APPENDIX A

TECHNICAL EVALUATION REPORT
OF THE
DETAILED CONTROL ROOM DESIGN REVIEW
FOR
PHILADELPHIA ELECTRIC COMPANY'S
LIMERICK GENERATING STATION

August 10, 1984

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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). Supplement 1 to NUREG-0737 requires each applicant or licensee to conduct a 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.

Guidelines for evaluating each phase are contained in draft NUREG-0801.

A Program Plan is to be submitted 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 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. Evaluation will include review of required documentation (Program Plan and Summary Report) and may also include reviews 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. Preimplementation audits may be conducted after submission of the Summary Report. Evaluation will be in accordance with the requirements of Supplement 1 to NUREG-0737. Additional guidance for the evaluation is provided by NUREG-0700 and draft 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 should be done promptly.

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 and 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.

The Summary Report for the Limerick DCRDR was submitted June 25, 1984, by letter from J. S. Kemper to A. Schwencer. Information in the Summary Report, along with information obtained earlier, was used to evaluate the organization, process, and results of the DCRDR. The NRC was assisted in the evaluation by its consultants from Lawrence Livermore National Laboratory. Results of the evaluation are summarized below.

3. 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 Limerick DCRDR Summary Report states that the review team selected for the supplemental review of the Limerick DCRDR functioned, in general, as presented in the Program Plan. This Limerick team consisted of the following:

- o One Nuclear/IC Systems Engineer
- o One IC/Systems Engineer
- o One Operations Engineer/SRO
- o Two Human Factors Consultants

This core DCRDR team was supplemented as required by:

- o One IC Systems/Power Generation Engineer
- o One Asst. Operations Engineer/SRO
- o Two Shift Superintendents/SROs

The resumes for members of the Limerick team that were not included in the Program Plan were included in Appendix C of the Limerick DCRDR Summary Report.

The position of nuclear engineer was being filled by Team Leader, T. Cabrey. Limerick feels that his combined experience and training are appropriate for this position.

The Limerick DCRDR Summary Report states that all team members "were extensively involved in team deliberations and review of solution designs." The team met to develop criteria, establish procedures, and to review each phase of the supplementary DCRDR. Guidance was provided by the Interlock Group of human factors consultants.

Although details of the specific roles and contributions of each team member are vague in the Limerick Final Report, we conclude that each team member contributed to the DCRDR in their field of expertise.

Based upon this review of the Limerick DCRDR supplemental review team's qualifications, the LLNL review concludes that the proposed review team satisfies the requirement of Supplement 1 to NUREG-0737 to establish a multidisciplinary review team to conduct a DCRDR.

4. MANAGEMENT RESPONSIBILITY

NUREG-0700 guidelines state that support of the applicant's management is needed to ensure to the DCRDR team that information, equipment, and all categories of manpower needed to conduct a control room design review.

Although this support was not specified in the Limerick Summary Report, it appeared to the NRC audit team that Limerick management does support the DCRDR process.

5. DATA MANAGEMENT

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

Information and data management involves:

- o 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.

The Limerick Summary Report refers to all reference material required to conduct the supplementary review of the DCRDR as input data. This includes twelve categories such as systems descriptions, lists of acronyms and abbreviations, piping and instrumentation drawings, and panel arrangement drawings.

During the course of the DCRDR review process, documentation of findings, analysis, and results were developed. This documentation is referred to as output data. The standard forms that were developed are discussed and samples were provided in the Summary Report and are described below.

- HED Assessment forms were used to record the discrepancy items, panel locations, problem descriptions, possible solutions, resolution, priority by safety significance, schedule for implementation, and training/procedure requirements. Those forms that were partially filled out by the BWROG Survey Team were completed by an "analysis of each BWROG HED to ensure the nature of the discrepancy was understood."

- HED Significance Checklist forms were used for all HEDs not to be corrected prior to fuel load. "This form was completed by the assembled team, with each team member discussing his perspective of the factors on the checklist." Checks were placed after items considered significant, and finally, a "consensus of significance", with respect to the probability of the HED causing an operator error, was obtained and recorded.

- HED Verification forms, as included in the Program Plan, were used to review all resolved HEDs. The team used this form to concentrate on the adequacy of the resolution recorded on the HED Assessment form. This review considered human factors, engineering design, and safety requirements. It also considered the possibility of the resolution causing another problem either singly or in combination with another resolution.

- A sample of a Supplementary Operator Experience Questionnaire that was developed for the supplementary review was provided.

The Limerick DCRDR team made the decision not to implement the plan to cross reference HEDs by computer matching, as described in the NRC In-Progress Audit Report. Their justification for this change was that relationships between HEDs could be determined by the integrated nature of the redesign.

We conclude that the scope and depth of the data management system, as described in the Limerick Summary Report, demonstrates that the intent of NUREG-0700 guidelines have been met.

6. 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.

We recommend 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.

