AUDIT REPORT

HUMAN FACTORS ENGINEERING
DETAILED CONTROL ROOM DESIGN REVIEW
IN-PROGRESS AUDIT

LIMERICK GENERATING STATION
PHILADELPHIA ELECTRIC COMPANY

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1. BACKGROUND

Licensees and applicants for operating licenses shall 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). The need to conduct a DCRDR was confirmed in NUREG-0737 and Supplement 1 to NUREG-0737. DCRDR requirements in Supplement 1 to NUREG-0737 replaced those in the earlier documents. Supplement 1 to NUREG-0737 requires each applicant or licensee to conduct their DCRDR on a schedule negotiated with the Nuclear Regulatory Commission (NRC).

NUREG-0700 describes four phases of the DCRDR and provides applicants and licensees with guidelines for its conduct. The phases are:

1. Planning,
2. Review,
3. Assessment and implementation,
4. Reporting.

Criteria for evaluating each phase are contained in NUREG-0801.

A Program Plan is to be submitted to the NRC by licensees/applicants within two months of the start of the DCRDR. Consistent with the requirements of Supplement 1 to NUREG-0737, the Program Plan shall describe how the following elements of the DCRDR will be accomplished:

1. Establishment of a qualified multidisciplinary review team,
2. Function and task analyses to identify control room operator tasks and information and control requirements during emergency operations,
3. A comparison of display and control requirements with a control room inventory,
4. A control room survey to identify deviations from accepted human factors principles,
5. Assessment of human engineering discrepancies (HEDs) to determine which HEDs are significant and should be corrected,

6. Selection of design improvements,

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

8. Verification that improvements will not introduce new HEDs,

9. Coordination of control room improvements with changes from other programs such as SPDS, operator training, Reg. Guide 1.97 instrumentation, and upgraded emergency operating procedures.

A Summary Report is to be submitted to the NRC by licensees/applicants at the end of the DCRDR. As a minimum it shall:

1. Outline proposed control room changes,

2. Outline proposed schedules for implementation,

3. Provide summary justification for HEDs with safety significance to be left uncorrected or partially corrected.

The NRC will evaluate the organization, process, and results of the DCRDR. This effort will include the review of required documentation (Program Plan and Summary Report) and may also include the review of additional documentation, briefings, discussions, and on-site audits. In progress audits may be conducted after submission of the Program Plan but prior to submission of the Summary Report. Pre-implementation audits may be conducted after submission of the Summary Report. The NRC review will be in accordance with the requirements of Supplement 1 to NUREG-0737. Additional guidance for the evaluation is provided by NUREG-0700 and NUREG-0801. Results of the NRC evaluation of a DCRDR will be documented in a Safety Evaluation Report (SER) or SER Supplement.

Significant HEDs should be corrected. Improvements which can be accomplished with an enhancement program may be done promptly. Other control room upgrades may begin following publication of the SER (or SER Supplement), resolution of any open issues, and NRC approval of a schedule for upgrade.

A human factors evaluation of the design of the remote shutdown capability provided to meet 10 CFR Part 50, Appendix A, GDC-19 and 10 CFR Part 50, Appendix R is not specifically identified as a requirement in Supplement 1 to NUREG-0737. Staff review of this issue is not completed. In the interim, we recommend that the scope of the DCRDR include a human factors evaluation of the design of the remote shutdown capability. To the extent practical, without delaying completion of the DCRDR, it should also address any control room modifications and additions (such as controls and displays for inadequate core cooling and reactor system vents) made or planned as a result of other post-TMI actions. The lessons learned from operating reactor events such as the Salem ATWS events should also be integrated. Implications of the Salem ATWS events are discussed in NUREG-1000 and required actions are described in Section 1.2, Post Trip Review - Data and information Capability, of the enclosure to Generic Letter 83-28.

2. DISCUSSION

The Limerick Generating Station, operated by Philadelphia Electric Company (PECo), is now under construction. Plant construction completion is scheduled for August 1 1984, at which time PECo desires a low-power operating license for Limerick. As required by Supplement 1 to NUREG-0737, a complete DCRDR is required before a license can be issued. The Limerick DCRDR process is in-progress.

PECo submitted a DCRDR program plan for Limerick and Peach Bottom (Ref. 1) to the NRC on August 31, 1983. As part of the Limerick DCRDR, PECo is using a control room survey conducted at Limerick in 1981-82 by a Boiling Water Reactor Owners' Group (BWROG) survey team. The NRC staff had reviewed and accepted the generic BWROG control room survey program (Refs. 4 and 5) for use in the planning and review phases of a DCRDR with limiting conditions that are documented in Generic Letter 83-18 (Ref. 6). These conditions require utilities using the BWROG survey program as part of their DCRDR to:

1. Submit an individual program plan to the NRC referencing the BWROG Control Room Survey Program. The plant-specific submittal should:

   a. Document the qualifications of survey team members, including the number of plant personnel participating and the extent of their participation,

   b. Identify portions of the DCRDR not performed in accordance with the methodology specified in the BWROG Program Plan,

   c. Discuss the program for prioritization of HEDs, reporting of DCRDR results, and implementation of control room enhancements.

2. Complete the BWROG Control Room Survey Checklist Supplement.

3. Prioritize HEDs, determine corrective actions, develop an implementation schedule, and report the results of the DCRDR to the NRC.

4. Repeat portions of the task analysis using updated plant-specific emergency operating procedures to account for differences in the new procedures.

5. Update the operating experience review.

The BWROG survey conducted at Limerick was designed to partially fulfill the planning and review phases of the DCRDR. The results of the BWROG survey of the Limerick 1 & 2 control rooms were documented in a report that was submitted to PECo by the BWROG Control Room Improvements Committee on April 6, 1982 (Ref. 3).

The PECo DCRDR program plan for Limerick was reviewed by the NRC staff as the applicant's response to the requirements of Supplement 1 to NUREG-0737 and the guidance in NUREG-0700 and NUREG-0801. NRC staff comments on the Limerick DCRDR program plan were issued November 16, 1983 (Ref. 2).

A NRC human factors engineering in-progress audit of the Limerick DCRDR was performed at the plant site near Pottstown, Pennsylvania, on December 5 through December 9, 1983. The audit was carried out by a team of NRC personnel from the Human Factors Engineering Branch (HFEB) and the Procedures and Systems Review Branch (PSRB) of the Division of Human Factors Safety and consultants from Lawrence Livermore National Laboratory, Livermore, California. This combined team is referred to in this audit report as the NRC audit team.

2.1 AUDIT TEAM ACTIVITIES

The Limerick DCRDR in-progress audit by the NRC audit team consisted of briefings by PECo personnel and Limerick DCRDR review team members, discussions with review team members, reviews of DCRDR documentation available at the plant site, and a brief review of the Limerick control room. The audit emphasized evaluation of the organization and processes of the Limerick DCRDR, evaluation of the applicant's conformance to their DCRDR program plan, and evaluation of DCRDR results to date.

PECo provided a number of documents to support the NRC in-progress audit before and during the audit. These documents include:

Document submitted before the audit:

- Detailed Control Room Design Review Program Plan for Philadelphia Electric Company's Limerick and Peach Bottom Plants, August 31, 1983, (Ref. 1).

Documents made available at the plant site during the in-progress audit:

- BWR Owners Group Control Room Improvements Committee, Human Factors Design Review of the Limerick 1 & 2 Control Room, Summary Report, April 6, 1982, (Ref. 3),
- BWR Owners' Group Control Room Improvements Committee, Human Factors Engineering Control Room Survey, by D. R. Pankratz and K. C. Ross, January 12, 1981, (Ref. 4),
- BWR Owners' Group Control Room Improvements Committee, Human Factors Engineering Control Room Survey Supplement, by Ronald S. Bunker and Kenneth C. Ross, (Ref. 5).
- HED descriptions,
- HED cross reference forms which will organize key HED information for computer access.

