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TECHNICAL EVALUATION  
OF THE  
DETAILED CONTROL ROOM DESIGN REVIEW  
SUMMARY REPORT  
FOR THE  
YANKEE-ROWE NUCLEAR POWER STATION

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This report documents the findings of an evaluation of Yankee Atomic Electric Company's (YAEC) Summary Report of the Detailed Control Room Design Review (DCRDR) of the Yankee-Rowe Nuclear Power Station. The purpose of the evaluation was fourfold: (1) to determine whether the DCRDR conducted by YAEC as documented in the Summary Report is acceptable; (2) to recommend to the NRC whether a pre-implementation audit or a meeting should be conducted; (3) to provide an audit or meeting agenda where appropriate; and (4) to provide a basis for feedback to YAEC. The requirements set forth in Supplement 1 to NUREG-0737, "Requirements for Emergency Response Capability" December 1982 (Reference 7), served as the basis of the Summary Report evaluation.

YAEC's DCRDR of Yankee-Rowe Nuclear Power Station began with the submittal of the Program Plan to the NRC on March 28, 1984 (Reference 1). The NRC staff comments on the Program Plan were forwarded to YAEC on June 6, 1984 with the recommendation that an in-progress audit be conducted (Reference 2). An in-progress audit was conducted at the Yankee-Rowe Nuclear Power Station on October 15-19, 1984, and the findings of the audit were forwarded to YAEC on January 2, 1985 (Reference 3). The DCRDR Summary Report was submitted by YAEC and received August 1, 1985 (Reference 4). The findings of the evaluation of the Summary Report follow a brief overview of the background of the DCRDR requirements.

#### 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 its 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-0800. (The NUREG documents cited are listed as References 5 through 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 Supplement 1 to NUREG-0737, 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 by providing a technical evaluation of the Yankee Rowe DCRDR process and results.

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 analysis 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 overall conclusion of the NRC staff in its review of YAEC's DCRDR Program Plan was that "the licensee has not demonstrated in its Program Plan that appropriate review methodologies and processes were developed to fulfill all of the DCRDR requirements of Supplement 1 to NUREG-0737." The NRC staff recommended that an in-progress audit be scheduled for the purpose of resolving the ambiguities and potential inadequacies of the Yankee-Rowe Program Plan. Those concerns that were identified by the NRC audit team but not satisfied during the in-progress audit, as well as any new concerns identified from the evaluation of the Summary Report, will be discussed for each DCRDR element in this report.

#### 1. Qualifications and Structure of the DCRDR Team

The NRC audit team concluded from the in-progress audit that, in general, the organization and structure of the DCRDR team was adequate for the

DCRDR tasks discussed. Specifically, the NRC audit team found the organization and structure of the Management Team was adequate for ensuring their familiarity with the DCRDR processes. Also, the NRC audit team concluded that "the addition of a qualified nuclear engineer to the Review Team, the involvement of all the Review Team disciplines in the various DCRDR tasks, and the identification of an adequately qualified supplementary staff ensure that YAEC will provide the appropriate personnel at the proper level of involvement for each activity in the DCRDR" (Reference 3 , p. 5).

A concern remaining from the in-progress audit regards the limited role of the Review Team in developing the corrections to HEDs. A review of the Summary Report has found that YAEC has addressed this concern by indicating that it intends to extend the role of the Review Team to include the review of the engineering staff's detailed design solutions. (For further discussion see the Selection of Design Improvements section of this report.)

At the time of the in-progress audit, YAEC's plans for selecting and verifying design improvements were not clearly defined. The assignments and level of effort of each of the Review Team personnel or disciplines for these DCRDR activities were found by the NRC audit team to be conceptually adequate. However, the plans for these activities have been altered to an extent that necessitates further review of the assignment and level of effort of the Review Team personnel.

In summary, the qualifications, organization and structure of the DCRDR personnel appear to be adequate for successfully accomplishing most of the DCRDR activities. In order for YAEC to fully satisfy this requirement of Supplement 1 to NUREG-0737, it must provide documentation which demonstrates a satisfactory level of involvement of the Review Team personnel in the selection and verification of design improvements.

#### REVIEW PHASE

YAEC's review phase activities as listed in the Summary Report include the following:

1. Derivation of Instrumentation and Control Needs
2. Comparison of Needs With Inventory

3. Control Room Static Survey
4. Operating Experience Review

Activities 1 through 3 address specific DCRDR requirements contained in Supplement 1 to NUREG-0737. Although a review of operating experience is not required by Supplement 1 to NUREG-0737, the results of this activity are integrated into required DCRDR activities and therefore will be given attention in this report. The activity entitled "Derivation of Instrumentation and Control Needs" addresses the function and task analysis requirement of Supplement 1 to NUREG-0737 and will be discussed in the following section of this report.

#### 1. Function and Task Analysis

The following concerns of the NRC audit team were not resolved during the in-progress audit:

- o The effect that the results of the NRC's review of YAEC's Procedure Generation Package (PGP) will have upon the task analysis.
- o The comprehensiveness of the coverage of emergency operations in the task analysis.
- o The existence of instances in the task analysis where "I&C requirements" were not defined in sufficient detail.
- o The inadequacy of performance of the analysis of traffic flow.
- o The lack of analysis of operator workload.

YAEC's task analysis was based on the symptom-oriented Emergency Operating Procedures (EOPs) developed previous to the DCRDR. YAEC states in the Summary Report that "no formal Task Analysis to develop EOPs was available at the time and/or an acceptable substitute" and that "the Review Team performed the necessary analysis to derive the required information from the emergency operating procedures" (Attachment B, p. B-1).

Since YAEC's task analysis was based on the EOPs, the adequacy of the task analysis is dependent upon the adequacy of the PGP and the EOPs. The NRC currently possesses YAEC's PGP but has not completed its review. Until the NRC has completed its review of YAEC's PGP and has presented its findings, the adequacy of the EOPs as the basis for performing the DCRDR task analysis is unknown. Review and necessary modifications to the task analysis should accompany any revisions to the EOPs resulting from the NRC's findings from its review of YAEC's PGP. Additional evaluation of the availability and suitability of instruments and controls in the control room should be performed by comparing any information and control requirements that were added or modified as a result of modifications with the task analysis. Any modifications to the task analysis and associated findings of the evaluation of instrument and control availability and suitability should be documented and submitted to the NRC for review.

Whereas NUREG-0700 recommends a "top-down" approach to performing a task analysis (i.e., identify systems, system functions, tasks, etc.), YAEC began with identifying the operator tasks necessary to perform the symptom-oriented EOPs. YAEC did not use the Westinghouse Owners Group (WOG) Emergency Response Guidelines (ERGs) because of the difference in the Yankee-Rowe plant design from those newer Westinghouse plants for which the WOG ERGs were more applicable. If the tasks in the EOPs were adequately detailed, YAEC quoted the tasks as described in the EOPs and entered these in the "task/subtask" column of the task analysis worksheet. Otherwise, YAEC provided a more detailed description of the task in the task analysis worksheet. For each task, YAEC identified the associated information and control requirements and recorded these in the "I&C Needs" and "I&C Requirements" columns of the task analysis worksheet. The identification of the procedure step number, operator tasks/subtasks, and information and control requirements was originally performed and documented on the task analysis worksheet by YAEC's human factors consultants. After Review Team assessment of this information, the task analysis worksheet was finalized and readied for comparison with the instruments and controls in the control room.

YAEC stated during the in-progress audit that the only EOP not covered in the task analysis was the "Loss of All AC Power." In Attachment B to the Summary Report, YAEC states that no one from the procedure writing group was

available at the time the statement was made and, subsequently, it has been determined that the Critical Safety Function, symptom-oriented EOPs do address loss of all AC power (p. B-2). YAEF further states that "the symptom-based procedures were developed to assure fuel cladding integrity by providing guidance to maintain five 'critical safety functions' without regard to which event was being experienced." This statement clarifies YAEF's earlier statement concerning the inclusion of loss of all AC power in the EOPs. However, to demonstrate the comprehensiveness of the EOPs and task analysis in covering all tasks involved in emergency operations, YAEF needs to submit documentation of a comparison of the EOPs covered in the task analysis with the function restoration guidelines and EOPs described in the WOG ERGs.

The NRC audit team concluded from a review of the task analysis worksheets that there were many instances in which the level of detail of the listed information and control requirements is too vague to allow an adequate comparison of the requirements with the existing instruments and controls in the control room. Except for these instances, YAEF usually provides appropriate detail on the required characteristics or refers to an adequately detailed standard. The concern here is the validity with which vague or general requirements were used to evaluate specific design characteristics of control room instruments and controls. YAEF states in the Summary Report that "the method chosen by YR to derive the I&C needs from the procedures did not lend itself to the level of detail in the [NRC] guidance" and that "all the available information in the procedure was evaluated to determine the minimum I&C needs and requirements" (Attachment B, p. B-3). In short, YAEF indicates that the detail with which it derived needed characteristics of instruments and controls was kept to a minimum and was not at a level acceptable to the NRC (for those instances referred to above). As previously mentioned, the concern here is the validity of the comparison of the requirements with the existing control room. YAEF's statement that "the comparison is indeed subjective, and deliberately so" increases the NRC's concern regarding the validity of the derivation of needed characteristics of instruments and controls as the basis for evaluating the suitability of the design of control room instruments and controls. An example from the NRC in-progress audit report of YAEF's vague and general approach to listing some of the needed characteristics of instruments and controls is cited below:



Step one of the Reactivity Anomaly procedure states that the task is to "Initiate Manual Reactor Scram by De-energizing Control Rod Drives." The I&C need is "Switch" and the I&C requirement is "Easily accessible, quick-acting, easily operated switch." The I&C requirement should list more specific requirements such as: switch positions, type of control/switch capability needed (discrete versus continuous), the control operation if the control capability needed is discrete (detented versus spring-loaded, momentary contact positioning), etc.

In the Summary Report, YAEF responded to this example by stating that "the details used in the auditor's example are not needed for the equipment to perform the procedure step" (Attachment B, p. B-3). This conclusion would have been acceptable to the NRC if it had been based upon an analysis of needed instrument and control characteristics that was performed to the level of detail suggested in the NRC's example. However, the task analysis documentation present at the in-progress audit did not demonstrate that such a detailed analysis was performed in those instances characterized by the above example. For all instances in the task analysis where the level of detail of the needed instrument and control characteristics is too vague or general, such as the above example, YAEF should either (1) reanalyze the related tasks to derive detailed characteristics of needed instruments and controls, or (2) demonstrate that the detailed level of analysis suggested in the NRC's example was not necessary for each instance where the level of detail is that of the above example.

Through discussions with YAEF, the NRC audit team concluded that the analysis of traffic flow was not adequately performed and that there did not appear to be an analysis of operator workload. The NRC audit team found the analysis of traffic flow lacked a systematic and rigorous application of criteria in an operational/dynamic context. In addition, no clearly discernable, systematic and rigorous analysis of operator workload was performed. In the Summary Report, YAEF's response to these conclusions was summarized in the statement, "We did not do, or ever expect to do, what the NRC consultant assumed the brief statement in the Program Plan meant" (Attachment B, p. B-4). The NRC concluded in its review of the Program Plan that YAEF's statements relative to its evaluation of traffic flow, operator workload, and "other issues" were in need of further explanation in order to clarify YAEF's approach. Discussion during the audit concerning these

activities revealed that YAEK's approach to analyzing traffic flow and operator workload lacked rigor in the application of human factors principles or criteria. Although the HEDs given in the Summary Report indicate that some discrepancies relative to traffic flow and operator workload were found, additional discrepancies or problems could have been overlooked.

In summary, YAEK has not taken any remedial action on the deficiencies identified by the NRC audit team in the task analysis. The Summary Report did not provide documentation requested by the NRC audit team which demonstrates the comprehensiveness of the EOPs and task analysis in covering the tasks performed and interfaces involved in emergency operations. In order to resolve the concerns identified in the in-progress audit relative to the function and task analysis requirement of Supplement 1 to NUREG-0737, YAEK should provide documentation demonstrating the following:

- o The comprehensiveness of the EOPs and task analysis in covering the tasks performed and interfaces involved in emergency operations.
- o Either (1) a further analysis of those tasks which resulted in "I&C requirements" of a vague or general nature (represented by the examples previously provided) to provide the necessary detail or (2) for each instance where the level of detail was too vague or general, the level of analysis suggested in the NRC's example was not necessary.
- o Although an analysis of operator traffic patterns and workloads is not an activity required by Supplement 1 to NUREG-0737, we suggest that YAEK perform a systematic and rigorous analysis of operator traffic patterns and workload in order to increase the benefit of the task analysis.

Any findings and HEDs identified from the above-listed improvements of the task analysis and the analysis of operator traffic patterns and workload should be documented as well. Currently, the NRC review of YAEK's PGP has not been completed. Until the results of the NRC review are reported, the adequacy of YAEK's PGP in supporting the EOPs and task analysis cannot be determined. Based on the in-progress audit findings and YAEK's responses to



these findings, we conclude that YAEC has not met the function and task analysis requirement of Supplement 1 to NUREG-0737.

## 2. Comparison of Display and Control Requirements With a Control Room Inventory

The following concerns of the NRC audit team were not resolved during the in-progress audit:

- o Instances exist where the requirements were modified to correlate with the instruments and controls in the control room.
- o The validity of the comparison may be affected by the vague or general description of the needed or required characteristics of instruments and controls.

