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NIAGARA MOHAWK

NIAGARA MOHAWK POWER CORPORATION/300 ERIE BOULEVARD WEST, SYRACUSE, N.Y. 13202/TELEPHONE (315) 474-1511

June 29, 1984
(NMP2L 0099)

Mr. A. Schwencer, Chief
Licensing Branch No. 2
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Schwencer:

Re: Nine Mile Point Unit 2
Docket No. 50-410

Enclosed for your review are eight (8) copies of information regarding the control room design review for Nine Mile Point Unit 2. This information provides the program plan which we committed to provide in our April 14, 1983 letter to Mr. Darrell Eisenhut.

In the April 14, 1983 letter, Niagara Mohawk advised the NRC that the Unit 2 control room design review would be performed in the fall of 1984. It has been determined that the effectiveness of the control room design review can be improved by rescheduling this effort. A recent re-evaluation of the control room design review schedule indicates that a later date, that is, October 1984 to February 1985, will improve the review for the following reasons:

1. There will be more trained operators available for operator surveys.

2. Operators will be more familiar with the control room and hence operator surveys will be more meaningful.

3. Control room design changes will be more complete. These design changes include such things as previous human factors improvements, TMI changes and design development improvements.

4. Procedures will be further developed and will more accurately reflect Unit 2 design.

A003
1/1

G

On this basis, we believe that a new control room design review schedule is clearly warranted and request your concurrence by July 30, 1984. An FSAR amendment will be submitted detailing the new schedule after your concurrence has been received.

Very truly yours,

T. E. Lempges
Vice President
Nuclear Generation

TEL/NLR:ja
Enclosure
xc: Project File

PROGRAM PLAN REPORT
DETAILED CONTROL ROOM DESIGN REVIEW

NINE MILE POINT NUCLEAR STATION - UNIT 2
NIAGARA MOHAWK POWER CORPORATION

June 1984

PREPARED BY

STONE & WEBSTER ENGINEERING CORPORATION
BOSTON, MASSACHUSETTS

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INTRODUCTION

This Program Plan Report describes Niagara Mohawk Power Corporation's plan to perform a detailed control room design review (DCRDR) of its Nile Mile Point Nuclear Station-Unit 2 (NMP-2). By letter of October 31, 1980 (NUREG-0737) and Supplement 1 to NUREG-0737 (Generic Letter No. 82-33) dated December 17, 1982, the Nuclear Regulatory Commission required implementation of some of the items listed in the TMI-2 Action Plan, NUREG-0660. Conduct of the NMP-2 DCRDR meets the intent of item I.D.1 of NUREG-0660. The DCRDR plan is based on guidance provided in NUREG-0700, Guidelines for Control Room Design Reviews, and draft NUREG-0801, Evaluation Criteria for Detailed Control Room Design Review.

The NMP-2 DCRDR is structured according to FSAR Section 1.10. The DCRDR has four major phases:

- Planning Phase
- Review Phase
- Assessment and Implementation Phase
- Reporting Phase

There are three purposes of the DCRDR:

1. To review and evaluate the control room (and auxiliary shutdown area) workspace, instrumentation, controls, and other equipment from a human factors engineering point of view in order to assess the relationship between the demands of plant operation and operator capabilities.

2. To identify and evaluate unsatisfactory items.

3. To establish an implementation plan in order to correct the unsatisfactory items through design modification.

The scope of this review is limited to the human factors engineering aspects of the control room and remote shutdown panel area, it is not concerned with the technical adequacy of the plant and system design. The final result of the DCRDR will be design modification recommendations and a schedule for implementation. Specific review objectives are defined in Section 1 of this plan.

Major milestones are the submittal of this Program Plan Report in June 1984, and submittal of the Final Report in April 1985. It is expected that an addendum to the Final Report will be required to report on the review of the remote shutdown panel which is still under design.

The DCRDR follows a major human factors engineering review performed in 1982 which led to significant upgrades of the NMP-2 control room. The original review involved the participation of the BWR Owner's Group, Stone & Webster Engineering Corp., and General Electric Co. with NMPC to develop and implement improvements to the control room while under construction. Implementation of improvements resulting from the review continue at the time of submittal of this plan. It is expected that the number of human engineering discrepancies cited in the DCRDR will be greatly reduced due to the results of the original review.

Plant Description

NMP-2 is a 1,080 MWe, BWR-5 nuclear power plant being built in Upstate New York on the shore of Lake Ontario in the town of Scriba in Oswego

County, about seven miles northeast of the city of Oswego. It is situated between two existing nuclear plants: the Fitzpatrick plant on the east, and NMP-1 on the west. NMP-2 is owned jointly by five electric utilities. New York State Niagara Mohawk Power Corporation, 41 percent owner of the plant, is supervising the construction on behalf of itself and the four partner utilities and will operate the plant. Stone & Webster Engineering Corporation designed the plant and is managing its contruction. General Electric Company designed the nuclear steam supply system. The plant is scheduled to go into commerical operation late in 1986.

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 detract from operator performance.

3. To analyze and evaluate the problems that could arise from discrepancies of the above kinds, and to analyze means of correcting those discrepancies which could lead to substantial problems.

4. To define and put into effect a plan of action that applies human factors principles to improve control room design and enhance operator effectiveness. Particular emphasis will be placed on improvements affecting control room design and operator performance under emergency conditions.

5. To integrate the control room design review with other areas of the plant which incorporate human factors design principles, such as the safety parameter display system.

Accomplishment of these objectives will be a major step toward improving nuclear power plant safety by 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, Evaluation Criteria for Detailed Control Room Design Review; Supplement 1 to NUREG-0737, Requirements for Emergency Response Capability - (Generic Letter 82-33); and references listed in Appendix A.

The 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 emergency functions and tasks effectively, and (2) identify differences from established human engineering criteria which could lead to control room operator errors.

Once concerns are identified they are documented as human engineering observations (HEOs) and the process of assessment begins. HEOs will be assessed to determine if the effect, or potential effect, of the HEO is significant in which case the HEO is redefined as an HED, and whether its effect is deemed serious enough to warrant analysis for correction. HEOs warranting correction will be defined as human engineering discrepancies (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, however. In such cases, a more

extensive design effort will be performed. Recommendations concerning engineering design efforts will then 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. Task Analysis
3. Control Room Inventory
4. Control Room Survey
5. Verification of Task Performance Capabilities
6. Validation of Control Room as an Integrated System

The sequencing, phasing, and durations of these activities are shown on a preliminary activity schedule (Figure 1-1). Although this preliminary schedule provides durations, such durations may be adjusted to ensure a complete review. The schedule provides expected durations.

1.3 IMPLEMENTATION OF CHANGES

The completion plus validation and verification of all modifications resulting from the DCRDR will determine the baseline control room. Any future changes will be evaluated according to a human factors engineering improvement procedure and guideline to be developed in conjuction with DCRDR. All future changes will be reviewed in accordance with the procedure before implementation.

1.4 FINAL REPORT

Upon completion of the DCRDR, a final report will be prepared and submitted to the NRC for review. The final report will describe the results of the DCRDR and will be submitted within six months of fuel load. This report will summarize the review process, provide descriptions of the identified HEDs, detail proposed corrective actions, and proposed implementation schedules for each action. Any deviation from the proposed DCRDR methodology described herein will be discussed. The final report will also identify the personnel who participated in the DCRDR and delineate their qualifications.

SECTION 2

MANAGEMENT AND STAFFING

2.1 UTILITY MANAGEMENT RESPONSIBILITIES

Management responsibilities will include the following:

1. Analysis of objectives and constraints

2. Commitment of resources

3. Selection of review team personnel

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

5. Integration of the DCRDR with other projects involving human factors concerns

6. Interface among the review team and vendors, consultants, and state and federal agencies

Management responsibilities will also include definition of responsibilities of utility and contractor personnel associated with the 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 appropriate supporting data including the prepared schedule for implementation. Justifications for human engineering discrepancies with safety significance to be left uncorrected or partially corrected shall also be included. The report

will then be presented to management for review and subsequent submittal to the NRC.

2.2 DCRDR ORGANIZATION AND REVIEW TEAM QUALIFICATIONS

2.2.1 Structure

The DCRDR organization will be structured as shown in Figure 2-1. The review team leader will report directly to the management team and coordinate the overall review team effort. The Stone & Webster engineer, General Electric engineer, and operating personnel will provide support for the human factors engineers (consultant) performing the review team activities (survey, interviews, verification, report writing, etc.). The consultant will provide a human factors specialist to direct the day-to-day activities of the human factors engineers. He will report to the team leader for overall coordination.

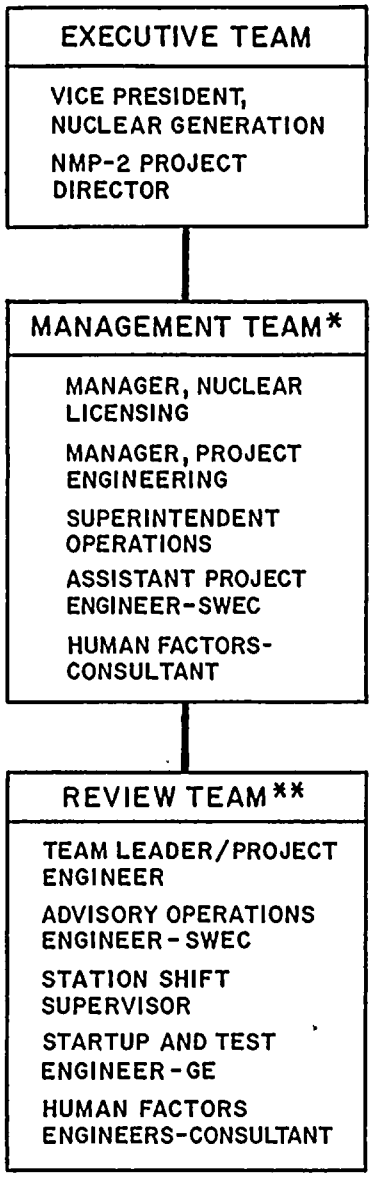
The team leader will be responsible for presenting the recommended changes, task completion reports, and final report to the management team for their review. He will also be responsible for providing the recommended changes and final report to the executive team for their approval.

