Detailed Control Room Design Review

Program Plan

For The

Standardized Nuclear Unit Power Plant System

(SNUPPS)

Wolf Creek Plant - Kansas Gas and Electric Co.

Docket No. STN 50-482

Callaway Plant - Union Electric Company

Docket No. STN 50-483

In Response To:

NRC Generic Letter 82-33

Supplement 1 to NUREG 0737

June 1983

OUTLINE

1.0 SUMMARY

Generic letter 82-33 "Supplement 1 to NUREG 0737" requires that all licensees submit a plan for satisfying the requirements for a Detailed Control Room Design Review (DCRDR). This required DCRDR program plan is contained herein. The SNUPPS DCRDR Program Plan was prepared by the SNUPPS Utilities (Kansas Gas and Electric Company, Kansas City Power & Light Company, and Union Electric Co.), with the assistance of the SNUPPS Staff organization and the Human Factors Technology Group, ARD Corporation of Columbia, Md.

The SNUPPS DCRDR began in September 1980 when Essex Corporation was engaged to perform a human factors engineering evaluation of the SNUPPS control room design in accordance with NUREG/CR-1580 "Human Engineering Guide to Control Room Evaluation".

Other elements of the SNUPPS DCRDR are based on work programs undertaken by the Westinghouse Owners Group. These programs include development of generic emergency response guidelines (ERGs), a generic system review and task analysis (SRTA), and verification and validation of the generic procedures on a SNUPPS simulator. As a consequence of these efforts, the SNUPPS DCRDR is well underway.

NUREG-0700, "Guidelines for Control Room Design Reviews", specifies four major activities for the DCRDR process:

- o Planning
- o Review
- o Assessment and Implementation
- o Reporting

This report describes how the SNUPPS DCRDR has addressed these human engineering processes, as follows:

Planning - Section 2.0 "Review Plan" discusses the requirement for, and status of, DCRDR elements and the approach for completing outstanding items.

Review - Section 3.0 "Review Process" describes or makes reference to detailed procedures or guidelines for performing the elements of the DCRDR review.

Assessment and Implementation - Section 4.0 "Assessment, Implementation, Documentation and Summary Report" describes the method of assigning priority to findings and discusses the implementation of approved resolutions.

Reporting - This Program Plan, its references, and the Summary Report, discussed in section 4.0, constitute reports for the DCRDR.

The SNUPPS Utilities believe that this Program Plan is responsive to all of NRC's requirements with respect to a DCRDR.

2.0 REVIEW PLAN

A number of comprehensive Human Factors Engineering review activities have been conducted at the SNUPPS plants over the past three (3) years. This Program Plan summarizes activities conducted prior to the issuance of Generic Letter 82-33, the human factors review processes currently in progress, and those scheduled for completion. The approach, which integrates these efforts, is in keeping with the NRC policy of crediting the human factors engineering activities conducted to date which meet the intent of a DCRDR and closely adheres to the guidelines established by the NRC.

A number of interrelated human factors engineering review activities have been performed which meet the intent and in many cases exceed the recommended guidelines for the conduct of a DCRDR. These activities made use of the SNUPPS simulators (located at the Westinghouse Training Center in Zion, Illinois and at the Callaway site), the partially completed Callaway and Wolf Creek control rooms, full-scale mock-ups of control board panels, the generic function and task analyses performed by the Westinghouse Owners Group, plant specific operating procedures, plant drawings, system descriptions, and numerous other design documents. The evaluation is applicable to both Callaway and Wolf Creek, since the control rooms are of a standardized design, except for the site-specific panels, which control the off-site power systems, the circulating water system and the service water systems. These aspects of both the Callaway and Wolf Creek panels have been reviewed on a plant specific basis. The following pages list required DCRDR elements and the approach taken by SNUPPS to satisfy these elements.