YAEC's comparison of information and control requirements with the existing instruments and controls in the control room was performed by comparing the "I&C needs" and "I&C requirements" identified in the task analysis with the control room. The NRC audit team found instances where the requirements listed on the task analysis computer printout were modified to correlate with the instruments and controls in the control room. No documentation was found which justified these modifications. In the Summary Report, YAEC states that in the two instances cited by the NRC audit team, the YAEC human factors consultant changed or corrected the requirements during the walk-through performed subsequent to the identification of information and control requirements (Attachment B, p. B-5). YAEC provides the following response or justification for these modifications:

"They [human factors consultant] inserted the requirement for the main coolant pump ammeter to have a linear scale. During the walk-through by the same consultant team, they found the actual scale was linear, except between zero and the first division the scale was compressed. He changed the requirement to 'readable.' In the second instance, the range for each of the four-loop flow indicators was incorrectly defined as the range for total core flow. The human factors consultant team corrected these numbers when they were discovered during the walk-through."

The basis of the NRC's concern with the first modification is that in changing a specific requirement to a general one, a meter scale previously found to be discrepant with the requirement was subsequently allowed to be acceptable, thus precluding documentation of a finding/HED and any justification (acceptable or not) for not intending to take corrective action. The basis of the NRC's concern with the second modification is that this and any other error made by the human factors consultants was not detected until the walk-throughs. This indicates that the identification of information and control requirements was not adequately reviewed by YAEC operations and engineering prior to the comparison activity. The overall concern these two instances spur is that the approach YAEC took to compare the requirements with the control room and its documentation was not as thorough as required to meet Supplement 1 to NUREG-0737.

The NRC audit team was also concerned about the validity of the comparison of the requirements with the control room. As previously discussed in the Function and Task Analysis section of this report and explicit in the changing of the requirement discussed above, general requirements such as "readable" or "easily accessible, reliable, quick-acting, easily operated switch" do not establish a satisfactory basis for an objective and thorough evaluation of instrument and control design suitability. As in the case of the task analysis, YAEC does not intend to take any remedial action for the deficiencies found in its approach. Until acceptable improvements are made to the methodology and any subsequent HEDs reviewed by the NRC, we do not believe YAEC has adequately met this requirement of Supplement 1 to NUREG-0737.

### 3. Control Room Survey

The NRC audit team's general findings from discussions with YAEC and review of its documentation of the static survey were that the survey was not found to be thorough or well documented. As discussed in the NRC staff comments on the Yankee-Rowe Program Plan and in the in-progress audit report, the survey approach YAEC used was that prescribed by the Boiling Water Reactor Owners Group (BWROG). According to Generic Letter 83-18 (Reference 10), the BWROG stated that "NUREG-0700 addresses many topics on a detailed, quantitative basis, whereas the BWROG believes a more general,

qualitative approach, coupled with survey team training, is more appropriate." With certain improvements in content, the NRC found the survey approach prescribed by BWROG to be acceptable.

To determine the adequacy of YAEC's application of the BWROG survey, the NRC audit team performed a small sample survey of the Yankee-Rowe control room using NUREG-0700. In a comparison of the HEDs identified in the sample survey with YAEC's survey and findings, the NRC audit team found instances where the documentation was incomplete and did not account for NRC audit team sample survey findings. The NRC audit team's review of the survey documentation found numerous instances where criteria or results were ambiguous, incomplete, and inconsistent. In addition, sections of the checklists were found to have been omitted. In the Summary Report, YAEC states, "We have subsequently gone over the checksheets again and filled in all the missing information. While a couple of questions were discovered to have been actually overlooked, no additional findings were found in the process" (Attachment B, p. B-9). Although YAEC has taken some action to improve its documentation and complete omitted evaluations, more information is needed to obtain a clearer understanding of those corrective actions. YAEC should describe how it completed the sections of the survey found to be omitted, ambiguous, and inconsistent.

The most significant instance where an NRC audit team sample survey finding was not accounted for in YAEC's findings concerns the ambiguity of the association among two circulating water pumps and their related motor operative valve indicator lights due to poor control/display integration on the panel. This particular omission in the findings was described in the NRC in-progress audit report. Three separate, independent assessments made by SAIC human factors, nuclear, and electrical engineers using YAEC's categorization approach consistently found this finding to be a Class A HED - YAEC's most significant HED classification. By YAEC's definition, a Class A HED is an HED that could potentially have a significant impact on safety or cause a deviation from technical specifications. In response to this and other examples presented in the NRC in-progress audit report, YAEC stated that "these examples were noticed by the DCRDR review team during the static survey and judged to be inconsequential" (Attachment B, p. B-6). In reference to this particular example, YAEC responds by stating, "The circulating water pump switches and corresponding indicating lights are located one

above the other on Panel 10. The position indicating lights for the pump discharge valves are located between the pump switches, one beside the other. While not adhering to the strictest human factors standard, which prefers everything consistently top to bottom, or right to left [left to right], no operator has ever been confused by this layout and the reviewers thought it unworthy of comment." This response is not an adequate justification for omitting this and any other HED from the assessment, resolution, and implementation processes. YAEC should include the HED described above in these processes in order to satisfy this specific concern.

In summary, YAEC has taken some action to improve upon the omissions and documentation of its control room survey. However, more information is needed to obtain a clearer understanding of those corrective actions. In addition, YAEC should provide evidence that it has included the HED concerning the circulating water pump switches and indicator lights in the assessment, resolution, and implementation processes. In order to meet adequately the control room survey requirement of Supplement 1 to NUREG-0737, YAEC needs to present documentation providing this information.

#### 4. Operating Experience Review

Although not a requirement of Supplement 1 to NUREG-0737, a review of operating experience can provide valuable insights into the adequacy of the control room, procedures, and other areas in mitigating plant emergency situations. YAEC has performed a review of operating experience consisting of a review of plant historical documentation and operator questionnaires and interviews. The NRC audit team's review of the documentation and results of these activities identified the following areas where improvements could be made:

- o The scope of the review of historical documentation.
- o The specificity of the operator comments from the operator questionnaires and interviews.
- o The tracking, documentation, and disposition of operator comments from the operator questionnaires and interviews.

- o The number of questionnaires and interviews performed.

YAEC's review of historical documentation consisted of a review of Licensee Event Reports (LERs), Plant Information Reports (PIRs), and the plant scram log. The NRC audit team found that with the exception of the LERs, the review of the plant historical documentation was fairly extensive (e.g., the plant scram log covers the plant's complete lifetime). The scope of the review of LERs is limited to 1982-83. Although YAEC's statement that the LERs have been required only in recent years is true, LERs do exist for Yankee-Rowe previous to 1982-83. In the Summary Report, YAEC indicates that some of the personnel involved in the operator questionnaires and interviews have extensive experience at Yankee-Rowe including two of the operators present from the original startup of the plant (Attachment B, p. B-8). YAEC states that the "probing for prior events" was accomplished during the interviews involving these persons. Using the memory of these persons as the sole data source for the review of plant events prior to 1982-83 is not reliable. A review of LERs prior to 1982-83 enhanced by the memory of these experienced persons would present a more reliable method. In its review of operator questionnaires and interview results, the NRC audit team did not find any questions or responses concerning events prior to 1982-83. This suggests that a concerted effort to identify potential problems associated with plant events prior to 1982-83 was not performed. In order to receive the fullest possible benefit from previous plant history concerning documented events, we suggest that YAEC expand the scope of its review of LERs to include a larger, more representative sample of documented events.

A review of the operator questionnaire and interview documentation by the NRC audit team found that, in general, the data collected reflected significant operator concerns which appeared to have been given candidly and seriously, resulting in the identification of HEDs. However, some operator comments were vague. Other operator comments, some concerning potentially significant problem areas, were not documented in HEDs. In addition, only 13 of the 31 questionnaires sent out were returned and only 11 of the operations personnel were interviewed. The overall concern of the NRC audit team regarding these findings is that operator concerns that identify problems of potential significance to plant safety and reliability have not been documented or documented adequately enough to create the impetus to perform



a concerted follow-up investigation. Such an investigation could potentially identify additional, significant HEDs. Although YAEC notes several times in the Summary Report that the operator interviews were voluntary and not required by Supplement 1 to NUREG-0737, there is a potential benefit to be realized by following through on all operator concerns identified previously as well as by obtaining greater operator participation and management support in collecting operator feedback through questionnaires and interviews.

In summary, although the operating experience review resulted in the identification of HEDs, the data collection efforts could have been more rigorous with a corresponding increase in valuable findings. Although this activity is not mentioned as a requirement of Supplement 1 to NUREG-0737, it is a significant and valuable contributor to the DCRDR and other improvement programs. We suggest that YAEC improve upon the deficiencies noted by the NRC audit team in the operating experience review.

#### ASSESSMENT AND IMPLEMENTATION PHASE

##### 1. Assessment of HEDs

The remaining concern of the NRC audit team from the in-progress audit regarding the assessment of HEDs was that YAEC did not have a system for prioritizing HEDs or for scheduling the implementation of their corrections. The NRC audit team found that the HED classification system YAEC developed was not used in the prioritization of HEDs. The purpose of classifying HEDs should be twofold: (1) to determine which HEDs are significant and should be corrected, and (2) to determine scheduling priorities for implementing HED corrections. YAEC does not appear to differ concerning the first purpose since in its Summary Report, YAEC states that "classification, as done at YR, defined the type of difficulty which could be caused by the HED, leaving the Management Committee the freedom to, for example, not implement an HED which was classified as an operator inconvenience (Class C)" (Attachment B, p. B-10). In the Summary Report, YAEC appears to address the second purpose by stating that "the schedule for correction of the HEDs will be based on their integration into other work for the next refueling cycle, the amount of effort for engineering and operations for the designed installation of individual HEDs, the classification of HEDs, the manpower available

and finally the location of the HEDs" (p. 20). However, YAEC does not clarify how much weight the classification of HEDs carried in determining the implementation schedule, and no implementation dates were reported for individual HEDs that would demonstrate this. The extent to which YAEC actually considered the classification of HEDs is further obscured by the statement "Using this method [separating classification and prioritization], the priority is established by the four factors listed, as well as the complexity of the fix and the lead time to order equipment" (Attachment B, p. B-10). The four factors referred to are:

- o Budget
- o Manpower
- o Calendar time
- o Refueling schedule.

Although all of these factors are certainly important considerations, the safety significance of HEDs should be the overriding factor for prioritization. During the in-progress audit and in the Summary Report, YAEC stated that it found no HEDs to be more significant than any of the others that would require a higher priority for scheduling the implementation of corrections. A review of the Summary Report found that of the 91 HEDs reported, 28 were Class A HEDs, 6 were Class B HEDs, and 54 were Class C HEDs (3 HEDs did not have classifications). YAEC's HED classes are defined as follows:

- o Class A - An HED that could potentially have a significant impact on safety or cause a deviation from technical specifications.
- o Class B - An HED that has the potential to cause human error that could be harmful to plant personnel or equipment.
- o Class C - An HED that could inconvenience the operator.

YAEC's distribution of HEDs across all three categories would seem to indicate that some HEDs, especially Class A HEDs relative to Class C HEDs, are far more significant and should have corrections implemented at a higher priority than others.



In its correction of HEDs, YAEK should ensure that its approach to correcting HEDs is systematic and reliable rather than piecemeal. This integrated approach entails cognizance of such interrelationships as the application of enhancements (e.g., demarcation, mimicking) with changes in panel component locations. The result of such an approach is the development of an integrated control room improvement package. Such an integrated package usually requires that many of the individual HED corrections be implemented at the same time regardless of classification. However, the schedule for implementing these corrections should be driven by the classification of the most significant HEDs in addition to constraints such as those factors listed by YAEK.

In summary, YAEK does not clearly indicate to what extent it is considering the safety significance of HEDs in its prioritization for implementing HED corrections. YAEK should implement corrections to the HEDs of higher significance (Class A and B HEDs) as much as possible in the next refueling outage while maintaining an integrated approach to control room improvement. The highest priority should be to implement safety-significant control room improvements appropriately in an integrated fashion as soon as practicable. YAEK should provide documentation describing how this will be done. This documentation should also provide a schedule including dates for the implementation of each HED to be corrected.

## 2. Selection of Design Improvements

The following concerns of the NRC audit team were not resolved during the in-progress audit:

- o The methodology and criteria for determining design improvements is not well defined.
- o The role of the Review Team in the development of design improvements is limited to the development of conceptual solutions.
- o The engineering staff supplementary to the Review Team will be used to develop the detailed solutions.

- o The description of the discrepancies on the HED forms is not detailed enough to convey adequately the information necessary to allow the engineering staff to proceed reliably with the development of detailed solutions.

During the in-progress audit, the NRC audit team found through discussions with YAEK that the methodology intended for selecting design improvements was not systematic and did not use criteria for determining the adequacy of proposed solutions to HEDs. The approach described by YAEK was that the Review Team would develop conceptual solutions and its engineering staff would develop the detailed solutions. YAEK defined these solutions during the in-progress audit as follows:

- o A conceptual solution is a general solution that does not specify, for example, how to mimic or demarcate; it specifies only that this type of solution is required.
- o A detailed solution specifies the actual design of the solution.

In the Summary Report, YAEK describes its approach to determining design improvements as follows:

"The Review Team creates the conceptual solution to a HED in full committee and generally with unanimous agreement. The Program Plan states that if the human factors expert disagrees, his view will be documented. No such disagreements have occurred. No formal criteria for creating conceptual solutions exist. However, in the minds of the Review Team adequate conceptual solutions have been proposed. One could wish for more specifics or more detail in the conceptual solution, but a conceptual solution may deliberately be non-specific to allow flexibility in implementation" (Attachment B, p. B-11). After the Review Team had developed its conceptual solutions, these were forwarded as recommendations for correcting HEDs to the Management Team. "After considerable study, it was agreed that 54 HEDs should be corrected. Of the remaining 37 HEDs, 18 have an individual explanation for not correcting. The remaining 19 HEDs include a notation 'benefit cannot be supported by cost.' For the latter group of HEDs, the Management Team believes that even though a design feature might

deviate from accepted human factors ideals, it does not necessarily require correction. Our review process included a careful evaluation of what potential reduction in operator error rate and commensurate increase in plant safety could be achieved by correcting this group of HEDs" (p. 19). The results of the Management Team's decisions from its review of the HEDs and recommended corrections by the Review Team were assigned to various engineering support groups for implementation.