2.2.2 Qualifications

Qualifications for members of the review team follow.

Review Team Leader

The review team has the review team leader as its key person. This individual provides the administrative and technical direction for the project and has responsibility for the project. Access to information,



APPROVE:

- RECOMMENDED CHANGES
- FINAL REPORT

REVIEW:
(PRELIMINARY AND FINAL)

- RECOMMENDED CHANGES
- TASK COMPLETION REPORTS
- FINAL REPORT

DEVELOP AND/OR PERFORM:

- PROGRAM PLAN
- SURVEY
- INVENTORY
- OPERATING EXPERIENCE REVIEW
- TASK ANALYSIS
- VERIFICATION
- VALIDATION
- ASSESSMENT AND IMPROVEMENT
- RECOMMENDED CHANGES
- TASK COMPLETION REPORT
- FINAL REPORT

* TEAM MEMBERS OR DESIGNEE
** PARTICIPATION ON AN AS-NEED BASIS

FIGURE 2-1
ORGANIZATION CHART
DETAILED CONTROL ROOM DESIGN REVIEW
NIAGARA MOHAWK POWER CORPORATION
NINE MILE POINT-UNIT 2

facilities, and individuals providing useful or necessary input to the team is coordinated by the review team leader. Because of the detailed knowledge of NMP-2 systems and methods, this individual provides a cohesive force for the various NMPC department personnel and vendor organizations involved with this project. Plant operations personnel provide input to the review team through contact with the review team leader.

It will be the responsibility of the review team leader to resolve human factors opinions on methodology, technique, review findings, assessment, and HED corrective actions that dissent with the majority opinion of the DCRDR Review Team. The minimum qualifications for the review team leader will include the following:

- Bachelor's level degree (or equivalent) in an engineering discipline
- Five years' experience in nuclear plant operations or engineering
- Two years' experience in nuclear plant control room design/modifications/HFE reviews

Human Factors Specialist

The human factors specialist will work closely with the review team throughout each phase of the control room review and share with the team the human factors technical leadership of the entire DCRDR project.

Advisory Operations Engineer - SWEC

The advisory operation engineer will assist in the identification of BOP system design goals and functions and will serve as the review team expert on the factors affecting system design decisions.

The minimum qualifications for the advisory operations engineer will include the following:

- BS degree in an engineering or applied science discipline
- five years of related experience or equivalent

Startup and Test Engineer - GE

The startup and test engineer will assist in the identification of NSS system design goals and functions and will serve as the review team expert on the factors affecting NSS system design decisions. The minimum qualifications for the startup and test engineer are equivalent of ANSI N45.2.6, 1978 as deceased for a level II person.

Station Shift Supervisor

The station shift supervisor (SSS) will assist in identifying operator tasks and will serve as the review team expert on the operational constraints for manipulations of plant systems.

The minimum qualifications for the SSS are:

- SRO license
- Equivalent of ANSI N18.1-1978 Section 4.3.1

2.3 UTILIZATION OF SPECIALISTS

Specialists (such as photographers, lighting experts, etc.) will be supplied by NMPC or the HFE Consultant on an as-needed basis.

2.4 TEAM RESPONSIBILITIES AND ORIENTATION

The review team will have the full support of management. It will have access to all pertinent records including system descriptions, logic and flow diagrams, drawings and procedures. The review team will also have access to necessary headquarters facilities, such as office services, communications, and computer services, and will be badged for access to appropriate areas of the plant.

Other personnel who can contribute to the review process will be available to the review team for discussions and consultation.

The review team will be thoroughly familiar with human factors engineering objectives and methodology, applicable NRC documents (e.g., NUREG-0700,-0737,-0801,-0899,-0696,-0835), and the design and operation of the plant.

Each member of the review team will contribute in-depth knowledge of specific topics to the team. It is important, however, that the review team be able to conduct the DCRDR from a common basis of understanding. Therefore, the review team will undergo an orientation program designed to provide each team member with a certain base level of knowledge, particularly of human factors. A secondary purpose of the orientation is to acquaint each team member with the other disciplines represented on the team. However, the intent is not to make each team member an expert in all specialties.

The orientation program will cover the following subjects:

- Human Factors - The orientation will familiarize the team with principles of human factors engineerilng and their application to DCRDR. Included in this area will be a brief synopsis of the history of the DCRDR requirement and its ultimate goals. This orientation will be directed toward those review team members with little or no background in human factors.

- A brief orientation covering the functions of the other review team members will also be provided.

- Miscellaneous - During the course of the review, other subjects requiring orientation will be identified and appropriate instruction will be provided.

2.5 COORDINATION WITH OTHER ACTIVITIES

Several post-TMI activities will be in progress concurrently with the DCRDR. One such task, the upgrading of EOPs, will be directly related to the DCRDR in that the draft EOPs for NMP-2 will provide the technical basis for the DCRDR task analysis. The NMP-2 safety parameter display system will be in preoperational testing during the performance of the DCRDR. As a control room component, the SPDS will be surveyed for consistency with control room design conventions such as color codes and nomenclature. The methodologies developed for the DCRDR will provide a foundation for the incorporation of human factors criteria in future equipment design and the development of an HFE procedure to guide such changes. Emergency response facilities are planned to be fully operational six months prior to fuel load.

Information requirements that ERFs place upon the control room will be identified and evaluated for their effect on emergency operations in the control room.

The post-accident monitoring instrumentation identified in the Regulatory Guide 1.97 review will serve as a primary input to the display identification portion of the task analysis.

SECTION 3

DOCUMENTATION AND DOCUMENT CONTROL

3.1 PURPOSE

The purpose of the DCRDR documentation system is to provide an organized method of developing and storing the large number of forms and documents used in the review.

3.2 METHOD

General

Data used by the review team will be divided into two categories; input data (existing plant documentation and references) and output data (results of various review activities). These categories are described below, along with the means of organizing and controlling the data. Indices and logs produced for control of documentation will be maintained on a computer/word processor data base as appropriate.

Input Data

Input data to the review will be existing documents which describe NMP-2 design and operation, operating experience in selected similar plants, and background information on human factors engineering. These documents will be available to the review team.

Output Data

Output data from the review will consist of records of various review activities (such as checklists, logs, and indices) and HEO identification and assessment forms.

Figures 3-1 and 3-2 show a typical HEO record form which can be used to document an instance where some facet of the control room design does not conform to accepted human engineering standards. One HEO record will be used to document all instances of a particular discrepancy. For example, if six control switches are positioned too close to the edge of a panel, a guideline deviation, all six would be documented on a single HEO record. HEOs will be tracked sequentially on an HEO log similar to Figure 3-3. This log will be used in conjunction with other sorting means, such as location, guideline, and system, to identify certain types of HEO groups.

The determination that an HEO is not significant is also documented on the HEO report (Figure 3-4) to provide for formal justification and traceability of this decision.

HEOs that are determined to be significant will be defined as human engineering discrepancies (HEDs) and documented as such in the HEO report. The HEO index (Figure 3-5) contains spaces for all assessment and implementation activities and is used in evaluating overall progress towards resolution of HEOs.

Photographs may be taken to document HEOs. All photos will be recorded in a photo log (Figure 3-6). This log will be maintained with the HEO log.

At the conclusion of the DCRDR, all files will be stored for permanent retention.

The human factors engineering consultant will establish the project library, establish and maintain the DCRDR document control system, and

HEO No. _____

PAGE ___ OF _____

HEO SOURCE: ☐ Operating Experience ☐ Guideline:

☐ Task Verification ☐ C.R. Validation

TITLE:

Panel Location –	Instr. No. –	System Code –	Service
–	–	–	
–	–	–	
–	–	–	
–	–	–	
–	–	–	

Photo/Drawing Ref: Total: _____ Items Continued on Page _____

Description of HEO:

Continued on Page _____

Assessment: Category _____ ☐ Significant (HED)
Level _____ ☐ Not Significant

Remarks:

Reviewer: Date / / Checked:

FIGURE 3-1
HEO RECORD (OBVERSE SIDE)
DETAILED CONTROL ROOM DESIGN REVIEW
NIAGARA MOHAWK POWER CORPORATION
NINE MILE POINT UNIT 2

HED 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)
DETAILED CONTROL ROOM DESIGN REVIEW
NIAGARA MOHAWK POWER CORPORATION
NINE MILE POINT-UNIT 2

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
DETAILED CONTROL ROOM DESIGN REVIEW
NIAGARA MOHAWK POWER CORPORATION
NINE MILE POINT-UNIT 2

HEO No. _____

PAGE 1 OF _____

HEO ASSESSMENT:

CATEGORY _____ ☐ SIGNIFICANT (HED)

LEVEL _____ ☐ NOT SIGNIFICANT

RESOLUTION:

Reviewer: Date / / Checked

DISPOSITION:

FIGURE 3-4
HEO REPORT
DETAILED CONTROL ROOM DESIGN REVIEW
NIAGARA MOHAWK POWER CORPORATION
NINE MILE POINT-UNIT 2

HEO INDEX

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

FIGURE 3-5
HEO INDEX
DETAILED CONTROL ROOM DESIGN REVIEW
NIAGARA MOHAWK POWER CORPORATION
NINE MILE POINT-UNIT 2

PHOTO No.	ROLL & FRAME No.	PHOTO CAPTION
1-A	16-6	$_{p}$H RECORDER
2-A	22-14	FIRE PROTECTION ANN. OI MISSPELLING
2-B	22-15	SERVICE WATER PUMP LABEL MISSPELLING

FIGURE 3-6
SAMPLE PHOTO LOG
DETAILED CONTROL ROOM DESIGN REVIEW
NIAGARA MOHAWK POWER CORPORATION
NINE MILE POINT-UNIT 2

transmit files to Niagara Mohawk Power Corporation (NMPC) at the completion of the DCRDR. NMPC will provide input to the project library and approve document control procedures.

