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EVALUATION OF THE DETAILED CONTROL ROOM DESIGN REVIEW SUMMARY REPORT FOR SALEM STATION UNITS 1 AND 2

Technical Evaluation Report

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FOREWORD

This Technical Evaluation Report (TER) was prepared by Science Applications, Inc. (SAI) under Contract NRC-03-82-096, Technical Assistance In Support of NRC Licensing Actions: Program III. The evaluation was performed in support of the Division of Human Factors Safety, Human Factors Engineering Branch (HFEB). SAI did not previously evaluate Public Service Electric and Gas Company's program plan for conducting Detailed Control Room Design Reviews (DCRDRs) of the Salem Station Units 1 and 2. However, HFEB did perform this evaluation and prepared their comments (Reference 4) for ultimate transmittal to the licensee. No in-progress audits have been conducted at these plants between evaluations of the program plan and the evaluation of the summary reports as described herein.

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EVALUATION OF THE
DETAILED CONTROL ROOM DESIGN REVIEW
SUMMARY REPORT
FOR SALEM STATION UNITS 1 AND 2

This report documents the Science Applications, Inc. (SAI) evaluation of the summary report of the Detailed Control Room Design Review (DCRDR) submitted to the Nuclear Regulatory Commission (NRC) on December 30, 1983, by Public Service Electric and Gas Company (PSE&G) for the Salem Station Units 1 and 2 (Reference 1). The DCRDR was conducted by PSE&G in accordance with their program plan (Reference 2). The PSE&G Program Plan for Salem Station Units 1 and 2 was submitted to the NRC by letter dated February 14, 1983. The NRC Human Factors Engineering Branch (HFEB) evaluated the PSE&G program plan and as of January 30, 1984 their comments (Reference 4) had not been transmitted to the licensee. Therefore, PSE&G did not have the benefit of these comments in the course of their review and the production of the summary report.

Results of the SAI evaluation follows a brief overview of the background leading up to the DCRDR summary reports.

BACKGROUND

Licensees and applicants for operating licenses are required to conduct a Detailed Control Room Design review (DCRDR). The objective is to "...improve the ability of nuclear power plant control room operators to prevent accidents or cope with accidents if they occur by improving the information provided to them" (NUREG-0660, Item I.D.1). The need to conduct a DCRDR was confirmed in NUREG-0737 and in Supplement 1 to NUREG-0737. DCRDR requirements in Supplement 1 to NUREG-0737 replaced those in earlier documents. Supplement 1 to NUREG-0737 requires each applicant or licensee to conduct their DCRDR on a schedule negotiated with the NRC. Guidelines for conducting a DCRDR are provided in NUREG-0700 while the assessment processes for NRC are contained in NUREG-0801. (The NUREG documents cited are listed as References 8 and 9).

A DCRDR is to be conducted according to the licensee's own program plan (which must be submitted to the NRC); according to NUREG-0700 it should

include four phases: (1) planning, (2) review, (3) assessment, and (4) reporting. The product of the last phase is a summary report which, according to NUREG-0737, Supplement 1, must include an outline of proposed control room changes, their proposed schedules for implementation, and summary justification for human engineering discrepancies with safety significance to be left uncorrected or partially corrected. Upon receipt of the licensee's summary report and prior to implementation of proposed changes, the NRC must prepare a Safety Evaluation Report (SER) indicating the acceptability of the DCRDR (not just the summary report). The NRC's evaluation encompasses all documentation as well as briefings, discussions, and audits, if any were conducted.

The purpose of this Technical Evaluation Report is to assist the NRC in the technical evaluation process by providing an evaluation of the PSE&G summary report.

The DCRDR requirements as stated in Supplement 1 to NUREG-0737 can be summarized in terms of the nine specific elements listed below:

1. Establishment of a qualified multidisciplinary review team.

2. Use of function and task analyses to identify control room operator tasks and information and control requirements during emergency operations.

3. A comparison of display and control requirements with a control room inventory.

4. A control room survey to identify deviations from accepted human factors principles.

5. Assessment of human engineering discrepancies (HEDs) to determine which HEDs are significant and should be corrected.

6. Selection of design improvements that will correct those discrepancies.

7. Verification that selected design improvements will provide the necessary correction.

8. Verification that improvements can be introduced in the control room without creating any unacceptable human engineering discrepancies.

9. Coordination of control room improvements with changes resulting from other improvement programs such as SPDS, operator training, new instrumentation (Reg. Guide 1.97, Rev. 2) and upgraded emergency operating procedures.

PLANNING PHASE

The HFEB staff review concluded that the PSE&G program plan appeared to be reasonably adequate. However, the HFEB review also concluded that more information was needed in several areas. Those areas included: The multidisciplinary team responsibilities during the various phases, sample Task Analysis Forms, comparison of control/display requirements to the inventory methodology, survey results integration, assessment methodology, design improvement methodology and coordination with other programs. The summary report adds no significant information regarding the planning phase.

The PSE&G program plan described the multidisciplinary review team job categories and provided the resumes for ten of the team members. The resumes indicate that in most cases the qualifications of the team members are adequate, especially those of the human factors personnel. However there is little documentation describing the specific tasks the various staff members are involved in and their extent of participation in each task. The summary report description of the review team structure and responsibilities is the same as the program plan. The summary report states only that "each staff member on the review team was assigned specific responsibilities corresponding to his or her level of education and experience in the required area of expertise" (p. 8). There is no further explanation of personnel assignments in the summary report. It is our conclusion that PSE&G conformed to the letter of NUREG-0737, Supplement 1 requirement for a qualified multidisciplinary review team. Their

description of the team would have been stronger if they had implemented some of the suggestions in the program plan assessment report.

REVIEW PHASE

PSE&G review phase plans and activities include:

1. Review of Operating Experience.
2. Control Room Inventory.
3. Control Room Survey.
4. Systems Function and Task Analysis.