7. EQUIPMENT AND WORKSPACE

NUREG-0700 recommends that:

> Workspace requirements and equipment needs for the Review Team need to be considered during the planning phase. Office, storage, and meeting space should be provided for the Review Team and for any part-time consultants and specialists. Equipment needs (e.g., sound-level meters, light meters, and photographic equipment) should be determined, and plans made to obtain all necessary equipment before the design review is initiated. Thought should be given to the means by which alternative design improvements are evaluated. Where space is available, the use of mockups to accomplish this evaluation process should be considered.

Although not specifically described in the Limerick Summary Report, the NRC Audit Team observed that adequate clerical, reproduction, and other peripheral support services have been available to the DCRDR Review Team. We conclude that Limerick management has made the decision to meet the guidelines of NUREG-0700 for equipment and workspace throughout the complete DCRDR process.

8. 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.

As recommended by the NRC Audit Team, the Limerick Summary Report contains a description of the Supplemental Operator Experience Review and the Licensee Event Report Review.

The supplemental experience review was performed in a manner similar to the BWROG methodology. Fifteen operators of various experience levels were given updated questionnaires. Analysis of the questionnaire results has not been completed. Limerick stated in the Summary Report that they would supply a summary of the findings as a future supplement to the Summary Report.

Plant specific LER data from the Peach Bottom plant were reviewed for their applicability to the Limerick DCRDR effort. Emphasis was placed on LERs resulting from plant procedural/operational deficiencies such as updates in plant technical specifications; inadequacies in operator training; and inadequate or improper instrumentation. Of the 195 LERs reviewed, only 32 fell into one or more of the above categories. Included in the Limerick Summary Report is a one page LER summary.

LLNL recommends that the Limerick supplement to the Summary Report should include a summary of the major results from the document review and operator interviews that states how the results were applied to the DCRDR. The NRC should also be apprised 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.

9. 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.

Operator information and control needs must be determined independently from existing CR design, and not be influenced by existing equipment.

The Limerick Summary Report states that an "undocumented" task analysis was used to verify that emergency operating procedures could be implemented from the control room. They do not report any general or specific method or data collection technique to be employed or specific variables to be included. The report states that a follow-up task analysis will be performed. However, PECo does not specify a time, date or milestone plan for execution. Furthermore, their statements that a "team approach" will be utilized tells us absolutely nothing about the method they will use.

Based upon this review and critique, the utility should be asked to provide a satisfactory response to a request for a detailed implementation plan of execution for the task analysis which includes the following:

A. Method to be used (step-by-step and complete)

B. Start and completion dates

C. Data (detailed) to be collected and rationale for each data element

D. Qualifications of the HFE or Task Analysis Expert performing the analysis

E. Provide a definition (operational) for "their" task analysis.

This minimum response would allow NRC to assess the scope, depth, utility, and degree of safety related importance or quality of the analysis. It would also ensure that the analysis could be examined from the point of view that it is independent and unbiased with respect to hardware already in place, e.g., that the hardware does not create the mission objectives and functional requirements.

10. 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.

Since the Limerick Summary Report so indicated that the task analysis has not been completed, it is unlikely that a top down analysis of sufficient depth and scope was developed to determine the extent of missing controls/displays. The performance/execution of the task/systems functions analysis, which is specific to Limerick, should generate control requirements needed for the inventory comparisons which have not been made. The Limerick Summary Report is presently deficient in meeting the requirements of NUREG-0737, dealing with these inventory comparisons.

11. 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.

As stated in the Limerick Summary Report, a supplemental CRS was done using checklists developed by the BWROG in order to update and complete the existing survey data generated during the initial CRS. The survey process included the following:

- Panels installed after the BWROG survey were evaluated against the initial and supplemental BWROG checklists.

- o Panels which had undergone design changes since the initial survey were reviewed to determine if the changes affected any of the initial HED results.

- o All panels were evaluated using the BWROG supplemental checklists.

All HEDs from the BWROG CRS and from the supplementary review were recorded on the HED Assessment forms. These forms provided accountability and format for managing each HED. The total number of HED Assessment sheets in the Summary Report is 163.

An independent review of human engineering suitability of the control room panels was performed by the Interlock human factors personnel. Items not conforming to general human suitability guidelines were identified as discrepancies and transferred to the HED Assessment forms.

It was stated in the Limerick Summary Report that a full-scale Unit 1 and Common Panel plant specific mockup was constructed. In evaluating the report, it was difficult to determine if this was in fact done. If so, was the mockup used to test and evaluate HED corrections and to verify that no new HEDs will be introduced by the design changes?

The Audit Team concluded that the Limerick control room survey is incomplete, but appears to have been executed with reasonable diligence and was adequately documented. The CRS has defined HEDs, and thus will meet the intent of NUREG-0700 guidelines and respond to the requirements of Supplement 1 to NUREG-0737.

12. 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.