2.1 Elements of the DCRDR

The elements of a DCRDR as required by generic letter 82-33 and recommended by NUREG 0700 include the following tasks:

- o Establishment of a Multidisciplinary Review Team
- o Review of Operating Experience
- o System Functions Review and Task Analysis
- o Control Room Inventory
- o Control Room Survey
- o Control Room Validation as an Integrated System
- o Assessment of Findings and Implementation of Resolutions

All but the last of these tasks are addressed in this section. Assessment of Findings and Implementation of Resolutions is discussed in secton 4.0.

2.1.1 Review Team

From the beginning of the SNUPPS DCRDR process in September 1980, SNUPPS has maintained a base group of individuals to follow and review human factors concerns. This base group of utility personnel has been supplemented by Human Factors consultants, the lead A/E and SNUPPS Staff as necessary.

The control room review activities were implemented by experienced engineering and operating personnel from the SNUPPS organization, Westinghouse, Bechtel, and human factors consultants. These personnel performed the control room review with input from other studies and analyses involving human factors engineering considerations discussed in NUREG-0737, "Clarification of TMI Action Plan Requirements".

The SNUPPS DCRDR has been coordinated by the SNUPPS Staff organization, which is the central organization established by the SNUPPS Utilities to manage the design and licensing of the SNUPPS plants. The Human Factors Plant Review Group (HFPRG), which has been continuously involved in the DCRDR, consists of a group of professionals from the operations and engineering departments of the SNUPPS Utilities. This core group of professionals was supplemented by the following participants in one or more of the interrelated programs of the DCRDR: Westinghouse Electric Corporation (engineering and operator training personnel), the Procedures Subcommittee of the Westinghouse Owners Group (engineering and operations personnel from several utilities with Westinghouse plants), Essex Corporation (the Human Factors Engineering consultant), and Bechtel (the architect/engineer). Essex Corporation was highly qualified as the HFE consultant due to their extensive experience in development and application of methods, measures, and criteria for test and evaluation activities in the areas of human factors engineering and training.

The HFPRG members reviewed and became familiar with the methods and content of relevant NRC reports and general human factors engineering objectives and methodology. The HFPRG members are familiar with the design and operational aspects of the SNUPPS plants. Several members had training on the SNUPPS simulator at Zion and were able to apply that training directly in the review.

The experience, qualifications and approximate time spent on the project for each of the core professionals of the HFPRG and SNUPPS Staff is given in Table 2.1.1.

2.1.2 Review of Operating Experience

Due to the SNUPPS plants being under construction at the time of the DCRDR, operating experience is factored into the DCRDR by (1) feedback provided by prospective operators from the Wolf Creek and Callaway plants who had training on the SNUPPS simulators, and (2) utilizing documents that are based on industry experience obtained through involvement of SNUPPS personnel in Westinghouse Owners Group (WOG) activities.

Title	Person	License Held	Education (Degree)	Nuclear Exp.	Time Spent on (with) HFPRG
Technical Director	F. Schwoerer (S)	-	MS Marine E	26 yrs.	2-1/2 yrs.
Project Leader	J. Klein (S)	-	BSME	6 yrs.	2-1/2 yrs.
Operations	D. Heinlein (U)	SRO certified	BSME	4 yrs.	2-1/2 yrs.
Operations	J. McKinstray (K)	SRO certified	BSAeroE	8 yrs.	2-1/2 yrs.
Sys. Engineer (I&C)	D. Kern (K)	-	BSEE	2-1/2 yrs.	2-1/2 yrs.
" "	M. Hellman (U)	-	BSEE	9 yrs.	2-1/2 yrs.
" "	S. Fu (K)	-	MSEE	4 yrs.	1/2 yr.
" "	J. Riley (S)	-	BSAeroE,MBA	7 yrs.	1 yr.
Operations	M. Taylor (U)	SRO certified	BSME	11 yrs.	1/2 yr.
Operations	S. Putthoff (U)	SRO certified	-	9 yrs.	1/2 yr.