The above activities are those recommended by NUREG-0700 guidelines as contributing to the accomplishment of review phase objectives. Activities two through four address specific DCRDR requirements contained in NUREG-0737, Supplement 1.

1. Review of Operating Experience.

A review of operating experience is not explicitly required by NUREG-0737, Supplement 1. However, the PSE&G program plan indicated that such a review would be performed. The comments below are made with reference to the methodology described in the program plan.

The PSE&G program plan stated that the first step in the Operating Experience Review would consist of a review of available and applicable documentation. The summary report describes the review of available documentation and summarizes the results. PSE&G reviewed LERs from Salem Units 1 and 2, Trojan, Zion Units 1 and 2, and North Anna Unit 1 for candidate HEDs. Those candidates were then reviewed by a design review team for resolution. In addition, Incident Reports for both units were reviewed for candidate HEDs but were not sufficiently detailed to allow an evaluation according to PSE&G. This methodology appears to follow the guidance provided in Section 3.3 of NUREG-0700.

The second step in the Operating Experience Review was to survey operating personnel. PSE&G states in their summary report that operating personnel were given questionnaires to (1) elicit information regarding the

positive and negative aspects of their control room and (2) identify potential HEDs. Although a sample questionnaire was not provided in the summary report, the areas listed as those addressed by the questionnaire appear to be comprehensive (p. 12 and 13).

It is our conclusion that the PSE&G Operating Experience review was fairly comprehensive and should have yielded significant information which would contribute to the overall DCRDR.

2. Control Room Inventory

The summary report states that an inventory of all instrumentation, controls, and equipment in the control room and the remote shutdown panel was conducted by PSE&G. The specified features of the inventoried instruments included: instrument number, unit number, type, drawing number, range, factor, scaling and channel identification. This fulfills part of the stated objective of the inventory as presented in Section 3.5.1 of NUREG-0700. NUREG-0700 states that "The objective of the inventory is to establish a reference set of data which identifies all instrumentation, controls, and equipment within the control room." But PSE&G does not state the purpose of their inventory or if it was used to meet NUREG-0737, Supplement 1 which requires "a comparison of the display and control requirements with a control room inventory to identify missing displays and controls."

In conclusion, we believe that the control room and remote shutdown panel inventory was conducted correctly. However, we cannot determine that the inventory results were used to meet this NUREG-0737, Supplement 1 requirement. PSE&G should also provide a description of how the control room inventory data was used to meet the NUREG-0737, Supplement 1 requirement quoted above.

3. Control Room Survey

The summary report methodology for the control room survey activity is very similar to the survey methodology described in the program plan. The summary report states that "the purpose of the control room survey was to compare design features of the control room to the human engineering guidelines presented in NUREG-0700 and other relevant human factors standards"

(p. 14). Although PSE&G does not allude to the content of the "other relevant human factors standards," the survey appears to be comprehensive relative to NUREG-0700 evaluation criteria.

The summary report indicated that control room operators and supervisors were involved in the panel layout and control/display integration portions of the survey and that they were especially helpful. However, PSE&G does not indicate who the operations personnel aided (i.e., who performed the survey).

PSE&G stated in the summary report that "while most of the checklist items were applicable at the component level, some guidelines applied specific uses of instruments and equipment, task sequence requirements, communications requirements or other aspects of dynamic operation" (p. 14, Sect. 2.4.3). PSE&G continues by stating that these dynamically-oriented guidelines were addressed from the task or function perspective described in the System Function Review and Task Analysis (SFR&TA). However, PSE&G does not describe how these guidelines were addressed or integrated with its SFR&TA effort.

In summary, the plans for conducting the control room survey methodology appears to be comprehensive. However, neither the methodology for integrating the "dynamically-oriented" guideline evaluation into the SFR&TA effort nor for performing the environmental surveys could be assessed due to the lack of information in these areas in the summary report. Furthermore, no sample checklists and environmental survey data forms were provided in the summary report. We conclude that PSE&G has demonstrated that they intended to meet the requirement for a control room survey but not the knowledge or commitment of necessary personnel to successfully complete the survey as required by NUREG-0737, Supplement 1.

4. System Function and Task Analysis.

Supplement 1 to NUREG-0737 states that the licensee is required to perform a "function and task analysis (that had been used as the basis for developing emergency operating procedures, Technical Guidelines and plant specific emergency operating procedures) to identify control room operator tasks and information and control requirements during emergency operations."

In other words, the object of the task analysis activity is to establish the input and output requirements of control room operator tasks. These input and output requirements are to serve as benchmarks for examinations of the adequacy of control room instrumentation, controls, and other equipment. PSE&G apparently has established the same objective for their SFR&TA. PSE&G states that "The steps in the review process were performed to determine the input and output requirements of operator tasks involved in the selected operating events. These requirements were used later in the analysis to assess the adequacy of the control room design" (p. 15, Sect. 2.4.4).

The PSE&G SFR&TA was conducted in four basic steps as follows:

- Identify systems
- Describe systems functions
- Identify event sequences
- Identify and analyze operator tasks

The identification of systems, functions, and event sequences follows the "top-down approach" recommended in NUREG-0700, Section 3.4.2. First, PSE&G identified 31 "safety-related systems" and 14 "safety-significant (non-safety related) systems" (p. 17-19). PSE&G states that the selection of these systems was based on the following factors:

- Manual control systems needed by the operator for real-time support to prevent plant trips.

- Manual control systems needed by the operator for post-trip control of decay-heat transfer from the core to the various heat sinks in the plant.

- The degree of interconnection on non-class 1E systems.

In addition, PSE&G states that "After the systems had been designated, those systems which are controlled or monitored from the control room were identified" (p. 16).