Selection of Corrective Actions and Significance located on page 1-16 of the Limerick Plant CRDR Summary Report states that "HEDs not to be corrected prior to fuel load were subjected to an assessment of significance and safety implications and were assigned a priority as defined in the program plan." Unfortunately, there is no adequate description of the method used to assess the significance and safety implications of the HEDs unless the document is referring to a checklist found on page 1-17 and a rating purporting to subjectively measure the probability of a particular HED causing an operator error (page 1-18). If this checklist constitutes the "method" and the rating scale constitutes the "metric", we have the following comments to make:

1. While a checklist approach is fine, the specific checklist used is inadequate in terms of its total specific content and indicates a lack of knowledge concerning the development, utilization and limitations of this device (checklist) and method.

2. The checklist statements themselves are ambiguous, not behaviorally anchored and are, at best, oblique. For example, under the heading "Reduction of Effectiveness of the Operator's Body and Mind," they present categories of rating such as undue fatigue and discomfort. These items are inadequately defined. What is needed is a great deal more specificity in content and definition, and fewer generic high level statements which create inadequate specificity. To amplify and illustrate; How do they operationally define "undue" or "fatigue"?, the rater would have to read the mind of the individual who constructed the checklist to find out.

3. The approach taken by the Limerick document defines an HED priority based more upon difficulty/cost of implementation rather than on safety significance. This approach is unacceptable and incongruent with Element 5 of NUREG-0737. Safety significance potential should first be determined for categories of HEDs and then be followed with implementation considerations such as time cost, scheduling, feasibility, difficulty. We conclude that more detail is needed to describe the step by step process used to assess HEDs in order to determine if the intent of NUREG-0737 is being met.

13. 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.

The Limerick Summary Report has failed to provide an ample description of any "method" employed in the selection of improvements. It would be sufficient to ask for a series of stepped examples of how they accomplished this facet of 0737, and describe the criteria they employed in making or arriving at their conclusions. A simple description which provides a clear picture of the method and criteria would be sufficient. It is further suggested that any and all safety related HEDs delayed for corrective action until after fuel loading be justified in writing by the utility stating the reason for the delay and providing a specific date as to when the HED will be corrected and the milestone schedule.

14. IMPLEMENTATION

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

An implementation schedule that includes each verified improvement should be prepared. The schedule should address completed improvements (generally, surface enhancements), improvements which can be made without interference with plant operations, and improvements which can only be made when the plant is not operating. Delays in accomplishing the implementation of any design improvement should be justified. Provision should be made to obtain feedback on how the improvements are working out in practice. Procedures should be established to ensure that the documentation of implemented design improvements extends to the updating of operating procedures, drawings, and training programs.

This component was omitted. Specific dates and schedules were not listed in the Limerick Summary Report.

The Audit Team expected 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 provided for all noncompleted HED corrective actions. PECo should provide justifications for all HEDs not corrected or partially corrected. It is recommended 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.

15. VERIFICATION OF DESIGN IMPROVEMENTS

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

For all of the HEDs listed and identified in the Limerick Summary Report, no section was provided to explain or delineate the verification of "improvements" or corrective action. Specifically, the report does not comply with NUREG-0737 in providing verification that selected design improvements will provide the necessary or adequate correction needed. In addition, there was no formally documented method as to how or when the utility will verify that the "improvements" will be examined to prevent the unintentional introduction of new HEDs. Perhaps they plan to use the "walk-through" method. If this is the case, they need to specify what criteria and or trade-off considerations they will use, the way they are using these criteria, and how and when they will use them. As the report stands now on this issue, we find it to be inadequate technically, and vague to the point of raising more questions then it was supposed to answer originally.

16. 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.

The HED Verification form (page 1-24) has two checklist elements which read:

1. Causes another discrepancy?
2. Adversely combines with other resolutions?

The Limerick Summary Report does not map out, in sufficient detail, how or what method was used to determine an adequate response to these and other items. What criteria was used? How did they go about making this decision? What factors were included in this "analysis"? How was the decision made to determine that the corrective solution to one HED did not itself infuse another, perhaps more serious HED? The text does not elaborate to the degree necessary to track what was actually done or the method actually employed. As presently written, the Summary Report does not meet the intent of NUREG-0737, Supplement 1.

17. 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).

The Limerick Summary Report does not provide an adequate description of the method used to coordinate changes from other programs. Hence, it is impossible to state whether this item was satisfactorily addressed.

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:

- o Emergency Operating Procedures,
- o Accident Monitoring Instrumentation - R.G. 1.97,
- o Safety Parameter Display System,
- o Emergency Response Facilities,
- o 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 Summary Report does not describe the specific details or methodology of how the coordination was 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 Corporation via normal construction and installation processes.

18. CONCLUSIONS

The following items in the Limerick Summary Report have been reviewed and found to be inadequate with the intent of Supplement 1 to NUREG-0737:

1. Limerick committed to perform a detailed task analysis. The plant specific task analysis proposed to identify control room operator tasks and information/control requirements for emergency operations should contain a complete description of the method, data, and documentation.

