will vary with the type and extent of the HED. A recommendation will specify what design correction is needed, why it is needed, and how to accomplish the correction. The recommendation will include:

1. Problem Statement
2. Scope of Work
3. Design Objectives

Recommendations will be based on preliminary design analyses performed by the review team. Analyses may include alternative solution identification, comparison, and selection for the case of a simple, isolated HED. The product of preliminary analysis will be a preliminary conceptual level design requiring further design analyses and engineering.

The first step in developing a design recommendation will be to ensure that the control room functions associated with an HED are completely and thoroughly defined. The second step will be to integrate control room design requirements and human factors engineering guidelines to develop design objectives for the conduct of a complete systems engineering analysis and design effort. Literature on system engineering will be reviewed to guide the development of recommendations. To avoid redundancy, each scope of work can reference a generic description of the systems engineering approach.

For more complex HEDs, the review team will conduct preliminary analyses directed towards producing design objectives but will not proceed beyond the point of developing a preliminary conceptual design. Design objectives will be used to guide design development efforts implemented subsequent to the DCRDR.

PROCEDURE CORRECTION

Change to existing procedures should not be overlooked as a possible means of correcting or mitigating the effects of an HED. Indeed the source of the HED may be found in the way the procedure was originally written. In these cases, correction of an HED by enhancement or redesign of the panels to conform to a procedure would be foolhardy.

Procedure revisions may also be very effective for correcting HEDS, where the procedure is not the root cause of the HED. Design limitations may dictate using a less than optimal type of control (or placement of a control) to accomplish a particular function, resulting in an HED. Procedures may then be used to compensate for the controller's deficiency.

The types of procedure changes required to correct or mitigate the effects of an HED will be varied, but may include:

1. a change in procedure format
2. improved quality of reproduction
3. larger or more legible type
4. inclusion of cautionary statements
5. re-ordering operator tasks

The review team will be responsible only for recommending changes to procedures. The actual changes will be made in accordance with established procedures. However, in order to make reasonable recommendations, or to be certain that procedure revision is the appropriate method of correction, the review team must be facile in the procedure revision process. They must also have knowledge of the historical development of the procedure in question. Temporary Operating Procedure Forms, Procedure Tracking Sheets and associated historical files are a good source of this information.

5.3.5 Verification and Validation

The approach used to verify and validate the design corrections will be that described in Sections 4.5 and 4.6.

5.3.6 Documentation

Documentation of the assessment and improvement process will be performed concurrently with each step. Documentation will include records of HED categorization and significance assessment. The records will be necessary for historical purposes and will be required for subsequent steps in the process; particularly correction method selection.

Correction analysis will be documented in the form of design recommendations. The recommendations may be supported by engineering drawings, photos, conceptual sketches, calculations, or other suitable materials.

Special emphasis will be placed on documenting justifications not to correct a significant HED.

5.4 RESULTS

The results of the HEO Assessment and HED Improvement process will be recommendations for changes to the control room design or to the operating procedures, intended to reduce the potential for operator error. These recommendations will address, in particular, the correction of HEDs identified in the review process.

There will be two types of design recommendations. One type will be detailed enhancement correction recommendations for surface treatments requiring limited financial and time resources. The second type will be design correction recommendations for the implementation of a systems engineering design project to develop detailed design corrections; i.e., corrections requiring more significant financial and time resources.

Where the design approach would be inappropriate for correcting a given HED, recommendations for changes to procedures may be made. These recommendations may include substantive changes in the procedures and/or simple modifications to the format.

Recommendations for improvement will be supported by documents produced throughout the assessment process. This information may be useful in prioritizing implementation of recommendations or to justify a decision not to implement the recommendations. Verification and validation of the final results of design efforts initiated after the completion of the DCRDR will be conducted, but are outside the scope of the DCRDR.

5.5 FUTURE CHANGES TO THE BASELINE CONTROL ROOM

The DCRDR establishes a base-line control room from a Human Engineering perspective. It does not, however, maintain this level of acceptability past completion of the DCRDR.

Additionally, verification and validation of design efforts, initiated after completion of the DCRDR, must be conducted to ensure the design's effectiveness in correcting the original HED and to maintain consistency with the baseline control room.

To insure proper Human Engineering input in the design of future control room modifications, the review team will provide detailed recommendations for new procedures or modifications to existing procedures which will:

1. Establish a mechanism for conducting Human Engineering Review of proposed changes to the control room.

2. Establish a methodology to validate the final results of these design efforts.

3. Insure maintenance of sound Human Engineering practice in the control room.

4. Provide operator input for proposed design changes and operator feedback when the changes are instituted.

5. Maintain the Control Room Conventions and Abbreviations listings generated during the DCRDR.

These procedures will provide the framework to assure that the baseline control room, achieved as a result of this review, will be maintained and built upon. This will obviate the need for future comprehensive efforts in this regard.

EXHIBIT 5-1

HEO SIGNIFICANCE RATING SHEET

HEO No.______________________________ Reviewer____________

Date______________

Description___________________________ Cumulative Total______

______________________________________ Number Rated________

Average Rating_______

To what extent do you agree with the following statements?