The summary report indicates that the identification of system functions was the second step in their SFR&TA. NUREG-0700 recommends that the

identification of system functions occurs after the event sequences have been established so that the event sequences provide a context in which system functions can be defined. However, if the identification of system functions is comprehensive, then the reversal of these steps in the order prescribed in NUREG-0700 should not have a detrimental effect upon PSE&G's SFR&TA.

The summary report indicates that descriptions of the functions for each of the systems identified in the previous step were prepared and included in Appendix A. The system descriptions included:

- Functions of the system ("function" is defined as a mission or goal),
- Conditions under which the system is used, and
- A brief explanation of how the system operates.

The third step in the systems function review and task analysis was the identification of event sequences. The summary report states that "the objective in identifying events to be analyzed was to choose events that would exercise all of the systems that were identified" (p. 16, Sect. 2.4.4.3). The events selected were based on operating experience and system safety significance. The events selected for analysis were as follows:

- Small break loss of coolant accident
- Start-up from hot standby to minimum load
- Anticipated transient without scram, following loss of main feedwater
- Inadequate core cooling
- Steam generator tube rupture
- Shutdown
- Large break loss of coolant accident
- Control room evacuation.

A detailed description of each of these events was included in Appendix B in the summary report. Each event sequence description included: procedures required (number, title, revision, date), sequence initiator,

initiating conditions, systems exercised and procedure steps and final sequence conditions. In addition, PSE&G provided a matrix which compared the event sequences and the safety-related and safety-significant systems in order to ensure that each system was included in the task analysis. We believe that the event sequences selected do reflect the spectrum of plant operations, with emphasis on abnormal and emergency conditions as recommended in NUREG-0700, Section 3.4.2.2.

PSE&G defined the operator information and control requirements for each event sequence (p. 20, Sect. 2.4.4.4 and the "step" sections in each operating sequence in Appendix B). The detailed descriptions of the event sequences present the event initiator along with detailed initiating conditions and assumptions. The initiator and the initial conditions and assumptions of each event sequence drive the operator information and control requirements. For example, the Small Break LOCA sequence is initiated with safety injection actuation. The initiating conditions and assumptions are as follows:

- turbine trip
- reactor trip
- safety injection
- low pressure pressurizer pressure (with alarm) and decreasing
- low pressurizer level (with alarm) and decreasing
- increasing containment parameters
    - temperature
    - pressure
    - RMS
    - sump
    - fan coil unit

From step 1 to the end of the detailed sequence description, the operator tasks, systems exercised, and information required by the operator to make decisions are listed.

In addition, the event sequence descriptions outline the procedures that are used by the operators to perform the event sequence. Although there is no indication that the generic EOPs were used in this analysis, PSE&G appears to have thoroughly analyzed the specific combinations of

emergency and normal procedures that are required to perform each event sequence.

The fourth step in the system function and task analysis was to identify and analyze operator tasks. In this step task analysis forms were pre-filled for each event (p. 21). The summary report states that "the purpose of the pre-filled task analysis form was to document the operator tasks and task resource requirements necessary to perform the operator functions required in each event prior to actually observing the crew perform the event in the control room" (p. 20). The pre-filled task analysis forms were used to detail the "tasks explicit and implicit in procedures" which were identified in the event sequence descriptions.

Although PSE&G lists the instrument and control requirements on the pre-filled task analysis forms, puts the information requirements in the event descriptions, and does all this prior to the walk-throughs in the control room, it appears that these requirements were not identified independently of the existing control room. The sample task analysis form (Figure 3, p. 21) indicates that the actual plant instruments and controls used in the tasks identified from the plant-specific procedures were identified prior to (1) the identification of information and control requirements and (2) the verification of task performance capabilities, thus rendering the verification of instrument and control availability (and possibly suitability) self-fulfilling and invalid. For a valid task analysis and verification of task performance capabilities to be performed, human factors engineers and operations personnel must identify information and control requirements independently of the actual instruments and controls in the control room. The instruments and controls which exist in the control room should be identified subsequent to the identification of information and control requirements during the verification of task performance capabilities. The sections of the plant-specific procedures (from which tasks and therefore information and control requirements are identified) that specify the actual instruments and controls to interface with must be excluded from the task analysis. Otherwise, the analysis may fail to identify instruments and controls that are missing from the control room which are necessary to support emergency operations.

PSE&G states that the purpose of performing a verification of task performance capabilities was to "determine if the instrumentation and controls that the operators need to perform their tasks are available in the control room and, if they are, to determine if the design allows for effective human/machine interface" (p. 20, Sect. 2.4.5).

The procedure for determining this was as follows:

- Information on input and output requirements was compared with the instrumentation and controls available in the control room.
- Required instrumentation or controls were confirmed as being present.
- Instrumentation parameters were confirmed as meeting the parameter information requirements.
- Instrumentation or control features were confirmed as allowing for adequate system functioning (successful task completion).

The summary report further states that this procedure was performed twice: (1) prior to the on-site visit when the talk-throughs of the operating events were conducted, and (2) after the videotapes of the walk-throughs had been analyzed. PSE&G does not clarify how they could perform this procedure the first time outside of the control room. PSE&G does not mention any use of mockups. Neither does PSE&G clarify how this procedure was performed the second time (also outside of the control room). Given the general nature of videotape data, it is not apparent how useful videotaping is for verifying the availability and suitability of controls and displays. Videotaping is better used as a supplemental rather than a primary means of collecting data.

The summary report also describes a validation of control room functions. It states that "the primary purpose of the validation step was (1) to identify performance difficulties, based on the control room design, in accomplishing the necessary tasks involved in the operating events, (2) to ascertain the validity of the previously identified discrepancies, and (3) to identify any discrepancies not previously recorded." PSE&G intended to

accomplish this by conducting a walk-through of the selected operating events and by videotaping the walk-throughs. PSE&G states that "As much information as possible was collected during the walk-through. However, the major portion of the task analysis information obtained from the walk-through was recorded and analyzed from the videotapes at a later date" (p. 22, Sect. 2.4.6). It appears that PSE&G has relied primarily on the videotapes to collect and analyze data rather than on-site data collecting during the walk-throughs. Again, videotaping is more acceptable as a supplementary means of collecting data due to the lack of control over the validity of data when compared to on-site data collection.