S = SNUPPS Staff
U = Union Electric Company
K = Kansas Gas and Electric Company

Table 2.1.1

2.1.2 (Continued)

A SNUPPS Operating Personnel Survey was conducted by Essex Corporation as part of its review done in 1980. Prospective operators from the Wolf Creek and Callaway plants who had training on the SNUPPS simulators were given questionnaires and interviewed regarding their evaluations of control room design features which they had experienced and/or observed in the course of preparing for operations. Results of these reviews prompted findings to be generated. Details of the questionnaires may be found in Section 3.1.

Together with other utilities having Westinghouse plants in operation or under construction, SNUPPS has participated in the formation and functioning of a Westinghouse Owners Group (WOG). A key element of the WOG, comprising approximately half of the total activity of the WOG, is the Procedures Subcommittee. This subcommittee consists of senior operating personnel, many who hold or have held SRO licenses, from approximately 20 utilities. This subcommittee was therefore able to bring direct operating experience, from many years of operations and several emergency events, to the development of improved Emergency Response Guidelines and the Systems Review and Task Analysis.

2.1.3 System Functions Review, Task Analysis and Control Room Inventory

A comprehensive systems review and task analysis (SRTA), performed by Westinghouse for the WOG, has served to identify all operator tasks and associated instrumentation and controls needed to implement the ERGs. The ERG SRTA program was begun in late 1981 to address the recommendation in Section 3.4 of NUREG 0700. The primary objective of this effort was to provide generic task analysis requirements for emergency operations based on the ERGs and to compile and organize these generic requirements to support a control room design review.

These task analyses were developed utilizing a top-down approach that identified the event sequences, the plant systems utilized in responding to event sequences, the operator functions and tasks performed in responding to event sequences, and the detailed elements that comprise the operators' tasks. Tables listing the instruments and controls required to perform the ERGs were developed from the detailed elements and section 3.2 describes how the control room inventory, based on the above, will be performed. The inventory is scheduled for completion in September 1983.

2.1.4 Control Room Survey

One of the initial elements of the DCRDR consisted of a control room survey performed by Essex Corporation during their review of the SNUPPS control room.

The human engineering review was performed using the guidelines of NUREG-CR/1580 and incorporated recognized human engineering principles and practices to identify and analyze the man-machine interaction of the control room systems and their components.

2.1.4 (continued)

The control room survey evaluated controls and displays located on the Callaway control room and a SNUPPS simulator, and led to the study of special areas, e.g., annunciator prioritization, safety status monitoring, and control/display enhancement.

Section 3.3 describes the processes that Essex utilized (e.g., checklists) in performing the control room survey.

Subsequent to the human engineering control room design review conducted for the SNUPPS plants, the NRC (HFSB) performed a review in July 1981 using the human engineering design criteria identified in the NUREG-0700 checklist. A thorough audit was conducted and Findings were identified. Results were documented in the form of correspondence and the subsequent Technical Evaluation Report (TER). Actions taken by SNUPPS in direct response to these reviews have been documented in a series of letters, dated from June 1981 to April 1982 (references 2 through 6). Given the stage of the control room construction, some areas normally addressed by the survey (ambient noise, lighting, communications) were not performed. These items are included in the SNUPPS TER and are discussed in more detail in Section 2.2.

2.1.5 Validation of Control Room Functions

A verification and validation program for the ERGs was performed at the Callaway simulator (which is a duplicate of the Callaway control room) in June 1982. The program consisted of a "walk-through" of forty-one of the ERGs (essentially the entire set) and evaluating the guidelines. The operators for this program were operating personnel from the Callaway and Wolf Creek plants. Westinghouse engineering and training personnel observed the program. An NRC representative was present part of the time.

Though the verification and validation program was specifically focused on the ERGs, the program also served to verify that all necessary instruments and controls are available and conveniently located in the SNUPPS control room. As described in Section 3.4 of this report, a structured evaluation of these aspects of the SNUPPS control room design is to be done using video tapes made during the verification and validation program. The performance of this evaluation, to be completed prior to fuel load, will validate the control room functions.