Although this description indicates the general approach YAEC took in determining design improvements, specific areas of this approach are not described in sufficient detail to allow a complete evaluation. YAEC indicates that the Review Team used no formal criteria to develop conceptual solutions. However, no mention was made of what guidelines or criteria the engineering staff referenced in the development of detailed solutions. In addition, YAEC did not describe the review process it took to evaluate what potential reduction in operator error rate and commensurate increase in plant safety could be achieved by correcting the 19 HEDs it noted with "benefit cannot be supported by cost."

During the in-progress audit, the NRC audit team indicated to YAEC that the planned role of the Review Team in the selection of design improvements was too limited. YAEC had intended to limit the role of the Review Team to the development of conceptual solutions. The remainder of the solution development process was to be performed by the engineering support staff which did not have the corresponding human factors or DCRDR experience. During the audit, the Management Team Chairman stated that the Review Team could remain in existence until all modifications were completed, but that such a change in plans would require management approval. In the Summary Report, YAEC states that "the Review Team will remain in existence until all designs have been reviewed" (Attachment B, p. B-11). Although the direct involvement of the Review Team in the development of detailed solutions would appear to be the effective approach since this would take advantage of their DCRDR experience, the involvement of the Review Team as reviewers would be acceptable and more effective if (1) the Review Team used a systematic approach to verify the engineering staff's detailed solutions using a set of criteria based upon human factors guidelines and conventions, and (2) the engineering staff used human factors guidelines and conventions in developing the detailed solutions. For example, human factors guidelines

such as NUREG-0700 contain a set of guidelines applicable to the design of mimics, demarcation, color-coding, component location, and so on. A reference such as this would enhance and facilitate the development and verification of the detailed solutions.

During the in-progress audit, the NRC audit team's review of the HED forms found that they were not detailed enough to convey adequately the problem, the components involved, and what was the necessary corrective action in order to allow the engineering staff to develop an appropriate detailed solution. The NRC audit team stated that this lack of detail could ultimately result in repeating the survey to obtain the necessary information. In its description of the use of the data management system, YAEC states, "The information in the HED and in the findings which comprises that HED are provided to the Management Team in the form of an HED list and a findings list sorted by HED. In this form the information is available in a general form and a detailed form as well" (p. 17 of the Summary Report). YAEC continues by stating, "Assignment of the implementation of a given HED to the design engineers, in the form described above, provides sufficient detail to implement the design." In order to conclude satisfactorily upon the adequacy of the HED forms for supplying the information necessary to proceed with the development of detailed solutions, the NRC must review representative HED forms.

In addition to the concerns identified during the in-progress audit, there is a concern for the finality of the HED resolutions in the Summary Report. YAEC states, "In some instances, e.g., the collection of annunciator deficiencies resulted in a recommendation that a study be made to resolve the best way to correct the deficiencies and then be implemented, the verification and validation were done only in the conceptual sense. Verification and validation of the actual design and installation would have to await those events" (p. 18 of the Summary Report). This statement and those HED recommendations for further study in the Summary Report appear to indicate that there is some potential for HED resolutions to change from those described. In addition to the uncertainty implied by recommending HEDs for further study, the delay of the verification and validation of some detailed solutions until studies are completed introduces the potential that changes will occur based on the outcome of the verification and validation. The Summary Report should provide final resolutions. Since this may not be

the case, the evaluation of the adequacy of the HED resolutions cannot be considered complete until the resolutions for all HEDs are final. (See the Analysis of Proposed Corrective Actions and Justifications for HEDs Left Uncorrected section of this report for further discussion.)

Relative to this issue, the implementation schedules for HEDs could not be evaluated due to the lack of implementation dates for individual HED corrections. In the Summary Report, YAEC states, "We expect to finalize a specific list of HEDs to be performed in the next refueling cycle and subsequent cycle by February 1, 1986. Because of the volume of HEDs and other work for engineering and operations, it is not expected that we could complete all HEDs in one cycle. Those HEDs which require only simple paint, label and tape corrections will be made by the end of 1985" (p. 20). Supplement 1 to NUREG-0737 suggests that improvements that can be accomplished with an enhancement program (paint-tape-label) be done promptly; YAEC appears to be following this suggestion. However, YAEC does not identify which specific HED corrections will be included in those implemented by the end of 1985. Supplement 1 to NUREG-0737 requires that the Summary Report include proposed schedules for implementation of proposed control room changes. The Yankee-Rowe DCRDR Summary Report does not meet this requirement. YAEC states that such a schedule will be finalized by February 1, 1986. Until this is provided to the NRC, we cannot conclude upon the adequacy of the schedule for implementing HED corrections as it relates to the selection of design improvements and the consideration of the classification of HEDs.

In conclusion, the YAEC Summary Report has addressed but not resolved all the concerns regarding selection of design improvements raised in the NRC in-progress audit report. YAEC has modified the roles of the Review Team and the Management Team in response to specific suggestions for improvement made by the NRC audit team. However, the following concerns need to be resolved in order for YAEC to meet the Supplement 1 to NUREG-0737 requirements for the selection of design improvements:

- (1) Specific portions of the process for developing solutions to HEDs were unclear. These were:



- (a) the guidelines or criteria the engineering staff has or will use to develop detailed solutions.
  - (b) the review process taken to evaluate what potential reduction in operator error rate and commensurate increase in plant safety could be achieved by correcting the 19 HEDs it noted with "benefit cannot be supported by cost."
- (2) The approaches taken by the engineering staff in its development of detailed solutions and the Review Team in its verification of these detailed solutions have not been described in detail in the Summary Report and do not refer to systematic processes that are based upon human factors guidelines and conventions.
  - (3) It is unclear how adequate the HED forms are for supplying the information necessary for the engineering staff to proceed with the development of detailed solutions. Representative HED forms should be provided for review.
  - (4) The resolutions for HED corrections described in the Summary Report do not appear to be final.
  - (5) Implementation schedules for all HED corrections have not been determined and included in the Summary Report.
3. Verification That Improvements Will Provide the Necessary Corrections Without Introducing New HEDs

At the time of the in-progress audit, the NRC audit team concluded that the role given the Review Team and the methodology proposed for verifying HEDs were not satisfactory. As discussed in the previous section of this report, the expansion of the Review Team's role to include the verification of the engineering staff's proposed detailed solutions is acceptable providing definite human factors guidelines and conventions are used in a systematic approach. In the Summary Report, YAEC states in its discussion of determining a logical modification to address the discrepancy that "...the determination that the modification would indeed correct the problem without

introducing another problem was made" (p. 18). YAEF continues by stating, "In some instances, e.g., the collection of annunciator deficiencies resulted in a recommendation that a study be made to resolve the best way to correct the deficiencies and then be implemented, the verification and validation were only done in the conceptual sense. Verification and validation of the actual design and installation would have to await those events. In those cases where the recommended modification was more specific, e.g., provide the missing engineering units on an indicator, the Review Team was able to make the determination that this simple change would indeed satisfy the two requirements." YAEF states that it made "the determination" but does not go into any further detail regarding methodology. Also, there is some ambiguity concerning the differentiation between this verification and validation process and the Review Team's review of the detailed solutions developed by the engineering staff. YAEF's overall discussion of its verification and validation process is not clear enough to perform a satisfactory assessment of its adequacy in meeting this requirement of Supplement 1 to NUREG-0737.

#### 4. Coordination of the DCRDR With Other Improvement Programs

During the in-progress audit YAEF indicated that the plans and methodology for coordinating and integrating the DCRDR with other improvement programs was in the development stage. In addition, the organization or mechanism by which the improvement programs would be coordinated and integrated had not been finalized. In the Summary Report, YAEF states, "Integration of the DCRDR with other improvement programs is being maintained. Procedures will be developed as needed. When a change from one improvement program affects another, it is recognized and continuity is maintained" (Attachment B, p. B-13). The statement "Procedures will be developed as needed" indicates incomplete procedures and methodology at present. In addition, YAEF does not describe how or by what mechanism it is maintaining the integration of the DCRDR with other improvement programs. Although YAEF recognizes the need to integrate the DCRDR with other improvement programs and appears to intend doing so, the Summary Report does not contain enough information about YAEF's methodology and mechanism to allow an adequate evaluation to be performed. Until YAEF provides satisfactory information on its procedures/methodology and mechanism for ensuring the DCRDR is integrated with other improvement programs, conclusions cannot be



made regarding the acceptability of its coordination effort in meeting this requirement of Supplement 1 to NUREG-0737.

#### ANALYSIS OF PROPOSED CORRECTIVE ACTIONS AND JUSTIFICATION FOR HEDs LEFT UNCORRECTED

YAEC documents 91 HEDs in the Yankee-Rowe DCRDR Summary Report. YAEC states that "fifty-four HEDs were judged by the Review Team to be in a category that could potentially inconvenience an operator, but would have no safety significance" (Class C HEDs). YAEC also states that "the remaining thirty-seven HEDs were evaluated to have some influence on safety" (Class A or B HEDs). SAIC's review of the HEDs documented in the Summary Report found 54 Class C HEDs, 6 Class B HEDs, 28 Class A HEDs, and 3 HEDs that did not have any classification indicated.

In the Summary Report, YAEC states that it determined that 54 HEDs should be corrected and 37 should not. SAIC's review of the HEDs in the Summary Report found that 53 HEDs are proposed for correction and 38 HEDs are not. Of those HEDs proposed for correction, 18 are Class A HEDs, 5 are Class B HEDs, 29 are Class C HEDs, and one is an HED with no classification indicated. Of those HEDs YAEC is not intending to correct, 10 are Class A HEDs, 1 is a Class B HED, 25 are Class C HEDs, and 2 are HEDs with no classification indicated.

A conclusive evaluation of the HEDs could not be performed due to either the brevity or ambiguity of the information provided or the lack of a definite solution. For those HEDs that had definite resolutions and had sufficient information to allow an evaluation, some but not all were found to be satisfactorily resolved. Those HEDs for which corrective actions were proposed and were found to be adequate are listed in Appendix A. Those HEDs for which corrective actions were proposed but were found to be inadequate are discussed in the Proposed Corrective Action section of this report and listed in Appendix B, Sections a through f. The HED for which a justification for not taking corrective action was provided and found to be adequate is listed in Appendix C. Those HEDs for which justifications for not taking corrective action were provided but were found to be inadequate are discussed in Appendix D, sections a, b, and c. The following two sections present examples where we elaborate on our findings of HEDs which

were found to be inadequately resolved. These HEDs and those listed in the appendices are identified in the format of "Summary Report page number/HED number."

## 1. Proposed Corrective Actions

Appendix B, sections a through f of this report contains the complete list of HEDs for which corrective actions were proposed but were found to be inadequate for one of the reasons discussed below.

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

22/0101 - The discrepancy described is that the fire panel has controls that are 14 inches above the standard. In addition, the panel is located behind the guard's station. Thus, the operator does not have easy access to this panel, but needs to in order to determine the location of a fire. YAEC's proposed corrective action is to relocate a small table with phones to allow better access, but not to relocate the controls above the standard since a "demonstration" showed access is easy enough for all operators. YAEC does not indicate what standard the controls are 14 inches above. Also, YAEC does not describe the demonstration that was performed.

46/0500 - The discrepancy described is that display instrumentation presents incorrect or confusing information to the operator. YAEC describes several examples of this type of discrepancy. YAEC's proposed corrective action is to correct the findings which comprise this HED. YAEC does not state what all the findings are (or type of findings) and how these will be corrected.

- b. The proposed corrective action was not finalized.

61/05ES - The discrepancy described is that power range meters have odd minor divisions of 2.5; operators are required to set these meters after calculating  $R_x$  power, and setting affects the

trip point and is difficult to do accurately. YAEC states that the calibration procedure will be reviewed and scale accuracy required will be provided. The adequacy of this resolution cannot be determined until the results of this review are reported and corrective actions described.

- c. The proposed corrective action will not correct the discrepancy.

63/05F0 - The discrepancy described is that the failure mode of display instrumentation, especially standby instruments, is not clearly evident on most displays. YAEC's proposed corrective action is to address the failure mode of instruments (e.g., live zeros, fail as is, etc.) in the training program. Training does not take into account behavioral responses to stress induced by emergency situations and is not a reliable substitute for appropriate display design.

93/1407 - The discrepancy described is that the load limit and governor controls require a control movement that is opposite to the feedback indication. YAEC's proposed corrective action for this Class A HED is to provide a warning label. Based on the information given for this proposed corrective action, the use of a warning label to compensate for an inappropriate, reverse-of-convention control design in emergency/stress situations is dubious. YAEC should describe this warning label and justify how it can compensate for inappropriate, reverse-of-convention control design in emergency/stress situations.

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

50/05C0 - The discrepancy described is that switch escutcheon plates (a) are worn so they cannot be read, (b) have positions marked 1 and 2 instead of start/stop (SI pumps), (c) are marked breakers instead of synchroscope, and (d) have handles which obscure pointers. YAEC's proposed corrective action is to replace the worn escutcheon plates and to ensure that all escutcheon

plates have correct operating nomenclature. No corrective action addressing the handles which obscure pointers was described.

66/0701 - The discrepancy described is that there are no provisions to prevent interchanging indicator light lenses. YAEC's proposed corrective action is to standardize the position of indicating light colors; lens and bulb replacement will be addressed by training. Although the standardization of color location for indicator lights and the training of personnel responsible for the replacement of lenses and bulbs are positive corrective actions, the incorporation of an administrative or maintenance procedure for lens and bulb checking and replacement appears to be necessary.