Furthermore, the summary report indicates that only 4 HEDs were identified from the validation of control room functions process and 2 from the verification of task performance capabilities process (see p. 475-482, Volume 2). All of these 6 HEDs were procedural discrepancies rather than the intended control room design-related discrepancies. This is a further indication to support our belief that the verification and validation efforts were not adequately conducted.

In summary, PSE&G's SFR&TA appears to be well structured and comprehensive relative to all emergency operations and system interfaces. However, the following features of PSE&G's task analysis and verification and validation processes may preclude a successful effort:

- The identification of information and control requirements was not performed independently of the existing control room.

- The verification of task performance capabilities was performed outside of the control room in both instances, apparently without the benefit of a mockup of the control boards and relying on videotapes of the walk-throughs.

- The validation of control room functions relies on videotapes for the major portion of the task analysis information obtained from the walk-through data collection.

We believe PSE&G has demonstrated that they intended to meet this NUREG-0737, Supplement 1 requirement. However, based on the task analysis,

verification, and validation processes as described in the summary report, we conclude that PSE&G has not successfully performed these processes nor met this requirement.

ASSESSMENT AND IMPLEMENTATION PHASE

1. HED Assessment Methodology

The summary report HED Assessment Methodology is basically the same as the methodology described in the program plan, with the exception of the Category II methodology. Although the objective of the Category II methodology remains the same - to categorize HEDs associated with potential or interactive error, PSE&G does not discuss the second source of Category II HEDs as they did in the program plan. PSE&G does discuss HEDs which degrade performance or increase the potential for operator error (the first source), but not HEDs determined to have a cumulative or interactive effect. It is not clear if PSE&G, according to the program plan, had further analyzed HEDs which were judged to not (1) degrade performance, (2) increase the potential for operating crew error, and (3) have adverse safety consequences to determine if there were any cumulative or interactive effects with other HEDs. Other than the Category II heading, no mention is made in the summary report of assessing HEDs associated with cumulative or interactive effects.

In Volume 2 of the summary report a number of HEDs associated with the same component, panel, or system have been assessed as Category IV HEDs (for an example, see p. 22, #2). The interactive or cumulative effect of these HEDs may be to increase the potential for error or degrade performance. By PSE&G's definition, these HEDs should be assessed as Category II HEDs. Since PSE&G has not assessed these HEDs as Category II HEDs or mentioned the interactive or cumulative effects of these HEDs in their justifications for not taking corrective actions, we believe that PSE&G has not adequately assessed or documented their assessment of HEDs with interactive or cumulative effects.

PSE&G states that in order to reduce the subjectivity of judging the significance of HEDs in affecting performance and the potential for error, the review team members answered a series of structured questions as

presented in NUREG-0801 (p. 24, Sect. 2.5.1.2). PSE&G did not continue by discussing how the answers were formulated into an indication that HEDs do or do not degrade operator performance or increase the potential for error.

Of the 469 HEDs documented in Volume 2 of the summary report, 429 HEDs were assessed as Category IV HEDs. A number of these 429 HEDs involved safety-related components and systems. According to PSE&G's categorization scheme, one of the determining factors for assigning HEDs to categories was the judged safety importance. We believe that the HEDs listed in Appendix C that were assessed as Category IV HEDs should at least have been assessed as Category III HEDs. PSE&G states that "HEDs with a low probability for error, but which could result in adverse conditions if such an error did occur, were considered to be significant and assigned to Category III" (p. 24, Sect. 2.5.1.3). We believe that either (1) the HED assessment process as described in the summary report may not have been followed or (2) PSE&G's assessment of HEDs may not have been completely objective. PSE&G should provide the rationale for assessing the HEDs listed in Appendix C as Category IV HEDs.

In summary, the following points on PSE&G's HED assessment process have been made:

1. It is not clear if or how interactive or cumulative effects among HEDs were assessed,

2. It is not clear how the answers to the series of structured questions were formulated into an indication that HEDs do or do not degrade performance or increase the potential for error, and

3. HEDs involving safety-significant components or systems may not always have been adequately categorized.

Although the categories for prioritizing HEDs to an implementation schedule and the factors which determine the HED categorization appear comprehensive, the results (HEDs) indicate that this assessment process may not have been adequately performed. We conclude that PSE&G has not demonstrated through the documentation provided in the summary report that they have adequately met this NUREG-0737, Supplement 1 requirement.

2. Selection of Design Improvements

A brief description of how HED corrections were selected was provided in the summary report (p. 25, Sect. 2.5.2). The paragraph essentially says that HED resolutions were proposed for all significant HEDs (Categories 1-3) by the DCRDR team and other specialists and that the recommendations took into account the impact of the correction upon (1) operating effectiveness, (2) system safety, (3) acceptability of design, (4) consistency with control room characteristics and (5) cost. Also, a schedule for implementing changes was provided (p. 27). However, no documentation was provided describing the HED resolution process in detail, including the process by which interactive HEDs were resolved. Since HED corrections are going to be implemented at various times, PSE&G should have developed a system for ensuring that all enhancements and design changes are integrated. Due to the overall lack of information on this and the rest of the HED resolution process, we conclude that PSE&G has not demonstrated the knowledge necessary to adequately perform the HED resolution process and meet this NUREG-0737, Supplement 1 requirement.

