ENCLOSURE 2

EVALUATION OF THE DETAILED CONTROL ROOM DESIGN REVIEW SUMMARY REPORT FOR OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3

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 Duke Power Company's program plan for conducting Detailed Control Room Design Reviews (DCRDRs) of the Oconee Nuclear Station Units 1, 2 and 3. However, HFEB did perform this evaluation and prepared their comments for ultimate transmittal to the licensee. Furthermore, the NRC performed a pre-implementation audit at Duke Power's Catawba Nuclear Station Unit 1 while completing its review of the summary report. Results of that audit and review process are described in Safety Evaluation Reports (SER, Reference 6 and SSER, Reference 15) transmitted to the licensee.

This report includes the SAI evaluation of the Duke Power Company's Final Report (Reference 1) and the Supplement to the Final Report for Oconee Nuclear Station, Units 1, 2, and 3 (Reference 3). Oconee was subjected to an in-progress audit by the NRC at the time of the Catawba preimplementation audit (August 9-12, 1983). SAI was not a participant at the audit. Findings relevant to the Oconee DCRDR were documented by the NRC (References 6, 14, and 15). Additional assessment of DCRDR activity are provided orally to SAI by the NRC at a meeting held on July 2, 1984 and are cited throughout this evaluation.

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Evaluation of the Detailed Control Room Design Review
Summary Report For Oconee Nuclear Station,
Units 1, 2, and 3

This report documents Science Applications, Inc.'s (SAI) evaluation of the Detailed Control Room Design Review (DCRDR) Summary Report and supplement submitted to the Nuclear Regulatory Commission (NRC) by Duke Power Company for the Oconee Nuclear Station (References 1 and 2).

Duke Power's review was conducted in accordance with a generic program plan, submitted to the NRC on April 14, 1983, for performing DCRDRs for all units of the Oconee, McGuire and Catawba Nuclear Stations. NRC staff evaluated the program plan and forwarded their comments to Duke Power on August 2, 1983. With the submission of the summary report for the Catawba Nuclear Station Unit 1, the NRC staff conducted a preimplementation audit of Catawba Unit 1 and an in-progress audit of Oconee and McGuire units on August 9-12, 1983. SAI did not participate in these audit activities and has not reviewed documentation provided at the audits. Findings relevant to the Oconee DCRDR were documented by the NRC (Ref. 6, 14 and 15). Additional assessments of DCRDR activities were provided orally to SAI by the NRC meeting held July 2, and are cited thoughout this evaluation.

Results of the SAI evaluation follow a brief overview of the background leading up to the DCRDR summary report.

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 1.D). 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 criteria for NRC's

evaluation of a DCRDR are contained in NUREG-0801 (draft). (The NUREG documents cited are listed as References 7-11).

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 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, 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 Oconee, Units 1, 2, and 3 summary report.

The DCRDR requirements as stated in Supplement 1 to NUREG-0737 can be summarized in terms of nine specific issues, a list of which provides a convenient outline of the areas covered in this technical evaluation. The nine issues are:

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 operators.

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

1. Preparation and Submission of a Program Plan

The N staff reviewed Duke Power's generic Control Room Review Plan for performing DCRDRs for all units of the Oconee, McGuire and Catawba Nuclear Stations. The NRC staff reviewed the Program Plan with reference to the requirements of Supplement 1 to NUREG-0737 and the guidance contained in NUREG-0700 and Draft-0801 and transmitted comments to Duke Power by letter, dated August 2, 1983.

2. Establishment of Qualified Multidisciplinary Review Team

Duke Power's Control Room Review was composed of four major elements: a steering committee, a review team, Duke line organizations, and consultants from Biotechnology, Inc. (BTI). The steering committee of eleven members represented an interdisciplinary approach to directing and managing the DCRDRs for all Duke nuclear units. The review team assembled by the steering committee possessed qualifications and experience to conduct successful DCRDRs.

The organization of Control Room Review lead assignments as illustrated in Figure 2.2 (Ref. 1, p.17) appears adequate to the task and the work breakdown structure is reasonable.

The orientation and training of review team members, participating line organization personnel, and consultants is significant and indicates the licensee's committment to conduct a successful DCRDR and to maintain a human factors presence beyond the DCRDR effort. The training approach and activities as described in the summary report appear comprehensive although the write up is somewhat disorganized.

In conclusion, we believe Duke Power has met the requirement of establishing a qualified multidisciplinary review team. The summary report would have been enhanced if it had contained a graphic illustration relating DCRDR activities to team members with person hours devoted to respective tasks. A description of the team's access to necessary support and materials and its capability to conduct an independent unbiased DCRDR also would have been of value. However, these areas were covered by Duke Power during the NRC's audit and found satisfactory.

REVIEW PHASE

Duke Power's summary report dated February 16, 1984 is a generic final report for all units of the Oconee, McGuire and Catawba Nuclear Stations. Pages 1-69 are devoted to a description of the DCRDR activities. Supplements to the Final Report, also dated February 16, 1984, were submitted summarizing plant-specific review phase and assessment phase activities. Appendices to the Supplements include the results of the assessment phase for each station and unit.