2.2 DCRDR Open Items

The following items are the remaining DCRDR elements yet to be completed:

- Validation of Control Room Functions (discussed in section 2.1.5)

2.2 (Continued)

- o Control Room Inventory and Verification (discussed in section 2.1.3)
- o TER Outstanding Items
    - o Environmental Study and other elements associated with control room workspace (discussed in Section 3.3.3)
    - o Review and evaluation of voice communications and auditory signal systems
    - o Control Room survey of Controls and Displays not installed or otherwise unavailable at the time of the NRC site audit
    - o Review and Evaluation of the Process computer display formats and effects of illumination unavailable at the time of the NRC site audit
    - o Review and Evaluation of the Remote Shutdown Panel

The TER outstanding items will be completed prior to fuel load.

The review of all open items will be performed in accordance with accepted human engineering guidelines (such as those provided in NUREG 0700).

3.3.1 SNUPPS Review

Two separate human engineering checklists were utilized by independent groups of reviewers to examine the SNUPPS control boards. These checklists were designed to consider the extent to which components and the environment are designed to accommodate basic human characteristics such as physical size and perceptual/motor capabilities. A comparison of control features to these guidelines was conducted by Essex Corporation using, where necessary, the data from the Essex task analysis and from visual observation. The complete results of the control room Survey were transmitted by reference 2.

The initial checklist review utilized NUREG/CR-1580 where human factors specialists, in concert with experienced SNUPPS personnel knowledgeable of plant systems, control room instruments and equipment, and plant operations, observed and measured control room features.

Instrumentation, controls and other equipment items were examined for human engineering acceptability as components without reference to their specific uses in task performance. Discrepancies were based on design incompatibility with human perceptual, motor, psychological or size characteristics. Results of the SNUPPS review are listed in the Essex Report transmitted by reference 2. Sample checklists and actual Human Engineering Finding forms are kept in the SNUPPS HEER files.

3.3.2 NRC HFSB Review

In addition to the above checklist review, the NRC HFSB conducted a human engineering audit of the SNUPPS control board using the NUREG-0700 Section 6 checklist. This review served as a check for adequacy of the initial review. Results are listed in the NRC TER on SNUPPS.

3.3.3 Environmental Measurement Procedures

As discussed in Section 2.2, the Environmental Study is required as part of the TER. The environmental measurements will be obtained when the control room is complete and considerations will be made for site unique characteristics. These results will be submitted to the NRC for review. The procedures for SNUPPS environmental measurements will follow the guidance of NUREG-0700 Appendix E, and findings will be handled in a manner similar to the control room survey.

3.3.3.1 Sound Survey Procedures

The locations for sound measurements will be noted on a control room layout drawing. The measurements will be taken at each operator position that requires verbal communication and/or auditory discrimination of a signal.

Considerations during measurement will include ambient noise levels (where ambient noise is defined as background control room noise without the contribution of alarms, printers or communications

3.0 REVIEW PROCESS

The objective of the SNUPPS DCRDR is to ensure that the control room provides the operator with sufficient information and controls to safely perform required operator functions and task responsibilities in response to emergency situations. The DCRDR also ensures the human engineering suitability of the design of the instrumentation and equipment in the control room. This section describes the details of the processes used in performing DCRDR element reviews, or refers the reader to appropriate documentation.

3.1 Review of Operating Experience

As discussed in Section 2.1.2, Essex distributed questionnaires to prospective SNUPPS operators. The questionnaire addressed the areas of: staffing and workload; workspace design; control/display integration and placement; communications; annunciator/warning system; operator protective equipment; computers; procedures/documentation; and operation. The interview covered operator feedback as a result of the operators' initial training experiences on the SNUPPS simulator at Zion.

This survey technique provided the SNUPPS review team with feedback on specific problems with the control room design. Examples of these findings were: confusion with the Engineered Safety Features Actuation System (ESFAS) status panel; difficulty in following the mimics on the Engineered Safeguard Features panel; difficulty in reading annunciator windows from the operating station; and poor positioning of annunciator acknowledge controls. These experiences reinforced the findings of Essex Corporation and were directly utilized in developing improved designs for these aspects of the control room.