Check N/A if Not Applicable
0 = No agreement through
5 = Complete agreement

	N/A	RATING
1. This observation will cause undue operator fatigue (physical or mental).		
2. This observation will cause operator confusion.		
3. This observation will cause operator discomfort.		
4. This observation presents a risk of injury to control room personnel.		
5. This observation will increase the operator's mental workload (for example, by requiring interpolation of values, remember inconsistent or unconventional control positions, etc.)		
6. This observation will distract operators from their duties.		
7. This observation will affect the operator's ability to see or read accurately.		
8. This observation will affect the operator's ability to hear correctly.		
9. This observation will affect the operator's ability to communicate with others (either inside or outside the control room).		
10. This observation will degrade the operator's ability to manipulate controls correctly.		
11. This observation will cause a delay of necessary feedback to the operator.		
12. Because of this observation, the operator will not be provided with positive feedback about control tasks.		

		N/A	RATING
13.	This observation violates control room conventions or practices.		
14.	This observation violates nuclear industry conventions.		
15.	This observation violates population stereotypes.		
16.	Operators have attempted to correct this themselves (by self-training, temporary labels, "cheaters," "helper" controls, compensatory body movements, etc).		
17.	Tasks in which this observation is involved will be highly stressful (i.e., highly time constrained, or of serious consequence, etc.)		
18.	This observation will lead to inadvertent activation or deactivation of controls.		
19.	If this observation caused a specific error, it is probable that another error of equal or more serious consequence will be committed.		
20.	This observation is involved in a task which is usually performed concurrently with another task (e.g. watching water level meter while maniuplating a throttle valve control).		
21.	This observation involves controls or displays that are used by operators while executing emergency procedures.		
22.	Assuming that this HEO caused an operator error, it is likely that this error would result in:		
	a. A violation of a technical specification, safety limit, or a limiting condition for operation.		
	b. The unavailability of a safety-related system needed to mitigate transients or system needed to shut down the plant safely.		
23.	This observation involves controls or displays that are part of an engineered safety function or are associated with a reactor trip function.		

No. Rated _____

Ref: NUREG-0801, Section 4.2.1

Total ___
Average ___

SECTION 6

APPENDICES

APPENDIX A

INDEX OF DOCUMENTS FOR DCRDR

APPENDIX A

INDEX OF DOCUMENTS FOR DCRDR

The following documents will be available to the review team:

WPSC Documents

1. Administrative Control Directives.

2. Annual Operating Reports.

3. Domestic and Foreign Drawings.

4. Engineering Control Directives.

5. Final Safety Analysis Report.

6. Instrument and Control Procedures.

7. Incident Reports/Licensee Event Reports.

8. Maintenance Procedures.

9. Master Systems List.

10. Equipment Information Retrieval Listings.

11. Operating Procedures.

12. Control Room Photographs.

13. Surveillance Procedures.

14. System Descriptions.

15. Agreement Between WPSC and International Union of Operating Engineers AFL-CIO, Effective November 1, 1979.

EPRI ERDA and NRC Documents

16. EPRI NP-309-SY and EPRI NP-309, Human Factors Review of Nuclear Power Plant Control Room Design, Lockheed Missile and Space Company, November 1976.

17. EPRI NP-1118-SY and EPRI NP-1118 (Vol. 1-4), Human Factors Methods for Nuclear Control Room Design, Lockheed Missile and Space Co. Inc.

18. EPRI NP-1637, Draft, Integrating Human Factors Engineering into Nuclear Power Plant Designs, June 1982.

19. ERDA-76-45-2, Human Factors in Design, U.S. Energy Research and Development Administration; Division of Safety, Standards, and Compliance.

20. NUREG-0696, Functional Criteria for Emergency Response Facilities, February 1981.

21. NUREG-0700, Guidelines for Control Room Design Review, September 1981.

22. NUREG-0799, Draft, Criteria for Preparation of Emergency Operating Procedures, June 1981.

23. NUREG-0801, Evaluation Criteria for Detailed Control Room Design Review, October 1981.

24. NUREG-0835, Human Factors Acceptance Criteria for the Safety Parameter Display System, October 1981.

25. SECY-82-111, NRC Staff Recommendations on the Requirements for Emergency Response Capability, March 10, 1982.

Human Factors Engineering Papers

26. Control Room Design: Lessons from TMI, O'Brien, J., and Disalvo, R.

27. Course in Human Factor Engineering, Stone & Webster Inc., Outline and Six Sections.

28. Bouchard, T.J. Jr., Field Research Methods, M.D. Dunnette (Ed) Handbook of Industrial Psychology, Chicago: Rand McNally College Publishing Company, 1976.

29. Human Factors in Nuclear Power Plants, Sheridan, T.B.

30. Preliminary Human Factors Engineering Recommendation, Shoreham Nuclear Power Station, LILCO.

31. Human Factors Engineering CRDR, LILCO Response to NRC Audit.

32. The Magical Number Seven, Plus or Minus Two: Some Limits in our Capacity for Processing Information, Miller, George A.

33. Words, Words, Words, Chapanis, A.

APPENDIX B

PHOTOGRAPHY PROCEDURE

APPENDIX B

PHOTOGRAPHY PROCEDURE

Purpose

Photographs will be taken to portray the control room and control panels accurately while minimizing interference with operations.

Photographs

Two types of photographs will be taken. First, a mosaic of all control surfaces will be taken in a picture format appropriate to the particular panel. Second, as HEOs are identified, the applicable device or panel will be photographed. This photography will be conducted in several sessions through the course of the review. All photographs will be color prints, and HEO photographs will be routinely printed on 8" x 10" paper.