Duke Power's Review Phase activities covered the following major areas:

1. Categorization of Guidelines
2. Control Room Survey
3. Operating Experience Review
4. Task Analysis

The above activities contribute to the accomplishment of review phase objectives. The Operating Experience Review is recommended by NUREG-0700 guidelines. The Control Room Survey and Task Analysis address specific DCRDR requirements contained in Supplement 1 to NUREG-0737.

Our evaluation of Duke Power's review activities is presented in the following order and is based on the DCRDR requirements as stated in Supplement 1 to NUREG-0737 and guidance suggested in NUREG-0801:

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

1. Review of Operating Experience

A review of operating experience is not explicitly required by Supplement 1 to NUREG-0737. However, it is an activity recommended by NUREG-0700 guidelines as contributing to the accomplishment of review phase objectives.

Duke Power conducted a two-part operating experience review (OER) at the Oconee plant to identify features of control room operation or design which could possibly degrade effective control of the plant during normal and emergency operations. The first part of the effort included a review of the operating history of the plant to document recurring problems and an examination of generic industry-wide problems applicable to the plant. The second part of the review included the conduct of a structured operator survey and semi-structured interviews to examine operating needs and problems from the operator's experience and perspective.

To accomplish the review of plant operating history and industry-wide experience, guidelines were developed for analyzing operating history reports in order to identify factors which might have had a significant effect on human performance. The developed guidelines were based on what could be "practically" expected in the documentation. Duke Incident Reports (DIRs), Station Incident Reports (SIRs), and INPO Significant Operating Event Reports (SOERs) were reviewed using the formulated guidelines to

identify potential HEDs. During the audit, the NRC observed that Licensee Event Reports (LERs) also were included in the review of operating experience conducted at Oconee. Forty-three HEDs were found potentially applicable to Oconee as a result of the review. These potential HEDs were documented for further consideration in subsequent DCRDR activities.

The Oconee operator survey effort entailed administration of a structured questionnaire to plant operations personnel. Although the licensee has provided little description in the submittal of the actual survey sample or numbers of questionnaires distributed versus those completed at Oconee, these specifics were provided for Oconee during the audit conducted by the NRC. From information provided in the submitted work plan, the superintendent of operations and all other licensed personnel including shift technical advisors and assistant nuclear control operators were to be provided questionnaires in order to include a wide range of staff experience in the survey. Survey instruments also were to be distributed to nuclear equipment operators in training to ensure a representative sampling of 50% of the operations staff.

Although questionnaires were distributed by Duke personnel to the various position levels on each operating shift, anonymity was guaranteed since each respondent returned his/her completed questionnaire directly to BTI in a pre-stamped, pre-addressed envelope. Once received at BTI, a tear-off slip containing the respondent's name (for use only by BTI in contacting the respondent for further clarification or information) was removed and stored in a secure file. Treatment of the questionnaire data was controlled by a coded questionnaire number with no indication of the respondent's name.

The survey questionnaire itself consisted of problem statements to which respondents indicated the degree to which they agreed or disagreed using a 7-point scale. Space was provided to encourage respondents to provide specific details about each problem statement. Problem statements included on the questionnaire were drawn from a number of sources including:

1. Generic questions for nuclear power plant operations;
2. Topics generated by Duke Power for inclusion in the survey; and
3. Potential HEDs identified during the operating history review.

The questionnaire also contained items that were generated from a review and categorization of human factors guidelines, principally from NUREG-0700. This categorization was accomplished prior to the outset of review phase activities in order to: 1) ensure that applicable human factors guidelines provided in NUREG-0700 were addressed in the DCRDR; 2) assign each guideline to the review activity that would provide the most appropriate perspective and expertise; and 3) eliminate repetition in the application of guidelines. By comparing guidelines to developed criteria, guidelines either were deleted from further consideration or allocated to one of the three DCRDR review phase activities (OER, task analysis, control room survey). Guidelines to be addressed specifically in the survey activity of the operating experience review were those where: 1) operating knowledge/experience was necessary to assess the guideline (e.g., user experience or knowledge of relationships between control room components was needed), and 2) measurement or systematic examination of control room components or ambient conditions against an absolute standard was not required.

As some information relevant to operator experience could not be solicited easily by using a structured questionnaire approach, individual semi-structured interviews also were conducted by BTI human factors professionals with selected plant-operators. Although not detailed in the submittals the licensee provided to the NRC at the audit information to describe the number and characteristics of operators that were interviewed at Oconee and characteristics of interviewees who did or did not complete survey questionnaires. Interview items were drawn from a number of sources. These included but were not limited to: 1) items difficult to include on the questionnaire; 2) areas of concern as suggested by preliminary questionnaire results; and 3) incidents or problems determined from the operating history review. Once interview data were collected, all information from the completed OER activities was compiled, reduced, and analyzed. Findings were reviewed by BTI staff to identify potential HEDs. All potential HEDs were reviewed and documented as: 1) a legitimate HED; 2) supporting documentation for HEDs identified in the control room survey and task analysis activities; 3) problems brought to the attention of plant management; or 4) areas of concern beyond the scope of the DCRDR or any other practical design or operational change.