3.3 DOCUMENTATION STORAGE

DCRDR documentation will be filed in a manner consistent with the sections outlined in this review plan. The control room operating personnel questionnaire will be stored so that confidentiality is maintained.

SECTION 4

REVIEW PROCEDURES

4.1 OPERATING EXPERIENCE REVIEW

The operating experience review consists of two parts: an examination of available documents and a control room operating personnel survey. Through these two activities, the review team will identify conditions that may adversely affect human performance and may be alleviated by the application of human engineering principles. The operating experience review is adapted from the method used for operating plants to improve the review since NMP-2 is not operating.

The operating experiences of plants similar to NMP-2 will be reviewed. NMP-1 is likely to be a major operating experience source. However, the applicability of NMP-1 experience will be limited in certain areas by plant variations including NSSS and control board technology. As needed, operating experiences with BWR-5s and Power Generation Control Complex (General Electric) based control rooms will be reviewed.

The detailed scope of the operating experience review will be defined during the review when the applicability of NMP-1 information is investigated. Another source to be investigated at the time of the review is operating experience findings of the BWR Owner's Group.

4.1.1 Examination of Available Documents

The Institute of Nuclear Power Operations (INPO) will be requested to provide NMPC with a printout of Licensee Event Reports (LERs) sorted by the following characteristics:

- LERs from BWR-5 plants
- LERs involving human error

The review will be limited to LERs from the past 5 years.

The review team will review the documents and summarize the events and circumstances related to pertinent LERs. The summaries will then be reviewed to determine whether a given LER arose from control room design and operation characteristics present in the NMP-2 design. In particular, the review team will seek to identify any case where:

- The equipment referenced in the LER is located in the control room or the remote shutdown panel area.
- The procedure (or steps therein) referenced in the LER are incorporated in NMP-2 procedures.
- The personnel error was related to conditions that could exist during NMP-2 operations.

HEOs will be cited in cases where LER reported problems are manifested in the NMP-2 control room and/or remote shutdown panel.

As an input to the LER review process as well as later review activities, documents such as those listed below will be available for reference purposes:

- Emergency Operating Procedures (Drafts)
- Final Safety Analysis Report
- Maintenance Procedures
- Draft Technical Specifications
- Instrument and Control Procedures

- Surveillance Procedures
- Administrative Procedures
- Assorted Training Documents
- Assorted Drawings, System Descriptions, Logics, P&IDs, etc

4.1.2 Control Room Operating Personnel Survey

The survey is designed to document the problems and positive features of the control room as perceived by operating personnel. Other potential sources of input if needed are:

- NMP-1 Operating Personnel
- NMP-1 & -2 Training Personnel
- Simulator Developers
- EOP Writers

The survey will consist of a questionnaire and interviews. Areas to be addressed in both the questionnaire and interviews include:

- Work space layout and environment
- Panel design
- Annunciator system
- Communications
- Process computers
- Corrective and preventive maintenance
- Procedures
- Staffing
- Training

The questionnaire will be self-administered. Responses will be returned to non-utility members of the review team for review and kept

confidential. The questionnaire responses will be examined both individually and in aggregate to identify responses indicating problem areas as well as positive features in the control room. Problem areas will be documented and inputted to the other review activities. Positive features reported will be recorded and inputted to the assessment and improvement process where they can provide insight into preferred practices and guide corrections.

Interviews will follow up on questionnaire responses. Interviewers will not be NMPC employees so as to ensure frank reponses from interviewers. Interviews will focus on problem areas reported in the questionnaire and will elicit general input from interviewees on opportunities for control room improvements. Problem areas and positive features identified through these interviews will be reported and used in the same manner as questionnaire results.

4.2 TASK ANALYSIS

4.2.1 Purpose

The purpose of the task analysis is to identify displays and controls required by the operators for emergency operations, according to the draft NMP-2 Emergency Operation Procedures (EOPs).

4.2.2 Approach

The task analysis will consist of three phases:

- Task identification and specification of control/display requirements

- Verification that displays and controls required to perform the tasks are available by comparing the control room inventory to the control/display requirements

- Validation of operator effectiveness in performing emergency functions using those displays and controls

4.2.3 Procedure

Task Identification and Specification of Requirements

The task identification and specification of requirements phase consists of two parts. The first part involves specification of the major steps (functions) to be accomplished by the given procedures; and within those, the detailed steps (tasks). Task flow charts will be prepared, as necessary, to delineate task sequences and interrelationships. A task analysis worksheet, such as the sample shown in Figure 4-1, will be used to document control and display requirements needed to accomplish the task. The second part is to identify the type of display or controls necessary to accomplish the tasks delineated in the first part. This includes such information as whether discrete or continuous indication or recording is necessary, and what range, units, resolution of measurement and display, and dynamic characteristics are appropriate for a display; or what type of selection, direction, and actuation are appropriate for a control.

Documentation of this second part will be in the form of a controls and displays requirements list such as the sample list shown in Figure 4-1, which will be used in the verification of instrumentation step described below.

EOP NAME: NOTE 1

TASK ANALYSIS WORKSHEET

REV:
SHEET OF

TASK/ STEP	REQUIREMENT	CAPABITITY	USED WITH	SYSTEM FEEDBACK	EOP BRANCH POINT	INDICATION(S) CONTROL(S) LOCATION	VERIFIED	REMARKS
NOTE 1	NOTE 1	NOTE 1	NOTE 1	NOTE 2	NOTE 2	NOTE 2	NOTE 3	

NOTES:

1. THESE ITEMS ARE FILLED IN DURING "TASK IDENTIFICATION"
2. THESE ITEMS ARE FILLED IN DURING "SPECIFICATION OF REQUIREMENTS"
3. FILLED IN (Y = YES, N = NO) DURING "VERIFICATION OF INSTRUMENTATION"

FIGURE 4-1
SAMPLE TASK ANALYSIS WORKSHEET
DETAILED CONTROL ROOM DESIGN REVIEW
NIAGARA MOHAWK POWER CORPORATION
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Verification of Instrumentation

This phase consists of two parts involving the displays and controls identified during the task identification phase. An inventory of existing control room instrumentation (Section 4.3) will be prepared. The inventory will include instrument descriptions and control room locations and will be matched with the requirements list of Section 4.2. For each control and display requirement, the device(s) fulfilling the requirement will be added to the requirement list. Any instance of missing controls or displays will be cited as an HEO and marked as such on the requirements list. Refer to the "verified" column of Figure 4-1.

The second part will be a comparison of the displays and controls found in the first part of this phase, based on the requirements in the EOPs for their use, with appropriate human engineering design criteria. Although the control room survey will have examined all control room instrumentation for conformance with human engineering design criteria, this verification step is required to determine if an indicator, for example, has the appropriate range and scale gradations to support the particular EOP-associated tasks under consideration. Any instance of non-conformance with human engineering design criteria and task requirements will be cited as an HEO.

Validation of Control Room Functions

The purpose of the Validation of Control Room Functions step is to determine whether functions allocated to control room operating crew can be accomplished effectively within (1) the structure of the event-associated EOPs, and (2) the design of the control room as it exists. Additionally, this step provides an opportunity to identify HEOs that

may not have become evident in the static processes of the review. The step includes talkthroughs of EOP associated tasks. Walkthroughs will also be performed for tasks judged to be time critical.

Talkthroughs

A typical operating crew will be provided with draft EOPs as well as copies of the task analysis forms (flow charts, worksheets) to follow as they are talking through the events.

Operators will be requested to perform the talkthrough in slower-than-real time to provide a relatively slow-paced simulation of the event. During the talkthroughs, the operators will be instructed to speak one at a time and describe their actions. Specifically, the operators will verbalize:

- The component or parameter being controlled or monitored
- The purpose of the action
- The expected result of the action in terms of system response

As the operators talk through the event, they will point to each control or display that they would use and indicate which annunciators are involved.

As the talkthroughs proceed, the operators will note any errors, such as improper step sequencing or branching that may occur on the Task Analysis Forms. These errors will be traced back to the EOPs for investigation to ascertain whether the error occurred because of a procedural problem. If a procedural problem is discovered, it will be documented and fed back to the ongoing EOP development activity.

Walkthroughs

When the talkthroughs of the events are completed, necessary walkthroughs will be performed. In the walkthroughs, the operators will perform the events in real time, where possible, as opposed to the slower time frame used in the talkthroughs. The operators will still point to the controls, displays, and appropriate annunciators, but will otherwise perform the event in as realistic a manner as possible.

Various data will be recorded during the walkthroughs. During the real time run, the movements of each crew member will be traced on a control room outline drawing by an observer. This information will be analyzed to determine the main paths between panels and panel sections and to identify any significant need to access back panel indications or controls. In addition to crew movements, observers will trace the path of the crew through the appropriate EOPs and plant systems. Notations will be made of significant communication links used during each procedure and any instance of crew member conflict (either physical access problems or communication problems) will be noted.