Facilities available at the audit site were:

- The Limerick control room main control board (MCB), which is being reviewed by PECo, and
- The Limerick simulator, which is significantly different from the main control board because modifications have been made to the control room but not to the simulator. The simulator was not visited by the NRC audit team.

PECo operating and engineering personnel and PECo's human factors consultants, The Interlock Group, assisted the NRC audit team during the audit by supplying supplemental DCRDR documentation, discussing the Limerick DCRDR process and activities, and answering audit team questions.

The Limerick DCRDR in-progress audit findings are summarized in Sections 2.2 through 2.5.

2.2 DCRDR PLANNING

2.2.1 Review Team Selection

Supplement 1 to NUREG-0737 requires the establishment of a qualified multidisciplinary review team. Guidelines in team selection are found in NUREG-0700 and NUREG-0801.

The PECo DCRDR program plan states that the BWROG control room survey team consisted of eight people:

- Four operations and engineering personnel from four utilities,
- Two human factors consultants,
- Two representatives from General Electric Company.

The experience and qualifications of BWROG survey team members were adequately documented in the PECo program plan.

Because the BWROG survey only partially fulfills the DCRDR requirements, PECo will establish a review team specifically for Limerick to complete the DCRDR. The Limerick DCRDR review team leader is to provide the administrative and technical direction for the project. The review team will provide the management overview to ensure that the DCRDR will be performed to meet the requirements of Supplement 1 to NUREG-0737.

At the time of the NRC in-progress audit, the NRC audit team determined that PECo (1) had named a new Limerick DCRDR review team leader to replace the original team leader, (2) had engaged The Interlock Group as human factors specialists, and (3) was considering candidates to be Limerick DCRDR team

members. The PECo program plan describes the qualifications and job description for each member of the DCRDR team except for the qualifications and job description of a nuclear engineer. The NRC audit team recommends that a position for a nuclear engineer with suitable documented qualifications and job description be added to the Limerick DCRDR team.

Because the qualifications and job description for DCRDR team members are rather broad, the NRC audit team recommends that detailed documentation of the qualifications of each Limerick DCRDR team member and details of their specific roles and contributions to the DCRDR be included in the Limerick DCRDR summary report. This will enable the NRC to relate specific qualifications and contributions to each team member. The qualifications and contributions of all human factors specialists and any part-time team members who might be chosen for their expertise in a particular field should also be described in the DCRDR summary report.

The PECo DCRDR program plan also states that the personnel that perform the Limerick DCRDR will also be used in conducting the Peach Bottom DCRDR. The NRC audit team found this approach acceptable and efficient.

Based upon their review of the Limerick DCRDR review team qualifications, the NRC audit team concluded that the proposed review team should satisfy the requirement of Supplement 1 to NUREG-0737 to establish a multidisciplinary review team to conduct a DCRDR.

2.2.2 Management Responsibility

NUREG-0700 guidelines state that support of the applicant's management is needed to ensure to the DCRDR team the information, equipment, and all categories of manpower needed to conduct a control room design review. Although this support was not specified in the PECo program plan, it was evident to the NRC audit team that management fully supports the DCRDR process. Some examples of management support observed by the NRC audit team were:

- Hiring The Interlock Group as human factors specialists to participate as members of the Limerick DCRDR team,
- Planning for construction of a full-size color photomosaic mock-up of the control room panels,
- Using personnel from the Peach Bottom plant, which is an operating plant, to contribute their appropriate expertise and experience to the Limerick DCRDR.

2.2.3 Data Management

NUREG-0700 guidelines recommend that methods of data management should be established before the DCRDR is commenced.

Information and data management involves:

- Providing the review team members with reference material such as panel layout drawings, control room floor plans, and piping and instrumentation drawings,
- Developing standard forms to be used for recording the results of the control room review,
- Establishing a system for recording, storing, and retrieving data during the control room review.

During the Limerick in-progress audit, the NRC audit team discussed but did not evaluate the data management system that was being used. However, DCRDR reference material was readily provided to the NRC audit team during the audit. Sample forms used to record DCRDR data were examined and are described below.

- HED Assessment forms will be used to record the discrepancy items, panel locations, problem descriptions, mitigating considerations, possible solutions, resolutions by code number, priority by safety significance, schedule, training and procedure requirements. Some forms have been partially filled out based on the BWROG survey. Completing the forms will require additional human factors analyses.
- HED Verification forms will be used to provide a review of the proposed resolution of each HED. Use of these forms to track modifications will help assure that human factors requirements are addressed.
- An HED Informational Cross Reference is being put together by The Interlock Group to list key information relative to individual HEDs. Cross reference data will be taken directly from the HED Assessment forms. All information will be part of a computerized data system, thereby making all or portions of it readily accessible.

In addition:

- A control room floor plan and a complete panel list by number, functional description, and type (vertical panel, console, etc.) was supplied for review team use.
- A numbering scheme will be used to identify each HED by number and locate it in an appropriate BWROG checklist category and subsection of that category.

The NRC audit team expects that PECo can demonstrate to the NRC that the intent of NUREG-0700 guidelines will be met. A description of the scope and depth of the data managmeent system should be included in the summary report.

2.2.4 Equipment and Workspace

The PECo program plan did not specifically describe plans for the DCRDR team workspace and equipment requirements as recommended in NUREG-0700. However, the NRC audit team found that adequate meeting space in the main control room building was made available to the BWROG survey team, and will be available to the Limerick DCRDR review team, Human Factors consultants, and operating personnel during the remainder of the survey and design improvement processes. PECo has committed space to complete the control board mock-up, and equipment needed to complete any remaining Limerick DCRDR tasks (e.g. illumination and sound level meters, HVAC evaluation equipment) will be made available to the review team when needed.

The NRC audit team observed that adequate clerical, reproduction, and other peripheral support services have been available to the DCRDR review team whenever needed.

2.2.5 DCRDR Schedule

NUREG-0700 recommends that the planning of the control room review include the development of a detailed schedule of review tasks. Figure 1 in the PECo DCRDR program plan (Ref. 1) shows the relative timing of sequences of major activities in the Limerick BWROG control room survey and the Limerick DCRDR process, but does not include a detailed schedule of all review tasks. PECo stated to the NRC audit team that there has been no formal Limerick DCRDR review team activity since the BWROG survey. PECo also stated that implementation of design improvements to panel HEDs will be scheduled based upon priorities assigned by the Limerick DCRDR review team during the HED assessment step. Implementation will be reviewed during the verification step to ensure that modifications will correct discrepancies without unacceptable side effects.

The Limerick DCRDR review team will be responsible for planning, scheduling, and coordinating the total integrated DCRDR. The review team plans to do this on an informal day-to-day basis in a manner that will accomplish the required tasks within a predetermined time period. Attendance at the review team meetings will be determined by the needs of the agenda at each particular meeting.

The NRC audit team recommends that the team leader anticipate and schedule the Limerick DCRDR tasks so that they may be executed in a way which will ensure the timely completion of the DCRDR.

2.3 DETAILED CONTROL ROOM DESIGN REVIEW

2.3.1 Review of Operating Experience

The NUREG-0700 guidelines recommend that a review of operating experience be performed that includes the examination of available operating experience documents and a survey of control room operating personnel.