98/1413 - The discrepancies described are that the EOPs require venting the vessel containment, but that the procedure is complex and the controls are located in the switchgear room. YAEC's proposed corrective action is to identify the valves and revise the procedure. Only the procedural discrepancy appears to be addressed. No corrective action addressing the location of the controls in the switchgear room appears to have been made.

- e. The proposed corrective action may introduce a new HED.

45/0480 - The discrepancy described is that multipoint recorders have labels that are either black letters on a white background or white letters on a black background, while the pens are red, blue, and green. YAEC's proposed corrective action is to letter the labels for the pens in the same color as the pen it represents. Although this will identify which label and function are associated with each of the pens, the use of colored lettering such as red on a white or black background may result in poor contrast and readability of the labels. YAEC should investigate the effectiveness of the following labeling scheme versus the use of colored letters:

label/function

"XXX - red"

"YYY - blue"

"ZZZ - green"

- f. The proposed corrective action must be seen, applicable standards reviewed, or NRC approval of the processes for selection and verification of design improvements obtained in order for a conclusive evaluation to be performed.

31/0202 - The discrepancy described is that the CCW and SW controls and displays on MCB Panel No. 8 are not grouped by system or laid out in a logical manner. YAEC's proposed corrective action is to apply demarcation and hierarchical labeling. Although this type of corrective action is conceptually adequate, it is necessary either to provide a description and illustration of the specific, detailed demarcation and hierarchical labeling or to obtain NRC approval of the processes for selection and verification of HED corrections.

39/300 - The discrepancy described is that color is used inconsistently in the control room. YAEC's proposed corrective action is to develop a color standard and to change the control panels to conform to the standard. Although this is an appropriate approach to resolving the inconsistent use of color in the control room, it is necessary either to provide the color standard or to obtain NRC approval of the processes for selection and verification of HED corrections.

2. Justifications for HEDs Left Uncorrected

Appendix D, sections a, b, and c of this report contains the complete list of HEDs for which justifications for not taking corrective actions were provided but were found to be inadequate for one of the reasons discussed below.

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

21/0100 - The discrepancy described is that instruments and controls exceed the anthropometric limits recommended by NUREG-0700. YAEK's justification for not taking corrective action is that none of the instruments and controls associated with this HED are required to be read or manipulated precisely or frequently/rapidly during emergency operations. YAEK does not describe what instruments and controls are associated with this HED or detail the extent or distance of these discrepant components from the anthropometric limits. In addition, YAEK does not describe how (by what process) it determined that these discrepant components were not required to be read or manipulated precisely or frequently/rapidly during emergency operations.

92/1406 - The discrepancy described is that there is no indication on the MCB of purification cooling flow, LP surge tank makeup, and shutdown cooling flow. YAEK's justification for not taking corrective action is that except for shutdown cooling flow, these parameters are controlled elsewhere by the AO. YAEK states that shutdown cooling flow is available in the "control room area." YAEK does not indicate which activity identified these three parameters as missing from the MCB. If the activity was the task analysis, this would imply that the location of all three indications are needed on the MCB to support emergency operations. If these indications are needed to support emergency operations, then YAEK's justification does not sufficiently address the discrepancy.

- b. The basis of the justification is inadequate because it does not address operational or behavioral factors.

26/0105 - The discrepancy described is that VC temp is required by the EOPs as a precursor of off-normal conditions; it is located on the back panel and is too low. YAEK's justification for not



taking corrective action is that benefit of correcting this problem cannot be supported by the cost. YAEC's justification does not address operational or behavioral factors. In the Summary Report, YAEC states that it performed a review of the 19 HEDs which have this justification. This review included an evaluation of the potential reduction in operator error rate and commensurate increase in plant safety that could be achieved by correcting this group of HEDs. Such an evaluation should have addressed operational and behavioral factors which should have been included in the justifications for not taking corrective actions.

36/0207 - The discrepancy described is that the numbering of the 2400 and 480 volt bus mimics is not laid out in a top to bottom order. YAEC's justification for not taking corrective action is that the layout is acceptable and familiar to the operators. YAEC does not elaborate in behavioral or operational terms why the layout is acceptable. Citing operator familiarity with the layout is not an acceptable justification without such an explanation.

c. The justification does not sufficiently address the discrepancy.

107/1426 - The discrepancy described is that the EOPs require determination of adequate shutdown margin and that using the procedure is cumbersome and time-consuming. YAEC's justification for not taking corrective action is that the determination of adequate shutdown margin is not time-related and that time exists to perform this calculation. Although YAEC has addressed the time aspect of this discrepancy, the procedure is still cumbersome and may result in operator error. YAEC needs to address this aspect of the procedures and determine how the procedure can be modified or rewritten to be more efficient.

#### CONCLUSIONS AND RECOMMENDATIONS

The Summary Report for the Yankee-Rowe DCRDR contains responses to most but not all of the concerns raised in the NRC in-progress audit report. YAEC's responses indicate that with a few exceptions, it does not intend to correct or improve upon the deficiencies identified in its DCRDR. The



exceptions to YAEC's position regard its improvement of (1) the control room survey documentation, and (2) the roles of the Management Team and the Review Team in the assessment of HEDs and selection of design improvements, respectively. With these exceptions, YAEC does not intend to take corrective action on the deficiencies identified that relate to the following Supplement 1 to NUREG-0737 requirements:

- o Function and Task Analysis
- o Comparison of Control and Display Requirements with a Control Room Inventory
- o Control Room Survey
- o Assessment of HEDs.

In addition, the description of the methodologies to perform the following activities was not detailed enough in the Summary Report to adequately evaluate:

- o Selection of Design Improvements
- o Verification that Improvements Provide the Necessary Corrections Without Introducing New HEDs
- o Coordination of the DCRDR With Other Improvement Programs.

At the time of the in-progress audit, YAEC's plans for selecting and verifying design improvements were not finalized and the involvement of Review Team disciplines in these activities appeared to be conceptually adequate. However, the plans for performing these activities have been altered to an extent that necessitates further review of the assignment and level of effort of Review Team personnel.

In order to provide a forum for discussion, further feedback, and documentation review, we recommend that a meeting with Yankee-Rowe DCRDR representatives be held by the NRC. Discussion and documentation review in the meeting should address the following actions YAEC should take to correct or improve upon the deficiencies identified in the Yankee-Rowe DCRDR, or to clarify those areas of the DCRDR not sufficiently described in the Summary Report, in order to meet the requirements of Supplement 1 to NUREG-0737:

- o Qualifications and Structure of the DCRDR Team
  - Provide documentation of the level of involvement of each of the Review Team personnel in each of the following activities:
    - (1) selection of design improvements
    - (2) verification that the improvements provide the necessary corrections without introducing new HEDs
- o Function and Task Analysis
  - Provide documentation demonstrating the comprehensiveness of the EOPs and task analysis in covering the tasks performed and interfaces involved in emergency operations.
  - Provide documentation either (1) describing the performance and results of an analysis of those tasks which have "I&C requirements" of a vague or general nature (as represented by the examples provided in the NRC in-progress audit report) to provide the necessary details or (2) demonstrating that for each instance where the level of detail was too vague or general, the level of analysis suggested in the NRC's example was not necessary.
- o Comparison of Display and Control Requirements With a Control Room Inventory
  - Provide documentation describing the performance and results of a comparison of the control room with the needed characteristics for instruments and controls identified in the analysis of those tasks previously found to be of a vague or general nature.

o Control Room Survey

- Provide documentation describing how the omitted sections of the survey were completed and ambiguities and inconsistencies clarified.
- Provide documentation describing the assessment, resolution, and implementation schedule for the HED concerning the circulating water pump switches and indicator lights.

o Assessment of HEDs

- Provide documentation describing how the implementation of control room improvements will be integrated and considerate of HED classification.

o Selection of Design Improvements

- Provide documentation describing the review process taken to evaluate what potential reduction in operator error and commensurate increase in plant safety could be achieved by correcting the 19 HEDs it noted "benefit cannot be supported by cost."
- Provide documentation describing the approach and guidelines or criteria the engineering staff have used or will use to develop detailed solutions.
- Provide representative HED forms demonstrating the adequacy of the HED forms for supplying the information necessary for the engineering staff to proceed with the development of detailed solutions.
- Provide a response to the concern that the resolutions for all HED corrections do not appear to be final.

- Prior to the initiation of HED corrections
  - , provide an implementation schedule for every HED to be corrected.
- o Verification that Improvements Will Provide the Necessary Corrections Without Introducing New HEDs
  - Provide documentation describing the methodology, including guidelines and criteria used, for determining that a modification would correct the problem without introducing another HED.
  - Clarify the relationship of the verification and validation process referred to in the Summary Report to the Review Team's review of the detailed solutions developed by the engineering staff.
- o Coordination of the DCRDR With Other Improvement Programs
  - Provide documentation describing the development of procedures or methodologies for integrating the changes among improvement programs.
  - Provide documentation describing the mechanism which ensures that the DCRDR will be coordinated with other improvement programs.
- o Proposed Corrective Actions
  - For each HED listed in Appendix B of this report, provide information which responds to the inadequacy described.
- o Justifications for HEDs Left Uncorrected
  - For each HED listed in Appendix D of this report, provide information which responds to the inadequacy described.

In addition to these actions, we recommend that YAEC improve upon its analysis of operator traffic patterns and workload and the review of operating experience. The following recommended actions are not intended as additional requirements but are to encourage increased benefit from the DCRDR:

- o Perform a systematic and rigorous analysis of operator traffic patterns and workload.
- o Expand the scope of the LER review to include a larger, more representative sample of documented events.
- o Perform a follow-up investigation on all operator concerns identified.
- o Survey additional operators.



## REFERENCES

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3. "In-Progress Audit of the Detailed Control Room Design Review for Yankee Atomic Electric Company's Yankee Rowe Nuclear Power Station," Science Applications International Corporation, December 11, 1984, Attachment to Memorandum from V.A. Moore, USNRC, to J. Zwolinski, USNRC, dated January 2, 1985.
4. "Detailed Control Room Design Review Summary Report for the Yankee Nuclear Power Station," Yankee Atomic Electric Company, Attachment to letter from G. Papanic, Jr., YAEC, to J.A. Zwolinski, USNRC, dated August 1, 1985.
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-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Section 18.1, Rev. 0, USNRC, Washington, D.C., September 1984.

10. "NRC Review of BWR Owners' Group Control Room Survey Program," Attachment to letter from D.G. Eisenhut, USNRC, to all boiling water reactor licensees of operating reactors, applicants for an operating license and holders of construction permits, dated April 19, 1983.

## APPENDIX A

HEDs for which corrective actions were proposed and were found to be adequate.

30/0101	53/05C3	77/1100	88/1401
35/0206	54/05D0	78/1101	90/1403
37/02A1	55/05D1	79/1200	96/1410
41/0401	56/05E0	80/1201	101/1417
42/0402	57/05E1	81/1202	102/1418
44/04A0	58/05E3	83/1204	104/1421
52/05C2	73/0904	85/1301	110/1429
		86/1302	

## APPENDIX B

HEDs for which corrective actions were proposed but were found to be inadequate for one of the following reasons:

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

22/0101	62/05E6
23/0102	76/1002
46/0500	82/1203
48/05A0	84/1300
60/05E4	94/1408

- b. The proposed corrective action was not finalized.

61/05E5, 64/0600, and 65/06A0

- c. The proposed corrective action will not correct the discrepancy.

63/05F0 and 93/1407

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

50/05C0, 66/0701, and 98/1413

- e. The proposed corrective action may introduce a new HED.

45/04B0

- f. The proposed corrective action must be seen, applicable standards reviewed, or NRC approval of the processes for selection and verification of design improvements obtained in order for a conclusive evaluation to be performed.

31/0202, 38/02B0, 39/0300, 40/0400, and 43/0403

## APPENDIX C

The HED for which a justification for not taking corrective action was provided and found to be adequate.

97/1411



## APPENDIX D

HEDs for which justifications for not taking corrective action were provided but were found to be inadequate for one of the following reasons:

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

21/0100	71/0902	95/1409
25/0104	87/1400	99/1414
28/01B0	89/1402	100/1415
32/0202	92/1406	103/1419
67/0800		

- b. The basis of the justification is not adequate (i.e., the justification does not address operational or behavioral factors).

24/0103	36/0207	69/0900	105/1422
26/0105	47/0501	70/0901	106/1425
27/01A1	49/05B0	72/0903	108/1427
29/0200	51/05C1	74/1000	109/1428
33/0204	58/05E2	75/1001	111/1500
34/0205	68/0801	91/1405	

- c. The justification does not sufficiently address the discrepancy.

107/1426

Docket No. 50-029

JAN 13 1986

Mr. George Papanic, Jr.  
Senior Project Engineer-Licensing  
Yankee Atomic Electric Company  
1671 Worcester Road  
Framingham, Massachusetts 01701

Dear Mr. Papanic:

SUBJECT: DETAILED CONTROL ROOM DESIGN REVIEW (DCRDR)  
TECHNICAL EVALUATION REPORT

Re: Yankee Nuclear Power Station

Enclosed is the technical evaluation report (TER) prepared by our contractor, Science Applications International Corporation. As described on page 31 of the TER, the report is intended to provide the basis for a meeting between technical staffs representing the Yankee Atomic Electric Company and the NRC. This meeting has been tentatively scheduled for January 29, 1985 at NRC headquarters in Bethesda. Further details regarding the time, place, and participants will be provided in a meeting notice to be issued by the NRC.

If you have any questions regarding the enclosed report that need to be addressed prior to the meeting, please contact us.