Problems identified in the talkthroughs and walkthroughs will be documented as HEOs.

4.3 CONTROL ROOM INSTRUMENTATION AND EQUIPMENT INVENTORY

4.3.1 Purpose

The control room inventory will establish a reference set of data which will identify all instrumentation, controls, and equipment in the control room for comparison with the requirements identified through the task analysis (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. A floor plan of the NMP-2 control room is shown in Figure 4-2.

4.3.2 Objectives

The objectives of the inventory are to obtain and/or produce:

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

2. A list of all nameplate and annunciator engravings

3. A list of abbreviations, color coding, and layout conventions

4.3.3 Procedure

The detailed list of control room devices will be derived from the existing instrument lists. It will be checked and updated from control board layout drawings and associated bills of material.

Similarly, the nameplate and annunciator engraving lists will be collected and added to the DCRDR library. Conventional meanings ascribed to shape, color, or other attributes will be identified during this phase and a list (including standard abbreviations and nomenclature) will be completed. Appendix B gives the procedure to be followed.

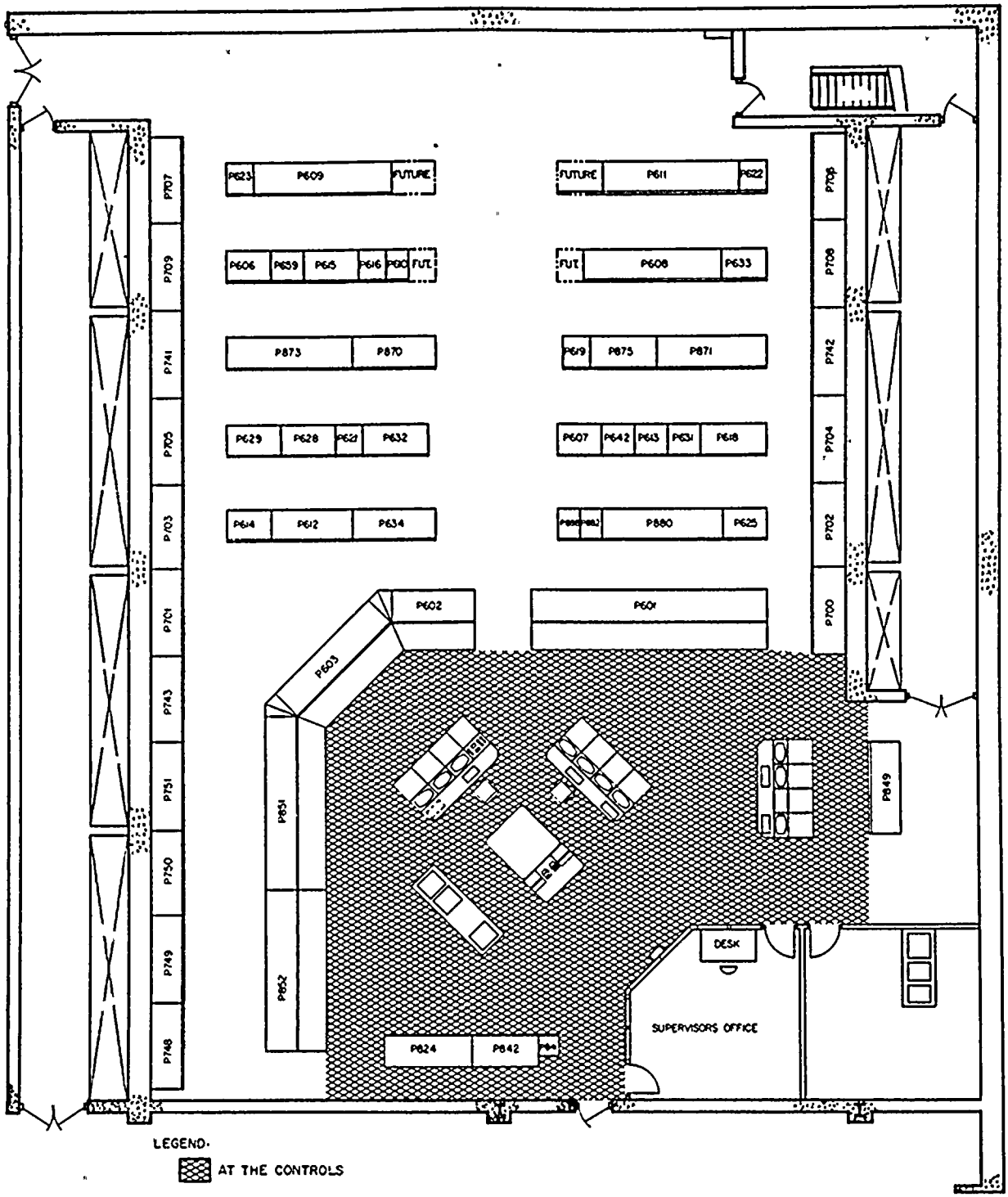

FIGURE 4-2
CONTROL ROOM FLOOR PLAN
DETAILED CONTROL ROOM DESIGN REVIEW
NIAGARA MOHAWK POWER CORPORATION
NINE MILE POINT-UNIT 2

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 operating personnel and whether the control room environment provides acceptable working conditions for operators. Further, the control room survey examines the consistency of control room conventions. The survey will be divided into the following nine areas:

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 systematically the control room against established human factors engineering guidelines (Criteria) such as the guidelines of Section 6, NUREG-0700.

Procedure

A comprehensive set of numbered guidelines will be formulated by the review team for use in the survey. Comparisons between the guidelines and the control room will be documented on individual guideline compliance sheets. Summary evaluations for all items to which a guideline refers will be recorded on the sheets along with a "compliance" or "noncompliance" grade. The guideline compliance sheets will be reviewed altogether for each of the nine survey areas to identify both individual HEOs and HEOs relating to the aggregate.

Documentation

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

Specific objectives of each of the nine survey areas are summarized in Sections 4.4-1 through 4.4-9.

4.4.1 Control Room Workspace Survey

The objectives of the control room workspace survey are:

1. To assess the anthropometric suitability of equipment in the control room.

2. To evaluate furniture, panel, and other equipment layout and interrelationships for their accessibility and suitability as operator workspaces.

3. To evaluate whether the control room manning is suited to the layout.

4. To evaluate the control room environment: temperature, ventilation, lighting, and acoustics.

4.4.2 Communications Survey

Objective

The objective of the communications survey is to evaluate the adequacy of each communications system used in emergency operation. 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 separately. The survey will evaluate the adequacy and appropriateness of available communication links between the control room and the plant.

4.4.3 Annunciator Warning System Survey

The objectives of the annunciator warning system survey are:

1. To evaluate the procedures and controls used to operate the annunciator warning system.

2. To compare annunciator engraving, color coding, and controls with established control room conventions.

3. To evaluate the viewing field and positioning of each annunciator.

4.4.4 Controls Survey

The objectives of the controls survey are:

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

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

3. To verify that control room conventions are consistently applied.

4.4.5 Visual Displays Survey

The objectives of the visual displays survey are:

1. To analyze visual display design and physical characteristics for suitability to its intended use.

2. To evaluate the ease of maintaining and servicing the displays.

3. To evaluate consistency of display design/application with other control room conventions.

4.4.6 Labels and Location Aids Survey

The objectives of the labels and location aids survey are:

1. To list all control room devices which are not labeled.

2. To define the convention used for hierarchical labeling or other labeling systems used in the control room.

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

4. To evaluate label contents for consistency in use of abbreviations, acronyms, and symbols.

5. To evaluate the labels in those systems used in the EOPs for the adequacy and appropriateness of information.

6. To examine location aids installed in the control room for consistency of application and identify areas where additional location aids should be used.

7. To evaluate procedures used to design and control the addition of labels, annunciator window engraving, and location aids (both temporary and permanent).

4.4.7 Process Computer Survey

The objectives of the process computer survey are:

1. To evaluate the organization and layout of computer-related operator work stations and other hardware devices.

2. To evaluate operator interaction required by the computer system.

3. To examine proposed operating procedures and data indices.

4. To evaluate cathode ray tube (CRT) graphic displays for adequacy of character size, color-coding, and screen layout, etc.

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

4.4.8 Panel Layout Survey

The objectives of the panel layout survey are:

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

2. To evaluate existing demarcation, mimic, and grouping methods, and to identify any unwritten conventions.

3. To identify those areas where additional control and display location aids are needed.

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

4.4.9 Control - Display Integration Survey

The objectives of the controls-display integration survey are:

1. To identify all control-display pairs and groups.

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

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

4.5 VERIFICATION OF TASK PERFORMANCE CAPABILITY

A verification will be made of the availability of instruments and equipment needed to perform the EOPs. The verification will be made by comparing the control and display requirements identified in the task analysis (Section 4.2) to the control room inventory (Section 4.3). This comparison will identify cases where a required control or display is not present in the control room. Such cases will be documented as HEOs. Documentation will include a list of correlated control display requirements and associated control room equipment.

4.6 CONTROL ROOM VALIDATION AS AN INTEGRATED SYSTEM

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 the draft NMP-2 EOPs can be executed in the NMP-2 control room.

The validation will be performed as part of the task analysis (Section 4.2) and involves talkthroughs and walkthroughs. Problems identified through the dynamic simulation of the EOPs will be reported as HEOs.