Neither the BWROG survey report nor the PECo program plan mentions a review of available documents, or describes plans to do so. However, it was stated by PECo to the NRC audit team that the Limerick DCRDR review team plans to review Peach Bottom LERs for the period of time following the BWROG LER review, which implies that a document review was, in fact, done by the BWROG. It was also stated that previous Peach Bottom LERs from Unit 2 (about 10 years of operation) and Unit 1 (about 9 years of operation) would be reviewed.

The BWROG survey report summarizes the results of operator interviews, but cautions that comments in the report apply only to the Limerick simulator, which differs from the control room.

The PECo DCRDR program plan lists, as an objective, that a supplementary experience review will be made using appropriate documentation and operator interviews to update operating experience information since the completion of the BWROG control room survey. However, details of the supplemental operational experience review are not proivided in the PECo program plan. The PECo program plan also states that operator feedback was used extensively in adjusting the operating procedures. No details of how this was accomplished were stated or discussed with the NRC audit team during the in-progress audit.

The NRC audit team was advised that The Interlock Group has prepared an improved and more comprehensive operator interview form for the supplementary review. The DCRDR review team expects that more complete operating experience results will be obtained because more and better trained operators who have had plant-specific experience on both the Limerick control room and the simulator will be interviewed.

The NRC audit team recommends that the Limerick DCRDR summary report should include a complete description of the document review and operator interview methodologies, summarize the major results from the document review and operator interviews, and should state how the results were applied to the DCRDR; e.g., identification of HEDs, selection of corrective actions, verification and validation. The NRC should also be appraised of how the results of the operating experience review have been recorded, interpreted, and factored into the function and task analyses and the identification of HEDs.

2.3.2 Systems Function and Task Analysis

Supplement 1 to NUREG-0737 requires the applicant to perform systems function and task analyses to identify control room operator tasks and information and control requirements during emergency operations. Furthermore, Supplement 1 to NUREG-0737 recommends the use of function and task analyses that had been used as the basis for developing emergency operating procedures technical guidelines and plant-specific emergency operating procedures to define these requirements.

The following steps for a top-down systems function and task analysis are identified in the NUREG-0700 guidelines.

1. Identification of Systems and Subsystems,

2. Identification of Operating Events for Analysis,

3. Function Identification,

4. Operator Task Identification and Analysis.

PECo used the generic Emergency Procedures Guidelines (EPGs) developed by the BWROG as the basis for task analyses performed at Limerick and at Peach Bottom. These guidelines were the foundation upon which the plant specific emergency operating procedures (EOPs) for both plants were developed. The plant specific Transient Response Implementation Procedures (TRIPs) were first developed for Peach Bottom because it was an operating plant. The Limerick TRIPs were then developed by modifying the Peach Bottom TRIPs to account for differences between the two plants.

The PECo program plan states that a procedures development team of four engineers performed a detailed function and task analysis using Revisions 1 and 2 of the BWROG EPGs to develop very detailed function and task flow diagrams. Then, the development team generated detailed basic and written descriptions of every step with appropriate cautions. Each step was compared against the Peach Bottom plant instrumentation and controls to ensure that the necessary controls and instrumentation were available. Then, the Peach Bottom TRIPs were formulated.

The PECo program plan also states that the instrumentation and controls were rigorously verified on the Limerick simulator as being available and suitable for the required emergency operating procedure steps, by verifying detector source, instrumentation range, accuracy of reading, and dynamic response. The procedures development team later made an engineering analysis of the Peach Bottom TRIPs and made changes to account for the design differences between the Peach Bottom and Limerick plants. This process produced the plant-specific Limerick TRIPs.

The top of each TRIPs flow chart defines the entry conditions of plant variables for entry into the emergency procedures. The lower levels of the TRIPs show operator decision points and control actions during emergency operations and define associated conditions of plant operating variables and parameters associated with each decision point. These diagrams provide evidence that basic functional analysis and operator task definition was done in development of the TRIPs. However, the process of rigorous determination of operator information and control requirements and the determination of suitable instrumentation and control characteristics from the task analysis has not been provided. PECo states only that they verified during walk-throughs that all instrumentation was present and had the correct ranges and accuracy.

The NRC audit team review of the applicant's task analyses was divided into two parts. The first part reviewed the process and results where PECo had determined that additional instrumentation and controls were needed by operators to execute the EOPs. The second part reviewed the applicant's evaluation to confirm that the control boards had the proper instrumentation and controls needed by operators to execute the EOPs.

In the first part, the NRC audit team reviewed operator task information and control needs within the flowpath of an EOP, the "Containment Control Procedure," designated by PECo at T-102. The audit was limited to one of the four procedure sections designated as "Suppression Pool Temperature." The entry condition to this section and several decision points within the section required the operator to compare suppression pool temperature with a predefined value of temperature. The results of the comparison required an operator decision to (1) continue to monitor suppression pool temperature or (2) perform a control action to change suppression pool temperature. Some of the decision points within the section were augmented with aids, such as charts, notes and cautions, to support the operator's decision process. (These aids were not reviewed during the audit because they will be evaluated by other elements of the NRC staff.)

A PECo walk-through of the T-102 Containment Control Procedure had previously determined that the information available to the operators to excecute the procedure was inadequate and identified the need for a suppression pool temperature monitor. PECo resolved this problem by generating a design/performance specification for a Suppression Pool Temperature Monitor. PECo then procured the monitor, which had been installed on the control board at the time of the NRC audit.

The NRC audit team evaluation of the design/performance specificiation (SPTMOS Spec. 8031-M-263) showed a one-to-one correlation of the color-coded display of temperature and setpoint for several decision points within the suppression pool temperature section of the procedure. It also appeared that human factors principles were used in specifying the color code of the data. The audit team observed that the operator information requirements had been determined from the task analysis of the procedure section, followed by a determination of instrumenttion characteristics, which were documented in the instrument specification. A partial review of a second specification for other new instrumentation resulted in similar findings.

The NRC audit team concluded from these findings that a reasonable top-down task analysis had been performed to identify information and control requirements and then was used to specify instrument and control characteristics for equipment that was to be added to the existing control room. The audit team concluded that the PECo function and task analyses described above for equipment to be added to the control room conforms to the requirements of Supplement 1 to NUREG-0737.

In the second part of the NRC audit team review of the applicant's task analyses for panels already installed in the control room, the NRC audit team was unable to confirm that the complete task analysis as described in the PECo program plan was indeed executed by the applicant. The NRC audit team could not determine that operator information and control requirements were used to define needed instrumentation and control characteristics and to develop instrument and control specifications independently from consideration of the characteristics of instruments and controls that were already installed in the control room.

The NRC audit team concluded that, for tasks which PECo associated with instruments and controls that were already installed in the control room, the function and task analyses activities conducted by the applicant do not satisfy the DCRDR requirements of Supplement 1 to NUREG-0737 to determine the operator information and control needs.

2.3.3 Control Room Inventory

Supplement 1 to NUREG-0737 requires the applicant to make a control room inventory and to compare the operator display and control requirements determined from the task analyses with the control room inventory to determine missing controls and displays.

A complete photomosaic mock-up of the Limerick control room will be constructed and will be used by PECo as the control room inventory. The NRC audit team concluded that the photomosaic mock-up and supporting panel drawings and instrument and control lists will satisfy the requirement of Supplement 1 to NUREG-0737 for a control room inventory.

Some missing components were identified during the task analysis conducted during the BWROG survey and during supplemental task analyses and walk-through activities. These supplemental activities were conducted at Peach Bottom and Limerick as part of the development of the TRIPs from the BWROG emergency procedure guidelines. However, as noted in Section 2.3.2, the NRC audit team could not determine that operator information and control requirements were systematically determined and documented from the function and task analyses.