Photomosaic

At the beginning of the review, photographs will be taken of all control panels to support making a photomosaic. As this photography is performed, a photo log (Figure B-1) will be maintained with appropriate entries of mechanical (panel layout) drawing number, panel name, panel section and film roll and frame number being made for each picture. A set of panel layout drawings will be marked to show the area covered by each photograph.

HEO Photographs

All HEOs will have photographs taken to support evaluation and disposition. Instructions for photographs including numbering and area to be covered are found in Section 3.3 of this plan.

Photograph Identification

All prints will be marked on the back with a stamp similar to Figure B-2. The HEO number will be marked "N/A" for control room mosaic prints.

Photo No.	Mech DWG No.	Panel	Section	Roll and Frame No.
1	M-			
2	M-			
3	M-			
4	M-			
5	M-			

Sample Photo Log - Control Panel Mosaic
Figure B-1

Photo No. ________ Date Taken / /
HEO No. ________
Roll ____ Frame ______
Detailed Control Room Design Review
Kewaunee Nuclear Power Plant

Photograph Identification Stamp
Figure B-2

APPENDIX C

CONTROL ROOM DESIGN CONVENTIONS SURVEY

APPENDIX C

CONTROL ROOM DESIGN CONVENTIONS SURVEY

Purpose

The purpose of defining control room design conventions is to establish in writing the normal and expected attributes of all devices and to establish normal and expected methods of grouping devices. These norms will serve as both baseline data for use during the DCRDR and as specifications for the correction analysis of HEDs.

Scope

Control room conventions will be defined for all control panels (including the Auxiliary Feedwater Panel and Dedicated Shutdown Panel) and computer displays/consoles.

Objective

The objective of defining control room conventions is to list the normal and accepted means to convey meaning using (among others) the following methods:

1. Abbreviations and Acronyms.
2. Color.
3. Position.
4. Orientation.
5. Shape.
6. Labels.

7. Function of Device.

8. Direction.

Procedure

1. From existing specifications and drawings, expected conventions for the above methods of conveying meaning will be defined.

2. All abbreviations and acronyms found on nameplates, operating procedures, and computer printouts will be listed.

3. The plant process computer hardware and software specifications and graphic display formats will be examined to determine applicable conventions for the above methods of conveying meaning.

4. The applicability of the expected conventions to determine conventions as actually built in the control room will be evaluated panel-by-panel.

5. Panel-specific conventions will be evaluated for the possibility of incorporation into common control room conventions.

6. A preliminary list of conventions to be used as benchmark data for the control room survey will be prepared, based on Items 1 through 5.

7. As the control room survey progresses, both the conventions and the control room will be checked for inappropriate or unlisted conventions.

8. A final list of conventions will be prepared for inclusion in the DCRDR report.

APPENDIX D

VIDEOTAPING PROCEDURE

APPENDIX D

VIDEOTAPING PROCEDURE

Purpose

Walkthroughs conducted in the control room validation as an integrated system procedure (Section 4.6) may be videotaped. Videotaping facilitates analyses of operating crew performance. Specifically, videotaping will be required to perform traffic analyses and timeline analyses. Videotapes can be reviewed as many times as necessary at any time by the review team to extract useful information. Operating personnel who participate in the walkthroughs will aid analysis of videotapes by describing in greater detail the actions and thoughts they experienced during the walkthrough. A videotape provides a permanent visual and audio record of walkthroughs.

Procedure

Since walkthroughs may be videotaped, a video camera will be mounted in a position providing a view of the pertinent control room floorspace, panels, consoles, and other equipment. Each walkthrough recording will start with display of an identification chart including: walkthrough title, participants, time, and place. If possible, a continuous digital time display should be superimposed on the video image.

Audio recordings will include all pertinent sounds and communications. A monitor will be available to check videotaping and for purposes of tape reviews following the walkthroughs.

The location of specific recordings (video cassette number, tape counter number) will be kept in a master log (Figure D-1).

Video recordings will be confidential; access to them will be limited to review team members and designated management personnel. The recordings will be stored in a secure location similar to that used to store the Control Room Operating Personnel Questionnaire (Section 3.5).

WALKTHROUGH NO.	DESCRIPTION	VIDEOTAPE NO.	TAPE COUNTER POSITION START	END
1	REACTOR STARTUP	1	0025	0316

FIGURE D-1
SAMPLE VIDEOTAPE LOG
KEWAUNEE NUCLEAR POWER PLANT
DETAILED CONTROL ROOM DESIGN REVIEW

APPENDIX E

AID TO REVIEW TEAM FOR CONDUCTING OPERATING PERSONNEL SURVEYS

QUESTION 1.

PURPOSE:

To determine which operations can be monitored from a primary operating area or work stations. These locations will be compared to current work station assignments to identify where mismatches exist and how assignments could be modified to improve centralization of operations.

OBJECTIVE:

Operators should be stationed at positions within the control room which facilitate coverage of controls, displays, and annunciators. The need for operators to leave a central area to monitor controls, displays, and annunciators should be minimized, particularly during operational sequences in which continuous monitoring may be critical.

ANALYSIS:

Inspect individual and aggregate question responses.

INTERVIEW TOPICS:

Yes Responses:	Identify primary operating areas. Identify work station assignments.
No Responses:	Determine why plant operations can not be monitored from a primary operating area.