In summary, Duke Powers' operating experience review at Oconee appears to have been extensive, thorough, and appropriately conducted. Consistent with NUREG-0700 objectives and guidelines, it entailed a systematic examination of industry-wide reports and plant-specific documents. Structured questionnaires and semi-structured interviews were administered to and conducted with a range of operating personnel by trained and experienced interviewers. Although not included in the submittal, a sample of the questionnaire and interview items and sample survey information were provided to the NRC at the audit and found to be satisfactory. Similarly, examples of survey instruments and interview protocols used on site were not provided in the submittal documentation. However, from information provided, the focus and content of the instruments appear comprehensive enough to facilitate the identification of potential HEDs. This was substantiated by the NRC review of such documents during conduct of its audit activities.

2. Systems 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) to identify control room operator tasks and information and control requirements during emergency operations." In other words, the objective of the task analysis is to establish the input and output requirements of control room operator tasks. These information requirements are then to serve as benchmarks for examination of the adequacy of control room instrumentation, controls, and other equipment.

Duke has been an active participant in the systems function and task analysis efforts of the owner's groups. The two owner's groups for Westinghouse and B&W reactors, have produced emergency response guidelines which differ somewhat in their approach and scope. The first set of abnormal transient response guidelines (ATOGs) that B&W produced were, in fact, based on Oconee. Therefore the ATOGs that Oconee used are plant specific (Ref. 3 pp. 2-3). Westinghouse has produced generic emergency response guidelines.

For licensees choosing to use either the Westinghouse Owner's Group (WOG) or the Boiling Water Reactor Owner's Group (BWROG) generic symptom-oriented emergency guidelines, the NRC has published clarifying memoranda

with regard to task analysis (Ref. 12 and 13 respectively). Thus, Duke has additional guidance for meeting NUREG-0737 Supplement 1 requirements for Catawba and McGuire, but not for Oconee. This report will, however, examine the Duke submittals in light of the underlying intent of the recent NRC clarifications.

The task analysis methodology initially was conceived by the Duke Power Company review team composed of a senior reactor operator (SRO) and a systems engineer from each of the three stations. Drs. Harry Snyder, Thomas Sheridan and H.L. Parris, human factors consultants, assisted Duke in this effort (Ref. 1, p. 16). After the review plan was approved by the DCRDR steering committee, Duke engaged BioTechnology, Inc. to further develop the plan and to implement the task analysis in conjunction with Duke review team members. One of the significant steps taken by BioTechnology was the provision of classroom training in human factors and task analysis for Duke team members. BTI also performed a one-week pilot task analysis which gave all team members an opportunity to practice what they had learned in the classroom training (Ref. 1, p. 51) before they performed the actual task analysis.

The scope of the task analysis included plant emergency response capabilities as well as problem areas in the normal operations of the plant. The task analysis conducted at Oconee consisted of three steps: 1) selection of operating sequences; 2) development of task descriptive data; and 3) human engineering discrepancy identification. These steps resulted in HED reports used during the assessment phase of the control room review and task descriptive documentation for the storage and retrieval systems (Ref. 1, p. 58). Each of the steps are described below.

Step 1: Sequence Selection and Orientation

The B&W Owner's Group has published plant-specific abnormal transient response guidelines (ATOGs) for Oconee. Duke Power chose five pathways of successive actions to analyze. They stated that these comprise a comprehensive inventory of possible emergency actions. Although the emphasis of the task analysis was placed on emergency operations, Duke also used the results of

operating experience reviews (OERs) to identify problem areas from normal operating sequences to be analyzed further.

Step 2: Development of Task Descriptive Data

Duke Power used the symptom-oriented, ATOG-based, event sequences as well as selected normal operating sequences to develop a listing of controls and displays used by the operators during emergency and normal operations. For Oconeee, they developed operating sequence overviews, clustered task sequence charts and task data forms.

Step 3: HED Identification

HEDs were identified by an "integrated effort" as stated but not described on page 54 of Reference 1. The process was described to the NRC during its audit activity. Each operating sequence was walked through on a full scale mockup to visualize the tasks. Then, using the task data forms previously generated and guided by the HED principles (Ref. 1, p. 62), Duke team members considered three types of problems:

1. Lack of particular controls or displays needed to do the task;

2. Inability to read pertinent displays from the location of the operator when doing the task; and

3. Information display inadequate to provide information of the type and accuracy needed for the task.

BioTechnology Inc. had the primary responsibility for providing human factors guidance. In addition to selecting and training the proper people for the task analysis, BTI reviewed the Duke product and re-instructed the team on an as-needed basis throughout the review.

The above three steps summarize the SF&TA methodology as described in Duke's submittal. In addition to the final report, the supplement for Oconee was reviewed in order to obtain as comprehensive a picture of the

SF&TA methodology as possible. From the descriptions of the methodology, it seems clear that Duke has complied with many of the NUREG-0737 Supplement 1 requirements for an SF&TA. In fact, the requirement has frequently been exceeded. For example, Duke not only used the plant-specific ATOGs as a basis for identifying emergency sequences, they also used selected normal operating sequences. Also for Oconee, Duke conducted walkthroughs on a static full-scale mockup.