The NRC audit team concluded that the applicant has not objectively compared display and control requirements throughout the control room with a control room inventory to identify missing controls and displays. The requirement of Supplement 1 to NUREG-0737 for comparison of operator instrument and control needs with the control room inventory has not been fully satisfied.

2.3.4. Control Room Survey

Supplement 1 to NUREG-0737 requires that a control room survey be conducted to identify deviations from accepted human factors principles. NUREG-0700 provides guidelines and criteria for conducting a control room survey.

The objective of the control room survey is to identify, for assessment and possible correction, characteristics of displays, controls, equipment, panel layout, annunciators and alarms, control room layout, and control room ambient conditions that do not conform to good human engineering practices. A partial control room survey of Limerick 1 was performed by the BWROG survey team.

The areas reviewed by the BWROG survey were:

- o Anthropometrics,
- o Functional control grouping,
- o Labeling,
- o Annunciator location and grouping,
- o Use of mimics and demarcation.

A significant number of incomplete areas are described in Appendix A of the BWROG survey report (Ref. 2). These areas include panel layout and design, instrumentation and hardware, annunciators, computers, procedures, and control room environment. These topics must be reviewed during the Limerick OCPOR.

The BWROG survey report states that the Limerick control room design was found to follow human factors guidelines in many areas; e.g., anthropometric guidelines, functionally grouped controls, acceptable labeling, location and grouping of annunciators above related controls and displays, use of mimics and demarcation lines. However, the BWROG report identified several significant areas of HEDs. Some of these are:

- o Some controls and displays are not inside anthropometric bounds and relocation should be considered,
- o Functional grouping of controls and displays could be enhanced with labels and demarcation,
- o A heirarchical labeling system should be used,
- o Large arrays of closely spaced components should be separated by labels and location aids,
- o A lamp test feature should be considered,
- o Use of a separate annunciator silence button is recommended,
- o Range markings identifying action levels addressed in emergency procedures should be provided on indicators and recorders.
- o Missing information potentially useful to the operator should be provided in the control room,
- o The ESW panel layout is crowded and confusing--this was also discussed at the exit briefing conducted by the NRC audit team.

PECo plans to complete the Limerick DCRDR control room survey using the methods developed in the BWROG survey program. Before the NRC in-progress audit, PECo transferred edited versions of the BWROG HEDs to PECo HED record forms. Beyond this, essentially no additional control room survey work has been done at Limerick.

The NRC audit team reviewed selected BWROG survey HEDs as recast by PECo on their record forms. The NRC audit team found that the HED statements identified actual HEDs in the control room. However, some of the HED statements reviewed were not specific about the exact nature of the discrepancy, or accurate in describing the locations where the HED occurs.

The NRC audit team also found several additional control room HEDs that were not included in the BWROG summary report. These are documented in Appendix A of this audit report.

The NRC audit team also observed that the attitude of PECo personnel led them to rationalize the importance of some minor HEDs into a "not-significant-enough-to-fix" state. The NRC audit team recommends that all HEDs be documented and assessed systematically.

PECo stated that design changes to the Limerick simulator are approximately 18 months behind implementation of design changes in the Limerick 1 control room. Since PECo plans to use a photomosaic mock-up of the control room rather than the simulator in their evaluation of HED corrections, the simulator was not reviewed by the NRC audit team.

Since the BWROG survey, PECo has added instrumentation to the Limerick control boards to resolve information needs of the operator discovered by task analysis and procedures development activities. The NRC audit team observed that these additions have made some panels more cluttered and may have generated new HEDs in the portions of the boards that were covered by the BWROG survey. During informal discussions with the NRC audit team, the Interlock Group identified discrepancies in the ECCS panels, including specific problems in crowded and confusing mimics.

The PECo DCRDR program plan calls for completing the control room survey and for classifying and prioritizing HEDs by the scheme used in the BWROG survey. PECo will construct a photomosaic mock-up of the Limerick control room which will be used to test and evaluate HED corrections and to verify that no new HEDs will be introduced by the proposed changes.

The NRC audit team concluded that the Limerick control room survey plan is adequate. If executed with reasonable diligence and adequately documented, the NRC audit team expects that the Limerick control room survey will define HEDs, and thus will meet the intent of NUREG-0700 guidelines and respond to the requirements of Supplement 1 to NUREG-0737.

2.4 ASSESSMENT AND IMPLEMENTATION

2.4.1 Assessment of HEDs

Supplement 1 to NUREG-0737 requires that HEDs be assessed to determine which HEDs are significant and should be corrected. NUREG-0700 and NUREG-0801 contain guidelines for the assessment process.

The applicant has chosen to divide HEDs into two types: "Panel HEDs" and "Procedural HEDs." In the context of this audit, HEDs relate not only to the panels but also relate significantly to how the panels are used, or in other words, to the emergency procedures. The content of the procedures themselves is beyond the scope of this audit. However, procedure changes or additions may be acceptable corrections to some HEDs. Since the applicant has stated that procedural HEDs will be assessed in a manner similar to the assessment of panel HEDs, the distinction between "Panel HEDs" and "Procedural HEDs" is ignored in this discussion.

PECo stated that they will perform a "top-down" analysis of the control room panels from an operator's point of view to identify the context of HEDs in regard to panel layout and control-display integration and to understand their specific meaning. HEDs will then be assessed and assigned priorities on the basis of safety significance as follows:

Priority 1 (High Safety Significance)
HEDs that are documented or judged likely to adversely affect the management of emergency conditions by the control room operators.

Priority 2 (Low Safety Significance)
HEDs that have caused problems or appear likely to cause problems during normal and off-normal operations that could not result in unsafe operations.

Priority 3 (Operational Reliability)
HEDs that are not safety significant but could degrade operational efficiency and reliability, either singularly or in combination with other HEDs.

Priority 4 (No Significant Improvement)
HEDs judged by the review team to have no significant effect on operations and are not documented as causing problems during operations.

The assigned priorities will be used in conjunction with resolution codes (Section 4.3.4 of the PECo DCRDR program plan) to schedule the implementation of the selected design improvements. The PECo DCRDR program plan states that to ensure continuity of work between the the BWROG survey and the follow-on assessment and implementation phase, a special analysis of existing HEDs will be conducted and an audit trail established to ensure that all information is carried over from the BWROG survey to the Limerick DCRDR team.

The NRC audit team concluded from the audit that the applicant's HED assessment method, when conscientiously applied, should meet the intent of NUREG-0700 and NUREG-0801 guidelines and should satisfy requirements of Supplement 1 to NUREG-0737.

2.4.2 Selection of Design Improvements

Supplement 1 to NUREG-0737 requires the selection of control room design improvements that will correct significant HEDs. It also states that improvements that can be accomplished with an enhancement program should be done promptly.

PECo will conduct a complete review of terminology used on control panels. Specific approved terminology will be developed and documented in a manual.

In addition, PECo will make class improvements to controls and displays by modifying the labeling, deleting extraneous markings, improving the scale markings on displays, and changing controls. HEDs that cannot be corrected by the enhancements or the class improvements will be addressed individually. Possible solutions include:

- o Component replacement and panel alteration,
- o Operator organization and communications,
- o CRT display alternatives,
- o Procedural and administrative solutions,
- o Special training requirements.

HED corrections will be verified by operator walk-throughs of procedures using the photomosaic mock-up of the Limerick control panels.

The NRC audit team observed that PECo seems biased toward enhancement-type corrective actions, but it was stated to the NRC audit team that corrections other than enhancements would be made if necessary. PECo will attempt to correct Limerick HEDs through panel enhancements including labeling, demarcation, color shading, and swapping of like components. Verbally, PECo personnel indicated that these enhancement changes would be made before fuel load.