Sincerely,



James W. Clifford, Project Manager  
Project Directorate #1  
Division of PWR Licensing-A

Enclosure:  
Technical Evaluation of the DCRDR  
Summary Report

cc: w/Enclosure:  
See next page

Office:	PM/PAD#1	D/PAD#1 PWR-A
Surname:	JClifford/jm	GLear
Date:	1/13/86	1/13/86

Dupe

JAN 13 1988

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Yankee Atomic Electric Company

Yankee Nuclear Power Station

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**JAN 13 1986**

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**JAN 13 1986**



SAIC/85-3093

TECHNICAL EVALUATION  
OF THE  
DETAILED CONTROL ROOM DESIGN REVIEW  
SUMMARY REPORT  
FOR THE  
YANKEE-ROWE NUCLEAR POWER STATION

October 10, 1985

Prepared for:

U.S. Nuclear Regulatory Commission  
Washington, D. C. 20555

Prepared by:

Science Applications International Corporation  
1710 Goodridge Drive  
McLean, Virginia 22102

Dupe

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TECHNICAL EVALUATION  
OF THE  
DETAILED CONTROL ROOM DESIGN REVIEW  
SUMMARY REPORT  
FOR THE  
YANKEE-ROWE NUCLEAR POWER STATION

This report documents the findings of an evaluation of Yankee Atomic Electric Company's (YAEC) Summary Report of the Detailed Control Room Design Review (DCRDR) of the Yankee-Rowe Nuclear Power Station. The purpose of the evaluation was fourfold: (1) to determine whether the DCRDR conducted by YAEC as documented in the Summary Report is acceptable; (2) to recommend to the NRC whether a pre-implementation audit or a meeting should be conducted; (3) to provide an audit or meeting agenda where appropriate; and (4) to provide a basis for feedback to YAEC. The requirements set forth in Supplement 1 to NUREG-0737, "Requirements for Emergency Response Capability" December 1982 (Reference 7), served as the basis of the Summary Report evaluation.

YAEC's DCRDR of Yankee-Rowe Nuclear Power Station began with the submittal of the Program Plan to the NRC on March 28, 1984 (Reference 1). The NRC staff comments on the Program Plan were forwarded to YAEC on June 6, 1984 with the recommendation that an in-progress audit be conducted (Reference 2). An in-progress audit was conducted at the Yankee-Rowe Nuclear Power Station on October 15-19, 1984, and the findings of the audit were forwarded to YAEC on January 2, 1985 (Reference 3). The DCRDR Summary Report was submitted by YAEC and received August 1, 1985 (Reference 4). The findings of the evaluation of the Summary Report follow a brief overview of the background of the DCRDR requirements.

#### 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 its 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-0800. (The NUREG documents cited are listed as References 5 through 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 Supplement 1 to NUREG-0737, 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 by providing a technical evaluation of the Yankee Rowe DCRDR process and results.

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 analysis 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 overall conclusion of the NRC staff in its review of YAEC's DCRDR Program Plan was that "the licensee has not demonstrated in its Program Plan that appropriate review methodologies and processes were developed to fulfill all of the DCRDR requirements of Supplement 1 to NUREG-0737." The NRC staff recommended that an in-progress audit be scheduled for the purpose of resolving the ambiguities and potential inadequacies of the Yankee-Rowe Program Plan. Those concerns that were identified by the NRC audit team but not satisfied during the in-progress audit, as well as any new concerns identified from the evaluation of the Summary Report, will be discussed for each DCRDR element in this report.

##### 1. Qualifications and Structure of the DCRDR Team

The NRC audit team concluded from the in-progress audit that, in general, the organization and structure of the DCRDR team was adequate for the



DCRDR tasks discussed. Specifically, the NRC audit team found the organization and structure of the Management Team was adequate for ensuring their familiarity with the DCRDR processes. Also, the NRC audit team concluded that "the addition of a qualified nuclear engineer to the Review Team, the involvement of all the Review Team disciplines in the various DCRDR tasks, and the identification of an adequately qualified supplementary staff ensure that YAEC will provide the appropriate personnel at the proper level of involvement for each activity in the DCRDR" (Reference 3 , p. 5).

A concern remaining from the in-progress audit regards the limited role of the Review Team in developing the corrections to HEDs. A review of the Summary Report has found that YAEC has addressed this concern by indicating that it intends to extend the role of the Review Team to include the review of the engineering staff's detailed design solutions. (For further discussion see the Selection of Design Improvements section of this report.)

At the time of the in-progress audit, YAEC's plans for selecting and verifying design improvements were not clearly defined. The assignments and level of effort of each of the Review Team personnel or disciplines for these DCRDR activities were found by the NRC audit team to be conceptually adequate. However, the plans for these activities have been altered to an extent that necessitates further review of the assignment and level of effort of the Review Team personnel.

In summary, the qualifications, organization and structure of the DCRDR personnel appear to be adequate for successfully accomplishing most of the DCRDR activities. In order for YAEC to fully satisfy this requirement of Supplement 1 to NUREG-0737, it must provide documentation which demonstrates a satisfactory level of involvement of the Review Team personnel in the selection and verification of design improvements.

#### REVIEW PHASE

YAEC's review phase activities as listed in the Summary Report include the following:

1. Derivation of Instrumentation and Control Needs
2. Comparison of Needs With Inventory

3. Control Room Static Survey
4. Operating Experience Review

Activities 1 through 3 address specific DCRDR requirements contained in Supplement 1 to NUREG-0737. Although a review of operating experience is not required by Supplement 1 to NUREG-0737, the results of this activity are integrated into required DCRDR activities and therefore will be given attention in this report. The activity entitled "Derivation of Instrumentation and Control Needs" addresses the function and task analysis requirement of Supplement 1 to NUREG-0737 and will be discussed in the following section of this report.

#### 1. Function and Task Analysis

The following concerns of the NRC audit team were not resolved during the in-progress audit:

- o The effect that the results of the NRC's review of YAEC's Procedure Generation Package (PGP) will have upon the task analysis.
- o The comprehensiveness of the coverage of emergency operations in the task analysis.
- o The existence of instances in the task analysis where "I&C requirements" were not defined in sufficient detail.
- o The inadequacy of performance of the analysis of traffic flow.
- o The lack of analysis of operator workload.

YAEC's task analysis was based on the symptom-oriented Emergency Operating Procedures (EOPs) developed previous to the DCRDR. YAEC states in the Summary Report that "no formal Task Analysis to develop EOPs was available at the time and/or an acceptable substitute" and that "the Review Team performed the necessary analysis to derive the required information from the emergency operating procedures" (Attachment B, p. B-1).

Since YAEC's task analysis was based on the EOPs, the adequacy of the task analysis is dependent upon the adequacy of the PGP and the EOPs. The NRC currently possesses YAEC's PGP but has not completed its review. Until the NRC has completed its review of YAEC's PGP and has presented its findings, the adequacy of the EOPs as the basis for performing the DCRDR task analysis is unknown. Review and necessary modifications to the task analysis should accompany any revisions to the EOPs resulting from the NRC's findings from its review of YAEC's PGP. Additional evaluation of the availability and suitability of instruments and controls in the control room should be performed by comparing any information and control requirements that were added or modified as a result of modifications with the task analysis. Any modifications to the task analysis and associated findings of the evaluation of instrument and control availability and suitability should be documented and submitted to the NRC for review.

Whereas NUREG-0700 recommends a "top-down" approach to performing a task analysis (i.e., identify systems, system functions, tasks, etc.), YAEC began with identifying the operator tasks necessary to perform the symptom-oriented EOPs. YAEC did not use the Westinghouse Owners Group (WOG) Emergency Response Guidelines (ERGs) because of the difference in the Yankee-Rowe plant design from those newer Westinghouse plants for which the WOG ERGs were more applicable. If the tasks in the EOPs were adequately detailed, YAEC quoted the tasks as described in the EOPs and entered these in the "task/subtask" column of the task analysis worksheet. Otherwise, YAEC provided a more detailed description of the task in the task analysis worksheet. For each task, YAEC identified the associated information and control requirements and recorded these in the "I&C Needs" and "I&C Requirements" columns of the task analysis worksheet. The identification of the procedure step number, operator tasks/subtasks, and information and control requirements was originally performed and documented on the task analysis worksheet by YAEC's human factors consultants. After Review Team assessment of this information, the task analysis worksheet was finalized and readied for comparison with the instruments and controls in the control room.

YAEC stated during the in-progress audit that the only EQP not covered in the task analysis was the "Loss of All AC Power." In Attachment B to the Summary Report, YAEC states that no one from the procedure writing group was

available at the time the statement was made and, subsequently, it has been determined that the Critical Safety Function, symptom-oriented EOPs do address loss of all AC power (p. B-2). YAEC further states that "the symptom-based procedures were developed to assure fuel cladding integrity by providing guidance to maintain five 'critical safety functions' without regard to which event was being experienced." This statement clarifies YAEC's earlier statement concerning the inclusion of loss of all AC power in the EOPs. However, to demonstrate the comprehensiveness of the EOPs and task analysis in covering all tasks involved in emergency operations, YAEC needs to submit documentation of a comparison of the EOPs covered in the task analysis with the function restoration guidelines and EOPs described in the WOG ERGs.

The NRC audit team concluded from a review of the task analysis worksheets that there were many instances in which the level of detail of the listed information and control requirements is too vague to allow an adequate comparison of the requirements with the existing instruments and controls in the control room. Except for these instances, YAEC usually provides appropriate detail on the required characteristics or refers to an adequately detailed standard. The concern here is the validity with which vague or general requirements were used to evaluate specific design characteristics of control room instruments and controls. YAEC states in the Summary Report that "the method chosen by YR to derive the I&C needs from the procedures did not lend itself to the level of detail in the [NRC] guidance" and that "all the available information in the procedure was evaluated to determine the minimum I&C needs and requirements" (Attachment B, p. B-3). In short, YAEC indicates that the detail with which it derived needed characteristics of instruments and controls was kept to a minimum and was not at a level acceptable to the NRC (for those instances referred to above). As previously mentioned, the concern here is the validity of the comparison of the requirements with the existing control room. YAEC's statement that "the comparison is indeed subjective, and deliberately so" increases the NRC's concern regarding the validity of the derivation of needed characteristics of instruments and controls as the basis for evaluating the suitability of the design of control room instruments and controls. An example from the NRC in-progress audit report of YAEC's vague and general approach to listing some of the needed characteristics of instruments and controls is cited below:

Step one of the Reactivity Anomaly procedure states that the task is to "Initiate Manual Reactor Scram by De-energizing Control Rod Drives." The I&C need is "Switch" and the I&C requirement is "Easily accessible, quick-acting, easily operated switch." The I&C requirement should list more specific requirements such as: switch positions, type of control/switch capability needed (discrete versus continuous), the control operation if the control capability needed is discrete (detented versus spring-loaded, momentary contact positioning), etc.

In the Summary Report, YAEK responded to this example by stating that "the details used in the auditor's example are not needed for the equipment to perform the procedure step" (Attachment B, p. B-3). This conclusion would have been acceptable to the NRC if it had been based upon an analysis of needed instrument and control characteristics that was performed to the level of detail suggested in the NRC's example. However, the task analysis documentation present at the in-progress audit did not demonstrate that such a detailed analysis was performed in those instances characterized by the above example. For all instances in the task analysis where the level of detail of the needed instrument and control characteristics is too vague or general, such as the above example, YAEK should either (1) reanalyze the related tasks to derive detailed characteristics of needed instruments and controls, or (2) demonstrate that the detailed level of analysis suggested in the NRC's example was not necessary for each instance where the level of detail is that of the above example.

Through discussions with YAEK, the NRC audit team concluded that the analysis of traffic flow was not adequately performed and that there did not appear to be an analysis of operator workload. The NRC audit team found the analysis of traffic flow lacked a systematic and rigorous application of criteria in an operational/dynamic context. In addition, no clearly discernable, systematic and rigorous analysis of operator workload was performed. In the Summary Report, YAEK's response to these conclusions was summarized in the statement, "We did not do, or ever expect to do, what the NRC consultant assumed the brief statement in the Program Plan meant" (Attachment B, p. B-4). The NRC concluded in its review of the Program Plan that YAEK's statements relative to its evaluation of traffic flow, operator workload, and "other issues" were in need of further explanation in order to clarify YAEK's approach. Discussion during the audit concerning these



activities revealed that YAEC's approach to analyzing traffic flow and operator workload lacked rigor in the application of human factors principles or criteria. Although the HEDs given in the Summary Report indicate that some discrepancies relative to traffic flow and operator workload were found, additional discrepancies or problems could have been overlooked.

In summary, YAEC has not taken any remedial action on the deficiencies identified by the NRC audit team in the task analysis. The Summary Report did not provide documentation requested by the NRC audit team which demonstrates the comprehensiveness of the EOPs and task analysis in covering the tasks performed and interfaces involved in emergency operations. In order to resolve the concerns identified in the in-progress audit relative to the function and task analysis requirement of Supplement 1 to NUREG-0737, YAEC should provide documentation demonstrating the following:

- o The comprehensiveness of the EOPs and task analysis in covering the tasks performed and interfaces involved in emergency operations.
- o Either (1) a further analysis of those tasks which resulted in "I&C requirements" of a vague or general nature (represented by the examples previously provided) to provide the necessary detail or (2) for each instance where the level of detail was too vague or general, the level of analysis suggested in the NRC's example was not necessary.
- o Although an analysis of operator traffic patterns and workloads is not an activity required by Supplement 1 to NUREG-0737, we suggest that YAEC perform a systematic and rigorous analysis of operator traffic patterns and workload in order to increase the benefit of the task analysis.

Any findings and HEDs identified from the above-listed improvements of the task analysis and the analysis of operator traffic patterns and workload should be documented as well. Currently, the NRC review of YAEC's PGP has not been completed. Until the results of the NRC review are reported, the adequacy of YAEC's PGP in supporting the EOPs and task analysis cannot be determined. Based on the in-progress audit findings and YAEC's responses to



these findings, we conclude that YAEC has not met the function and task analysis requirement of Supplement 1 to NUREG-0737.