3. Proposed Schedules for Implementing HED Corrections

Base[illegible] HED assessment process, PSE&G has developed an HED priority [illegible]ng and an implementation schedule for changes to be made in the control room. According to the schedule proposed in the summary report (p. 27), changes will either be made (1) at the first refueling after submittal of this report or the first outage after receipt of the equipment (prompt implementation), (2) at the second refueling outage after submittal of this report (near-term implementation), or (3) at any time but are optional (long-term/optional implementation). Although PSE&G structures the implementation around the first and second refueling outages after the summary report submittal, the specific dates of these refueling outages are not given.

NUREG-0737, Supplement 1 requires that "improvements that can be accomplished with an enhancement program (paint-tape-label) should be done promptly." PSE&G has not discussed plans for promptly implementing enhancement-type changes in the control room on an overall basis. Only in

the individual HEDs is there an indication of the intended schedule for implementation. In the HEDs PSE&G proposed to perform enhancement-type changes such as modifying or replacing labels, different schedules for implementation are planned, including possible long-term actions. PSE&G must ensure that all enhancement-type changes, especially those independent of panel layout changes, are implemented promptly. Furthermore, PSE&G must ensure that enhancements that will be performed must be integrated with all other enhancements and other kinds of changes such as panel layout modifications.

In summary, PSE&G does not provide documentation which assures us that enhancements will be done promptly and in an integrated manner. Also, PSE&G does not provide documentation describing how they intend to schedule changes from the DCRDR with other programs' changes. Overall, the summary report does not provide a dated schedule for implementing changes from the DCRDR nor for changes from other improvement programs. PSE&G does not demonstrate that they will promptly implement improvements that can be accomplished with an enhancement program nor that they have an adequate plan for integration of all control room changes.

4. Verification that Improvements Will Provide the Necessary Corrections Without Introducing New HEDs

One of the factors PSE&G stated that they will take into account when proposing resolutions to HEDs is the impact of the correction upon the "acceptability of design." Without further definition, the meaning of this terminology is too nebulous to determine if PSE&G is referring to the HED verification process. Other than "acceptability of design," there is no other documentation in the summary report that can be construed as addressing the HED verification process. We conclude that PSE&G has not adequately demonstrated the intent to meet this NUREG-0737, Supplement 1 requirement.

5. Coordination of the DCRDR With Other Improvement Programs

PSE&G states in the summary report that "Every attempt was made during the conduct of the DCRDR at Salem to coordinate efforts and findings with the other areas of emergency response," which they listed as:

- o Safety Parameter Display System (SPDS),
- o Emergency Response Facilities (ERFs), and
- o Emergency Operating Procedures (EOPs).

PSE&G did not acknowledge the coordination of other improvement programs, most notably Reg. Guide 1.97 instrumentation and training. For these programs and those listed above, PSE&G did not present in the summary report a system or methodology for coordinating and integrating changes. We believe PSE&G has not demonstrated the existence of a well defined system for coordinating changes among improvement programs and therefore has not met this NUREG-0737, Supplement 1 requirement.

ANALYSIS OF PROPOSED CORRECTIVE ACTIONS AND JUSTIFICATIONS FOR HEDS LEFT UNCORRECTED

PSE&G documents the proposed changes to be made by new Design Change Requests (DCRs) and the ongoing design changes in Volume 1 of the summary report (p. 28-39). PSE&G also documents 469 HEDs in Volume 2. However, an HED numbered 725 indicates a large number of HEDs have not been accounted for in Volume 2. PSE&G does not offer an explanation for this discrepancy in numbers.

Since PSE&G did not include an illustration of the panel arrangement in the control room nor a listing of systems by panel. Many of the HEDs, especially those grouped under the "Workspace and Environment" heading, could not be completely evaluated. These and other HEDs are grouped in the first category of our summary of HED evaluation findings in the following two sections: (1) Proposed Corrective Actions and (2) Justifications for HEDs Left Uncorrected. In each of these two sections is a categorical summarization of our findings from an evaluation of the HEDs documented in Volume 2. The HEDs listed under these categories represent those in which we found PSE&G's proposed corrective actions or justifications for not taking corrective actions inadequate or ambiguous. The remaining, unlisted HEDs are those which we found to be adequately resolved. The complete HED listing can be found in Appendices A and B. In the two sections below are examples in each category where we elaborated on our findings.

1. Proposed Corrective Actions

Appendix A of this evaluation report contains the complete list of HEDs in which corrective actions were proposed but were found to be inadequate for one of the 4 reasons/categories discussed below. Examples in each category are arranged by Volume 2 page number.

a. The description of the proposed corrective action is too brief, general, or ambiguous to allow an adequate evaluation to be made.

60 (HED 536) - The discrepancy with these annunciators is that they do not alarm for both units although the systems are shared by both units. The proposed correction is to provide Units 1 and 2 with these alarms. However, it is not clear from the change description (Vol. 1, p. 34) if the alarms will be provided separately or still be shared.

117 (HED 18) - The discrepancy with these meters is that parallax exists at the low end of the scale where the meters always run. The proposed correction is to change the GPM range from 0-10,000 to 0-5,000 and recalibrate the indicator and transmitter (Vol. 1, p. 28). However, PSE&G did not describe at what range the meters always run and if the indicator will still be at the low end of the scale with the 0-5,000 range. The parallax still exists and if the indicator still runs at the low end of the scale, then the required accuracy that the indication must be read at must be determined. PSE&G does not discuss this or the effect of apparently eliminating the upper 5,000 GPM of the scale. The discrepancy and the proposed correction cannot be fully evaluated until this information is provided.

332 (HED 70) - The discrepancy is that legend indicators are not readily distinguishable from legend pushbuttons. The proposed corrective action is to engrave Bailey pushbutton inserts with identification codes to indicate either an operate, indicate, or alarm function (Vol. 1, p. 29). It is not apparent whether all the discrepant legend pushbuttons are of the Bailey type and if not, whether the non-Bailey types will be engraved as well.

b. The proposed corrective action was not finalized.