The NRC audit team recommends that the DCRDR summary report include acceptable justification for all enhancements which result in partial corrections of HEDs. The NRC audit team also recommends that the Limerick DCRDR document alternative approaches that are considered in correcting HEDs as well as the solutions adopted.

The NRC audit team concluded that the applicant's plan to select design improvements should be adequate to meet the intent of NUREG-0700 guidelines and the requirements of Supplement 1 to NUREG-0737. The Limerick DCRDR summary report should completely document the methodology and the results of design improvement selection so that the NRC can confirm that the requirements have been satisfied.

2.4.3 Implementation

NUREG-0700 describes guidelines for determining the implementation schedule for design improvements.

The PECo program plan states that the schedule for implementation of design improvements will be based upon priorities assigned during the assessment step. Design improvements will be reviewed during the verification step. The PECo program plan also states that continuity between the BWROG survey and the ongoing DCRDR effort will be ensured by establishing an audit trail, which will include the HED assessment, correction, and implementation phases. Examples of the HED assessment form and the HED verification form provided in the PECo program plan have spaces to enter the schedule for resolution of each HED.

It is the NRC audit team's understanding that priorities may not be assigned to all HEDs since the applicant plans to implement many corrective actions (e.g., enhancements, component corrections) prior to loading fuel. PECo personnel stated that only corrective actions not completed by fuel load will need to have a priority assigned. PECo stated that enhancements would be done first followed by component corrections.

The Limerick DCRDR schedules for implementation of HED resolutions must mesh with construction, testing, and start-up schedules. These schedules will be determined during meetings attended by appropriately qualified Limerick review team members and will be reported in a monthly status report submitted to PECo management. Top management priority will be given to items related to licensing, safety, and operating requirements. A safety significance evaluation method will be written to direct the team discussions of the implementation of HED corrective actions.

The NRC audit team expects that PECo will generally follow the guidelines in NUREG-0700 and NUREG-0801. PECo should correct as many Limerick HEDs as possible prior to loading fuel. An implementation schedule acceptable to the NRC should be stated for all uncompleted Limerick HED corrective actions. PECo should provide justifications for all HEDs not corrected or partially corrected. It is recommended by the NRC audit team that the Limerick DCRDR summary report include sufficient descriptions of the implementation methodology and of the audit trail of records so that the NRC staff can accurately evaluate the HED correction process.

2.4.4 Verification of Design Improvements

Supplement 1 to NUREG-0737 requires verification that selected design improvements will provide the necessary corrections of HEDs.

The PECo program plan states that a verification program will review the proposed resolution of each HED and ensure that each modification will correct the discrepancy without creating any side effects. The NRC audit team understands that verification of HED corrective actions will be an ongoing iterative process which will be conducted by PECo and The Interlock Group using the planned photomosaic mock-up of the Limerick control panels. PECo plans that final verification of HED corrective actions will be completed close to fuel load.

The NRC audit team reviewed the planned verification program during the in-progress audit at Limerick. The NRC audit team expects that when the Limerick HED verification program is completed and reported as planned, the requirement of Supplement 1 to NUREG-0737 to verify correction of HEDs should be satisfied. The Limerick DCRDR summary report should describe all aspects of the verification methodology so that the NRC staff can determine that the requirement of Supplement 1 of NUREG-0737 has been satisfied.

2.4.5 Verification No New HEDs Created

Supplement 1 to NUREG-0737 requires verification that control room design improvements will not introduce new HEDs into the control room.

PECo plans to verify that HED corrective actions will correct discrepancies without creating unacceptable side effects as part of its ongoing verification program and as part of its final validation of Limerick control room design changes. The PECo program plan states that final validation will follow implementation of design changes on the Limerick control room mock-up and will precede implementation in the control room. The final validation is planned to be a dynamic walk-through by operators of the Limerick TRIP procedures using either the enhanced Limerick simulator or the Limerick control panel photomosaic mock-up. The walk-through will be supervised and reviewed by the DCRDR team. Video and audio recordings will be made to record operator actions and comments. HEDs which result will be assessed, corrected, and verified using the same DCRDR methodology used previously.

The NRC audit team reviewed the PECo plans for final validation of the Limerick control room design changes during the NRC in-progress audit at Limerick. The NRC audit team concluded that verification and validation are part of an ongoing iterative effort which will not be completed until after the DCRDR summary report is submitted. PECo has stated that a DCRDR addendum report will be submitted to the NRC after the final validation is completed.

The NRC audit team expects that when the Limerick HED verification program and the final validation are completed and reported as planned, the requirement of Supplement 1 to NUREG-0737 to verify that control room design changes do not introduce new HEDs should be satisfied.

2.4.6 Coordination of Control Room Improvements with Other Programs

Supplement 1 to NUREG-0737 requires that control room improvements be coordinated with changes from other programs; e.g., safety parameter display system (SPDS), operator training, Regulatory Guide 1.97 (R.G. 1.97), and emergency operating procedures (EOPs).

PECo states in Section 2.4 of the DCRDR program plan that integration and coordination of other post-TMI initiative activities as required by Supplement 1 to NUREG-0737 will be completed prior to the completion of the DCRDR. The results of the designs and requirements from these post-TMI initiatives are to be made available to the DCRDR review team for coordination with the enhancements and corrections of other HEDs. PECo plans to refer any difficulties found in integrating control room improvements to the PECo design group for resolution and coordination with the DCRDR team. After control room improvements are installed, they will be followed by walk-throughs for validation purposes.

The PECo program plan acknowledges that the following initiatives must be coordinated:

- Emergency Operating Procedures,
- Accident Monitoring Instrumentation - R.G. 1.97,
- Safety Parameter Display System,
- Emergency Response Facilities,
- Detailed Control Room Design Review.

The NRC audit team noted that operator training is not mentioned and recommended that PECo address this issue in the Limerick DCRDR summary report.

The PECo program plan does not describe the specific details or methodology of how the coordination will be accomplished. PECo stated to the NRC audit team that, up until now, the PECo review team leader has done the coordination of all initiatives, except procedures, using the part of the BWROG committee responsible for R.G. 1.97 instrumentation. This coordination was done informally in meetings without documentation or letters of transmittal. PECo intends to implement design improvements through Bechtel Corp. via normal construction and installation processes.

There has been no formal assignment of coordination responsibility to the PECo engineer who recently replaced the previous Limerick DCRDR review team leader. PECo stated that coordination problems which arise as a result of verification activities by the The Interlock Group will be resolved by the DCRDR review team leader.

Limerick personnel stated to the NRC audit team that the driving force for most changes was R.G. 1.97. The NRC audit team believes that a more complete and systematic approach be used to determine the influences of all initiatives, (e.g., SPDS, upgraded EOPs, operator training, RG-1.97), and to describe how the coordination effort is executed.

The NRC audit team believes that PECo intends to comply with the requirement of Supplement 1 to NUREG-0737 to coordinate the DCRDR with other control room improvement programs. For the NRC staff to evaluate this activity, the Limerick DCRDR summary report should describe the coordination methodology, activities, and documentation.

2.5 REPORTING

PECo submitted their program plan for the Limerick DCRDR to the NRC on August 31, 1983. The NRC staff reviewed the PECo program plan and concluded that an appropriate approach to the Limerick DCRDR has been planned. The NRC staff comments on the Limerick program plan were transmitted to PECo via the Division of Licensing on November 16, 1983 (Ref. 3).