SECTION 5

ASSESSMENT AND IMPROVEMENT

5.1 PURPOSE

In theory, each HEO identified in the review process is a deviation from human engineering criteria which could be eliminated by some form of design or task modification. However, the number and extent of modifications that can be implemented will be limited for reasons of economic feasibility, practicality, and worth. Therefore, a process is required which will identify HEOs worth considering for correction. The assessment and improvement process will meet this requirement by assessing the importance or significance of given HEOs to identify HEDs (significant HEOs), identifying the appropriate method of correction for HEDs, and producing either enhancement descriptions for immediate implementation or design objectives for later development of design corrections for HEDs. Where possible, enhancements and design corrections will be verified and validated using the review techniques employed in Sections 4.5 and 4.6.

The result of this process will be the selection of HEDs from the set of HEOs, and a set of recommended design corrections for HEDs. In some cases, an extensive design effort, conducted separately from the DCRDR over an extended time period may be necessary to correct an HED. Verification and validation of these design corrections, therefore, will not be done in the scope of the DCRDR, but will be performed at the completion of the design effort.

In summary, the assessment and improvement process will provide an organized approach to identifying necessary design changes to the control room on a rational, consistent, and thorough basis.

5.2 APPROACH

The approach to the assessment and improvement process is diagramed in Figure 5-1.

The approach to each major step is described in greater detail in the following sections.

5.2.1 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 HED identification and decisions to correct HEDs fully, partially, or not to correct them may be made rationally.

The HEO categorization procedure distinguishes between HEOs on the basis of risk (probability) of operator error and error importance (severity of consequences).

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

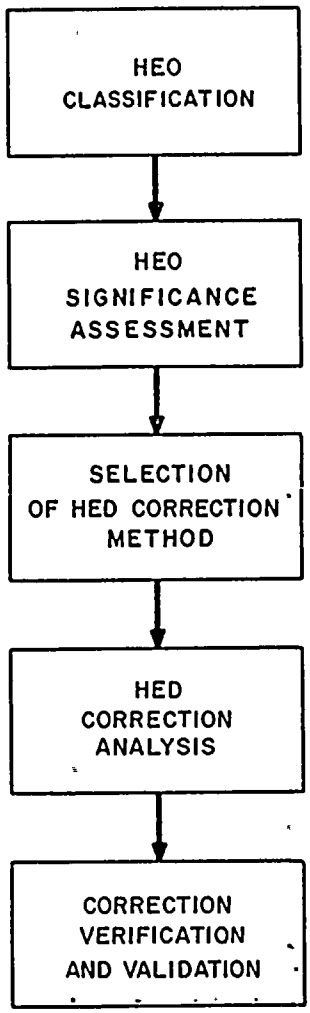

FIGURE 5-1
ASSESSMENT AND
IMPROVEMENT PROCESS
DETAILED CONTROL ROOM DESIGN REVIEW
NIAGARA MOHAWK POWER CORPORATION
NINE MILE POINT-UNIT 2

This information will be used to evaluate the potential consequences of operator error and the assignment of HEOs to categories and levels.

The categorization process (Figure 5-2) details the logical steps to determine HEO category and level. There are four categories (1, 2, 3, 4) and five levels (A, B, C, D, E) for HEOs. These categories and levels are defined in Sections 5.3.1 and 5.3.2. Figure 5-2 shows the flow of the categorization process. The flow chart indicates the process through which Category 4 HEOs can be redefined as Category 2 HEOs due to interactive effects of unacceptable consequence disclosed through analysis.

5.2.2 HEO Significance Assessment

The purpose of this step is to determine which HEOs among those identified during the review process are significant and should be defined as HEDs. An HED represents a potential source of operator error with significant 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 management. Accordingly, all HEOs involving plant safety and selected nonsafety-related HEOs of concern to management will be considered significant. Significant HEOs (i.e. HEDs) must be analyzed for correction while non-significant HEOs need not be.

Before an individual, nonsafety-related HEO may be discounted as non-significant, a second stage of assessment will be performed in which the interrelationships or cumulative effects of nonsignificant HEOs will be studied to identify any unacceptable safety- or nonsafety-related

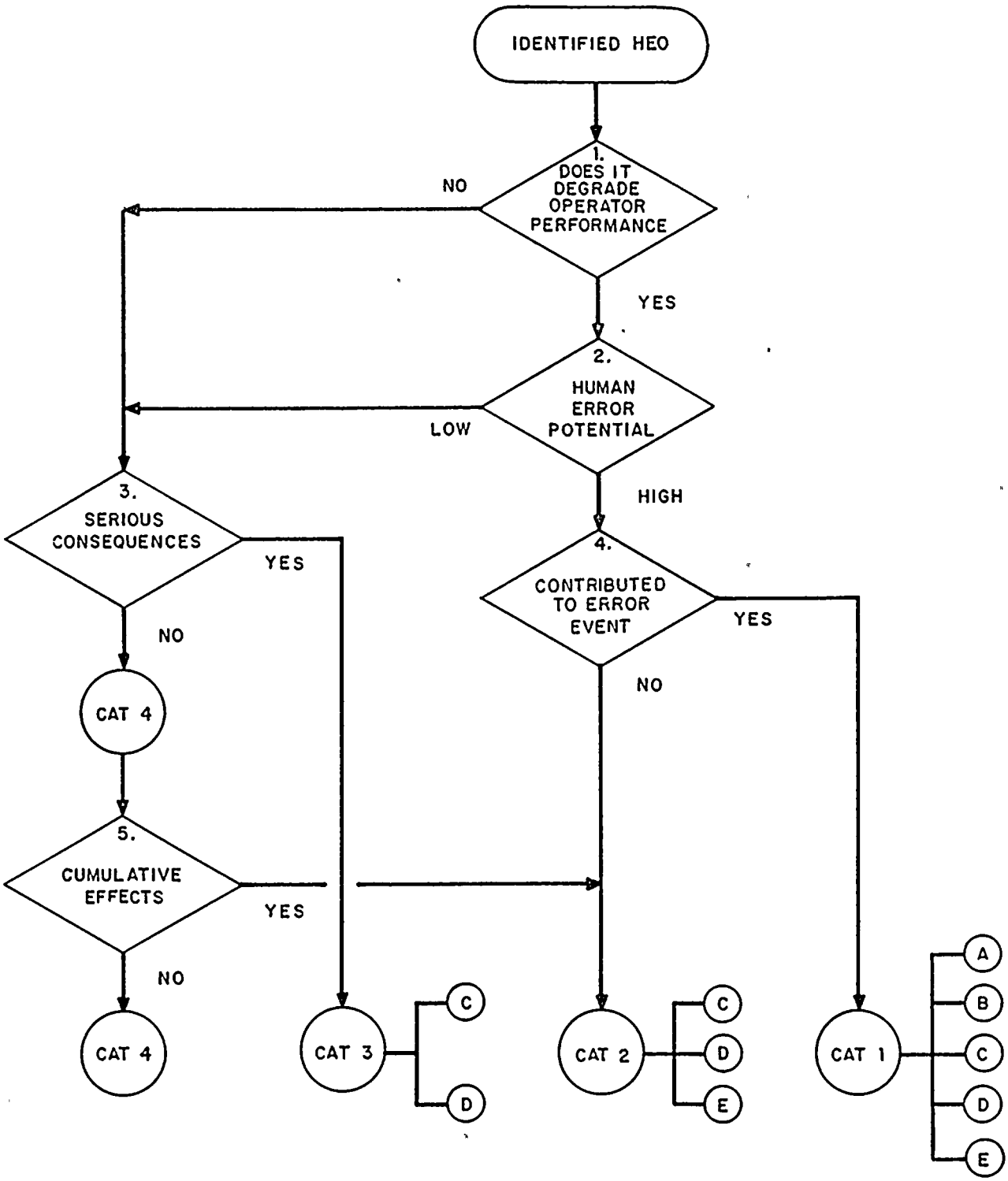

FIGURE 5-2
HEO CATEGORIZATION PROCESS
DETAILED CONTROL ROOM DESIGN REVIEW
NIAGARA MOHAWK POWER CORPORATION
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effects on plant operation. If unacceptable effects are identified, the HEOs originally classified as nonsignificant are redefined as significant, defined as HEDs, and will be analyzed for correction.

Specialized techniques have been developed to aid the assessment of HEO significance. These techniques are described in Section 5.3.3. The 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. One or more techniques may be used, as needed, until a determination of significance can be made.

5.2.3 Selection of Correction Method

The purpose of this step is to choose the appropriate method of correcting a given HED and does not apply to nonsignificant HEOs. Two methods to correct an HED are defined to account for the range in HED type and extent. One method is termed enhancement and applies to HEDs which can be satisfactorily corrected by simple surface treatment techniques or administrative charges. The other method, for HEDs which cannot be satisfactorily corrected by enhancement, is correction by means of a separate design effort.

Enhancement corrections are distinguished from design corrections by the physical nature of the correction and the scope of analysis and design effort required to develop them. Corrections, such as labeling changes, array demarcation, changing chart recorder paper, or modifying a procedure, are clear cut and require limited analysis. Recommendations for enhancement corrections will be developed by the review team. Other corrections such as a major panel redesign are beyond the scope of the

DCRDR and will have to be approached as a separate design project requiring significant resources not allocated to the DCRDR. In such a case, the review team will prepare design objectives and a scope of work for the design effort.

One other option is to select both correction methods. This is the appropriate choice when a near-term, quick-fix solution is warranted while a more effective long-term solution is developed.

The final product of this step will be a correction method assignment for each HED.

5.2.4 Correction Analysis

The approaches to HED correction by enhancement and by design are described in the following sections. In both cases, analysis will be weighted towards using the judgment of the review team members in developing design recommendations. Special analyses employed in the development of recommendations will be identified by the review team at the time of correction analysis and, therefore, are not described here.