RESULTS/DOCUMENTATION:

Document mismatches between primary operating areas and work station assignments.

Document decentralized operations.

QUESTION 2.

PURPOSE:

To determine which persons in the control room interfere with operator performance of assigned tasks during the given operations and the kind of interference.

OBJECTIVE:

Interference between operators and other control room personnel is minimized by optimizing traffic patterns and by limiting access of non-operating personnel to the control room.

ANALYSIS:

Inspect individual and aggregate question responses.

INTERVIEW TOPICS:

Yes Responses:	Identify interference, personnel involved, and associated task.

RESULTS/DOCUMENTATION:

Document interference, personnel involved and associated task.

QUESTION 3.

PURPOSE:

To identify which controls and displays operators have difficulty locating and what causes the difficulty.

OBJECTIVE:

Controls and displays should be designed, arranged, and located so that search and detection is fast and accurate.

ANALYSIS:

Inspect individual and aggregate question responses.

INTERVIEW TOPICS:

Yes Responses: Determine which controls and displays are difficult to locate and the cause of the difficulty.

RESULTS/DOCUMENTATION:

Document controls and displays which are difficult to locate and the cause of the difficulty.

QUESTION 4.

PURPOSE:

To determine if kitchen and restroom facilities can be utilized by operators during their shift in a manner which does not compromise operations.

OBJECTIVE:

Control room manning practices should allow utilization of kitchen and restroom facilities by operators without compromising operations.

ANALYSIS:

Inspect individual and aggregate question responses.

INTERVIEW TOPICS:

Followup on specific responses.

RESULTS/DOCUMENTATION:

Document any manner in which utilization of kitchen and restroom facilities by operators compromises operations.

QUESTION 5

PURPOSE:

To identify control room hazards related to the physical environment and/or operational task which could lead to personal injury.

OBJECTIVE:

The control room design should safeguard against personal injuries under all operating conditions.

ANALYSIS:

Inspect individual and aggregate question responses.

INTERVIEW TOPICS:

Rarely/Sometimes/Often Responses: Identify type, frequency, severity, and cause of injury.

RESULTS/DOCUMENTATION:

Document type, frequency, severity, and cause of injury.

QUESTION 6.

PURPOSE:

To investigate the operator's opinion of, or satisfaction with, the control room environmental parameters listed.

OBJECTIVE:

Control room environmental parameters should be maintained at levels conducive to efficient and effective operator performance.

ANALYSIS:

Prepare bar charts of the rating responses and inspect for consensus of opinion.

INTERVIEW TOPICS:

Poor/Fair Responses: Identify reasons why parameter was rated poor or fair.

RESULTS/DOCUMENTATION:

Document general problem areas identified by bar charts and specific problems reported in interviews.

QUESTION 7.

PURPOSE:

To determine if operators feel that the seating provided in the control room meets their needs.

OBJECTIVE:

Seating should be provided so that design objectives related to mental and physical workload, dimensional requirements, and comfort needs are met.

ANALYSIS:

Prepare bar chart of the responses and inspect for consensus of opinion.

INTERVIEW TOPICS:

Never/Rarely/Sometimes responses: Identify reasons for never/ rarely/sometimes responses.

RESULTS/DOCUMENTATION:

Document general dissatisfaction with adequacy of seating and specific problems repeated in interviews.

QUESTION 8.

PURPOSE:

To determine if operators experience mental fatigue (degradation of alertness) as a result of the listed factors.

OBJECTIVE:

The control room manning, operational tasks, and environmental design should facilitate operator mental alertness.

ANALYSIS:

Inspect individual and aggregate question responses.

INTERVIEW TOPICS:

Yes Responses: Identify the specific cause and frequency of mental fatigue.

RESULTS/DOCUMENTATION:

Document aspects of the control room manning, operational tasks, and/or environment which reportedly cause mental fatigue and the specific causes and frequencies reported.

QUESTION 9.

PURPOSE:

The rating system provides an overall assessment of control room panels and consoles on the basis of the listed parameters.

OBJECTIVE:

Panels and consoles in the control room should be accessible, organized logically, and properly labeled, illuminated, and color-coded to support control room functions.

ANALYSIS:

Calculate the average of the ratings for each parameter and each panel or console. Enter these averages into the matrix and calculate the overall average for each parameter (matrix column).

INTERVIEW TOPICS:

Followup on specific reponses and/or aggregate trends.

RESULTS/DOCUMENTATION:

Matrix of average ratings.

Average rating for each parameter.

QUESTION 10.

PURPOSE:

To evaluate the adequacy of the surface space allocated to controls and displays on the listed panels as perceived by the operators.

OBJECTIVE:

Board surface space allocated to controls and displays should be optimized to meet human factors guidelines on spacing while minimizing the overall size of the control panels and consoles.

ANALYSIS:

Find cumulative totals for each response option and record on the given format.

INTERVIEW TOPICS:

Inadequate/Excessive Responses:	Determine the reason(s) for the ratings.

RESULTS/DOCUMENTATION:

Summary of rating frequency.

Document reasons for inadequate/excessive ratings.

QUESTION 11.

PURPOSE:

To determine:

a) The relative ease or difficulty of learning to operate the listed systems.

b) The relative ease or difficulty of operating the listed system after the operations have been learned.

OBJECTIVE:

System operations should not be inordinately difficult to learn or operate.

ANALYSIS:

Find the cumulative response totals for each response option and record on the given format.