The control room survey conducted at Limerick by the BWROG and reported to PECo in April 1982 covers only portions of the the planning and review phases of the Limerick DCRDR. There are several areas in which the Limerick DCRDR is incomplete. A supplemental control room survey is now in progress. It will cover incomplete and remaining phases of the Limerick DCRDR which were described in the PECo program plan. To satisfy the reporting requirements of Supplement 1 to NUREG-0737, PECo is required to submit a Limerick DCRDR summary report, as planned, after completing their supplemental survey.

3. CONCLUSIONS

PECo is currently conducting its Limerick DCRDR. The NRC staff reviewed the PECo DCRDR program plan and conducted a DCRDR in-progress audit at the Limerick Generating Station on December 5-9, 1983.

PECo is using the results of a BWROG control room survey conducted at Limerick as part of its Limerick DCRDR. The BWROG control room survey at Limerick recommended enhancement and/or correction of the following discrepancies:

- o Some controls and displays were not anthropometrically located,
- o Some functionally grouped components should be enhanced with labels and location aids,
- o Some large arrays of components should be separated by labels and location aids,
- o Hierarchical labeling should be used,
- o A lamp test feature should be provided,
- o A separate annunciator silence button was recommended,
- o Range markings should be provided on displays addressed in emergency operating procedures,
- o Some potentially useful operator information is missing from the control room, and
- o The ESW panel layout is crowded and confusing.

The BWROG control room survey report did not include all areas of review recommended in NUREG-0700 and NUREG-0801. Those areas which were covered were judged to generally follow the NRC human factors guidelines. Review of topics not covered by the BWROG survey remain to be done as part of the Limerick DCRDR. Those DCRDR areas not covered by the BWROG survey should be completed and reported to the NRC. Assessment of discrepancies and implementation of corrective actions also remain to be done during the Limerick DCRDR.

The NRC audit team determined that the Limerick DCRDR does not meet the requirements of Supplement 1 to NUREG-0737 for the following items:

1. The performance of system function and task analyses to determine operator information and control requirements during emergency operations, and,
2. The comparison of display and control requirements which were determined by the function and task analyses with a control room inventory to identify missing displays and controls.

The NRC audit team review of the Limerick DCRDR function and task analysis process did not find evidence that a systematic objective determination had been made of operator information and control requirements. These information and control requirements serve as the review basis for evaluating the adequacy of the characteristics of instrumentation and controls available in the control room. Information requirements should be based on the needs of the operator to successfully perform the described task, not on the instrumentation that happens to already be installed in the control room. This finding applies to the information and control requirements that the BWROG survey and the Limerick DCRDR review team have associated with instruments and controls that are already installed in the Limerick control room.

The NRC audit team did find that the applicant appears to be using a reasonable approximation to the recommended top-down analysis to define the requirements for controls and displays that have been added since the BWROG control room survey. The NRC audit team concluded that the task analysis and inventory comparison requirements of Supplement 1 to NUREG-0737 have not been fully met.

The NRC audit team concludes that completion of the Limerick DCRDR in accordance with the PECo DCRDR program plan should result in the successful resolution of all presently identified HEDs and the successful resolution of all additional HEDs identified during the DCRDR completion process. PECo should document their DCRDR review team activities. Any needed corrective actions resulting from the above efforts should be implemented prior to licensing or on a schedule acceptable to the NRC.

PECo is required to submit a DCRDR summary report to the NRC documenting the results of the Limerick DCRDR to fulfill the reporting requirements of Supplement 1 to NUREG-0737.

The NRC audit team concludes that when PECo corrects and reports the above discrepancies, the Limerick DCRDR generally should meet the requirements of Supplement 1 to NUREG-0737 and the guidelines of NUREG-0700.

4. REFERENCES

1. Letter to A. Schwencer, NRC Division of Licensing, from J. S. Kempes, Vice-President, Philadelphia Electric Company; Limerick Generating Station, Units 1 and 2 Control Room Design Review, August 31, 1982; with enclosure: Detailed Control Room Design Review Program Plan for Philadelphia Electric Company's Limerick and Peach Bottom Plants.

2. NRC Memorandum to Thomas M. Novak, DOL, from William T. Russell, DHFS, Response to Limerick Program Plan Submittal, November 16, 1983.

3. BWR Owners Group Control Room Improvements Committee, Human Factors Design Review of the Limerick 1 & 2 Control Room, Summary Report, by Ronald S. Bunker and Kenneth C. Ross, April 6, 1982.

4. BWR Owners Group Control Room Improvements Committee, Human Factors Engineering Control Room Survey, by D. R. Pankratz and K. C. Ross, January 12, 1981.

5. BWR Owners' Group Control Room Improvements Committee, Human Factors Engineering Control Room Survey Supplement, by Ronald S. Bunker and Kenneth C. Ross.

6. NRC Generic Letter 83-18, NRC Staff Review of the BWR Owners Group (BWROG) Control Room Survey Program, April 19, 1983.

7. BWR Owners Group, Draft Emergency Procedure Guidelines, Revision 2, BWR 1 through 6, May 20, 1982.

8. BWR Owners Group letter BWROG-8257 to Darrell G. Eisenhut from T. J. Dente, Errata to BWR Emergency Procedure Guidelines, October 4, 1982.

5. APPENDIX

Disposition and Status of HEDs

APPENDIX

This appendix discusses the disposition and status of Limerick HEDs documented during the BWROG control room survey and reviewed by the NRC audit team during the Limerick DCRDR in-progress audit of December 6-9, 1983. It also includes HEDs identified by the NRC audit team.

Part A of this appendix contains HEDs identified by the NRC audit team during the in-progress audit.

Part B of this appendix contains a list of the 79 Limerick panel HEDs as shown in their record file of HED assessment forms.

Part C of this appendix contains identification and descriptions of photos taken by the NRC audit team during the Limerick DCRDR in-progress audit.

The 79 Limerick panel HEDs that were found during the BWROG control room survey were placed in the following BWROG checklist categories:

- 28 HEDs in Panel Layout and Design,
- 37 HEDs in Instrumentation and Hardware,
- 14 HEDs in Annunciators.

There were no panel HEDs assigned in the following BWROG checklist categories:

- Computers,
- Procedures,
- Environment (Control Room),
- Maintainance and Surveillance.

A prioritization of potential enhancements is also included on each panel HED. This is in the form of an evaluation product (EP) number. These EPs have been derived from two numerical rating factors: one indicating the degree to which the panel under consideration complies with the BWROG checklist criterion and the second representing the relative likelihood that noncompliance with that item would cause or contribute to operator error. Derivations of the scalar values of the two EP factors are not defined in the BWROG summary report.

The 79 Limerick panel HEDs fell into the following EP number categories:

	EP	
16 HEDs	9-12,	Modification is recommended,
7 HEDs	7-8,	Modification should be strongly considered,
29 HEDs	5-6,	Modification should be considered,
27 HEDs	1-4.	Modification may be beneficial in some cases.

APPENDIX

The column headings in Parts A and B of this appendix are defined as follows:

- o HED - A word description of the HED.
- o 0700 - the appropriate NUREG-0700 Chapter 6 human factors discrepancy guideline paragraph numbers.
- o FINDING - an arbitrary, unique HED identification number assigned by the NRC audit team.
- o PECo - an alpha-numeric, BWROG HED-identifier code number, which is explained in the BWROG HED assessment form instructions.
- o PHOTO - The ID number of photos taken by the NRC audit team.
- o EP - The BWROG evaluation product number calculated to indicate the relative possibility of operator error.

Part A

This part contains HEDs identified by the NRC Audit Team during the in-progress audit. The number in parentheses (B-xxx) is the HED ID number assigned by the NRC audit team. The applicant should assess these HEDs and should be required to submit the resolutions and propose a schedule for implementing the corrective actions in sufficient time prior to licensing to permit the staff to conduct a review and document its evaluation. The applicant should be required to acceptably justify and report to the NRC any discrepancy which is not corrected.