31 (HED 550) - The discrepancy is that glare problems exist on the CRT displays, meter faces, and indicators. PSE&G states that corrections will be investigated for feasibility.

c. The proposed corrective action does not correct the discrepancy.

251 (HED 60) - The discrepancy is that the operator must convert the percent indication of the meter to gallons. The proposed corrective action is to incorporate zone markings on the indicator scale. Although the zone marking will allow the operator to interpret if the indication is in or out-of-the-normal operating range, the operator may still need to convert percent to gallons if an out-of-normal range indication occurs. PSE&G must address whether or not an out of normal range indication requires the operator to take action based on a reading of gallons.

d. The proposed corrective action only partially corrects the discrepancy.

172 (HED 58) - The discrepancy is that values on a recorder must be multiplied by 6 GPM, which is a more difficult mental conversion than by 10. The proposed correction is to provide the recorder with new scales having increments of one, from zero through six with five minor divisions between each major division (Vol. 1, p. 29). However, the intended multiplication factors are not addressed.

270 (HED 627) - The discrepancy is that meter scales are graduated in units of 8 and have non-linear scales. The proposed correction is to change the scale graduation units to multiples of 5 (Vol. 1, p. 38). However, the issue of non-linear meter scales is not addressed.

284 (HED 306) - The discrepancy is that the turbine trip pushbutton is yellow and that it performs two functions (turbine trip and alarm acknowledgement). The proposed correction is to

separate the two functions by moving the alarm function to another panel within close proximity to the turbine trip pushbutton (Vol. 1, p. 31). However, the issue of pushbutton color is not addressed.

2. Justifications for HEDs Left Uncorrected

Appendix B of this evaluation report contains the complete list of HEDs left uncorrected in which justifications were provided but were found to be inadequate for one of the five reasons/categories discussed below. HEDs listed in category two may also appear in other categories. Examples in each category are arranged by Volume 2 page number.

a. The justification (or HED description, component identifier, etc.) is too brief, general, ambiguous, or does not sufficiently address the discrepancy or NUREG-0700 guidelines to allow an adequate evaluation to be made.

3 (HED 282) - The discrepancy says that the RCP Pedestal Vibration meter is mounted in the back of the IRP-4 panel and the operators must leave the room to read this. PSE&G essentially states that no corrective action will be taken because the meter is within the established boundary of the control room. However, the potential problem, which still remains, is that it is outside the primary operating area and the operator's field of vision. PSE&G should address guideline 6.1.1.1.b as well as 6.1.1.1.a for this discrepancy.

4 (HED 1) - The discrepancy says that the space between the vertical panels and the back of the console is less than the guideline requirements of 50 inches. PSE&G states that this is satisfactory as is, the dimensions cannot be changed, and that no action will be taken. In their justification, PSE&G does not address the problems typically inherent with small separation distances between panels, such as accidental activation of controls and parallax among displays located lower or higher than the recommended range of placement. By only stating that the "dimensions cannot be changed," PSE&G does not demonstrate that

they have addressed all relevant issues and backfit options to this discrepancy.

20 (HED 181) - The discrepancy says that the START-UP TEMP recorder is 23 inches above floor level and does not meet the minimum guideline requirement for display height of 41 inches. PSE&G justifies taking no corrective action by stating "satisfactory as is." This justification offers no valid reason or rationale for leaving the discrepancy uncorrected. The PSE&G justification begs the question "Why is it satisfactory as is?"

28 (HED 626) - The discrepancy says that the levels of illumination vary greatly over a given work area, such as 2, 25, and 50 foot candles. PSE&G justification for not taking corrective action is that the discrepancy is not considered to be a significant problem. This justification is not sufficient because it offers no rationale for considering the discrepancy to be an insignificant problem.

126 (HED 521) - The discrepancy says that the charging system isolation valves "could be better arranged to reflect system design." In addition to PSE&G's response "satisfactory as is," the description of the discrepancy is too brief or ambiguous. PSE&G does not describe how these valves are actually arranged.

b. The justifications of individual HEDs do not consider the cumulative or interactive effect from other HEDs. Below is a summary of five cumulative or interactive effects.

1. It is apparent that at least panels CC-1, CC-2, and CC-3 have layout problems. The HEDs identifying these panels described a multitude of discrepancies, such as (1) large or long groupings of controls and displays without any physical or visual break, (2) the arrangement of controls is not sequentially arranged, (3) a lack of functional grouping of controls and displays, (4) unclear association of related controls and displays, and (5) a lack of demarcation. PSE&G responds to each discrepancy by stating that either no

corrective actions will be taken or that the discrepancy will be handled by training. It is possible that perhaps one HED of this type may be able to be adequately resolved by training, but not entire panels consisting of several to many of these HEDs. The summation of the HEDs listed in Appendix B indicates panel layout problems which transcend training as a sole source of corrective action. At a minimum, operator aids such as demarcation and other enhancement techniques must be addressed.

2. Individual HEDs discuss the location of controls and displays above and below the recommended range of location on panels RP-1, RP-3, RP-4, and RP-6. PSE&G's justification for not taking corrective action on these discrepancies does not address the compounding effect the close proximity of these panels to the back of the console (p. 4, Vol. 2) has on the (1) readability of displays located higher or lower than the height required by the guidelines and (2) the operability and potential for accidental activation of controls located below the height required by the guidelines. The available work-space restricts the operators capability to improve the angle of his line of sight in a standing position by backing off and thus compensating for any parallax effects. In addition, the space available for the operator to readily read the control label and operate the control in conjunction or succession with other controls may not be sufficient.

3. Several HEDs cite discrepancies related to the operability of the computer/CRT system. In summary, the operator does not have ready access to procedures and other procedural aids for operating the computer system in the control room. PSE&G essentially responds to these HEDs by stating that the procedures and cross indices for aiding in the operation of the computer are not used by the operator. However, if the operator interfaces with the computer system in a mode which requires procedural guidance, then the necessary aids must be readily accessible. It is apparent from these HEDs that the

operator does not possess readily accessible or attainable aids for operating the computer system.