A review of the Supplement to the Final Report (Ref. 4) reveals that of the HEDs falling into the "surface enhancement" category, 31 were identified by task analysis, 105 by the human factors survey, and 6 by the operational experience review. HEDs falling into the "physical change" category were not identified by source of the discovery. However, it is possible to deduce that some of them resulted from the Duke task analysis process as many missing and unsuitable controls and displays were identified.

Duke Power selected "five credible pathways...within the ATOG," and stated that they are "fully credible and provide a reasonable and comprehensive exercise of control room interfaces" (Ref. 1, p. 53). Duke has not clarified if this means that the entire spectrum of emergency operating task sequences has been analyzed by task analysis. Nor has the licensee described whether single as well as multiple (including sequential and concurrent) failures have been included (Ref. 3, p. 6).

Examination of Figure 4-8, "Clustered-Task Sequence Chart," reveals that Duke has identified individual task steps associated with major operating sequences. These individual tasks do not contain specific plant parameters or instrument and control characteristics. Figure 4-9, "Task Data Form," shows the control room instruments and controls associated with a specific task in a particular operating sequence. These forms do contain specific plant parameters but no required instrument and control characteristics. Figure 4-10, "Task Analysis HED Principles" was used during walkthroughs in the mockup.

Based on the above details, we conclude that the Duke task analysis team determined the information and control needs systematically via Figures 4-8 and 4-9. This was not accomplished independently of the control room. Furthermore, the instrument and control characteristics were determined

during the walkthroughs using Figure 4-10 instead of establishing the required characteristics prior to walkthroughs. Similarly, missing and unsuitable controls or displays were identified during the walkthroughs. Thus, the task analysis concentrated on examining existing instruments and controls for their suitability instead of defining the required characteristics first and then comparing them to the actual control room. The potential problem with the Duke process is that the review team could have had difficulty being fully objective when they applied the "Task Analysis HED Principles."

In conclusion, we believe that Duke Power has met the intent of the NUREG-0737 Supplement 1 requirement for a function, and task analysis if Duke can verify that the scope of the emergency operating procedures is complete. We have arrived at this conclusion in spite of the fact that technically Duke did not determine the required instrument and control characteristics independently of the control room. However, the systematic approach that their team used provided assurance that the proper human factor principles were asked for each control, instrument and display used in the emergency tasks.

3. Control Room Inventory

According to the NRC requirement stated in Supplement 1 to NUREG-0737 the DCRDR should include: "(iii) A comparison of the display and control requirements with a control room inventory to identify missing displays and controls" (Ref. 9, p. 10).

Duke Power constructed full-scale photo-mosaic mockups for each nuclear unit control board which was used for review activities. The mockups served as an inventory of control room controls and instrumentation. Duke Power performed walkthroughs of tasks on the mockups, using task element descriptions and task analysis HED principles to identify HEDs. One type of problem considered by Duke Power was the lack of particular controls or displays needed by the operators to perform the tasks.

In conclusion, Duke Power assembled an inventory of control room instrumentation in the form of a full-scale photo-mosaic mockup. We believe it was suitable for comparison with display and control requirements. It

appears that talkthroughs and walkthroughs on the mockup revealed missing controls and displays. Although not identified independently of the control room, information and control requirements for selected emergency procedures were compared to existing instruments. Therefore, we conclude that the requirement has been met assuming the full spectrum of operating procedures was analyzed to determine information and control requirements.

?. Control Room Survey

Duke Power conducted a control room survey (CRS) for Oconee Units 1, 2, and 3. The purpose of the survey was to determine the extent to which control room equipment, components, and environment were in compliance with human factors guidelines. By making "pass/fail" comparisons, the survey systematically identified HEDs. The survey focused on the main control boards and other ancillary operating panels in the control room and the operating panels in the auxiliary shutdown area.

Organization and conduct of the survey was the responsibility of the Oconee line organization in the Design Engineering Department. A control room survey team (CRST) staffed by Duke personnel familiar with control room/board layout and design was assembled and trained by BTI. The CRST conducted the surveys and documented HEDs and other survey results. It also worked closely with BTI to develop survey methods and materials. BTI, on the other hand, was given primary responsibility for defining survey methods, preparing final materials, training, and providing human factors assurance of survey results.

The CRS effort included development, administration, and analysis of three types of surveys - physical, engineering, and environmental. For each survey, a human factors principles checklist was prepared. Each checklist was comprised of a number of principles statements and their examples, organized under major topic headings consistent with the organization of guideline materials in NUREG-0700 (workspace, communications, annunciators, controls, visual displays, labels/location aids, computers, panel layout, control-display integration). Each checklist also contained a section which focused on codes and conventions.

The content of each survey varied as a function of NUREG-0700 and Duke Power Company guidelines being evaluated. The initial pool of guidelines assigned to the CRS effort resulted from the categorization and assignment of Duke Power and applicable NUREG-0700 guidelines to DCRDR review activities as previously described. The pool of guidelines allocated to the CRS included those guidelines for which: 1) a systematic examination against an absolute standard was required, and 2) task data and operating knowledge were not necessary. Guidelines assigned to the CRS were then assigned to one of the three surveys based on the type(s) of observations or evaluations which had to be made to determine compliance with the guideline.