INTERVIEW TOPICS:

Difficult Responses: Identify the difficulties and their cause.

RESULTS/DOCUMENTATION:

Summary of rating frequency.

Document difficulties and their cause.

QUESTION 12.

PURPOSE:

To develop an operator consensus on whether control system mimics are helpful to their job performance.

OBJECTIVE:

Survey results will aid decision-making regarding implementation of additional mimics. Whereas properly designed mimics should decrease the operator's decision making load, improperly designed mimics may increase the operator's decision making load.

ANALYSIS:

Find the cumulative totals for each response option.

INTERVIEW TOPICS:

Yes/No Responses: Critique existing control system mimics.

RESULTS/DOCUMENTATION:

Document critique results.

QUESTION 13.

PURPOSE:

To evaluate the effectiveness of the alarm system as perceived by operators. Alarms which are difficult to detect are identified for improvement. Alarms reported as easy to detect are evaluated to assess operator preference in alarm designs.

OBJECTIVE:

To ensure that incoming alarms are readily detected and properly interpreted.

ANALYSIS:

Find the cumulative totals of each response option and summarize on given format.

INTERVIEW TOPICS:

Difficult Responses: Critique alarm system.

RESULTS/DOCUMENTATION:

Document critique results.

QUESTION 16.

PURPOSE:

To determine if operators feel there are too many or too few annunciator windows.

OBJECTIVE:

To develop an operator consensus on the quantity of annunciator windows for the listed panels and consoles. A consensus that there is an inadequate number of annunciator windows indicates that operators perceive a need for information they currently do not receive through the annunciator system. A consensus that there is an excessive number of annunciator windows indicates that the system could overburden operators and interfere with detection and response to high priority signals.

ANALYSIS:

Find the cumulative totals of each response option and summarize on the given format.

INTERVIEW TOPICS:

Inadequate/Excessive Responses: Critique annunciator panels.

RESULTS/DOCUMENTATION:

Document critique results.

QUESTION 17.

PURPOSE:

To develop an operator consensus on the readability of annunciator window printing.

OBJECTIVE:

To determine if there is a perceived need among operators to improve the annunciator window printing and how it could be improved.

ANALYSIS:

Find cumulative totals of each response option.

INTERVIEW TOPICS:

No Responses: Determine reasons for response.

RESULTS/DOCUMENTATION:

Document reasons for responses that printing is not readable.

QUESTION 18.

PURPOSE:

To develop an operator consensus on the adequacy of annunciator proximity to controls necessary to respond to the alarm.

OBJECTIVE:

To determine if there is a perceived need to improve the proximity of annunciators to associated control panels.

ANALYSIS:

Find the cumulative totals of each response.

INTERVIEW TOPICS:

No Response: Identify where problems exist.

RESULTS/DOCUMENTATION:

Document reported problems.

QUESTION 19.

PURPOSE:

To determine if false or nuisance alarms are perceived by operators to interfere with their job performance.

OBJECTIVE:

To develop an operator consensus regarding false or nuisance alarms which interfere with their job performance and which should be modified or eliminated.

ANALYSIS:

Find the cumulative totals of each response option.

INTERVIEW TOPICS:

Yes Responses: Identify why the alarms reportedly interfere with operator job performance.

RESULTS/DOCUMENTATION:

Document alarms which reportedly cause interference.

QUESTION 20.

PURPOSE:

To determine if annunciator Test-Acknowledge-Reset controls are accessible, are close to associated annunciator windows, and are sufficient for the number of annunciator windows.

OBJECTIVE:

To provide annunciator Test-Acknowledge-Reset controls to meet operator needs.

ANALYSIS:

Inspect individual responses.

INTERVIEW TOPICS:

No Responses: Identify problematic controls.

RESULTS/DOCUMENTATION:

Document problematic controls.

QUESTION 21.

PURPOSE:

To determine the adequacy of voice and electronic communications between the control room and the listed facilities to support control room functions.

OBJECTIVE:

Communication between the control room and the listed facilities should be adequate to support control room functions.

ANALYSIS:

Inspect the individual and aggregate responses.

INTERVIEW TOPICS:

No Responses: Identify communications problems and causes.

RESULTS/DOCUMENTATION:

Document inadequacies within the plant communication systems.

QUESTION 22.

PURPOSE:

To evaluate plant communication equipment on the basis of equipment availability, on the basis of equipment accessibility and function.

OBJECTIVE:

Plant communication systems and equipment in specific should be designed and maintained so that control room operators will not experience usage problems.

ANALYSIS:

Inspect individual and aggregate responses.

INTERVIEW TOPICS:

Yes Responses: Identify system and equipment problems, the cause of the problem, and the frequency of the problem.

RESULTS/DOCUMENTATION:

Document the communication systems and specific equipment problems, reasons for the problem, and the frequency of the problem.

QUESTION 24.

PURPOSE:

To determine if the information supplied by the currently installed plant computer (P250) is of sufficient quantity and quality to support all control room functions.

OBJECTIVE:

The information supplied by the existing plant computer should be legible and presented to the operator in a usable form avoiding the need for data conversion, transposition, computation, or interpolation.

ANALYSIS:

Inspect individual and aggregate responses.

INTERVIEW TOPICS:

Inadequate or Excessive Responses:	Identify which computer displays (printouts and/or CRTs) provide information requiring conversion, transposition computation, or interpolation by the operator.
Poor response:	Identify which computer displays (printouts and/or CRTs) produce unreadable information.