4. A number of HEDs cite labeling, illumination and other visibility/readability discrepancies in the control room. Each HED individually may not represent a potential hindrance in reading labels and display, but the cumulative effect of all these HEDs may present a real problem to the operator for reading labels and displays correctly or in a timely manner. Two specific examples of where illumination problems may combine with labeling and display discrepancies to effect the visibility or readability of labels and displays are (1) the wind speed and direction recorders on RP-1 and (2) the fire protection legend indicators on RP-5. In general, PSE&G response to these HEDs is to take no corrective action. Singularly, the HEDs identified for these components may or may not create a problem. However, the combined effect of these labeling, contrast, and illumination discrepancies can potentially degrade the readability of the labels and displays and thus the performance of the operator.

5. A number of HEDs discuss various discrepancies found with the annunciator system. These HEDs cite alarms that are too frequent, too lengthy, and undistinguishable from other alarms and the auditory environment. With the exception of one HED undergoing further investigation, PSE&G does not intend to take any corrective action. The cumulative effect of these HEDs is a noisy environment in which the operator may have real difficulties in distinguishing individual alarms or perhaps some communications. PSE&G's justifications for not taking corrective actions do not address cumulative effects.

c. The justification cites utility, industry, or manufacturer's convention or absence of previous operator errors.

195 (HED 562) - The discrepancy is that the visibility of the TIGRAPH recorder markings is poor due to the low level of contrast

between black markings and paper. PSE&G only states that no action will be taken because it is the manufacturer's standard.

67 (HED 716) - The discrepancy is that the intensities and clear signals of various alarms are not sufficiently above and distinguishable from the ambient noise level in the control room. PSE&G justifies taking no corrective action by stating that the sound level is adjustable and that the alarms have never failed in the past to elicit operator response. One must not only question why PSE&G therefore does not adjust the sound level but also how they can ensure that operators' responses in the future will always be elicited.

d. The justification refers to further documentation or sample data which has not been furnished in the summary report.

27 (HED 625) - The discrepancy is that illumination levels do not meet the recommended criteria for control room work areas and task situations. PSE&G responds by stating "see sample data and recommendations in Appendix B," among other things. No sample data and recommendations in Appendix B or anywhere else in the summary report could be found.

e. The justification cites the degree of deviation from NUREG-0700 guideline requirements.

5 (HED 2) - The discrepancy is that the Dymac Probe Monitors are "90 inches above the floor, well above the reach of the 5th percentile female (78.3 inches)." PSE&G responds by stating that this is "satisfactory as is. The difference from recommended height for 5th percentile female does not warrant moving the monitors. No action will be taken." Citing the difference from the guideline requirements, rather than addressing such issues as the accuracy and frequency at which the monitors must be read, is not a satisfactory justification.

CONCLUSION AND RECOMMENDATIONS

The summary report demonstrates PSE&G's commitment towards meeting most of the requirements of NUREG-0737, Supplement 1. Several areas of the summary report include a great deal of documentation and in-depth discussion, such as the System Functin Review and Task Analysis and the HED categorization structure. Other areas of the summary report were sparsely detailed, such as the control room survey, the HED resolution and resolution verification processes, the implementation schedule for HED corrections, and the methodology for coordinating other improvement programs with the DCRDR.

Although PSE&G demonstrates commitment towards meeting most of the NUREG-0737, Supplement 1 requirements, they do not demonstrate the knowledge or understanding necessary to accomplish a successful DCRDR. Some of the methodologies described in the summary report did not lead to valid results. The most notable examples are the task analysis and the verification and validation processes. The results of the DCRDR and the proposed corrections and justifications for HEDs left uncorrected, as documented in Volume 2, indicate that some of the DCRDR processes were less than adequately conducted. In addition to the processes mentioned above, an example of this is the HED assessment and resolution process.

Based upon the documentation provided in the summary report, we conclude that the overall performance of the DCRDR by PSE&G did not accomplish a valid and successful DCRDR and fully meeting the requirements of NUREG-0737, Supplement 1. Therefore, we recommend that a pre-implementation audit be conducted to clarify the points made in this evaluation report and provide PSE&G with additional feedback before they continue with the implementation schedule. The points made in this evaluation report that should be addressed during the pre-implementation audit are summarized below.

Illustrative Agenda for a Pre-implementation Audit

- Control Room Inventory; the purpose of the inventory or its function in the DCRDR is not addressed.

- Control Room Survey

  - The content or origin of the "other relevant human factors standards" is not addressed.

  - The personnel who performed the survey are not described.

  - The methodology for integrating the dynamically-oriented guidelines with the SFR&TA is not described.

  - The methodology for performing the environmental surveys is not described.

  - No sample checklists or data collection forms were made available.

- System Function Review and Task Analysis; the methodology of the task analysis and the verification and validation processes appear to be inadequate and the type of HEDs resulting from these processes reflect this.

- HED Assessment

  - The inclusion of HEDs with cumulative or interactive effects in Category II is not apparent.

  - The methodology for converting answers to structured questions into an indication of HED significance is not described.

  - The rationale for assessing some of the HEDs as Category IV is not apparent.

- Selection of Design Improvements; there is no methodology described for identifying which HEDs will be corrected, finalizing the corrections, and ensuring the integration of changes/corrections.