2. Since the plant specific task analysis was not performed, an adequate comparison of display/control requirements with existing control room inventory was not made.

3. The method utilized to assess HED significance was insufficiently detailed and explained. The checklist of significance was found to be inadequate in content for use on a plant specific basis. In many instances, HEDs identified as highly significant by the BWROG method were considered to be relatively unimportant/significant in the Limerick Summary Report.

4. The specific process used to verify that selected design improvements will provide necessary correction was inadequately explained in the Limerick Summary Report. In this regard, the report lacks specificity and detail.

5. That portion of the Limerick Summary Report which was supposed to address the process whereby new design improvements would be verified not to introduce new HEDs was inadequate. To say that this will be accomplished via "walk-throughs" is sufficiently vague to require more information. We cannot determine whether the requirements of NUREG-0737 are being met.

6. 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).

The Limerick Summary Report does not provide an adequate description of the method used to coordinate changes from other programs. Hence, it is impossible to state whether this item was satisfactorily addressed.

The following items have been reviewed and found to be consistent and compliant with the intent and content of Supplement 1 to NUREG-0737.

1. The Limerick Summary Report adequately establishes the multidisciplinary Review Team members.

2. The Limerick Summary Report indicates that the control room survey utilized to identify deviations from accepted human factors

principles was satisfactorily executed, but was incomplete. (See Appendix A, Parts A and B.)

19. CONCLUSION SUPPLEMENT AND MODIFICATION

As a direct result of the initial findings (Sections 9-17) and subsequent conclusions (Section 18), a meeting was scheduled and held on August 7-9, 1984. The objective of the meeting and subsequent audit was to resolve issues based upon the TER conclusions generated by LLNL concerning the Limerick Summary Report. Representatives from PECo, LLNL, NRC, and Interlock initially met in Bethesda on August 7, 1984, and the audit took place at Limerick on August 8 and 9, 1984. The following issues were addressed with the corresponding resolution:

1. Systems Function and Task Analysis (Section 9)

   PECo and Interlock representatives verbally agreed and committed to supply a detailed task analysis method, operational definition, data to be collected and rationale for each data element inclusion to NRC along with the completed analysis no later than June 30, 1985.

2. Control Room Inventory (Section 10)

   At the present time, the control room inventory and comparisons between functions and equipment had not been completed. PECo and Interlock representatives verbally agreed and committed to successfully execute this task as stated in NUREG-0737 and in a manner described in NUREG-0700 by June 30, 1985.

3. Control Room Survey (Section 11)

   While the present control room survey of Limerick is incomplete; both PECo and Interlock representatives agreed to complete the survey and implement all improvements of safety related HEDs before October 31, 1984, with the exception of the HFE evaluation of the SPDS. The SPDS evaluation will be conducted before fuel loading.

4. Assessment of HEDs

Because of our findings listed on page 14 of this report and the conclusions generated (page 18, item 3), we asked Interlock and PECo to verbally describe the method and process used to assess each HED. They executed this verbal description to us in a manner which indicated minimal compliance with NUREG-0737 and additionally provided written documentation to support their verbal descriptions. This evidence is to be found in Appendix B of this report.

5. Selection and Verification of Design Improvements (Sections 13 and 15)

Since the Limerick Summary Report was initially found to be deficient in providing a traceable method utilized to identify design improvements, PECo was asked to provide verbal stepped examples of this process and a written general methodology which they did to our satisfaction. Mockups were used to test and evaluate HED corrections and verify no new HEDs. We now conclude that the materials included in Appendix B along with the audit/evaluation and verbal explanations we received indicate adequate compliance with NUREG-0737, Supplement 1, regarding the selection and verification of design improvements.

6. Verification that No New HED Created

Originally, the Limerick Summary Report did not adequately detail the method or process used to verify that design enhancements used to correct one HED would not itself create or infuse a new or different HED. As a result of discussions held on August 7-9 and the review of additional supplementary information provided in Appendix B, LLNL concludes that adequate verification was obtained to meet the intent of NUREG-0737, Supplement 1.

7. Coordination of Control Room Improvements with Other Programs (Section 17)

No significant change in status (see page 17, Section 17 and page 18, item 6). LLNL recommends that PECo provide NRC with a detailed description of how the coordination process and method will be executed.

20. APPENDIX A

Part A

This part contains HEDs identified by the NRC Audit Team during the in-progress audit that have not been resolved due to the construction in the control room. 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 any discrepancy which is not corrected.

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.

1.3 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.

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 unneeded 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)

Part B

This part contains a list of HEDs taken from Limerick's Summary Report. It is arranged in HED number order and is made up of 38 HEDs that needed some clarification of the proposed schedule. In general, LLNL agrees with the resolution of these HEDs, but any schedule for implementing the corrective actions after fuel load should be justified 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.