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, a requirement to provide a near-term solution as well as an integrated control room design in the long-term will be resolved.

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 recommendation. The final design recommendation 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 partial correction or no correction will be justified and documented. The basis of justification will be benefit/cost or other appropriate analyses.

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 problem description, design objectives, and proposed correction description.

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.

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 recommendation. Design objectives will be used to guide design development efforts implemented subsequent to the DCRDR.

The review team may conclude that it is not feasible to correct certain HEDs identified as significant. This conclusion will be justified and documented.

In the event that a recommended design development process requires a considerable time period, its validation and verification will be at the completion of the design and conducted separately from the scope of the DCRDR.

5.2.5 Verification and Validation

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

5.2.6 Documentation

Documentation of the assessment and improvement process will be performed concurrently with each step. Documentation will include records of HEO categorization and significance assessment. The records will also 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 is placed on documenting justifications not to correct a significant HED.

5.3 PROCEDURE

The assessment and improvement process (Figure 5-1) incorporates four methods:

1. HEO categorization.
2. Significance assessment.
3. Correction method selection.
4. Correction implementation.

5.3.1 HEO Categorization

The HEO categorization process is diagramed in Figure 5-2. The steps shown in the figure are designed to categorize HEOs into 4 categories.

Figure 5-2 includes a branch where HEOs categorized as Category 4 may be re-categorized as Category 2 due to the cumulative effects of multiple Category 4 HEOs. The purpose of analyzing the cumulative effects among Category 4 HEOs and not HEOs in Categories 1, 2, and 3, is that Category 4 HEOs would otherwise be discounted as non-significant and dropped out of the assessment and improvement process.

HEO Categories are summarized below:

1. Category 1 -- HEOs Associated with Documented Errors in Similar Plants Included in the Operating Experience Review

   Category 1 includes HEOs 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. Since NMP-2 has no operating history, this information will be obtained from selected similar plants and correlated with NMP-2 design characteristics.

2. Category 2 -- HEOs Associated with Potential Errors

   Category 2 includes all HEOs which have been assessed and determined to increase the potential for causing or contributing to a human error.

3. Category 3 -- HEOs Associated with Low Probability Errors of Serious Consequence

   Category 3 includes all HEOs that are associated with low probability errors of serious consequence. HEOs in this category will be those associated with errors which are intolerable because of their possible adverse consequences.

4. Category 4 -- HEOs not Associated with Errors

Category 4 includes any HEO 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.

5.3.2 HEO Category Levels Definition

HEOs will be further categorized by level. Levels are based on an HEO's actual or potential adverse effect on plant safety and operability. Each level is defined below and graphically portrayed on Figure 5-3.

Level A - Includes those HEOs for which the related documented (in similar plants) error:

1. Was associated with a safety-related function, and

2. Resulted in unsafe operation.

Level B - Includes those HEOs for which the related documented (in similar plants) error:

1. Was associated with a safety-related function, and

2. Resulted in violation of a technical specification.

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

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

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

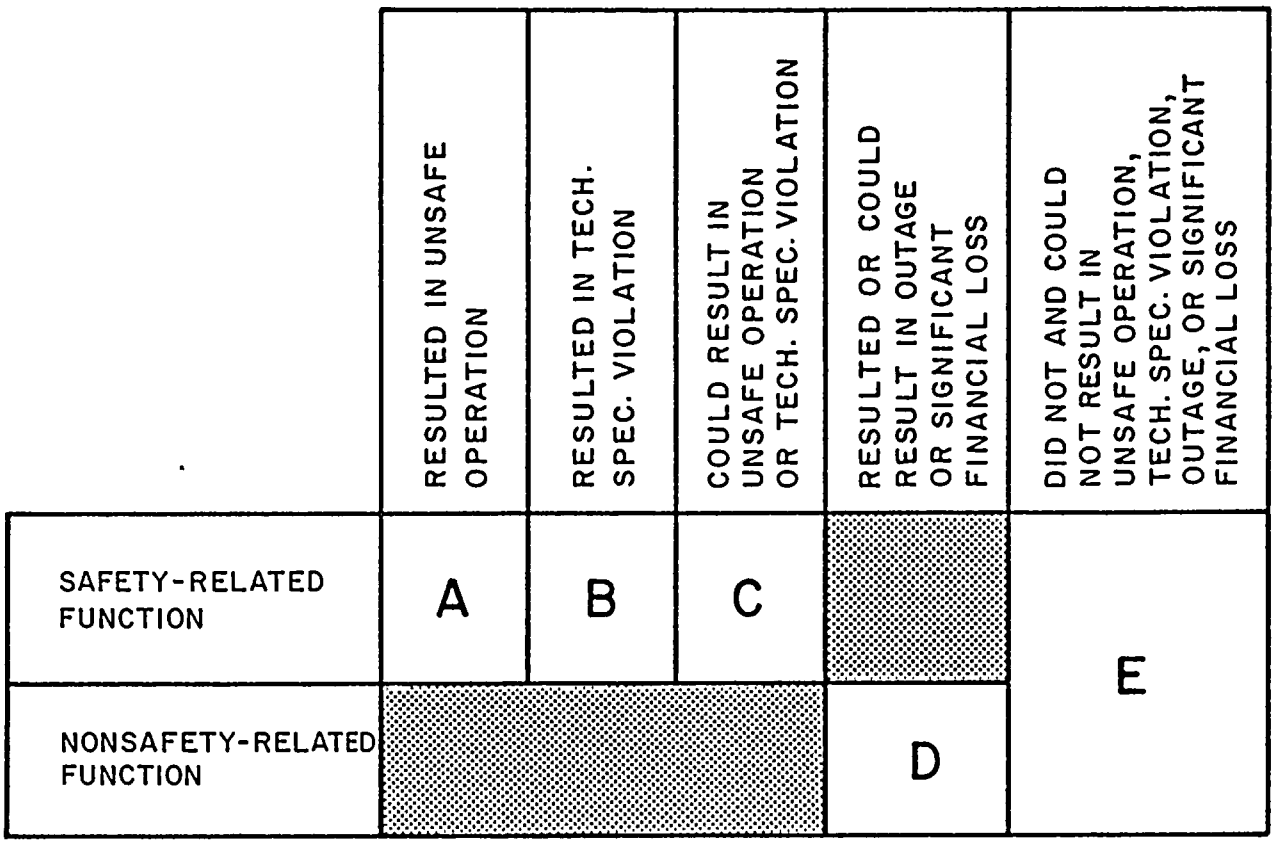

FIGURE 5-3
CATEGORY LEVEL DEFINITION
DETAILED CONTROL ROOM DESIGN REVIEW
NIAGARA MOHAWK POWER CORPORATION
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Level D - Includes those HEOs for which the related potential error:

1. Is associated with a nonsafety-related function, but

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

Level E - Includes those HEOs for which the related potential error:

1. Is associated with either a safety-related function or a nonsafety-related function, but

2. Could not result in unsafe operation, the violation of a technical specification, a plant outage, or a significant financial loss.

Not all levels are applicable to all HEO categories by definition.

An HEO may be placed into the following categories and levels:

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

2. Category 2 (C, D, and E)

3. Category 3 (C and D)

4. Category 4 (No levels)

5.3.3 Significance Assessment

Significance assessment distinguishes HEOs from HEDs using one or more of the specialized techniques listed below:

Technique 1 -- Assessment by HEO Category and Level

Technique 2 -- Assessment by HEO Significance Rating

Technique 3 -- Assessment by HEO Mockup Mapping and Computer Sorting of HEOs

Technique 4 -- Assessment by Review Team Judgment

Each technique is described in detail in the following section.

Technique 1 -- Assessment by HEO Category and Level

The category and level of an HEO will give a general indication of the significance of an HEO. Figure 5-4 shows the expected distribution of various HEO categories and levels over a comparative range of significance. The middle range of significance in the chart indicates HEOs for which the need for additional evaluation beyond HEO category and level evaluation, is indicated in order to determine HEO significance.

The chart's primary purpose is to give the reviewer a general sense of HEO significance on the basis of HEO category and level. Decisions regarding HEO significance in most cases can not be made solely on the basis of HEO category and level.