## 2. Comparison of Display and Control Requirements With a Control Room Inventory

The following concerns of the NRC audit team were not resolved during the in-progress audit:

- o Instances exist where the requirements were modified to correlate with the instruments and controls in the control room.
- o The validity of the comparison may be affected by the vague or general description of the needed or required characteristics of instruments and controls.

YAEC's comparison of information and control requirements with the existing instruments and controls in the control room was performed by comparing the "I&C needs" and "I&C requirements" identified in the task analysis with the control room. The NRC audit team found instances where the requirements listed on the task analysis computer printout were modified to correlate with the instruments and controls in the control room. No documentation was found which justified these modifications. In the Summary Report, YAEC states that in the two instances cited by the NRC audit team, the YAEC human factors consultant changed or corrected the requirements during the walk-through performed subsequent to the identification of information and control requirements (Attachment B, p. B-5). YAEC provides the following response or justification for these modifications:

"They [human factors consultant] inserted the requirement for the main coolant pump ammeter to have a linear scale. During the walk-through by the same consultant team, they found the actual scale was linear, except between zero and the first division the scale was compressed. He changed the requirement to 'readable.' In the second instance, the range for each of the four-loop flow indicators was incorrectly defined as the range for total core flow. The human factors consultant team corrected these numbers when they were discovered during the walk-through."

The basis of the NRC's concern with the first modification is that in changing a specific requirement to a general one, a meter scale previously found to be discrepant with the requirement was subsequently allowed to be acceptable, thus precluding documentation of a finding/HED and any justification (acceptable or not) for not intending to take corrective action. The basis of the NRC's concern with the second modification is that this and any other error made by the human factors consultants was not detected until the walk-throughs. This indicates that the identification of information and control requirements was not adequately reviewed by YAEC operations and engineering prior to the comparison activity. The overall concern these two instances spur is that the approach YAEC took to compare the requirements with the control room and its documentation was not as thorough as required to meet Supplement 1 to NUREG-0737.

The NRC audit team was also concerned about the validity of the comparison of the requirements with the control room. As previously discussed in the Function and Task Analysis section of this report and explicit in the changing of the requirement discussed above, general requirements such as "readable" or "easily accessible, reliable, quick-acting, easily operated switch" do not establish a satisfactory basis for an objective and thorough evaluation of instrument and control design suitability. As in the case of the task analysis, YAEC does not intend to take any remedial action for the deficiencies found in its approach. Until acceptable improvements are made to the methodology and any subsequent HEDs reviewed by the NRC, we do not believe YAEC has adequately met this requirement of Supplement 1 to NUREG-0737.

### 3. Control Room Survey

The NRC audit team's general findings from discussions with YAEC and review of its documentation of the static survey were that the survey was not found to be thorough or well documented. As discussed in the NRC staff comments on the Yankee-Rowe Program Plan and in the in-progress audit report, the survey approach YAEC used was that prescribed by the Boiling Water Reactor Owners Group (BWROG). According to Generic Letter 83-18 (Reference 10), the BWROG stated that "NUREG-0700 addresses many topics on a detailed, quantitative basis, whereas the BWROG believes a more general,

qualitative approach, coupled with survey team training, is more appropriate." With certain improvements in content, the NRC found the survey approach prescribed by BWROG to be acceptable.

To determine the adequacy of YAEC's application of the BWROG survey, the NRC audit team performed a small sample survey of the Yankee-Rowe control room using NUREG-0700. In a comparison of the HEDs identified in the sample survey with YAEC's survey and findings, the NRC audit team found instances where the documentation was incomplete and did not account for NRC audit team sample survey findings. The NRC audit team's review of the survey documentation found numerous instances where criteria or results were ambiguous, incomplete, and inconsistent. In addition, sections of the checklists were found to have been omitted. In the Summary Report, YAEC states, "We have subsequently gone over the checksheets again and filled in all the missing information. While a couple of questions were discovered to have been actually overlooked, no additional findings were found in the process" (Attachment B, p. B-9). Although YAEC has taken some action to improve its documentation and complete omitted evaluations, more information is needed to obtain a clearer understanding of those corrective actions. YAEC should describe how it completed the sections of the survey found to be omitted, ambiguous, and inconsistent.

The most significant instance where an NRC audit team sample survey finding was not accounted for in YAEC's findings concerns the ambiguity of the association among two circulating water pumps and their related motor operative valve indicator lights due to poor control/display integration on the panel. This particular omission in the findings was described in the NRC in-progress audit report. Three separate, independent assessments made by SAIC human factors, nuclear, and electrical engineers using YAEC's categorization approach consistently found this finding to be a Class A HED - YAEC's most significant HED classification. By YAEC's definition, a Class A HED is an HED that could potentially have a significant impact on safety or cause a deviation from technical specifications. In response to this and other examples presented in the NRC in-progress audit report, YAEC stated that "these examples were noticed by the DCRDR review team during the static survey and judged to be inconsequential" (Attachment R, p. B-6). In reference to this particular example, YAEC responds by stating, "The circulating water pump switches and corresponding indicating lights are located one

above the other on Panel 10. The position indicating lights for the pump discharge valves are located between the pump switches, one beside the other. While not adhering to the strictest human factors standard, which prefers everything consistently top to bottom, or right to left [left to right], no operator has ever been confused by this layout and the reviewers thought it unworthy of comment." This response is not an adequate justification for omitting this and any other HED from the assessment, resolution, and implementation processes. YAEC should include the HED described above in these processes in order to satisfy this specific concern.

In summary, YAEC has taken some action to improve upon the omissions and documentation of its control room survey. However, more information is needed to obtain a clearer understanding of those corrective actions. In addition, YAEC should provide evidence that it has included the HED concerning the circulating water pump switches and indicator lights in the assessment, resolution, and implementation processes. In order to meet adequately the control room survey requirement of Supplement 1 to NUREG-0737, YAEC needs to present documentation providing this information.

#### 4. Operating Experience Review

Although not a requirement of Supplement 1 to NUREG-0737, a review of operating experience can provide valuable insights into the adequacy of the control room, procedures, and other areas in mitigating plant emergency situations. YAEC has performed a review of operating experience consisting of a review of plant historical documentation and operator questionnaires and interviews. The NRC audit team's review of the documentation and results of these activities identified the following areas where improvements could be made:

- o The scope of the review of historical documentation.
- o The specificity of the operator comments from the operator questionnaires and interviews.
- o The tracking, documentation, and disposition of operator comments from the operator questionnaires and interviews.

- o The number of questionnaires and interviews performed.

YAEC's review of historical documentation consisted of a review of Licensee Event Reports (LERs), Plant Information Reports (PIRs), and the plant scram log. The NRC audit team found that with the exception of the LERs, the review of the plant historical documentation was fairly extensive (e.g., the plant scram log covers the plant's complete lifetime). The scope of the review of LERs is limited to 1982-83. Although YAEC's statement that the LERs have been required only in recent years is true, LERs do exist for Yankee-Rowe previous to 1982-83. In the Summary Report, YAEC indicates that some of the personnel involved in the operator questionnaires and interviews have extensive experience at Yankee-Rowe including two of the operators present from the original startup of the plant (Attachment B, p. B-8). YAEC states that the "probing for prior events" was accomplished during the interviews involving these persons. Using the memory of these persons as the sole data source for the review of plant events prior to 1982-83 is not reliable. A review of LERs prior to 1982-83 enhanced by the memory of these experienced persons would present a more reliable method. In its review of operator questionnaires and interview results, the NRC audit team did not find any questions or responses concerning events prior to 1982-83. This suggests that a concerted effort to identify potential problems associated with plant events prior to 1982-83 was not performed. In order to receive the fullest possible benefit from previous plant history concerning documented events, we suggest that YAEC expand the scope of its review of LERs to include a larger, more representative sample of documented events.

A review of the operator questionnaire and interview documentation by the NRC audit team found that, in general, the data collected reflected significant operator concerns which appeared to have been given candidly and seriously, resulting in the identification of HEDs. However, some operator comments were vague. Other operator comments, some concerning potentially significant problem areas, were not documented in HEDs. In addition, only 13 of the 31 questionnaires sent out were returned and only 11 of the operations personnel were interviewed. The overall concern of the NRC audit team regarding these findings is that operator concerns that identify problems of potential significance to plant safety and reliability have not been documented or documented adequately enough to create the impetus to perform



a concerted follow-up investigation. Such an investigation could potentially identify additional, significant HEDs. Although YAEC notes several times in the Summary Report that the operator interviews were voluntary and not required by Supplement 1 to NUREG-0737, there is a potential benefit to be realized by following through on all operator concerns identified previously as well as by obtaining greater operator participation and management support in collecting operator feedback through questionnaires and interviews.

In summary, although the operating experience review resulted in the identification of HEDs, the data collection efforts could have been more rigorous with a corresponding increase in valuable findings. Although this activity is not mentioned as a requirement of Supplement 1 to NUREG-0737, it is a significant and valuable contributor to the DCRDR and other improvement programs. We suggest that YAEC improve upon the deficiencies noted by the NRC audit team in the operating experience review.

#### ASSESSMENT AND IMPLEMENTATION PHASE

##### 1. Assessment of HEDs

The remaining concern of the NRC audit team from the in-progress audit regarding the assessment of HEDs was that YAEC did not have a system for prioritizing HEDs or for scheduling the implementation of their corrections. The NRC audit team found that the HED classification system YAEC developed was not used in the prioritization of HEDs. The purpose of classifying HEDs should be twofold: (1) to determine which HEDs are significant and should be corrected, and (2) to determine scheduling priorities for implementing HED corrections. YAEC does not appear to differ concerning the first purpose since in its Summary Report, YAEC states that "classification, as done at YR, defined the type of difficulty which could be caused by the HED, leaving the Management Committee the freedom to, for example, not implement an HED which was classified as an operator inconvenience (Class C)" (Attachment B, p. B-10). In the Summary Report, YAEC appears to address the second purpose by stating that "the schedule for correction of the HEDs will be based on their integration into other work for the next refueling cycle, the amount of effort for engineering and operations for the designed installation of individual HEDs, the classification of HEDs, the manpower available



and finally the location of the HEDs" (p. 20). However, YAEC does not clarify how much weight the classification of HEDs carried in determining the implementation schedule, and no implementation dates were reported for individual HEDs that would demonstrate this. The extent to which YAEC actually considered the classification of HEDs is further obscured by the statement "Using this method [separating classification and prioritization], the priority is established by the four factors listed, as well as the complexity of the fix and the lead time to order equipment" (Attachment B, p. B-10). The four factors referred to are:

- o Budget
- o Manpower
- o Calendar time
- o Refueling schedule.

Although all of these factors are certainly important considerations, the safety significance of HEDs should be the overriding factor for prioritization. During the in-progress audit and in the Summary Report, YAEC stated that it found no HEDs to be more significant than any of the others that would require a higher priority for scheduling the implementation of corrections. A review of the Summary Report found that of the 91 HEDs reported, 28 were Class A HEDs, 6 were Class B HEDs, and 54 were Class C HEDs (3 HEDs did not have classifications). YAEC's HED classes are defined as follows:

- o Class A - An HED that could potentially have a significant impact on safety or cause a deviation from technical specifications.
- o Class B - An HED that has the potential to cause human error that could be harmful to plant personnel or equipment.
- o Class C - An HED that could inconvenience the operator.

YAEC's distribution of HEDs across all three categories would seem to indicate that some HEDs, especially Class A HEDs relative to Class C HEDs, are far more significant and should have corrections implemented at a higher priority than others.

In its correction of HEDs, YAEK should ensure that its approach to correcting HEDs is systematic and reliable rather than piecemeal. This integrated approach entails cognizance of such interrelationships as the application of enhancements (e.g., demarcation, mimicking) with changes in panel component locations. The result of such an approach is the development of an integrated control room improvement package. Such an integrated package usually requires that many of the individual HED corrections be implemented at the same time regardless of classification. However, the schedule for implementing these corrections should be driven by the classification of the most significant HEDs in addition to constraints such as those factors listed by YAEK.

In summary, YAEK does not clearly indicate to what extent it is considering the safety significance of HEDs in its prioritization for implementing HED corrections. YAEK should implement corrections to the HEDs of higher significance (Class A and B HEDs) as much as possible in the next refueling outage while maintaining an integrated approach to control room improvement. The highest priority should be to implement safety-significant control room improvements appropriately in an integrated fashion as soon as practicable. YAEK should provide documentation describing how this will be done. This documentation should also provide a schedule including dates for the implementation of each HED to be corrected.

## 2. Selection of Design Improvements

The following concerns of the NRC audit team were not resolved during the in-progress audit:

- o The methodology and criteria for determining design improvements is not well defined.
- o The role of the Review Team in the development of design improvements is limited to the development of conceptual solutions.
- o The engineering staff supplementary to the Review Team will be used to develop the detailed solutions.

- o The description of the discrepancies on the HED forms is not detailed enough to convey adequately the information necessary to allow the engineering staff to proceed reliably with the development of detailed solutions.

During the in-progress audit, the NRC audit team found through discussions with YAEC that the methodology intended for selecting design improvements was not systematic and did not use criteria for determining the adequacy of proposed solutions to HEDs. The approach described by YAEC was that the Review Team would develop conceptual solutions and its engineering staff would develop the detailed solutions. YAEC defined these solutions during the in-progress audit as follows:

- o A conceptual solution is a general solution that does not specify, for example, how to mimic or demarcate; it specifies only that this type of solution is required.
- o A detailed solution specifies the actual design of the solution.