HED No.	EP	Schedule	Remarks
A1-01	4	F.L.	Will the resolution as stated be done on all annunciator panels by fuel load?
A1-02	4	2nd R.O.	What is the justification for the 2nd R.O. and what is the interim proposal?
A1-03	4	Coord. with Ann. Impr.	The general discussion is vague and seem to imply that this schedule can mean from F.L. to not at all. Any delay after F.L. should be justified to the NRC.

HED No.	EP	Schedule	Remarks
A1-04	4	Coord. with Ann. Impr.	See A1-03
A1-06	6	Coord. with Ann. Impr.	See A1-03
A1-07	6	Coord. with Ann. Impr.	See A1-03
A1-08	6	Coord. with Ann. Impr.	See A1-03
A1-13	12	1st R.O.	Licensee should justify to the NRC any delay after F.L.
SA2-02	6	Coord. with Ann. Impr.	See A1-03
D2-05	6	Before Criticality	The staff agrees with the resolution, but licensee should justify why not by F.L.
D3-05	6	Various	There are five parts to this HED. Any delay after F.L. should be justified.
D3-06	9	1st R.O.	See D3-05d
SD2-03	None	1st R.O.	See D3-05d
SD3-04	None	1st R.O.	See A1-13
SD3-06	None	N/A	See A1-13
SD3-07	None	1st R.O.	Is there any interim schedule? Any delay after F.L. should be justified to NRC.
SD3-14	6	N/A	When will the HED be scheduled? Any delay after F.L. should be justified to NRC.
SD3-16	6	N/A	See A1-13
SD4-03	6	1st R.O.	See A1-13
I2-04	6	N/A	See A1-13
I2-06	4	1st R.O.	See A1-13
I2-08	4	Various	See D3-05

HED No.	EP	Schedule	Remarks
I2-12	6	Various	See D3-05
I5-01	6	Various	See D3-05
I5-03	6	Various	See D3-05
I5-06	6	1st R.O.	See A1-13
I5-10	8	1st R.O.	See A1-13
I5-11	4	1st R.O.	See A1-13
SI1-01	6	1st R.O.	See A1-13
SI2-10	8	1st R.O.	See A1-13
SI4-04	6	1st R.O.	See A1-13
SI5-08	6	1st R.O.	See A1-13
SI6-01	9	1st R.O.	See A1-13
A1-11	3	None	Resolution and schedule needs to be approved by NRC.
I5-04	9	None	See A1-11
SI2-04	6	None	See A1-11
SD3-15	9	None	See A1-11

21. APPENDIX B

THE INTERLOCK GROUP

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14 August 1984

Mr. William W. Banks
Human Factors Engineering L-97
Lawrence Livermore National Laboratory
University of California
Livermore, California 94550

Subject: Methodology used in Performing the Limerick Nuclear Power Station CRDR

Reference: NRC visit to Limerick, 9 August 1984

Dear Bill:

Again, let me express our appreciation for the professional manner in which you carried out your assigned task in the referenced meeting.

As promised, I am forwarding the subject documentation for your files.

Sincerely,

Joe Breslin

Joseph A. Breslin
President

JAB/jrb

Enclosure

METHODOLOGY USED IN PERFORMING THE LIMERICK CRDR

Review Phase

This portion of the CRDR continued the Control Room Survey that was performed by the Boiling Water Reactor Owner's Group (BWROG) as described in the Program Plan. This amplifies the Final Report to describe in more detail the methodology used in completing the CRDR.

The attached flow diagram (Attachment 1) illustrates the sequence of events as they were conducted and the more significant interrelationships among those events. The following paragraphs describe the methodology used in each of the activities shown on the flow diagram.

BWROG HEDs

An initial Control Room Survey (CRS) was conducted by the Boiling Water Reactor Owner's Group (BWROG) in 1982. The methodology used and extent of the coverage was discussed in the Program Plan.

TOP-DOWN ANALYSIS

In order to maintain continuity between the BWROG Control Room Survey and the completion process, it was necessary to investigate each listed HED from the BWROG survey. In addition, it was desired to provide an overall check that the initial survey was complete in coverage. Therefore, a top-down analysis of the control room panels was performed. A panel-by-panel analysis was conducted by identifying instruments by functional groups and blocking in the groups using arbitrary color codes so that group relationships could be clearly understood. Where the groups were difficult to relate, or were spread out and intermixed, additional analyses were performed to show functional flow among controls and indicators. In the process of performing these analyses, it was necessary to consult piping and instrumentation diagrams (P&ID), and in many cases develop schematic diagrams in order to understand the purpose of installed controls and indicators. The top-down analysis was performed by human factors specialists who also have experience in operation of nuclear power plants and have experience in conducting previous CRDRs on other plants.

This process provided the ideal vehicle for identifying most of the BWROG discrepancies. This information was used to further identify and in some cases expand on the initial identification of the discrepancy. The analysis served to place the discrepancies in context and allowed a better understanding of the interrelational problems that existed on the panels. In addition, it revealed additional discrepancies.