RESULTS/DOCUMENTATION:

Document which computer displays (printouts or CRTs) produce inadequate or unreadible information.

QUESTION 25.

PURPOSE:

To determine whether operators experience problems inputting information into the plant computer (P250).

OBJECTIVE:

The man-plant computer interface and interaction should be optimized to support control room functions.

Operators should be able to interact successfully with the plant computer during all plant operations.

ANALYSIS:

Find the cumulative total of yes and no responses.

INTERVIEW TOPICS:

No Responses: Identify aspects of information input to the computer in which the operator lacks proper training or experience.

RESULTS/DOCUMENTATION:

Document the aspects of information input to the computer in which the operator lacks proper training or experience.

QUESTION 26.

PURPOSE:

To assess the availability of control room procedures used by operators.

OBJECTIVE:

Control room procedures should be labeled, indexed, and stored to facilitate ease of use by operators. Sets of procedures should be complete and any procedural references should be accurate.

ANALYSIS:

Inspect individual and aggregate responses.

INTERVIEW TOPICS:

Yes Responses: Identify specific problems related to the procedures.

RESULTS/DOCUMENTATION:

Document specific problems related to the procedures.

QUESTION 27.

PURPOSE:

To determine if references and terms used in the procedures agree with the labels on control room panels and consoles.

OBJECTIVE:

There should be no mismatch between nomenclature used in control room procedures and that printed on control room labels.

ANALYSIS:

Find the cumulative total of yes and no responses.

INTERVIEW TOPICS:

No Responses: Identify the procedures and label nomenclature which are mismatched.

RESULTS/DOCUMENTATION:

Document procedure and label nomenclature which is mismatched.

QUESTION 28.

PURPOSE:

To identify control room procedures which operators find difficult to comprehend. This question is not designed to judge the competency of the operator but to identify procedures which can be rewritten to improve comprehension by users.

OBJECTIVE:

Operators should be able to comprehend and implement all control room procedures.

ANALYSIS:

Find the cumulative total of yes and no responses.

INTERVIEW TOPICS:

Yes Responses:	Identify the procedures which are difficult to comprehend and follow and the reason(s) for the difficulty.

RESULTS/DOCUMENTATION:

Document the procedure title, volume, page, section, and paragraph (where applicable) for each difficulty.

QUESTION 29.

PURPOSE:

To determine if operators have sufficient space to lay out procedures where they do not interfere with controls or displays.

OBJECTIVE:

There should be provisions for laying out and using procedures without interfering with controls or displays.

ANALYSIS:

Find the cumulative total of yes and no responses.

INTERVIEW TOPICS:

No Responses: Identify instances when use of the procedures interferes with controls and displays.

RESULTS/DOCUMENTATION:

Document the instances which involve interference with controls and displays and the frequency and severity of the interference.

QUESTION 30.

PURPOSE:

To determine whether the procedures describe all the required actions to be taken by the operators.

OBJECTIVE:

All actions taken by the operator in performing a task should be included in the appropriate procedure.

ANALYSIS:

Inspect individual and aggregate responses.

INTERVIEW TOPICS:

Identify procedures which do not adequately describe operator action requirements.

RESULTS/DOCUMENTATION:

Document procedures which do not adequately describe operator action requirements.

<u>QUESTION 31.</u>

PURPOSE:

To assess operator expectations of effort required to perform the listed tasks. These expectations will be compared to the established manning levels to indicate possible work under- or overload and the need for workload reallocation.

OBJECTIVE:

Control room manning levels should be set at levels which while supporting all control room functions, place optimal workloads on operators to avoid fatigue due to overload and boredom due to underload.

ANALYSIS:

Inspect individual and aggregate question responses.

Compare with established manning lists.

INTERVIEW TOPICS:

Discuss operator opinions on manning levels which vary from the established manning levels.

RESULTS/DOCUMENTATION:

Document mismatches between the existing and perceived optimum manning levels.

Document why operators perceive existing manning levels as non-optimal.

QUESTION 32.

PURPOSE:

To identify any aspects of an operator's recordkeeping duties that operators perceive as enhancing or detracting from their job performance.

OBJECTIVE:

Recordkeeping tasks should be designed to enhance job performance by alleviating boredom as well as satisfying recordkeeping requirements.

ANALYSIS:

Inspect individual responses.

INTERVIEW TOPICS:

Yes Responses: Followup on specific responses.

RESULTS/DOCUMENTATION:

Identify recordkeeping procedures which may be associated with certain LERs.

Document recordkeeping procedures that enhance or detract from operator job performance.

QUESTION 33.

PURPOSE:

Identify aspects of extended shifts or overtime which operators perceive as degrading their job performance. Specifically identify potential work overload conditions caused by long work hours.

OBJECTIVE:

Extended shifts or overtime practices which have the potential to degrade operator performance should be modified.

ANALYSIS:

Find the total cumulative yes and no responses.

INTERVIEW TOPICS:

Yes Responses: Identify specific problems.

RESULTS/DOCUMENTATION:

Document specific problems.

QUESTION 34.

PURPOSE:

To develop an operator consensus on the extent and appropriateness of automation of the listed functions.

OBJECTIVE:

Identify specific event sequences where manual control would be preferable to the operator. Identify problems with the existing automatic control system.