In the Summary Report, YAEC describes its approach to determining design improvements as follows:

"The Review Team creates the conceptual solution to a HED in full committee and generally with unanimous agreement. The Program Plan states that if the human factors expert disagrees, his view will be documented. No such disagreements have occurred. No formal criteria for creating conceptual solutions exist. However, in the minds of the Review Team adequate conceptual solutions have been proposed. One could wish for more specifics or more detail in the conceptual solution, but a conceptual solution may deliberately be non-specific to allow flexibility in implementation" (Attachment B, p. B-11). After the Review Team had developed its conceptual solutions, these were forwarded as recommendations for correcting HEDs to the Management Team. "After considerable study, it was agreed that 54 HEDs should be corrected. Of the remaining 37 HEDs, 18 have an individual explanation for not correcting. The remaining 19 HEDs include a notation 'benefit cannot be supported by cost.' For the latter group of HEDs, the Management Team believes that even though a design feature might

deviate from accepted human factors ideals, it does not necessarily require correction. Our review process included a careful evaluation of what potential reduction in operator error rate and commensurate increase in plant safety could be achieved by correcting this group of HEDs" (p. 19). The results of the Management Team's decisions from its review of the HEDs and recommended corrections by the Review Team were assigned to various engineering support groups for implementation.

Although this description indicates the general approach YAEC took in determining design improvements, specific areas of this approach are not described in sufficient detail to allow a complete evaluation. YAEC indicates that the Review Team used no formal criteria to develop conceptual solutions. However, no mention was made of what guidelines or criteria the engineering staff referenced in the development of detailed solutions. In addition, YAEC did not describe the review process it took to evaluate what potential reduction in operator error rate and commensurate increase in plant safety could be achieved by correcting the 19 HEDs it noted with "benefit cannot be supported by cost."

During the in-progress audit, the NRC audit team indicated to YAEC that the planned role of the Review Team in the selection of design improvements was too limited. YAEC had intended to limit the role of the Review Team to the development of conceptual solutions. The remainder of the solution development process was to be performed by the engineering support staff which did not have the corresponding human factors or DCRDR experience. During the audit, the Management Team Chairman stated that the Review Team could remain in existence until all modifications were completed, but that such a change in plans would require management approval. In the Summary Report, YAEC states that "the Review Team will remain in existence until all designs have been reviewed" (Attachment B, p. B-11). Although the direct involvement of the Review Team in the development of detailed solutions would appear to be the effective approach since this would take advantage of their DCRDR experience, the involvement of the Review Team as reviewers would be acceptable and more effective if (1) the Review Team used a systematic approach to verify the engineering staff's detailed solutions using a set of criteria based upon human factors guidelines and conventions, and (2) the engineering staff used human factors guidelines and conventions in developing the detailed solutions. For example, human factors guidelines

such as NUREG-0700 contain a set of guidelines applicable to the design of mimics, demarcation, color-coding, component location, and so on. A reference such as this would enhance and facilitate the development and verification of the detailed solutions.

During the in-progress audit, the NRC audit team's review of the HED forms found that they were not detailed enough to convey adequately the problem, the components involved, and what was the necessary corrective action in order to allow the engineering staff to develop an appropriate detailed solution. The NRC audit team stated that this lack of detail could ultimately result in repeating the survey to obtain the necessary information. In its description of the use of the data management system, YAEC states, "The information in the HED and in the findings which comprises that HED are provided to the Management Team in the form of an HED list and a findings list sorted by HED. In this form the information is available in a general form and a detailed form as well" (p. 17 of the Summary Report). YAEC continues by stating, "Assignment of the implementation of a given HED to the design engineers, in the form described above, provides sufficient detail to implement the design." In order to conclude satisfactorily upon the adequacy of the HED forms for supplying the information necessary to proceed with the development of detailed solutions, the NRC must review representative HED forms.

In addition to the concerns identified during the in-progress audit, there is a concern for the finality of the HED resolutions in the Summary Report. YAEC states, "In some instances, e.g., the collection of annunciator deficiencies resulted in a recommendation that a study be made to resolve the best way to correct the deficiencies and then be implemented, the verification and validation were done only in the conceptual sense. Verification and validation of the actual design and installation would have to await those events" (p. 18 of the Summary Report). This statement and those HED recommendations for further study in the Summary Report appear to indicate that there is some potential for HED resolutions to change from those described. In addition to the uncertainty implied by recommending HEDs for further study, the delay of the verification and validation of some detailed solutions until studies are completed introduces the potential that changes will occur based on the outcome of the verification and validation. The Summary Report should provide final resolutions. Since this may not be



the case, the evaluation of the adequacy of the HED resolutions cannot be considered complete until the resolutions for all HEDs are final. (See the Analysis of Proposed Corrective Actions and Justifications for HEDs Left Uncorrected section of this report for further discussion.)

Relative to this issue, the implementation schedules for HEDs could not be evaluated due to the lack of implementation dates for individual HED corrections. In the Summary Report, YAEC states, "We expect to finalize a specific list of HEDs to be performed in the next refueling cycle and subsequent cycle by February 1, 1986. Because of the volume of HEDs and other work for engineering and operations, it is not expected that we could complete all HEDs in one cycle. Those HEDs which require only simple paint, label and tape corrections will be made by the end of 1985" (p. 20). Supplement 1 to NUREG-0737 suggests that improvements that can be accomplished with an enhancement program (paint-tape-label) be done promptly; YAEC appears to be following this suggestion. However, YAEC does not identify which specific HED corrections will be included in those implemented by the end of 1985. Supplement 1 to NUREG-0737 requires that the Summary Report include proposed schedules for implementation of proposed control room changes. The Yankee-Rowe DCRDR Summary Report does not meet this requirement. YAEC states that such a schedule will be finalized by February 1, 1986. Until this is provided to the NRC, we cannot conclude upon the adequacy of the schedule for implementing HED corrections as it relates to the selection of design improvements and the consideration of the classification of HEDs.

In conclusion, the YAEC Summary Report has addressed but not resolved all the concerns regarding selection of design improvements raised in the NRC in-progress audit report. YAEC has modified the roles of the Review Team and the Management Team in response to specific suggestions for improvement made by the NRC audit team. However, the following concerns need to be resolved in order for YAEC to meet the Supplement 1 to NUREG-0737 requirements for the selection of design improvements:

- (1) Specific portions of the process for developing solutions to HEDs were unclear. These were:



- (a) the guidelines or criteria the engineering staff has or will use to develop detailed solutions.
  - (b) the review process taken to evaluate what potential reduction in operator error rate and commensurate increase in plant safety could be achieved by correcting the 19 HEDs it noted with "benefit cannot be supported by cost."
- (2) The approaches taken by the engineering staff in its development of detailed solutions and the Review Team in its verification of these detailed solutions have not been described in detail in the Summary Report and do not refer to systematic processes that are based upon human factors guidelines and conventions.
  - (3) It is unclear how adequate the HED forms are for supplying the information necessary for the engineering staff to proceed with the development of detailed solutions. Representative HED forms should be provided for review.
  - (4) The resolutions for HED corrections described in the Summary Report do not appear to be final.
  - (5) Implementation schedules for all HED corrections have not been determined and included in the Summary Report.
3. Verification That Improvements Will Provide the Necessary Corrections Without Introducing New HEDs

At the time of the in-progress audit, the NRC audit team concluded that the role given the Review Team and the methodology proposed for verifying HEDs were not satisfactory. As discussed in the previous section of this report, the expansion of the Review Team's role to include the verification of the engineering staff's proposed detailed solutions is acceptable providing definite human factors guidelines and conventions are used in a systematic approach. In the Summary Report, YAEC states in its discussion of determining a logical modification to address the discrepancy that "...the determination that the modification would indeed correct the problem without

introducing another problem was made" (p. 18). YAEc continues by stating, "In some instances, e.g., the collection of annunciator deficiencies resulted in a recommendation that a study be made to resolve the best way to correct the deficiencies and then be implemented, the verification and validation were only done in the conceptual sense. Verification and validation of the actual design and installation would have to await those events. In those cases where the recommended modification was more specific, e.g., provide the missing engineering units on an indicator, the Review Team was able to make the determination that this simple change would indeed satisfy the two requirements." YAEc states that it made "the determination" but does not go into any further detail regarding methodology. Also, there is some ambiguity concerning the differentiation between this verification and validation process and the Review Team's review of the detailed solutions developed by the engineering staff. YAEc's overall discussion of its verification and validation process is not clear enough to perform a satisfactory assessment of its adequacy in meeting this requirement of Supplement 1 to NUREG-0737.

#### 4. Coordination of the DCRDR With Other Improvement Programs

During the in-progress audit YAEc indicated that the plans and methodology for coordinating and integrating the DCRDR with other improvement programs was in the development stage. In addition, the organization or mechanism by which the improvement programs would be coordinated and integrated had not been finalized. In the Summary Report, YAEc states, "Integration of the DCRDR with other improvement programs is being maintained. Procedures will be developed as needed. When a change from one improvement program affects another, it is recognized and continuity is maintained" (Attachment B, p. B-13). The statement "Procedures will be developed as needed" indicates incomplete procedures and methodology at present. In addition, YAEc does not describe how or by what mechanism it is maintaining the integration of the DCRDR with other improvement programs. Although YAEc recognizes the need to integrate the DCRDR with other improvement programs and appears to intend doing so, the Summary Report does not contain enough information about YAEc's methodology and mechanism to allow an adequate evaluation to be performed. Until YAEc provides satisfactory information on its procedures/methodology and mechanism for ensuring the DCRDR is integrated with other improvement programs, conclusions cannot be

made regarding the acceptability of its coordination effort in meeting this requirement of Supplement 1 to NUREG-0737.

#### ANALYSIS OF PROPOSED CORRECTIVE ACTIONS AND JUSTIFICATION FOR HEDs LEFT UNCORRECTED

YAEC documents 91 HEDs in the Yankee-Rowe DCRDR Summary Report. YAEC states that "fifty-four HEDs were judged by the Review Team to be in a category that could potentially inconvenience an operator, but would have no safety significance" (Class C HEDs). YAEC also states that "the remaining thirty-seven HEDs were evaluated to have some influence on safety" (Class A or B HEDs). SAIC's review of the HEDs documented in the Summary Report found 54 Class C HEDs, 6 Class B HEDs, 28 Class A HEDs, and 3 HEDs that did not have any classification indicated.

In the Summary Report, YAEC states that it determined that 54 HEDs should be corrected and 37 should not. SAIC's review of the HEDs in the Summary Report found that 53 HEDs are proposed for correction and 38 HEDs are not. Of those HEDs proposed for correction, 18 are Class A HEDs, 5 are Class B HEDs, 29 are Class C HEDs, and one is an HED with no classification indicated. Of those HEDs YAEC is not intending to correct, 10 are Class A HEDs, 1 is a Class B HED, 25 are Class C HEDs, and 2 are HEDs with no classification indicated.

A conclusive evaluation of the HEDs could not be performed due to either the brevity or ambiguity of the information provided or the lack of a definite solution. For those HEDs that had definite resolutions and had sufficient information to allow an evaluation, some but not all were found to be satisfactorily resolved. Those HEDs for which corrective actions were proposed and were found to be adequate are listed in Appendix A. Those HEDs for which corrective actions were proposed but were found to be inadequate are discussed in the Proposed Corrective Action section of this report and listed in Appendix B, Sections a through f. The HED for which a justification for not taking corrective action was provided and found to be adequate is listed in Appendix C. Those HEDs for which justifications for not taking corrective action were provided but were found to be inadequate are discussed in Appendix D, sections a, b, and c. The following two sections present examples where we elaborate on our findings of HEDs which

were found to be inadequately resolved. These HEDs and those listed in the appendices are identified in the format of "Summary Report page number/HED number."

## 1. Proposed Corrective Actions

Appendix B, sections a through f of this report contains the complete list of HEDs for which corrective actions were proposed but were found to be inadequate for one of the reasons discussed below.

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

22/0101 - The discrepancy described is that the fire panel has controls that are 14 inches above the standard. In addition, the panel is located behind the guard's station. Thus, the operator does not have easy access to this panel, but needs to in order to determine the location of a fire. YAEC's proposed corrective action is to relocate a small table with phones to allow better access, but not to relocate the controls above the standard since a "demonstration" showed access is easy enough for all operators. YAEC does not indicate what standard the controls are 14 inches above. Also, YAEC does not describe the demonstration that was performed.

46/0500 - The discrepancy described is that display instrumentation presents incorrect or confusing information to the operator. YAEC describes several examples of this type of discrepancy. YAEC's proposed corrective action is to correct the findings which comprise this HED. YAEC does not state what all the findings are (or type of findings) and how these will be corrected.

- b. The proposed corrective action was not finalized.

61/05ES - The discrepancy described is that power range meters have odd minor divisions of 2.5; operators are required to set these meters after calculating  $R_x$  power, and setting affects the

trip point and is difficult to do accurately. YAEC states that the calibration procedure will be reviewed and scale accuracy required will be provided. The adequacy of this resolution cannot be determined until the results of this review are reported and corrective actions described.

- c. The proposed corrective action will not correct the discrepancy.

63/05F0 - The discrepancy described is that the failure mode of display instrumentation, especially standby instruments, is not clearly evident on most displays. YAEC's proposed corrective action is to address the failure mode of instruments (e.g., live zeros, fail as is, etc.) in the training program. Training does not take into account behavioral responses to stress induced by emergency situations and is not a reliable substitute for appropriate display design.

93/1407 - The discrepancy described is that the load limit and governor controls require a control movement that is opposite to the feedback indication. YAEC's proposed corrective action for this Class A HED is to provide a warning label. Based on the information given for this proposed corrective action, the use of a warning label to compensate for an inappropriate, reverse-of-convention control design in emergency/stress situations is dubious. YAEC should describe this warning label and justify how it can compensate for inappropriate, reverse-of-convention control design in emergency/stress situations.