In addition to differences in survey content, different methods were employed to conduct the surveys to ensure use of the most effective and efficient way to obtain data. Regardless of the method employed, the desired outcome of each survey effort was the identification of HEDs. The scope and methods for each survey are described below.

A physical survey was conducted to evaluate control room components and equipment in terms of configuration, panels, boards, and equipment arrangement. To accomplish this, human factors principles in a specific topic area such as controls were applied to a specific physical aspect of the control room (e.g., major panel). Each topic was evaluated for all portions of the unit control room before moving on to the next topic. Evaluations were initially made in the full-scale mockup. Topics and principles that could not be assessed adequately in the mockup were evaluated in the control room.

The physical survey team at each unit conducted the survey and recorded HEDs. Each team consisted of two Duke Power Company engineers familiar with the station equipment. Both members had participated in the development of the methods and materials and attended the two-day classroom training session conducted by BTI for all CRS team members. In addition, team members at Oconee Unit 1 engaged in pilot test of the physical survey. The purpose of the pilot tests was to continue the training of physical survey team members beyond that achieved through classroom training. Pilot surveys also provided an excellent opportunity to test survey methods and materials.

An engineering survey was conducted to evaluate the control room against designated guidelines by using engineering drawings and specifications or by implementing engineering studies. For this survey, checklist principles were applied to drawings and other forms of documentation that described the control room features of topical interest. A checklist package was provided to survey each unit's main control room panels, back panels, and local panels. The engineering survey was conducted by Duke Power Company personnel with expertise in four major technical categories: 1) control board design; 2) computer and CRT equipment design; 3) systems engineering; and 4) other miscellaneous specialties.

An environment survey also was performed by Duke Power to assess the degree to which control room environmental factors conformed to relevant guidelines. Accomplishment of this survey required data collection or measurement in three categories: HVAC, sound, and lighting. Data relevant to these categories were collected at all areas of the units' control room: i.e., primary operator work stations, the Auxiliary Shutdown area, and the Auxiliary Feedwater Pump panels. Checklists then were completed using the recorded environmental data. Discrepancies were recorded and resultant HEDs were identified.

The environmental survey primarily was conducted by a team comprised of two Duke employees familiar with the station and its equipment. One team member was an industrial hygienist from Production Environmental Services of the Production Support Department. The other member was an instrumentation and control engineer from the Design Engineering Department. Environmental data for the measurement of control room lighting was collected by an independent consultant.

In summary, the control room survey requirements of NUREG-0737, Supplement 1 are satisfied by activities performed by Duke Power at Oconee. Overall the effort appears thorough and complete. The objectives of the survey and methods employed were consistent with those suggested in NUREG-0700. Appropriate areas of the control room, including the auxiliary shutdown panel, were surveyed.

As no differences between the three units of Oconee's control rooms were documented, it was assumed that identical surveys were conducted at

each unit. This was substantiated by the NRC as a result of the audit. The licensee did not provide examples of checklists employed for review in the submittal. However, the use of criteria for assigning guidelines to distinct control room survey efforts suggests that a systematic and comprehensive survey effort was conducted by trained personnel with relevant areas of expertise. Criteria for exclusion of certain NUREG-0700 guidelines from the survey were provided in the submittal. The NRC has indicated that the licensee did provide a list of those guidelines excluded, specific reasons for exclusion, and justifications for using Duke versus NUREG-0700 criteria and standards during the audit.

ASSESSMENT AND IMPLEMENTATION PHASE

Duke Power's assessment and implementation phase is addressed in Section 5, page 63 of the Final Report. The Supplement to the Final Report also contains a summary of these activities.

1. HED Assessment Methodology

Duke Power's assessment process relied on recognized safety prioritization criteria which included the potential for operator error, the consequences of error occurrence and the potential for operator recovery. Duke Power expressed these criteria in a logically consistent equation to determine the significance of a HED to the operator's task performance. It appears that this formal assessment procedure was applied in a systematic, replicable manner which resulted in a numerical rank ordering to judge the relative significance of HEDs. HEDs were reviewed to determine whether they were appropriate for this process. Those not appropriate were screened out and fell into the following categories:

1. HEDs that were not a deficiency
2. HEDs requiring individual study
3. HEDs that could be easily resolved
4. HEDs to be resolved to maintain consistent control room conventions
5. HEDs that were part of a generic HED or were duplicates

6. Minor HEDs that could be resolved by operator awareness in training
7. HEDs being resolved by an existing design change

In addition to the formal significance evaluation, the judgement of an assessment team, composed of three Senior Reactor Operators, two mechanical/nuclear engineers, two electrical engineers and one human factors specialist, provided the final determination of HED significance.

The licensee appears to fully understand the assessment process and the commitment to apply that process is demonstrated by the informative yet succinct presentation in the summary report and supplement. We conclude that Duke Power's assessment process fulfills the requirement of Supplement 1 to NUREG-0737 to determine which HEDs are significant and should be corrected.