SUPPLEMENTAL SURVEY

The BWROG Control Room Survey (CRS) was conducted in 1982, and some changes had been made to the panels since that time. In addition, because of the state of construction of the Limerick plant, some aspects could not be surveyed in 1982. Therefore, supplemental surveys were conducted to fill these gaps. The methodology used is discussed in the Final Report. This survey resulted in additional HEDs.

SUPPLEMENTAL EXPERIENCE REVIEW

Again, the period of time that had elapsed between the initial survey and the completion of the CRDR resulted in additional experience by operators with the control room as well as operating experience on similar plants, particularly on the Peach Bottom plant. The methodology used in performing these supplemental experience surveys is discussed in the final report.

HED ASSESSMENT FORMS

The results of the owner's group survey of the Limerick plant, conducted in 1982, was a report containing a summary of discrepancies. These were generally listed in single sentence descriptions of each discrepancy or, in some cases, groups of discrepancies. In many cases the exact nature of the discrepancy was not clear without further investigation. Therefore, it was necessary to elaborate on the nature of the discrepancy and to put each in a format that would allow further processing and analysis. Therefore, each BWROG discrepancy was converted to a HED Assessment form as shown in the Final Report, Figure 1-1. Additional information developed in the Top-Down Analysis was added to the information provided by the owner's group survey. Discrepancies discovered during Supplemental Surveys and Supplemenal Experience Reviews was recorded directly on the HED Assessment forms. A complete accounting of all discrepancies was then compiled in the HED Assessment format. Most important, these HEDs were understood in the context of the existing panel arrangements as well as being individually understood.

The initial intention was to correct most of the discrepancies, without regard to priority, prior to fuel load on this NTOL plant. For this reason, actual determination of priority of HEDs was delayed and the design of corrections was started immediately. With this exception of the order in which the determination of HED significance and assignment of Priority with respect to safety significance was determined, the methodology described in NUREG 0700, sections 4.2 and 4.3 were followed exactly. Further description of the methodology of assessment of priority is provided later in this explanation.

Until this point, most of the work was performed by the human factors consultants who have expertise in both nuclear plant operation and human factors.

ASSIGNMENT OF HEDS

Experience in conducting CRDRs on other plants made it clear that initial HED assignment to correction catagories can be inaccurate because it is difficult in many cases to predict how the discrepancy will finally be corrected. Therefore, HEDs were divided into only three catagories: (1) those that would be corrected by enhancements, (2) those that represented a class of problems that would have corrections designed as a group, and (3) those that represented seemingly unique problems that must be resolved individually. The HEDs were then assigned to catagories labeled: Enhancements, Class, and Indivdual.

Assessment and Implementation Phase

HF BRIEF

With the commencement of the assessment and correction phase, the CRDR core team was assembled for the first time. The first session provided a human factors briefing for the team. This briefing was conducted by the human factors consultants and provided for discussion and interaction with the team. Discussions were encouraged and the team discussed specific examples of principles being presented that related to the Limerick and Peach Bottom plants. The reactions of the team to this briefing were considered to be very satisfactory and provided a sound basis for continued cooperative efforts. Attachment 2 is a copy of the briefing outline as actually given.

CRITERIA

The first step in the entire correction process was to have the team define the criteria for the redesign of the control room. This criteria was developed interactively with the team, led by the human factors consultants, and was agreed to by the whole team. The attached summary of criteria (Attachment 3) is labeled Enhancement Criteria because it was first discussed with the team in relation to commencing the enhancement effort. Nevertheless, the criteria represented the basis for the entire correction effort for Class and Individual HEDs as well as enhancements.

PANEL DESIGN AND IMPROVEMENT

Because the enhancement effort commenced first, and consisted of a major revision to the layout and appearance of the control room, it set the context in which all other changes in response to HEDs would be made. The redesign of the control room proceeded directly from the Top-down Analysis conducted in the first step described in this discussion.

After the team agreed on the design criteria as just described, it was agreed to develop a sample design for one section of control panels. This design was developed by the human factors consultants. It was based upon the human factors criteria provided by NUREG 0700 and conformed to the criteria developed by the team. The process of design included an indepth analysis of the purpose of each control and indication on the panel as well as the system configuration.

In order to prepare for this detailed effort, the human factors design team was given a two day tutorial by the Limerick training department. This served to ground the designers very well in the operating and systems design philosophy of the Limerick plant. The personnel used in this redesigned effort are persons experienced in human factors design and in nuclear power plant operation.

In the process of training instruction, it was found that the overall system diagrams used in training had system layouts that, although correct, did not conform well to the arrangement of systems on the control room panels. Therefore, the first step of redesign was to develop an overall system arrangement schematic that conformed with the actual panel layouts of the control room. It included the valves and machinery controlled from the control room. This served as a basis for grouping controls and instruments and for the development and redesign of mimics on the panels. By redesigning, using an approach that was integrated by the overall system layout, there is an understandable continuity of mimics and control layouts throughout the control room. Attachments 4 and 5 are copies of the before and after integrated system diagrams.