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

50/05C0 - The discrepancy described is that switch escutcheon plates (a) are worn so they cannot be read, (b) have positions marked 1 and 2 instead of start/stop (SI pumps), (c) are marked breakers instead of synchroscope, and (d) have handles which obscure pointers. YAEC's proposed corrective action is to replace the worn escutcheon plates and to ensure that all escutcheon



plates have correct operating nomenclature. No corrective action addressing the handles which obscure pointers was described.

66/0701 - The discrepancy described is that there are no provisions to prevent interchanging indicator light lenses. YAEC's proposed corrective action is to standardize the position of indicating light colors; lens and bulb replacement will be addressed by training. Although the standardization of color location for indicator lights and the training of personnel responsible for the replacement of lenses and bulbs are positive corrective actions, the incorporation of an administrative or maintenance procedure for lens and bulb checking and replacement appears to be necessary.

98/1413 - The discrepancies described are that the EOPs require venting the vessel containment, but that the procedure is complex and the controls are located in the switchgear room. YAEC's proposed corrective action is to identify the valves and revise the procedure. Only the procedural discrepancy appears to be addressed. No corrective action addressing the location of the controls in the switchgear room appears to have been made.

- e. The proposed corrective action may introduce a new HED.

45/0480 - The discrepancy described is that multipoint recorders have labels that are either black letters on a white background or white letters on a black background, while the pens are red, blue, and green. YAEC's proposed corrective action is to letter the labels for the pens in the same color as the pen it represents. Although this will identify which label and function are associated with each of the pens, the use of colored lettering such as red on a white or black background may result in poor contrast and readability of the labels. YAEC should investigate the effectiveness of the following labeling scheme versus the use of colored letters:



label/function

"XXX - red"

"YYY - blue"

"ZZZ - green"

- f. The proposed corrective action must be seen, applicable standards reviewed, or NRC approval of the processes for selection and verification of design improvements obtained in order for a conclusive evaluation to be performed.

31/0202 - The discrepancy described is that the CCW and SW controls and displays on MCB Panel No. 8 are not grouped by system or laid out in a logical manner. YAEC's proposed corrective action is to apply demarcation and hierarchical labeling. Although this type of corrective action is conceptually adequate, it is necessary either to provide a description and illustration of the specific, detailed demarcation and hierarchical labeling or to obtain NRC approval of the processes for selection and verification of HED corrections.

39/300 - The discrepancy described is that color is used inconsistently in the control room. YAEC's proposed corrective action is to develop a color standard and to change the control panels to conform to the standard. Although this is an appropriate approach to resolving the inconsistent use of color in the control room, it is necessary either to provide the color standard or to obtain NRC approval of the processes for selection and verification of HED corrections.

2. Justifications for HEDs Left Uncorrected

Appendix D, sections a, b, and c of this report contains the complete list of HEDs for which justifications for not taking corrective actions were provided but were found to be inadequate for one of the reasons discussed below.

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

21/0100 - The discrepancy described is that instruments and controls exceed the anthropometric limits recommended by NUREG-0700. YAEC's justification for not taking corrective action is that none of the instruments and controls associated with this HED are required to be read or manipulated precisely or frequently/rapidly during emergency operations. YAEC does not describe what instruments and controls are associated with this HED or detail the extent or distance of these discrepant components from the anthropometric limits. In addition, YAEC does not describe how (by what process) it determined that these discrepant components were not required to be read or manipulated precisely or frequently/rapidly during emergency operations.

92/1406 - The discrepancy described is that there is no indication on the MCB of purification cooling flow, LP surge tank makeup, and shutdown cooling flow. YAEC's justification for not taking corrective action is that except for shutdown cooling flow, these parameters are controlled elsewhere by the AO. YAEC states that shutdown cooling flow is available in the "control room area." YAEC does not indicate which activity identified these three parameters as missing from the MCB. If the activity was the task analysis, this would imply that the location of all three indications are needed on the MCB to support emergency operations. If these indications are needed to support emergency operations, then YAEC's justification does not sufficiently address the discrepancy.

- b. The basis of the justification is inadequate because it does not address operational or behavioral factors.

26/0105 - The discrepancy described is that VC temp is required by the EOPs as a precursor of off-normal conditions; it is located on the back panel and is too low. YAEC's justification for not

taking corrective action is that benefit of correcting this problem cannot be supported by the cost. YAEC's justification does not address operational or behavioral factors. In the Summary Report, YAEC states that it performed a review of the 19 HEDs which have this justification. This review included an evaluation of the potential reduction in operator error rate and commensurate increase in plant safety that could be achieved by correcting this group of HEDs. Such an evaluation should have addressed operational and behavioral factors which should have been included in the justifications for not taking corrective actions.

36/0207 - The discrepancy described is that the numbering of the 2400 and 480 volt bus mimics is not laid out in a top to bottom order. YAEC's justification for not taking corrective action is that the layout is acceptable and familiar to the operators. YAEC does not elaborate in behavioral or operational terms why the layout is acceptable. Citing operator familiarity with the layout is not an acceptable justification without such an explanation.

- c. The justification does not sufficiently address the discrepancy.

107/1426 - The discrepancy described is that the EOPs require determination of adequate shutdown margin and that using the procedure is cumbersome and time-consuming. YAEC's justification for not taking corrective action is that the determination of adequate shutdown margin is not time-related and that time exists to perform this calculation. Although YAEC has addressed the time aspect of this discrepancy, the procedure is still cumbersome and may result in operator error. YAEC needs to address this aspect of the procedures and determine how the procedure can be modified or rewritten to be more efficient.

#### CONCLUSIONS AND RECOMMENDATIONS

The Summary Report for the Yankee-Rowe DCRDR contains responses to most but not all of the concerns raised in the NRC in-progress audit report. YAEC's responses indicate that with a few exceptions, it does not intend to correct or improve upon the deficiencies identified in its DCRDR. The

exceptions to YAEC's position regard its improvement of (1) the control room survey documentation, and (2) the roles of the Management Team and the Review Team in the assessment of HEDs and selection of design improvements, respectively. With these exceptions, YAEC does not intend to take corrective action on the deficiencies identified that relate to the following Supplement 1 to NUREG-0737 requirements:

- o Function and Task Analysis
- o Comparison of Control and Display Requirements with a Control Room Inventory
- o Control Room Survey
- o Assessment of HEDs.

In addition, the description of the methodologies to perform the following activities was not detailed enough in the Summary Report to adequately evaluate:

- o Selection of Design Improvements
- o Verification that Improvements Provide the Necessary Corrections Without Introducing New HEDs
- o Coordination of the DCRDR With Other Improvement Programs.

At the time of the in-progress audit, YAEC's plans for selecting and verifying design improvements were not finalized and the involvement of Review Team disciplines in these activities appeared to be conceptually adequate. However, the plans for performing these activities have been altered to an extent that necessitates further review of the assignment and level of effort of Review Team personnel.

In order to provide a forum for discussion, further feedback, and documentation review, we recommend that a meeting with Yankee-Rowe DCRDR representatives be held by the NRC. Discussion and documentation review in the meeting should address the following actions YAEC should take to correct or improve upon the deficiencies identified in the Yankee-Rowe DCRDR, or to clarify those areas of the DCRDR not sufficiently described in the Summary Report, in order to meet the requirements of Supplement 1 to NUREG-0737:

- o Qualifications and Structure of the DCRDR Team
  - Provide documentation of the level of involvement of each of the Review Team personnel in each of the following activities:
    - (1) selection of design improvements
    - (2) verification that the improvements provide the necessary corrections without introducing new HEDs
- o Function and Task Analysis
  - Provide documentation demonstrating the comprehensiveness of the EOPs and task analysis in covering the tasks performed and interfaces involved in emergency operations.
  - Provide documentation either (1) describing the performance and results of an analysis of those tasks which have "I&C requirements" of a vague or general nature (as represented by the examples provided in the NRC in-progress audit report) to provide the necessary details or (2) demonstrating that for each instance where the level of detail was too vague or general, the level of analysis suggested in the NRC's example was not necessary.
- o Comparison of Display and Control Requirements With a Control Room Inventory
  - Provide documentation describing the performance and results of a comparison of the control room with the needed characteristics for instruments and controls identified in the analysis of those tasks previously found to be of a vague or general nature.

o Control Room Survey

- Provide documentation describing how the omitted sections of the survey were completed and ambiguities and inconsistencies clarified.
- Provide documentation describing the assessment, resolution, and implementation schedule for the HED concerning the circulating water pump switches and indicator lights.

o Assessment of HEDs

- Provide documentation describing how the implementation of control room improvements will be integrated and considerate of HED classification.

o Selection of Design Improvements

- Provide documentation describing the review process taken to evaluate what potential reduction in operator error and commensurate increase in plant safety could be achieved by correcting the 19 HEDs it noted "benefit cannot be supported by cost."
- Provide documentation describing the approach and guidelines or criteria the engineering staff have used or will use to develop detailed solutions.
- Provide representative HED forms demonstrating the adequacy of the HED forms for supplying the information necessary for the engineering staff to proceed with the development of detailed solutions.
- Provide a response to the concern that the resolutions for all HED corrections do not appear to be final.



- Prior to the initiation of HED corrections
  - , provide an implementation schedule for every HED to be corrected.
- o Verification that Improvements Will Provide the Necessary Corrections Without Introducing New HEDs
  - Provide documentation describing the methodology, including guidelines and criteria used, for determining that a modification would correct the problem without introducing another HED.
  - Clarify the relationship of the verification and validation process referred to in the Summary Report to the Review Team's review of the detailed solutions developed by the engineering staff.
- o Coordination of the DCRDR With Other Improvement Programs
  - Provide documentation describing the development of procedures or methodologies for integrating the changes among improvement programs.
  - Provide documentation describing the mechanism which ensures that the DCRDR will be coordinated with other improvement programs.
- o Proposed Corrective Actions
  - For each HED listed in Appendix B of this report, provide information which responds to the inadequacy described.
- o Justifications for HEDs Left Uncorrected
  - For each HED listed in Appendix D of this report, provide information which responds to the inadequacy described.

In addition to these actions, we recommend that YAEC improve upon its analysis of operator traffic patterns and workload and the review of operating experience. The following recommended actions are not intended as additional requirements but are to encourage increased benefit from the DCRDR:

- o Perform a systematic and rigorous analysis of operator traffic patterns and workload.
- o Expand the scope of the LER review to include a larger, more representative sample of documented events.
- o Perform a follow-up investigation on all operator concerns identified.
- o Survey additional operators.

## REFERENCES

1. "Program Plan for a Detailed Control Room Design Review at Yankee Nuclear Power Plant at Rowe, Massachusetts," Yankee Atomic Electric Company, March 28, 1984.
2. "Nuclear Regulatory Commission Staff Comments on the Yankee Rowe Detailed Control Room Design Review Program Plan," Attachment to Memorandum from W.T. Russell, USNRC, to F.J. Miraglia, USNRC, dated June 6, 1984.
3. "In-Progress Audit of the Detailed Control Room Design Review for Yankee Atomic Electric Company's Yankee Rowe Nuclear Power Station," Science Applications International Corporation, December 11, 1984, Attachment to Memorandum from V.A. Moore, USNRC, to J. Zwolinski, USNRC, dated January 2, 1985.
4. "Detailed Control Room Design Review Summary Report for the Yankee Nuclear Power Station," Yankee Atomic Electric Company, Attachment to letter from G. Papanic, Jr., YAEC, to J.A. Zwolinski, USNRC, dated August 1, 1985.
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-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Section 18.1, Rev. 0, USNRC, Washington, D.C., September 1984.

10. "NRC Preview of BWR Owners' Group Control Room Survey Program," Attachment to letter from D.G. Eisenhut, USNRC, to all boiling water reactor licensees of operating reactors, applicants for an operating license and holders of construction permits, dated April 19, 1983.

## APPENDIX A

HEDs for which corrective actions were proposed and were found to be adequate.

30/0101	53/05C3	77/1100	88/1401
35/0206	54/05D0	78/1101	90/1403
37/02A1	55/05D1	79/1200	96/1410
41/0401	56/05E0	80/1201	101/1417
42/0402	57/05E1	81/1202	102/1418
44/04A0	59/05E3	83/1204	104/1421
52/05C2	73/0904	85/1301	110/1429
		86/1302	

## APPENDIX B

HEDs for which corrective actions were proposed but were found to be inadequate for one of the following reasons:

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

22/0101	62/05E6
23/0102	76/1002
46/0500	82/1203
48/05A0	84/1300
60/05E4	94/1408

- b. The proposed corrective action was not finalized.

61/05E5, 64/0600, and 65/06A0

- c. The proposed corrective action will not correct the discrepancy.

63/05F0 and 93/1407

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

50/05C0, 66/0701, and 98/1413

- e. The proposed corrective action may introduce a new HED.

45/04B0

- f. The proposed corrective action must be seen, applicable standards reviewed, or NRC approval of the processes for selection and verification of design improvements obtained in order for a conclusive evaluation to be performed.

31/0202, 38/02B0, 39/0300, 40/0400, and 43/0403



## APPENDIX C

The HED for which a justification for not taking corrective action was provided and found to be adequate.

97/1411

## APPENDIX D

HEDs for which justifications for not taking corrective action were provided but were found to be inadequate for one of the following reasons:

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

21/0100	71/0902	95/1409
25/0104	87/1400	99/1414
28/01B0	89/1402	100/1415
32/0202	92/1406	103/1419
67/0800		

- b. The basis of the justification is not adequate (i.e., the justification does not address operational or behavioral factors).

24/0103	36/0207	69/0900	105/1422
26/0105	47/0501	70/0901	106/1425
27/01A1	49/05B0	72/0903	108/1427
29/0200	51/05C1	74/1000	109/1428
33/0204	58/05E2	75/1001	111/1500
34/0205	68/0801	91/1405	

- c. The justification does not sufficiently address the discrepancy.

107/1426