2. Selection of Design Improvements

Duke Power developed and proposed HED solutions which included physical changes, procedural modifications, surface enhancements (paint, tape, label) and training improvements. Duke states most appropriately that "undue reliance on training and procedure solutions was avoided" (Ref. 1, p. 65). Integrated design solutions were proposed through solution team efforts by reviewing the solutions on a control board basis to assure that new HEDs were not created and to assess the impact of the correction on operations and system safety. Three solution teams were involved in the process. Each team was composed of one operator, one engineer, engineers from Design Engineering and human factors specialists from BioTechnology, Inc. (Ref. 4, p. 4).

All solutions with the exception of surface enhancements were evaluated for cost feasibility including realistic concerns such as physical resources (engineering and construction), the installation constraints of the existing board design, plant operation costs, and resources for additional training and/or simulator changes.

Ratios of the HED significance to the cost estimate were calculated to provide the solution team with an aid to arrive at a final subjective

determination concerning the selection of an optimal solution. All HEDs without assigned significance estimates subjectively were reviewed for cost-effectiveness. Alternative solutions were explored for those situations deemed to be cost-prohibitive.

The process and criteria implemented by Duke Power to analyze and arrive at a design improvement were judged to be comprehensive and relevant to the real world of design improvement selection. If the process was conducted as described, the HED solutions presented should be effective. This stage of Duke Power's assessment phase is found to be complete and fulfills the requirement of Supplement 1 to NUREG-0737 to select design improvements.

3. Verification That Selected Design Improvements Will Provide the Necessary Corrections

Duke Power has stated that they used, "control board mockups to insure that solutions to HEDs would be developed in an integrated manner" (Ref. 1, pg. 64). They have also stated that, "all proposed physical change solutions were evaluated... to assure that they could be implemented in accordance with good human engineering practice" (Ref. 1, pg. 65).

Neither of these statements taken from the submittal fully described a formal verification process required by NUREG-0737, Supplement 1.(5.1.d) to ensure that each selected design improvement would provide the necessary correction in an effective integrated fashion. Also of concern was the low level of detail documenting proposed design solutions as submitted in the supplement. The NRC staff has indicated that Duke, as part of the audit and follow-up activities, provided sufficient documentation and description of a process to assure that the modifications proposed would be implemented properly and would provide the necessary corrections.

4. Verification That Improvements Will Not Introduce New HEDs

NUREG-0737, Supplement 1 also requires that the licensee verify that the design improvements will not introduce any new HEDs. Although Duke Power states that HED solutions were reviewed to assure that no new HEDs were created, it did not sufficiently document the process necessary to meet

this requirement. This process was described in detail to the NRC, who found it to be satisfactory for meeting the requirement.

5. Coordination of Control Room Improvements With Changes Resulting From Other Improvement Programs

During the DCRDR conducted at Oconee Units 1, 2, and 3, the determination of HEDs and the implementation of corrective actions were coordinated with Duke Power programs to upgrade emergency operating procedures, to install a safety parameter display system, to install post accident monitoring instrumentation (Reg. Guide 1.97), and to improve operator training. In fact, during the investigative and assessment phases, the Duke Power DCRDR served as a forum to discuss concepts, review human factors, and schedule the integration of these programs (Ref. 1, p. 9 and 15).

The improvement programs and their complex interfaces are shown in Figure 1-1 and 1-7 of the submittal (Ref. 1, p. 3 and 12). In addition, Duke Power outlined some of the interfaces that existed. For example, the Emergency Procedure Guidelines (EPGs) from B&W served as the starting point for Emergency Operating Procedures (EOPs), SPDS, and the Control Room Task Analysis. Therefore, as specified on page 9 of the Final Report, "a program plan was developed to keep all organizations appraised of progress in each activity and to inform each organizations of revisions to the EPGs" (Ref. 1). This information and other examples cited by the licensee provide substantial evidence that the Duke Power DCRDR for Oconee is meeting the requirements of NUREG-0737, Supplement 1 to coordinate improvements with other control room improvement programs.

6. Proposed Schedules for Implementing Design Changes

The schedule for implementing HED solutions from the results of the Oconee DCRDR was submitted as Revision 4 (Ref. 5). Duke Power notes that the coordination of HED solution changes with other control room improvement changes such as the SPDS, EOPs, Reg. Guide 1.97, and operator training is a complete effort. They have adopted a policy of completing the more significant changes first and coordinating all changes with operations and training rather than just completing surface enhancements. They have established four groups of HED solutions organized by priority with installation

scheduled piecemeal during the next four successive fuel outages. The basis for assigning HED solutions to the four groups was not discussed. The design work to initiate implementation plans is currently in progress at Oconee.

It appears that Duke Power has considered the complex problem of implementing NUREG-0737, Supplement 1 improvement efforts as a whole. However, the discussion in this submittal is very general, which prohibits an adequate evaluation to be made at this time. We have observed, however, that while Supplement 1 to NUREG-0737 states that surface enhancements should be made promptly, Duke indicates that they do not intend to comply with this. We concur with Duke Power that some flexibility is required to schedule an implementation program of the magnitude called for in NUREG-0737, Supplement 1 activities. However, we believe that the delay of HED solutions until the end of the fourth refueling outage is unacceptable. Duke Power's submittal would be enhanced by providing a milestone chart with the implementation dates to correct each HED or groups of HEDs.