PHOTO	FINDING	HED
1.0 CONTROL ROOM WORKSPACE		
	1.1	Since the control room at Limerick is not completed, the arrangement could not be evaluated according to Subsection 1 in Section 6 of NUREG-0700.
	1.2	On all vertical panels, the bottom 1/3 is not visible from the front of the benchboard. (B104)
	1.3	No procedures or place to store emergency shutdown procedures is provided at the remote shutdown panels. (B110)
2.0 COMMUNICATIONS		
	2.1	Since the control room at Limerick is not completed, the communications system could not be evaluated according to Subsection 2 in Section 6 of NUREG-0700.
3.0 ANNUNCIATOR WARNING SYSTEMS		
	3.1	The annunciator audible alarm for two different sets of annunciators uses the same bell sound. Localization is by direction of sound only. (B111)
	3.2	Coding of annunciator controls is inconsistent in shape and layout. The color coding of red for central reset and black for local reset is acceptable. (B109)
4.0 CONTROLS		
		No HEDs found in this category.
5.0 VISUAL DISPLAYS		
	5.1	The four-rod display is too dim to be read in normal room light. (B103)

Part A (Continued)

PHOTO	FINDING	HED
	6.0 LABELS AND LOCATION AIDS	
	6.1	Containment boundary demarcation does not make clear which side is in and which is out. (B107)
	6.2	On Reactor and Containment Cooling and Isolation Panel 801, the mimics are confusing. (B108)
	6.3	On Panel 647 there are labels marked "BOP". These are redundant displays or insufficient labels. (B102)
	6.4	Abbreviations are inconsistent. Several acronyms are used for one word. (B101)
	7.0 PROCESS COMPUTERS	
	7.1	Since the computer system is not fully installed at Limerick, it could not be completely evaluated according to Subsection 7 in Section 6 of NUREG-0700.
	7.2	There is excessive glare on the concave keys which make the engraving difficult to read, and there are many un-needed keys among the 70 keys over and above the QWERTY board. (B201)
	7.3	Contrast of engraved printing on keys is not very good, using white on gray QWERTY keys. This is due partly to dirt in engraving. (B202)
	7.4	On the printers, the guide on the paper drive covers part of the printing of approximately 16 lines (covers 4 to 5 characters near margin of paper). (B203)
	7.5	Printouts are subject to dust cover glare from overhead lights on both front and top - especially from a sitting position. (B204)
	7.6	Physical access to printer copy is difficult inside the bottom compartment in front of the printer. (B205)
	8.0 PANEL LAYOUT	
	8.1	On Panel 648, RCIC Divsion 3 and Division 1 are not in numerical order left to right. (B106)

Part A (Continued)

PHOTO	FINDING	HED
8.0 PANEL LAYOUT (Continued)		
	8.2	On Panel 668, the orders of controls is reversed numerically. (B112)
	8.3	On Panel 648, RCIC status lights have different arrangements for Division 3 and Division 1. (B105)
9.0 CONTROL/DISPLAY INTEGRATION		
		No HEDs found in this category.

Part B

This part contains a list of the PECo panel HEDs as shown in their HED assessment form record file. It is arranged in the order of the nine subsections of human factors guidelines in Section 6 of NUREG-0700. Each subsection is in alpha-numeric order of the PECo HED numbers. The applicant should be required to submit the resolutions for these HEDs and propose a schedule for implementing the corrective actions in sufficient time prior to licensing to permit the NRC staff to conduct a review and document its evaluation. The applicant should be required to acceptably justify and report to the NRC any discrepancy which is not corrected.

FINDING	0700	PECo	PHOTO	EP
1.0 CONTROL ROOM WORKSPACE				
1.3	1.2.2.e	A1-05		9
1.4	1.2.2.e	D1-02		6
1.1	1.1.3.a	D1-04		9
1.5	1.2.4.a	D3-10		9
1.6	1.2.5.a	I5-05		6
1.2	1.2.2.d	I5-06		6
2.0 COMMUNICATIONS				
There were no HEDs listed in this subsection.				
3.0 ANNUNCIATOR WARNING SYSTEMS				
3.4	3.3.1.a	A1-01	A1	4
3.2	3.1.4	A1-02		4
3.7	3.3.4.d	A1-03		4
3.6	3.3.4.c	A1-09		4
3.1	3.1.2.c	A1-10		6
3.8	3.3.5.a	A1-12		8
3.9	3.4.1.a	A1-13	A4	12
3.3	3.1.5.b	A1-14		4
3.5	3.3.1.a	D1-05		6
4.0 CONTROLS				
4.1	4.1.1.c	D2-04	A6	6
4.4	4.2.2	D2-05		6
4.5	4.2.2	D3-09		9
4.3	4.2.1	I5-01		6
4.2	4.1.1.c	I5-07		9
4.8	4.4.5.b	I5-08		6
4.7	4.2.2.d	I5-10		8
4.6	4.2.2.a	I5-11		4
4.9	4.4.5.c	I5-12		4

Part B (Continued)

FINDING	0700	PECo	PHOTO	EP
5.0 VISUAL DISPLAYS				
5.13	5.1.6.e	A1-11		3
5.15	5.2.3	I2-01		12
5.21	5.4.1.b	I2-02		9
5.3	5.1.2	I2-03		6
5.2	5.1.1.b	I2-04		6
5.14	5.2.2.a	I2-05		6
5.8	5.1.5.d	I2-07		4
5.10	5.1.5.f	I2-09		4
5.6	5.1.5.a	I2-10		6
5.7	5.1.5.c	I2-11		3
5.9	5.1.5.e	I2-12		6
5.16	5.2.4.a	I2-13		4
5.5	5.1.4.a	I2-14		4
5.23	5.4.2.b	I3-01	A7	8
5.22	5.4.1.b	I3-02		4
5.11	5.1.6.d	I3-03		4
5.4	5.1.2.d	I3-04	–	12
5.1	5.1.1.f	I4-01		6
5.17	5.3.1.a	I4-02		8
5.18	5.3.1.a	I4-03		4
5.19	5.3.1.b	I4-04		6
5.12	5.1.6.d	I4-05		4
5.20	5.3.1.b	I4-06		4
6.0 LABEL AND LOCATION AIDS				
6.10	6.4	A1-04		4
6.6	6.3.5	A1-06		6
6.4	6.3.1	A1-07		6
6.5	6.3.2	A1-08		6
6.11	6.6.2	D2-02		4
6.1	6.1.2	D2-06		12
6.12	6.6.2	D2-07		6
6.16	6.6.4.b	D2-08		4
6.15	6.6.4.a	D2-09		4
6.13	6.6.2.a	D2-10		8
6.14	6.6.2.a	D2-11		4
6.3	6.2.2.c	D2-12		4
6.17	6.6.4.b	D2-13		12
6.2	6.2.1.f	D3-08		9
6.7	6.3.8	I5-02		6
6.8	6.3.8.a	I5-03		6
6.9	6.3.8.a	I5-04		9

Part B (Continued)

7.0 PROCESS COMPUTERS

There were no HEDs listed in this subsection.