The initial panel enhancement redesign consisted of not only enhancements, but suggested physical changes that involved moving controls and indicators as necessary to better group functions and allow the addition of effective mimics. The redesign also included a complete revision of all labels on the panels to provide reduced wording by the use of hierarchial labeling and a consistent set of terminology. The terminology was prepared from a list of standard names and abbreviations developed by Limerick operations for use in emergency procedures, and was modified to include additional terms and suggest revisions to some entries. The new terminology list (Attachment 6) was prepared as a manual entitled Nomenclature for Control Room (Proposed). This manual was kept updated through the redesign effort.

Extensive use was made of available reference data such as original panel prints, label data, and P&IDs. This data was augmented by a photo mosaic prepared to support analysis and preparation of the full scale mockup. In addition to available data, it was necessary to visit the control room to make additional lists of instrument identification and nomenclature.

The CRDR team, augmented by additional operationally experience personnel, reviewed the initial redesign in great detail. Each control and indication label was reviewed as well as the grouping and relationships. Colors were assigned by general systems and were used to help related functions on the panels.

The team made on the spot revisions, and talked through the conventions used in order to set the methods to be used for all panels. To ensure acceptance at all levels of Philadelphia Electric Company, the panel redesign for the initial panels was implemented on a full scale mockup being constructed by the human factors consultants for review by higher management. Approval was obtained from the company president. Redesign drawings in color were then prepared for all pertinent control room panels.

REVIEW/APPROVE

Panel designs were submitted serially for review by team members. These designs were submitted to team members individually with time to carefully review all details and make written comments. Additional reviews of these drawings were made by design engineers and plant operators, where considered necessary, to ensure accuracy and acceptability. These efforts were coordinated by the CRDR team leader and comments were provided in detail to the human factors consultants for review and implementation. These comments were given to the consultants as suggested changes to be implemented based upon good human factors practices. Where the consultants considered the suggested change to be inappropriate, the item was discussed with the team leader and acceptable solutions were agreed upon. Where necessary, the person originating the comment, as well as other experts were consulted. All agreed upon changes were then incorporated into the redesign.

CLASS IMPROVEMENT DESIGN

All HEDs assigned to class improvements were further arranged in improvement groups so that similar improvements could be designed as a class. The methodology for analysis of design alternatives described in section 4.2.2.2 of NUREG 0700 was used. As suggested in that methodology, the human factors consultants analyzed all HEDs and prepared recommended resolutions to discrepancies. Each resolution was reviewed for compliance with the human factors criteria in NUREG 0700. Designs were integrated with the panel redesigns being developed under the enhancement effort. Not all recommended resolutions conformed to all human factors criteria because compromises sometimes had to be made to fit with other design requirements as well as the correction of other HEDs. Very often separation criteria for safety systems prevented full compliance with all human factors criteria. Where all criteria could not be met, the factors were pointed out to the team during the review of resolutions discussed later. Where the ideal resolutions for different HEDs resulted in conflict, the best overall arrangement was developed based upon the panel design revision drawings in a manner that best suited the needs of the operator. In such cases, the needs of the operator were verified with team members having actual operating experience.

The panel redesign drawings thus became much more than enhancement drawings. They represented the integrating factor for all design improvements. This was true whether or not the actual proposed solution to a HED discrepancy appeared on the improvement drawing. The drawing still set the context and standards for the design.

The design of HED resolutions usually required extensive technical investigation and team analysis. This was accomplished by many visits to the control room to identify design details, and referral to the engineering staff for additional design information and review. Often, a functional analysis was conducted by members of the team using operational experience to analyze the specific use and sequence of events in the use of the discrepancies being investigated. To coordinate these investigations, an action item tickler system was developed and maintained on the computer by the consultants to ensure timely follow-up and resolution of technical questions.

Extensive status lists and cross-reference lists were maintained on the computer to keep track of HED resolutions and to coordinate their completion. A cross-reference list tied HEDs in correction catagories to panels so that all HEDs pertaining to each panel could be reviewed for consistency.

The overall effect of this integrated approach to HED resolution design was an effective method of ensuring that the resolution of any HED did not conflict with other resolutions, and that they did not create new discrepancies.

INDIVIDUAL IMPROVEMENT DESIGN

The design of resolution to HEDs that represented a unique problem, not directly related to other HEDs, was performed in exactly the same way as for Class designs. All design changes from both individual HEDs and Class HEDs that could be represented on the mockup were (are being) included on the mockup.

REVIEW HED RESOLUTIONS

When proposed resolutions had been developed, the CRDR team met to review resolution and to designate the approved resolution. This was by no means a perfunctory approval. Each HED was thoroughly reviewed and discussed. At this time the relationship of the proposed resolution was considered with respect to other resolutions and the overall panel design. Members were by this time thoroughly familiar with the panel redesign plans and most HED resolution efforts. This enabled design consideration to be discussed from many points of view. In many cases, the resolution was revised to meet new requirements that were not known to the consultants when designing the proposed resolution. In some cases, the proposed resolution was found to cause new problems and was revised to ensure compatibility. For some, additional technical information was required. These discussions were led by the human factors consultants, but were by no means dominated by them. All members of the team represented decision making levels in their area of expertise so that decisions by the team could be considered to be grounds for proceeding with preparation for implementation.