Technique 2 -- Assessment By HEO Significance Rating

The HEO Significance Rating Sheet (Exhibit 5-1) and human performance criteria listed below may be used for HEO assessment. The rating sheet evaluates the HEO in terms of the following human performance criteria:

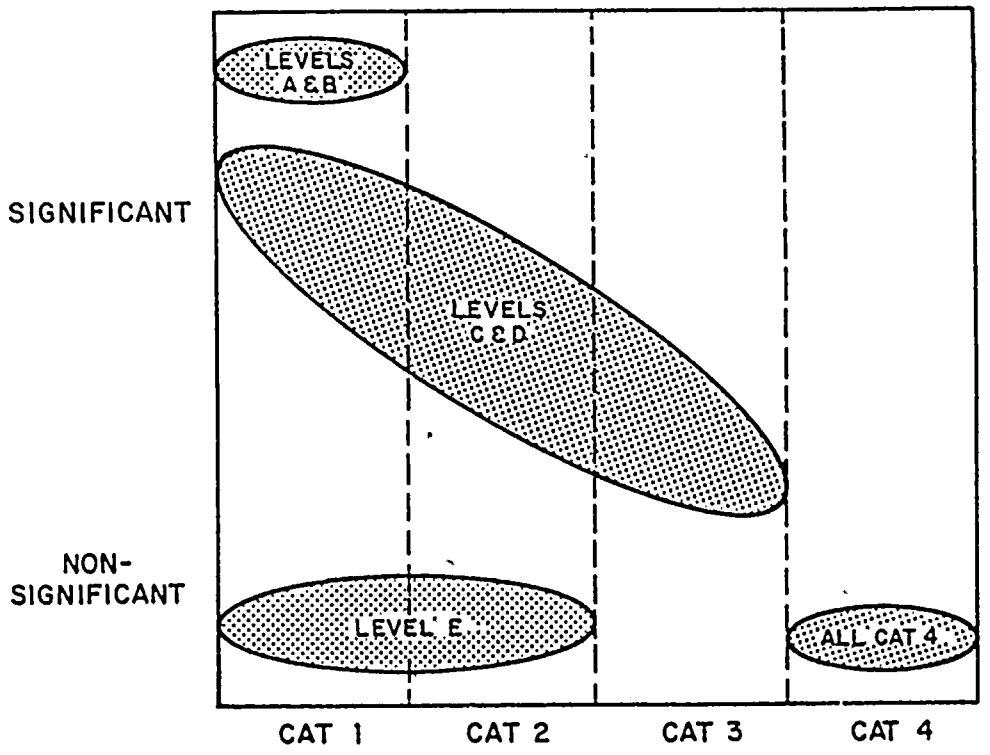


FIGURE 5-4
SIGNIFICANCE ASSESSMENT BY HED CATEGORY AND LEVEL
DETAILED CONTROL ROOM DESIGN REVIEW
NIAGARA MOHAWK POWER CORPORATION
NINE MILE POINT-UNIT 2

N/A RATING

EXHIBIT 5-1

HEO SIGNIFICANCE RATING SHEET

HEO No. _____

Description _____

_____

Reviewer _____
Date _____
Cummulative 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 HEO will cause undue operator fatigue (Physical or Mental).		
2. This HEO will cause operator confusion.		
3. This HEO will cause operator discomfort.		
4. This HEO presents a risk of injury to control room personnel.		
5. This HEO will increase the operator's mental workload (for example, by requiring interpolation of values, remember inconsistent or unconventional control positions, etc).		
6. This HEO will distract operators from their duties.		
7. This HEO will affect the operator's ability to see or read accurately.		
8. This HEO will affect the operator's ability to hear correctly.		
9. This HEO will affect the operator's ability to communicate with others (either inside or outside the control room).		
10. This HEO will degrade the operator's ability to manipulate controls correctly.		
11. This HEO will cause a delay of necessary feedback to the operator.		

	N/A	RATING
12. Because of this HEO the operator will not be provided with positive feedback about control tasks.		
13. This HEO violates control room conventions or practices.		
14. This HEO violates nuclear industry conventions.		
15. This HEO violates population stereotypes.		
16. Operators have attempted to correct this HEO themselves (by self-training, temporary labels, "cheaters","helper" controls, compensatory body movements, etc).		
17. Tasks in which this HEO is involved will be highly stressful (i.e., highly time constrained, or of serious consequence, etc).		
18. This HEO will lead to inadvertent activation or deactivation of controls.		
19. If this HEO caused a specific error, it is probable that another error of equal or more serious consequence will be committed.		
20. This HEO is involved in a task which is usually performed concurrently with another task (e.g., watching water level meter while manipulating a throttle valve control).		
21. This HEO 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 HEO involves controls or displays that are part of an engineered safety function or are associated with a reactor trip function.		

No. Rated _____

Total _____

Average _____

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 can be used to assess the comparative significance of related and unrelated HEOs. HEO significance is quantified to aid in distinguishing between significant and nonsignificant HEOs and to aid the assessment of correction priority. 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 provides some basis of comparison. Some of the statements on the rating sheet are not be applicable to certain HEOs. In these cases, "Not Applicable" ("N/A") responses are entered.

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

The significance rating sheet can also be used to assess the significance of individual HEOs by examining the results of individual rating sheets. Judgment of the assessment team members can be used to formulate the ratings and then to formulate decisions regarding what rating frequency and magnitude of severe ratings 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.

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

1. Calculate the individual HEO mean ($\overline{X}$) rating (cumulative total divided by number rated).

2. Calculate the population (all HEO ratings) mean (μ) and standard deviation (σ) of the means ($\overline{X}$).

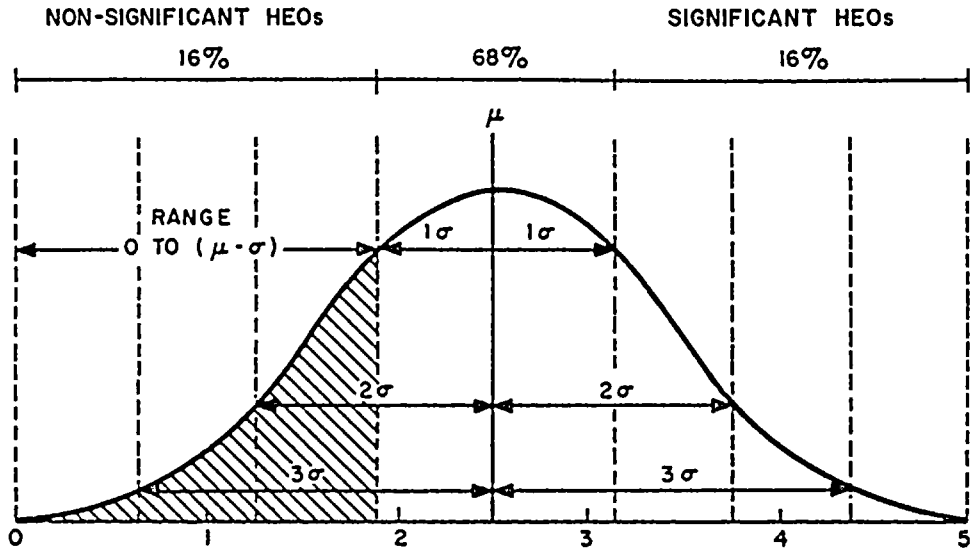
3. Calculate the range: $\mu \pm \sigma$.

A normal probability distribution is assumed for the mean ratings ($\overline{X}$). Given this assumption, the range of $\mu \pm 1\sigma$ includes 68 percent of the mean ratings ($\overline{X}$), $\mu \pm 2\sigma$ includes 95 percent, and $\mu \pm 3\sigma$ includes 99.7 percent. Figure 5-5 illustrates these ranges for a sample normal distribution. Differentiation of HEDs from HEOs using this technique is also reflected in Figure 5-6.

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

Technique 3 -- Assessment By HEO Mockup Mapping and Computer Sorting of HEOs

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 is the possibility of cumulative effects. The technique involves

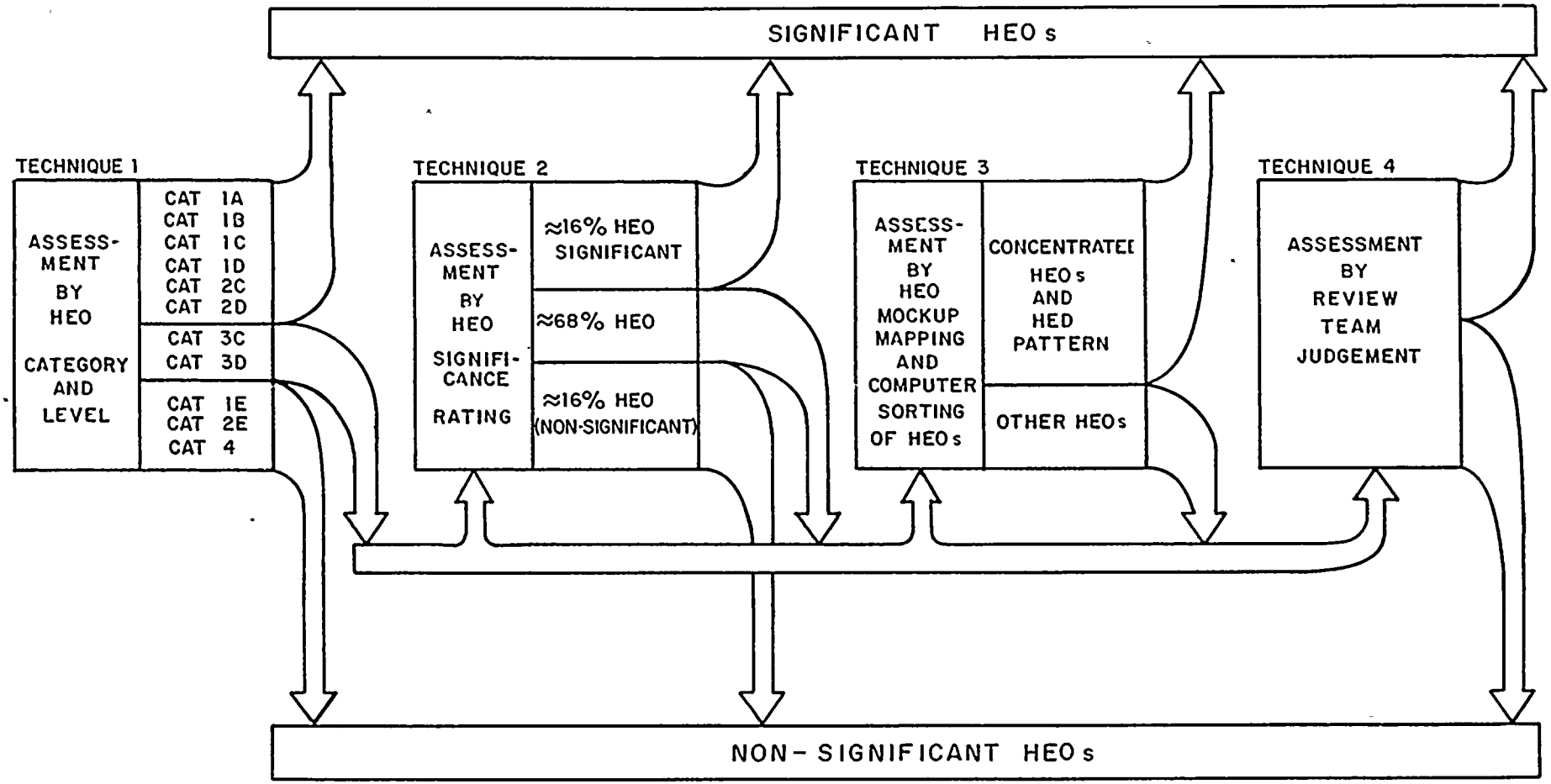


$\bar{X}$ = MEAN RATING

μ = POPULATION MEAN OF MEANS ($\bar{X}$)