FINDING	0700	PECo	PHOTO	EP
8.0 PANEL LAYOUT				
8.9	8.2.3.b	D1-03		8
8.2	8.1.3.b	D2-01		8
8.1	8.1.1.b	D2-03		6
8.10	8.2.3.b	D3-01		9
8.3	8.2.1.a	D3-02		6
8.4	8.2.1.a	D3-04		6
8.8	8.2.2.b	D3-05		6
8.5	8.2.1.c	D3-06		9
8.13	8.3.2	D3-07		9
8.11	8.3.1.a	I1-01		3
8.7	8.2.2	I2-06		4
8.6	8.2.1.c	I2-08		4
8.12	8.3.1.a	I5-09	-	6
9.0 CONTROL/DISPLAY INTEGRATION				
9.2	9.1.1.c	D3-03		6
9.1	9.1.1.a	D3-11		6

Part C

Photo Summary

CAROUSEL LOCATION	PHOTO ID NO.	PHOTO DESCRIPTION
1	A1	Shows distance between annunciator and related control. (A1-01)
2	A2	Abbreviations are inconsistent on computer display: RECIR, RECRC, RCCIRC, PMP, PUMP. (A1-03) (B101)
3	A3	Inconsistency in type size and style on annunciator tiles. (A1-04)
4	A4	No silence button has been provided for alarm response. (A1-13)
5	A5	Two displays labeled BOP. Either is a redundant display or insufficient label. (B102)
6	A6	Manual SCRAM buttons not easily distinguished from other controls. (D2-04)
7	A7	There is no point select on 24-point recorder. Have to wait for recorder to cycle through all points. (I3-01)
8	A8	Different arrangement of RCIC status lights between DIV. 3 and DIV. 1. (B105)
9	A9	RCIC DIV. 3 and DIV. 1 not in numerical order left to right. (B106)
10	A10	Containment boundary does not make clear which side is in and which side is out. (B107)
11	A11	Reactor and containment cooling and isolation panel has confusing mimics. (B108)
12	A12	Inconsistent coding of annunciator controls in shape and layout. (Red for central reset and black for local reset is OK) Panel 655 (B109)
13	A13	Same as above only Panel 603. (B109)
14	A14	Same as above only Panel 661. (B109)
15	A15	Same as above only Panel 667. (B109)
16	A16	On the Drain Dump Condenser, the controls are in reversed numerical order. (B112)
UNIT 1 PANELS		
17	1-647	HPCI Panel
18	1-648	RCIC Panel
19	1-601R	Reactor and Containment Cooling and Isolation Panel (right side)
20	1-601C	Same as above only center
21	1-601L	Same as above only left side
22	1-626	ADS and MSIV Leakage Control Panel
23	1-600	Rad Monitoring and Cont Gas Analyzing System Panel

Part C (Continued)

CAROUSEL LOCATION	PHOTO ID NO.	PHOTO DESCRIPTION
UNIT 1 PANELS (Continued)		
24	1-649	Rod Status Display Panel
25	1-607	TIP Control and Monitoring Panel
26	1-614	NSSS Temp Recorder and Leak Detection Panel
27	1-610	RPS Test and Monitoring Panel
28	1-670	Turbine Panel
29	1-669	Condensate Panel
30	1-668	Feedwater Panel
31	1-681	Heating and Ventilating Panel
32	1-655	Plant Services Panel
33	1-602	Reactor Water Cleanup and Recirculation Panel
34	1-603R	Reactor Control Panel - Right
35	1-603C	Reactor Control Panel - Center
36	1-603L	Reactor Control Panel - Left
37	1-653	Turbine Panel
38	1-652	Condensate Panel
39	1-651	Feedwater Panel
UNIT 2 PANELS		
40	2-647	HPCI Panel
41	2-648	RCIC Panel
42	2-601	Reactor and Containment Cooling and Isolation Panel
43	2-626	ADS and MSIV Leakage Control Panel
44	2-600	Rad Monitoring and Cont Gas Analyzing System Panel
45	2-649	Rod Status Display Panel
46	2-607	TIP Control and Monitoring Panel
47	2-614	NSSS Temp Recorder and Leak Detection Panel
48	2-610	RPS Test and Monitoring Panel
49	2-670	Turbine Panel
50	2-669	Condensate Panel
51	2-668	Feedwater Panel
52	2-681	Heating and Ventilating Panel
53	2-655	Plant Services Panel
54	2-602	Reactor Water Cleanup and Recirculation Panel
55	2-603R	Reactor Control Panel - Right
56	2-603C	Reactor Control Panel - Center
57	2-603L	Reactor Control Panel - Left
58	2-653	Turbine Panel
59	2-652	Condensate Panel
60	2-651	Feedwater Panel
61	0-650	Fire Protection System/Evac Alarm Panel
62	1-661	Safeguard System Panel

Part C (Continued)

CAROUSEL LOCATION	PHOTO ID NO.	PHOTO DESCRIPTION
PLANT PANELS - UNIT 1, UNIT 2 and COMMON (Continued)		
63	0-656/0-671	Plant Electrical Metering Panels
64	1-654	Generator and Auxiliary Power Panel
65	0-660	Startup Power Panel
66	2-654	Generator and Auxiliary Power Panel
67	0-667	ESW/RHRSW Panel
68	1-673	Gaseous Radwaste Recombination Panel
69	2-673	Gaseous Radwaste Recombination Panel
70	2-661	Safeguard System Panel
71	0-681	Heating and Ventilating Panel
72	0-624	Area and Process Radiation Monitoring Panel
73	0-693	Plant Seismic Station Panel

Because of the confined space between the RSPs, it was impossible to get a good overall frontal picture. One picture each of Unit 1 and Unit 2 was taken at a very sharp angle and a mosaic of Unit 1 was photographed in 9 pictures as outlined below.

CAROUSEL LOCATION	PHOTO ID NO.	PHOTO DESCRIPTION
REMOTE SHUTDOWN PANELS		
74	RSP-2	Overall view of the Unit 2 Remote Shutdown Panels
75	RSP-1	Overall view of the Unit 1 Remote Shutdown Panels
76	RP-1	Unit 1 RSP Mosaic
77	RP-2	Unit 1 RSP Mosaic
78	RP-3	Unit 1 RSP Mosaic
79	RP-4	Unit 1 RSP Mosaic
80	RP-5	Unit 1 RSP Mosaic
81	RP-6	Unit 1 RSP Mosaic
82	RP-7	Unit 1 RSP Mosaic
83	RP-8	Unit 1 RSP Mosaic
84	RP-9	Unit 1 RSP Mosaic

Part C (Continued)

MISCELLANEOUS

85	1-680	Computer Operator's Console (Keyboard and CRT)
86	1-682	Computer Peripheral Console (Alarm and On-demand Printers)
87	0-679	Computer Supervisory Console (Keyboard and CRT)
88	1-689/690	Loose Parts Monitoring and Safety Relief Valve Position Indication Panels
89	1-696	LOCA Hz Recombiner Panel
90	CT-1	Cooling Tower
91	CT-2	Cooling Tower
92	J-1	Ladies' John (HED)
93	J-2	Ladies' and Men's Johns

Due to construction and the lack of lights behind the main CR panels, the following rear panels could not be photographed.

BEHIND UNIT 1

0AC699	Meteorlogical Instrumentation
0BC699	Meteorlogical Instrumentation
00Z557	RMDS Display
00Z558	RMDS LA-120 Line Printer
0DZ586	MMDRS/RM-21A 4014-1 Operator Terminal
0DZ585	MMDRS/RM-21A 4631 Hard Copy Unit
0AZ698	VMS VT100 Annunciator Terminal CRT
0AZ699	VMS VT100 Operator Terminal CRT
00C424	Drywell Sump Tank Level Monitor
20C689	Loose Parts Monitoring
00C692	Suppression Pool Temp Monitoring
00C691	Radiation Monitoring Control Panel
20C690	Safety Relief Valve Position Indication
2AC696	LOCA Hz Recombiner "A"
2BC696	LOCA Hz Recombiner "B"