- Proposed Schedules for Implementing HED Corrections
  - No specific dates were provided
  - The prompt implementation of enhancement-type changes is not discussed on an overall HED basis.
  - No methodology described for integrating enhancements with panel layout changes.
- Verification that Improvements Will Provide the Necessary Corrections Without Introducing New HEDs; PSE&G did not appear to address this requirement.
- Coordination of the DCRDR With Other Improvement Programs
  - No system for accomplishing this requirement was described.
  - No reference was made to Reg Guide 1.97 instrumentation and training.
- Analysis of Proposed Corrective Actions and Justifications for HEDs Left Uncorrected
  - 256 HEDs are unaccounted for.
  - Various inadequacies were found in the proposed corrective actions and justifications for HEDs left uncorrected.

REFERENCES

1. "Detailed Control Room Design Review Report for the Public Service Electric and Gas Company, Salem Station Units 1 and 2, Volume 1: Review Plan and Summary, Volume 2: HED Documentation," December 30, 1983.

2. "Salem Generating Station Units 1 and 2 Control Room Design Review Program Plan," Public Service Electric and Gas Company, November, 1982.

3. Letter from E. A. Liden, PSE&G to S.A. Varga, NRC, dated February 14, 1983, submitting Control Room Design Review Program Plan for Salem Generating Station Units 1 and 2.

4. "NRC Review Comments on Salem DCRDR Program Plan," attachment to Memorandum from W.T. Russell, NRC, to G.C. Lainas, NRC, dated October 7, 1983.

5. NUREG-0660, Vol. 1, "NRC Action Plan Developed as a Result of the TMI-2 Accident," USNRC, Washington, D.C., May 1980; Rev. 1, August 1980.

6. NUREG-0737, "Requirements for Emergency Response Capability," USNRC, Washington, D.C., November 1980.

7. NUREG-0737, Supplement 1, "Requirements for Emergency Response Capability," USNRC, Washington, D.C., December 1982, transmitted to reactor licensees via Generic Letter 82-33, December 17, 1982.

8. NUREG-0700, "Guidelines for Control Room Design Reviews," USNRC, Washington, D.C., September 1981.

9. NUREG-0801, "Evaluation Criteria for Detailed Control Room Design Reviews," USNRC, Washington, D.C., October 1981, draft report.

Salem 1 and 2
TAC Nos. 51278 and 51279
SAI/1-263-07-557-61/62
NRC-03-82-096

APPENDIX A

HEDs (by page number) in which corrective actions were proposed but were found to be inadequate for one of the following 4 reasons/categories:

a. The description of the proposed corrective action is too brief, general, or ambiguous to allow an adequate evaluation to be made.

43, 50, 60, 110, 117, 332, and 460

b. The proposed corrective action was not finalized.

31	54	103	370
41	55	156	378
46	63	161	452
47	68	163	477
48	74	176	479
49	82	303	480
51	87	314	482

c. The proposed corrective action does not correct the discrepancy.

251 and 369

d. The proposed corrective action only partially corrects the discrepancy.

172, 270, and 284

APPENDIX B

HEDs (by page number) left uncorrected in which justifications were provided but were found to be inadequate for one of the following 5 reasons/ categories:

a. The justification (or HED description, component identifier, etc.) is too brief, general, ambiguous, or does not sufficiently address the discrepancy or the NUREG-0700 guidelines to allow an adequate evaluation to be made.

3	62	138	239	299	348	405	441
4	64	139	240	302	349	406	442
6	66	140	241	305	350	408	444
8	72	141	244	309	351	409	445
9	73	142	245	310	352	410	446
11	78	143	249	312	359	411	447
12	84	144	250	317	363	412	449
13	92	146	253	319	367	415	450
15	102	147	267	320	371	417	451
18	111	148	268	321	375	419	453
19	112	150	269	324	379	421	454
20	114	151	275	325	384	422	455
21	118	152	276	326	385	423	456
22	119	155	280	327	386	425	459
26	121	159	283	329	387	426	461
28	123	160	285	330	388	427	465
30	124	162	288	331	389	428	467
32	125	165	289	333	391	429	471
33	126	167	290	334	393	431	472
36	127	168	292	337	394	432	473
45	128	169	293	338	395	433	
52	129	174	294	339	396	435	
56	132	178	295	342	397	436	
57	134	210	296	345	398	437	
58	135	216	297	346	401	438	
59	136	233	298	347	402	440	

b. The justifications of individual HEDs do not consider the cumulative or interactive effect from other HEDs.

1. CC-1: 128, 410, 412, 425, 429, 437, 444, 447, 450, and 462
   CC-2: 126, 127, 408, 413, 415, 426, 432, 433, 434, 438, 445, 447, 449, and 453.
   CC-3: 405, 406, 414, 431, 443, 447, and 448.

2. 4, 9, 13, 15, 17, 18, and 19.

3. 386, 387, and 388.

4. Illumination/contrast: 27, 28,33, and 131.
   El 300' and 33' wind speed and direction recorders:
   193, 202, 223, and 235
   Fire protection legend indicators:
   29, 177, 185, 214, 242, 243, 402, and 430
   Others: 69 and 75; and 111.

5. 34, 54, 55, 63, 64, 65, and 67.

c. The justification cites utility, industry, or manufacturer's convention (below) or absence of previous operator errors (67).

97	256	293	354
164	259	297	355
180	265	306	390
195	273	311	414
212	287	328	443
255	291	335	448

d. The justification refers to further documentation or sample data which has not been furnished in the summary report (27).

e. The justification cites the degree of deviation from NUREG-0700 guideline requirements.

5	197	204	210	217	223	229
14	198	205	211	218	224	230
34	199	206	213	219	225	231
130	200	207	214	220	226	232
179	202	208	215	221	227	234
196	203	209	216	222	228	238

APPENDIX C

The following HEDs (by page number) were found to have the potential to cause operator errors of either low or high probability which could result in adverse plant conditions. However, these HEDs were assessed as Category IV HEDs. We believe PSE&G should provide the rationale for this assessment of these HEDs.

6	58	119	428	446
8	62	405	429	447
18	65	410	435	449
22	66	415	437	450
56	67	422	438	453
57	114	427	445	455