ANALYSIS OF PROPOSED DESIGN CHANGES AND JUSTIFICATION FOR HEDS TO BE LEFT UNCORRECTED FROM THE RESULTS OF THE OCONEE NUCLEAR STATIONS DCRDR

Licensees are required by Supplement 1 to NUREG-0737 to submit an outline of proposed design changes, including their proposed schedules for implementation and a summary justification for HEDs with safety significance to be left uncorrected or partially corrected.

The companion supplement for Oconee Units 1, 2, and 3 accompanies the final report of the Duke Power Company's DCRDR. Together these two documents constitute the completed Summary Report. The Appendices to the Supplement contain the results of the HED assessment phase. Appendix A lists HEDs to be solved by surface enhancements with a brief explanation of the techniques. Appendix B lists HEDs with the proposed physical changes to solve them. Appendix C lists HEDs to be left uncorrected but provides a justification for not taking corrective action. Also provided is a cross-reference list of HED numbers indicating commonalities and differences among the three units.

The following are the results of a SAI's team evaluation of proposed corrections and justifications for nor correction. The lists that follow are organized by section to correspond with those in the licensee's submittal. The number assigned to the HED by the licensee is also provided.

1. Surface Enhancement Solution HEDs

In general we concur with the surface enhancement techniques chosen by the licensee to correct or improve the design deficiencies. However, many of the proposed surface enhancement solutions could not be assessed completely due to the general or vague description of the problem and/or the solution. Our major concern stems from the brevity of the recommendation or proposed solution for corrective action. If these descriptions are to be transmitted to line organizations as design implementation directions, further precise design details will be necessary. In summary, documentation of design solutions remains to be developed if it has not already been done.

Of the 140 HEDs to be solved by surface enhancements, we concur with the proposed solutions for the following HEDs.

0-1-0001	0-1-0245	0-1-0542	0-2-0259	0-3-0244
0-1-0008	0-1-0247	0-1-0567	0-2-0260	0-3-0249
0-1-0010	0-1-0250	0-1-0590	0-2-0264	0-3-0256
0-1-0014	0-1-0259	0-2-0001	0-2-0277	0-3-0257
0-1-0016	0-1-0260	0-2-0002	0-2-0290	0-3-0258
0-1-0017	0-1-0261	0-2-0020	0-2-0355	0-3-0275
0-1-0025	0-1-0262	0-2-0051	0-2-0362	0-3-0373
0-1-0031	0-1-0279	0-2-0054	0-2-0367	0-3-0375
0-1-0046	0-1-0284	0-2-0217	0-2-0379	0-3-0383
0-1-0075	0-1-0297	0-2-0222	0-2-0410	0-3-0392
0-1-0077	0-1-0238	0-2-0223	0-2-0411	0-3-0397
0-1-0216	0-1-0368	0-2-0226	0-2-0416	0-3-0404
0-1-0219	0-1-0371	0-2-0233	0-3-0065	0-3-0408
0-1-0222	0-1-0376	0-2-0238	0-3-0216	0-3-0410
0-1-0223	0-1-0381	0-2-0242	0-3-0220	0-3-0412
0-1-0226	0-1-0400	0-2-0245	0-3-0221	0-3-0415
0-1-0228	0-1-0412	0-2-0247	0-3-0224	0-3-0421
0-1-0233	0-1-0417	0-2-0250	0-3-0231	0-3-0426

0-1-0238	0-1-0422	0-2-0253	0-3-0237	0-3-0430
0-1-0241	0-1-0488	0-2-0258	0-3-0240	

The following is a listing of the HED number and generic reason for concluding which surface enhancement solution descriptions are inadequate.

a. The description of the proposed problem, recommendation and/or implementation for correction is too brief, general, or ambigious to allow a valid assessment.

0-1-0026	0-1-0575	0-3-0025
0-1-0032	0-1-0576	0-3-0034
0-1-0093	0-1-0587	0-3-0063
0-1-0094	0-2-0050	0-3-0226
0-1-0121	0-2-0058	0-3-0253
0-1-0218	0-2-0069	0-3-0254
0-1-0254	0-2-0228	0-3-0276
0-1-0280	0-2-0254	0-3-0279
0-1-0282	0-2-0278	0-3-0411
0-1-0432	0-2-0281	0-3-0413
0-1-0480	0-2-0418	0-3-0417
0-1-0490		

b. The proposed recommendation and/or implementation does not correct the discrepancy.

0-1-0253	0-3-0077
0-1-0411	0-3-0252

c. The description of the proposed implementation is not finalized.

0-2-0377

2. Physical Change Solution HEDs

It is noteworthy that a relatively large percentage of the HEDs in this section stem from the identification of either missing or unsuitable controls and/or displays. This indicates that Duke Power has generated

significant findings from a human factors standpoint. The licensee is to be commended for an apparently comprehensive effort.

Of the 79 HEDs to be solved by physical changes, we concur with Duke Power's solution for the following HEDs.