A copy of the questionnaire administered by Essex is kept in the SNUPPS Human Engineering Evaluation Report (HEER) files.

3.2 System Functions Review, Task Analysis and Control Room Inventory

As described in Section 2.1.3, the WOG SRTA identified all instrumentation and controls needed to implement the tasks listed in the ERGs. This documentation is available for NRC review.

SNUPPS will perform the control room inventory by comparing the list of generic instrument and control requirements with existing SNUPPS instruments and controls. This task will verify completeness of the Control Room. Discrepancies, if any, will be identified as Human Engineering Findings which will be resolved.

3.3 Control Room Survey

The major portion of the control room survey is complete and documented in the Essex report, transmitted by reference 2. A discussion of this report, the subsequent NRC audit and procedures for the environmental measures to be performed, is discussed in the ensuing subsections.

3.3.3.1 (Continued)

equipment), annunciator alarm levels (work station annunciator and any other annunciators that must be heard at that work station) under both ambient and high noise level conditions (e.g., with printers, other alarms and signals), telephones and other communication equipment and evacuation signals and other alarms.

3.3.3.2 Lighting Survey Procedures

The location for the illumination measurements will be noted on a control room layout drawing. Readings will be taken:

- o In front of each front panel
- o In the center of the control room
- o In front of each back panel

This study will include the various combinations of power supplies.

3.3.3.3 Humidity/Temperature Procedures

Humidity and temperature will be measured by setting meters in an area where they will not be disturbed. Readings at floor level and at 6 ft. above floor level every hour for at least a 24-hour period will be taken.

3.3.3.4 Air Velocity Survey Procedures

The locations for air velocity readings will be noted on a control room layout drawing. Measurements will be taken at principal operator work stations at an elevation of 6 ft. for standing positions, and at 4 ft. for sitting positions.

3.4 Validation of Control Room Functions

The validation review determines if the operator tasks needed to implement the ERGs can be accomplished effectively within the structure of the established operating and emergency procedures and the design of the control room. This will ensure an accurate and complete human engineering review was conducted.

Validation efforts were conducted for the SNUPPS control room using a walk-through video-tape at the SNUPPS simulator at Zion. The following plant procedures were evaluated during the validation:

- o Immediate Action and Diagnosis
- o Loss of Primary Reactor Coolant
- o Loss of Secondary Coolant
- o Steam Generator Tube Rupture

3.4 (Continued)

- o High Wind/Tornado Station Blackout
- o Reactor Trip
- o Turbine Trip
- o Loss of One Feedwater Pump

Each procedure was taped twice, once with a full complement of operators without any interruptions and once with an operator explaining each step. The videotapes were then used to analyze the operator actions for each of these procedures. Instances of poor control/display relationships, lack of necessary information and inadequate presentation of information were identified from the analysis and identified as findings.

As stated in Section 2.1.5, a verification and validation program directed to the Emergency Response Guidelines was performed at the Callaway simulator in June 1982 and, though primarily directed to the ERGs themselves, confirmed that the Callaway control room is suitable for performance of the ERGs. In order to quantify this conclusion, a sampling of the ERG verification and validation videotapes will be compared against criteria established to ascertain human engineering considerations. Examples of these considerations include:

- o The indications and annunciators should be referenced in the procedure(s).
- o The units of measurement displayed should be appropriate and consistent with the procedure(s).
- o The operator actions expressed or implied by the procedure(s) should be within the capability of the operator(s).

Operators in conjunction with human factors specialists will perform the analysis. In addition, using a unit floor diagram, work station flow will be recorded and the following issues addressed:

- o Direction of movement
- o Sequence of movement
- o Frequency of the movement
- o Estimated time criticality of the movement
- o Real time estimate of the time that the operator(s) spends at each work station

Results of the review will be included in the summary report and are expected to validate the locations of installed instrumentation and controls. Any deviations will be recorded as findings.