σ = STANDARD DEVIATION OF MEANS ($\bar{X}$)

FIGURE 5-5
SIGNIFICANCE RATING STATISTICAL EVALUATION GUIDE
DETAILED CONTROL ROOM DESIGN REVIEW
NIAGARA MOHAWK POWER CORPORATION
NINE MILE POINT-UNIT 2



NOTES:

1. TECHNIQUE 1. USED FOR ALL HEOs
   TECHNIQUES 2,3,4 USED AS REQUIRED
2. SIGNIFICANT HEOs = HEDs

FIGURE 5-6
SIGNIFICANCE ASSESSMENT DECISION PROCESS
DETAILED CONTROL ROOM DESIGN REVIEW
NIAGARA MOHAWK POWER CORPORATION
NINE MILE POINT-UNIT 2

mapping HEOs on panel layout drawings using suitably coded symbols; color coding is the likely method.

The review team decides how to code HEO mapping symbols. HEOs will be coded to communicate information such as:

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 Category and Level

4. HEO Significance rating

Each mapping symbol will be a single, solid color marker large enough to accommodate labeling with the HEO number. Mapping symbol codes assigned to the HEDs will be documented on the HEO report.

The review team analyzes the panel layout drawings mapped with HEOs to identify HEO patterns and high density areas of HEOs related to individual panels. Patterns identified and dense groupings of HEOs are 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.

Typical sorting classes that may be incorporated in the HEO documentation system are:

1. HEO Category
2. HEO Level
3. Effect on Human Performance
4. Functional Title
5. Emergency Operating Procedure
6. Task Reference
7. Device Type
8. Panel Location Number

The review team will specify data base contents along with the specific computer sorts required to assess HEO significance.

Technique 4 -- Assessment By Review Team Judgment

In some cases, HEO assessment using the previously described techniques may not be desired or conclusive. In those cases, expert judgment will be used as the basis of significance assessment. Final decisions will represent the consensus of the review team.

5.3.4 Selection of Correction Method

In order to divide significant HEOs, from this point on referred to as HEDs, into separate groups to be corrected by methods of enhancement versus design, all HEDs will be screened for possible correction through enhancement. For this purpose, an enhancement checklist is provided in Figure 5-7 to aid the review of possible enhancement techniques which may be applied. In some cases, the difference between an enhancement and a design correction will not be easily distinguished. To select an enhancement approach when a design approach is more appropriate will not be critical because all enhancements will be reviewed before recommendation for implementation. If the enhancement is judged inadequate, it may be reworked or a design effort may be undertaken instead. To select a design approach when enhancement would suffice would be a conservative, and potentially expensive, solution.

The result of screening HEDs for enhancement will be the division of all HEDs into two categories:

1. HEDs to be corrected by enhancement

2. HEDs to be corrected by design

ENHANCEMENT

VISUAL

- DEMARCATION
- MIMICS
- COLOR CODING
- SYMBOL CODING
- INDICATOR SCALES
- INDICATOR ZONE MARKING
- GLARE REDUCTION
- PANEL COLOR
- ANNUNCIATOR LEGENDS
- LABELING

PHYSICAL

- SHAPE CODING (CONTROLS)
- FURNITURE
- FURNITURE ARRANGEMENT
- DOCUMENT STORAGE
- PROTECTIVE BARRIERS
- RECORDER PAPER
- MAINTENANCE TAGS

ENVIRONMENTAL

- TEMPERATURE
- HUMIDITY
- VENTILATION
- LIGHTING
- SOUND BARRIERS
- DECOR

ADMINISTRATIVE

- TRAINING
- PROCEDURES
- CONTROL ROOM ACCESS
- OPERATOR AIDS
- COMMUNICATION
- DOCUMENTATION

FIGURE 5-7
ENHANCEMENT CHECKLIST
DETAILED CONTROL ROOM DESIGN REVIEW
NIAGARA MOHAWK POWER CORPORATION
NINE MILE POINT-UNIT 2

5.3.5 Correction Implementation

Enhancement Correction Procedure

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

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 may be to consolidate the set of HEDs for correction by design since a comprehensive demarcation effect is a substantial undertaking.

If consolidation of HEDs is not appropriate and/or the enhancement correction is still within the scope of the review team's resources and responsibilities, enhancement analyses and design of the enhancement will commence. Analysis and design will be based on standards for human

engineering design, standards for NMPC control rooms, and will conform to the objectives of an integrated control room design. All enhancements will be verified and validated using procedures described in Sections 4.5 and 4.6.

Enhancements of significant value in improving plant operability and safety will be recommended for immediate implementation. Recommendations for enhancements not requiring immediate implementation will be made by means of design recommendations. The recommendations will include:

1. Problem Statement

2. Enhancement Description

3. Verification and Validation Documentation

If the review team decides that HED correction is not necessary, the decision will be justified and documented. All HEDs will be accounted for either by correction recommendation or by justifying the decision not to correct.

Design Correction

The objective of the design correction procedure is to produce design recommendations. These will be of sufficient detail to support decision-making regarding the conduct of the design effort. They will include:

1. Problem Statement

2. Scope of Work

3. Design Objectives

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.

5.4 RESULTS

The results of the HED assessment and improvement process will be recommendations for changes to the control room design intended to reduce the potential for operator error. The design recommendations will address, in particular, the correction of HEDs identified in the review processes as having the potential to compromise plant safety and/or operability.

There will be two types of design recommendations. One type will be enhancement correction recommendations for surface treatments requiring limited financial and time resources. The other 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.

Documentation of enhancement correction recommendations will include final concept designs for enhancements. Documentation materials may include calculations, drawings, mockups, etc. The materials will be organized into a problem statement, enhancement description and verification and validation description. Documentation of design

correction recommendations will include a problem statement, the scope of work, and design objectives which will guide the design development process. The detail of the task specifications will be on a level which will assure conformance to human engineering standards, and the objectives of an integrated control room design.

Recommendations for improvement will be supported by documents produced throughout the assessment process. This information may be useful in establishing the implementation priority of design recommendations or in justifying 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.

APPENDIX A

INDEX OF DOCUMENTS FOR DCRDR

APPENDIX A

INDEX OF DOCUMENTS FOR DCRDR

The following documents will be available to the review team:

Utility Documents

Nile Mile Point Nuclear Station - Unit 2 Final Safety Analysis Report (FSAR).

Emergency Procedure Guidelines developed by the BWR Owners Group.

NMP-2 Emergency Operating Procedures (Drafts).

Draft Technical Specifications

NMP-2 Engineering Change Control Procedure

NMP-2 Response to Generic Letter 82-33.

Engineering Drawings:

- Control Room and Remote Shutdown Panel

- Control Boards

Regulatory Guide 1.97 Equipment List

Plant Communications Plan

Bills of Material (Control Room Eqipment)

EPRI, ERDA, INPO, and NRC Documents

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.

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

EPRI NP-1637, Draft, Integrating Human Factors Engineering into Nuclear Power Plant Designs, [illegible] 1982.

EPRI NP-2411, Human Engineering Guide for Enhancing Nuclear Control Rooms, Honeywell Inc. and Lockheed Missiles & Space Co., Inc., May 1982.

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

INPO 82-014, INPO/TVA Pilot Systems Review, June 1982.

INPO 83-026 (NUTAC), Control Room Design Review Implementation Guideline, July 1983.

INPO 83-036 (NUTAC) Human Engineering Principles for Control Room Design Reviews, 1983.

INPO 83-042 (NUTAC), Control Room Design Review Survey Development Guideline, November 1983.

INPO 83-046 (NUTAC), Control Room Design Review Task Analysis Guideline, December 1983.

INPO 83-048 (NUTAC), Guidance for an Integrated Implementation Plan for Emergency Response Capabilities, December 1983.

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

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

NUREG-0737, Clarification of TMI Action Plan Requirements, November 1980.

Supplement 1 to NUREG-0737, Requirements for Emergency Response Capability - (Generic Letter No. 82-33), December, 1982.

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

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

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

NUREG-0899, Guidelines for the Preparation of Emergency Operating Procedures, January, 1982.

NUREG/CR-2987, Identification and Analysis of Human Errors Underlying Electrical/Electronic Component Related Events Reported by Nuclear Power Plant Licensees, June 1983.

Regulatory Guide 1.97, Rev. 2, Instrumentation for Light-Water Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident, December 1980.

APPENDIX B

CONTROL ROOM DESIGN CONVENTIONS SURVEY

APPENDIX B

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. The conventions survey will be performed as a preliminary step in the control room survey.

Scope

Control room conventions will be defined for all control panels 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 and used to guide design corrections and future modifications.