INTERVIEW TOPICS:

Yes Responses: Determine which specific automatic functions should be performed manually according to the operator's preferences.

RESULTS/DOCUMENTATION:

List automatic functions perceived as excessive or inappropriate.

QUESTION 35.

PURPOSE:

To develop an operator consensus on the extent and appropriateness of manual control of the listed functions.

OBJECTIVE:

Identify specific event sequences where automatic control would be preferable to the operator. Compare these responses with Question 31 and establish an overall operator consensus on the application of manual versus automatic control.

INTERVIEW TOPICS:

Yes Responses: Determine which manual functions should be performed automatically according to operator preferences.

RESULTS/DOCUMENTATION:

List manual functions which operators feel should be automated.

QUESTION 36.

PURPOSE:

Identify systems which impose heavy workloads on operators.

OBJECTIVE:

List particular systems which require continuous attention during particular event sequences. Compare attention requirements with current control room manning.

ANALYSIS:

Inspect individual and aggregate responses.

INTERVIEW TOPICS:

Yes Responses:	Identify particular systems and event sequences which require continuous attention.

RESULTS/DOCUMENTATION:

List systems which require continuous attention.

QUESTION 37.

PURPOSE:

To determine what strategies operators employ in responding to a work overload condition; specifically, an excessive number of annunciator alarms.

OBJECTIVE:

To determine what strategies are used to cope with work overload, and which strategies should be avoided due to the possibility of adverse effects on operations, and to assess the effectiveness of the annunciator alarm system.

ANALYSIS:

Inspect individual responses.

INTERVIEW TOPICS:

Followup on specific responses.

RESULTS/DOCUMENTATION:

Document relevant findings.

QUESTION 38.

PURPOSE:

To determine the extent of physical fatigue experienced by operators.

OBJECTIVE:

To identify what aspects of control room operation cause physical fatigue and the potential for degraded operator performance. These aspects can be studied to determine means of reducing the degree of physical fatigue induced.

ANALYSIS:

Find the response totals.

INTERVIEW TOPICS:

Yes Responses: Identify the cause(s) of physical fatigue. Elicit suggestions for means to reduce the degree of physical fatigue induced.

RESULTS/DOCUMENTATION:

Document causes of physical fatigue and suggested means to reduce the degree of fatigue induced.