4.0 ASSESSMENT, IMPLEMENTATION, DOCUMENTATION AND SUMMARY REPORT

4.1 Assessment

The DCRDR review process described in this Program Plan has resulted in the identification of a number of Human Engineering Findings (HEFs). The HEFs were first evaluated by Essex to determine the extent to which they may affect the ability of the operators to perform their tasks and to determine how best to correct the findings deemed to have a potential effect on operator actions. A systematic method for evaluating both the significance of HEFs and the feasibility/viability of the recommended improvements or corrections for the HEFs was implemented with a priority ranking. Subsequently, the NRC review team that performed the Callaway site audit developed a similar set of findings and confirmed or reassigned priority ratings.

4.2 Implementation

Proposed resolutions were discussed with the NRC and agreements were documented by the NRC on February 16, 1982. Several changes have been made or are in the process of being made. Periodic updates have been sent to the NRC (references 5 and 6).

4.3 Documentation

A data base library was established for the DCRDR process. This subsection describes the documentation system (input/output documents) and documentation management/control library used to support the Detailed Control Room Design Reviews.

Input Documentation:

The following references were available and/or developed throughout the DCRDR program:

- o FSAR
- o System Lists
- o System Specification, Section 3-SNUPPS BOP Functional Description
- o Piping and Instrumentation Drawings
- o Control Room Floor Plan (Lighting, HVAC, Accustics, etc.)
- o Panel Layout Drawings
- o List of Acronyms, Abbreviations
- o Color Coding Conventions for CRT
- o BOP Computer System Displays

4.3 (continued)

- o Standardized Valve Nomenclature List
- o Procedures (Emergency, Abnormal and Operating)
- o Operational Procedure Preparation Guide
- o Preliminary Design Assessment Report
- o WOG Emergency Response Guidelines
- o WOG System Functions Review and Task Analysis Study
- o Full Scale Mockups of Control Panels
- o Other Human Factors/Control Room Studies

Output Documentation:

While performing the SNUPPS PDA, Essex utilized standard forms to facilitate systematizing and recording results of the review. Standard forms used included:

- o Human Engineering Checklists
- o Human Engineering Finding Forms
- o HEF Priority Sheet
- o Operator Questionnaire

A detailed explanation of data collection and reduction may be found in the Essex report, transmitted by reference 2.

Typical forms intended for the remainder of the DCRDR are listed below:

- o Air Velocity Survey Record
- o Humidity/Temperature Record
- o Lighting Survey - Luminance and Reflectance Record
- o Lighting Survey - Illuminance Record
- o Sound Survey Record

DCRDR document control provides for traceability, retrievability and assurance of quality.

The Human Engineering Evaluation Report (HEER) generated by Essex during their review, is kept on file at the SNUPPS offices in Rockville.

4.4 Summary Report

A summary report will be submitted to the NRC which will reference previous submittals to the NRC and describe the results of those aspects of the DCRDR not previously reported. The summary report will be submitted within 120 days prior to fuel load of the first SNUPPS unit. All details of the DCRDR, along with complete documentation, will be available for NRC evaluation and review.

Samples of control room inventory forms and forms used in the control room survey for unreviewed items will be contained in the appendices and a summary of the inventory process and survey procedures will be provided. All procedures used for verification of task performance capabilities and validation of control room functions will be summarized.

Findings of the DCRDR will be organized according to the human factors engineering survey categories. Details of the assessment procedure used in this process will be summarized and supporting documentation provided as required. Design changes will be described.

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5.0 REFERENCES

1. SLNRC 81-26, 04/21/81
2. SLNRC 81-51, 06/26/81
3. SLNRC 81-65, 08/12/81
4. SLNRC 82-04, 01/19/82
5. SLNRC 82-016, 03/16/82
6. SLNRC 82-020, 04/12/82
7. SLNRC 83-0019, 04/15/83