0-1-0004	0-1-0047	0-1-0081	0-1-0105	0-1-0232
0-1-0007	0-1-0048	0-1-0082	0-1-0106	0-1-0269
0-1-0009	0-1-0049	0-1-0083B	0-1-0111	0-1-0286
0-1-0011	0-1-0052	0-1-0083C	0-1-0113	0-1-0406
0-1-0013	0-1-0056	0-1-0083D	0-1-0114	0-1-0447
0-1-0019	0-1-0060	0-1-0086	0-1-0116	0-1-0504A
0-1-0020	0-1-0061	0-1-0088	0-1-0117	0-1-0509
0-1-0022B	0-1-0064	0-1-0089	0-1-0119	0-1-0581A
0-1-0029	0-1-0066	0-1-0090A	0-1-0120	0-1-0595
0-1-0034	0-1-0067	0-1-0090B	0-1-0156	0-2-0043
0-1-0037	0-1-0068	0-1-0091B	0-1-0161	0-2-0053
0-1-0038	0-1-0071	0-1-0092	0-1-0174	0-2-0071
0-1-0040	0-1-0073	0-1-0095	0-1-0211	0-2-0282
0-1-0041	0-1-0078	0-1-0100	0-1-0213	0-2-0032
0-1-0042				

The following is a listing of the HED number and generic reason for concluding that descriptions for proposed physical change solutions are inadequate.

a. The description of the problem and/or solution is too brief, general or ambiguous to permit a valid assessment.

0-1-0015	0-1-0069	0-1-0099
0-1-0039	0-1-0083A	0-1-0118
0-1-0062	0-1-0087	

b. The solution description does not appear to correct the HED or only partially corrects the HED.

0-1-0504A: Installation of an RCP Seal Flow indication will give an indirect reading of RCP flow rather than a direct reading.

3. HEDs Not Corrected

Of the 4 HEDs that are not to be corrected we concur with Duke Power's justifications.

CONCLUSIONS AND RECOMMENDATIONS

Duke Power Company's Final Report for the DCRDR demonstrates a strong commitment towards meeting many of the requirements of NUREG-0737, Supplement 1. The documentation submitted includes a thorough and comprehensive discussion of review activities conducted to perform a DCRDR and indicates that Duke Power has met all the requirements with the exception of the following:

- Based on our evaluation of methodology described, we believe that Duke has basically met the intent of the requirement for a function and task analysis although controls and displays and their characteristics were not identified independently of the control room. We recommend that Duke Power provide assurance that emergency procedures analyzed represent a comprehensive set for its plant and that all emergency tasks were covered.

- The licensee has met the requirement for a control room inventory if the full spectrum of emergency procedures has been analyzed.

- The proposed schedules for implementing design changes does not describe the scheduling process or milestones in sufficient detail to determine that HED corrective actions will be implemented in an acceptable time frame.

- Various inadequacies were found in the proposed corrective actions for HEDs. Justifications for HEDs to be left uncorrected were reasonable.

Based on the documentation provided in the summary report and information provided by the NRC on the basis of its in-progress audit of Oconee, we believe it is reasonable to conclude that Duke Power has conducted a DCRDR that substantially meets the requirements of NUREG-0737, Supplement 1.

Additional information is required, to assure the requirements stated above are satisfied.

REFERENCES

1. Duke Power Company, Control Room Review Final Report, Volume 1, Revision 3, February 16, 1984.

2. Duke Power Company Control Room Review Plan for Oconee, McGuire and Catawba Nuclear Power Stations, April 14, 1983.

3. Memo for G. Lainas from W. Russell, Subject: Safety Evaluation Report Oconee Nuclear Station Units 1, 2 and 3 Procedures Generation Package, June 13, 1984.

4. Duke Power Company Control Room Review Supplement to Final Report, Oconee Nuclear Station, Units 1, 2, and 3, February 16, 1984.

5. Revision 4, Control Room Review Implementation Priority Schedule for Oconee Units 1, 2, and 3, Docket Date March 23, 1984.

6. "Human Factors Engineering Branch Detailed Control Room Design Review Safety Evaluation Report, Supplement No. 2 for Catawba Nuclear Station Unit 1," attachment to Memorandum from W.T. Russell, NRC, to T.M. Novak, NRC, dated January 31, 1984.

7. 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.

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

9. 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.

10. NUREG-0801 Draft, "Evaluation Criteria for Detailed Control Room Design Review," U.S. NRC, October, 1981.

11. NUREG-0700, "Guidelines for Control Room Design Reviews, USNRC, September, 1981.

12. Memorandum from H.B. Clayton, NRC, to D.L. Ziemann, NRC, "Summary of Meeting with Westinghouse Owner's Group Concerning Task Analysis Requirements," April 5, 1984.

13. Memorandum from S.H. Weiss, NRC, to V.A. Moore, NRC, "Summary of Meeting with BWR Owner's Grcup Concerning Task Analysis Requirements," May 14, 1984.

14. Memorandum from W.T. Russell, NRC to T.M. Novak, NRC, "Detailed Control Room Design Review Safety Evaluation Report for Catawba Nuclear Station Unit 1," April 23, 1984.

15. Catawba SSER 2, NRC, June 1, 1984.

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