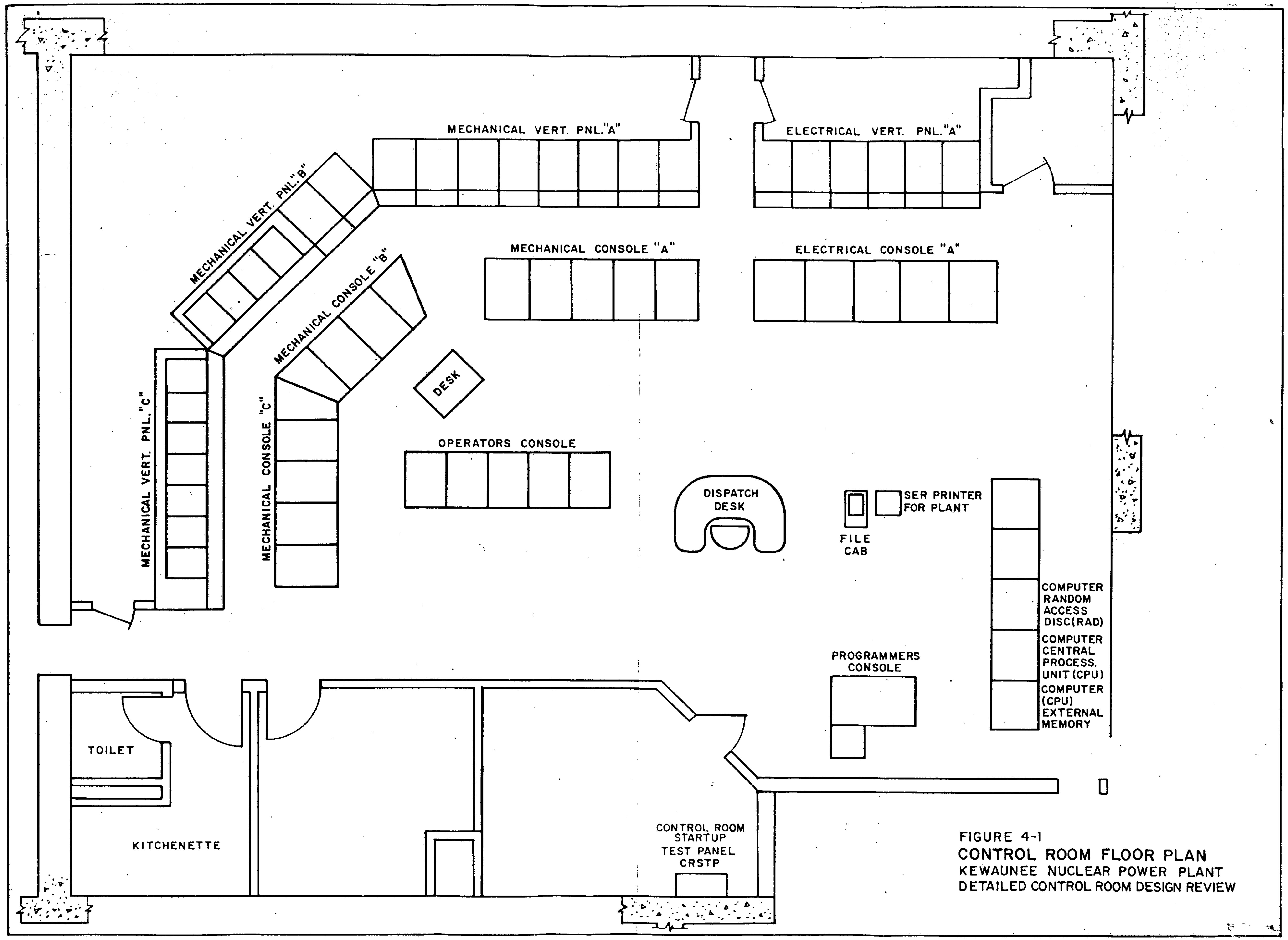
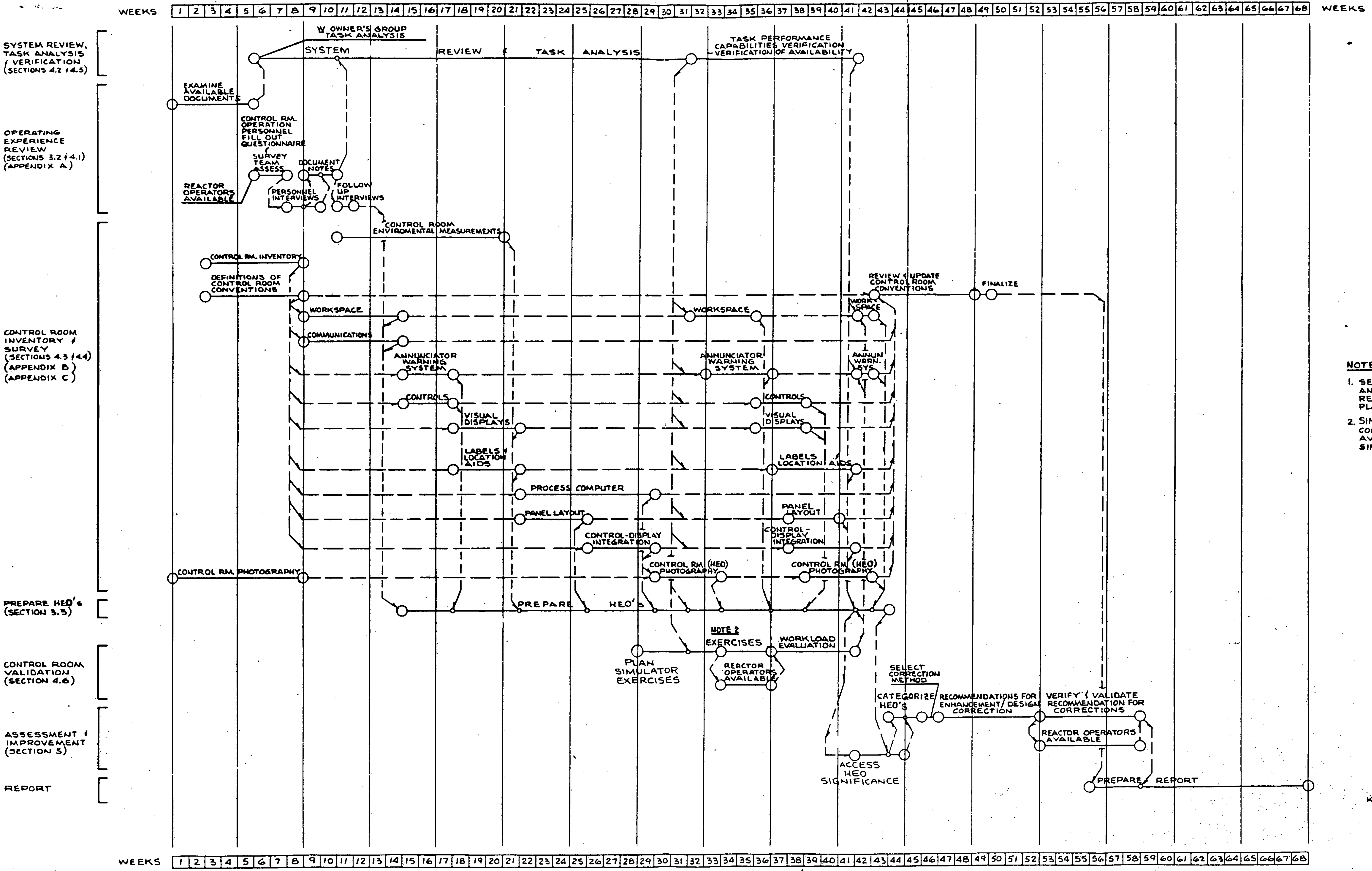


FIGURE 4-1
CONTROL ROOM FLOOR PLAN
KEWAUNEE NUCLEAR POWER PLANT
DETAILED CONTROL ROOM DESIGN REVIEW



NOTES:

1. SECTION NUMBERS AND APPENDICES REFER TO PROGRAM PLAN REPORT
2. SIMULATOR EXERCISES ARE CONTINGENT UPON AVAILABILITY OF SIMULATOR.

FIGURE 1-1

ACTIVITY SCHEDULE

KEWAUNEE NUCLEAR POWER PLANT DETAILED CONTROL ROOM DESIGN REVIEW