A technique of assigning resolution codes imposed a discipline on the team. These ensured that the degree of compliance with the human factors guidelines in NUREG 0700 was understood by all members. These codes are defined in the Final Report, Table 1-3. Codes suggested by the consultants were reviewed for each HED, and for each item within a HED where required, and verified or changed. Changes were frequently made to more accurately identify the degree of compliance. Where compliance was not complete, the rational for deviation was addressed in the resolution. This ensured that the team was completely aware of any deviations from human factors guidelines and understood the reasons for deviation.

The main emphasis of this review was to ensure that the HED resolution solved the identified problem and that it did not create a new HED. During this review, the team also identified any special additional requirements that existed for training or operational procedures. Only special requirements were listed since it was initially presented that all changes to the panels and components must be identified to the operators through a special training session. This review resulted in being a major step toward the verifiction required by Supplement 1 to NUREG 0737.

SIGNIFICANCE/PRIORITY/SCHEDULE

The team then met to determine the significance of the HEDs, and to assign a priority with respect to safety, and finally, to assign a schedule for completion. All HEDs that would be implemented in the control room prior to fuel load were exempted from this process. The methodology described in NUREG 0801, section 4.2 was followed. Exhibits 4-1 and 4-2 in that document were reorganized for better team understanding and a discription of the process to be used by the team was given to the team prior to starting the process. Attachment 7 is a copy of this instruction The items were discussed among team members and the procedure explained. Then a trial use of the HED significance list was used and the process was further discussed until all members understood the methodology.

The HED Significance list is shown in the final report as Figure 1-2. It is a condensation of the explanation provided to the team and was used as a reminder list. Team members referred to the more detailed list as necessary. The method used was to have each member review the statement of the HED discrepancy, and then independently review the significance list to identify which factors applied to that discrepancy. Each member presented his own point of view. Then the team discussed the items suggested by each member in turn. The reasons for selecting the applicable items from the list were explained and discussed by the team. Much give and take was involved in these discussions. The recorder completed a list by checking those items that were agreed upon by the team, however, no items were omitted that any member felt should be included. With this agreement on the human factors involved, the team then discussed and agreed by consensus as to an overall statement of the significance of the HED. This was indicated on a significance scale of 1 to 5. This was an agreed upon subjective estimation by the team of experts. The term probablity was meant in the normal English sense, not as a statistical probability.

The owner's group provided an Evaluation Product (EP) in their survey format. This EP is noted on the HED Assessment sheet for each HED that was originated by the BWROG. The methodology for development of the EP is explained in the BWROG Development and Methodology description and the appropriate part is Attachment 8. The method used to get the EP was generic in nature and did not necessarily apply to the specific HED discrepancies found at the Limerick plant. The team noted when the EP differed from it's own estimation of the significance level and discussed the difference. The assigned significance level in all cases considered the EP. At the time the significance level was determined the team had a great deal of knowledge of each HED and therefore was qualified to determine the level for that specific discrepancy.

Then, refering to a list of safety related systems and other criteria, again used as a reference list, the team considered the safety significance of that HED. This list is Attachment 9. Finally, the team considered the definitions of priorities with respect to safety as listed in Table 1-2 of the Final Report (Attachment 10). The first two priorities are safety related and are taken from section 4.2.2 of NUREG 0801. The Priority 1 definition is a summary of catagories IA,B,C, IIA, AND III. This catagory pertains to HEDs that should be corrected as soon as possible. Priority 2 summarizes catagories ID, IIB,C and pertains to HEDs that should be corrected by the next refueling outage. Priority 3 are HEDs that are not safety significant, but could result in reduced operational reliability. Priority 4 are HEDs that would not result in significant improvement and may or may not be corrected. The selection of a priority was first done in the same manner as the selection of the significance levels. Each member made his own decision based upon his particular expertise, then the team discussed the selections thoroughly and arrived at a consensus.

VERIFICATION

Finally, a verification of each HED was performed by the team. This consisted of joint discussion of each item of the HED verification checklist shown in Figure 1-3 of the Final Report. Each item on the checklist was discussed individually by the team, using their individual expert knowledge, and then arriving at a decision on each item as either satisfactory, or requiring some revision. If revision was required, revisions were made immediately if possible. This checklist procedure resulted in many revisions to the various aspects of HEDs considered. These checklists were completed for all HEDs. Reference was made to supporting data and panel designs as necessary. Item 5 specifically considered compounding effects with other HEDs and the possibility of creating a new HED with the resolution chosen, as required by NUREG 0737, Supplement 1.

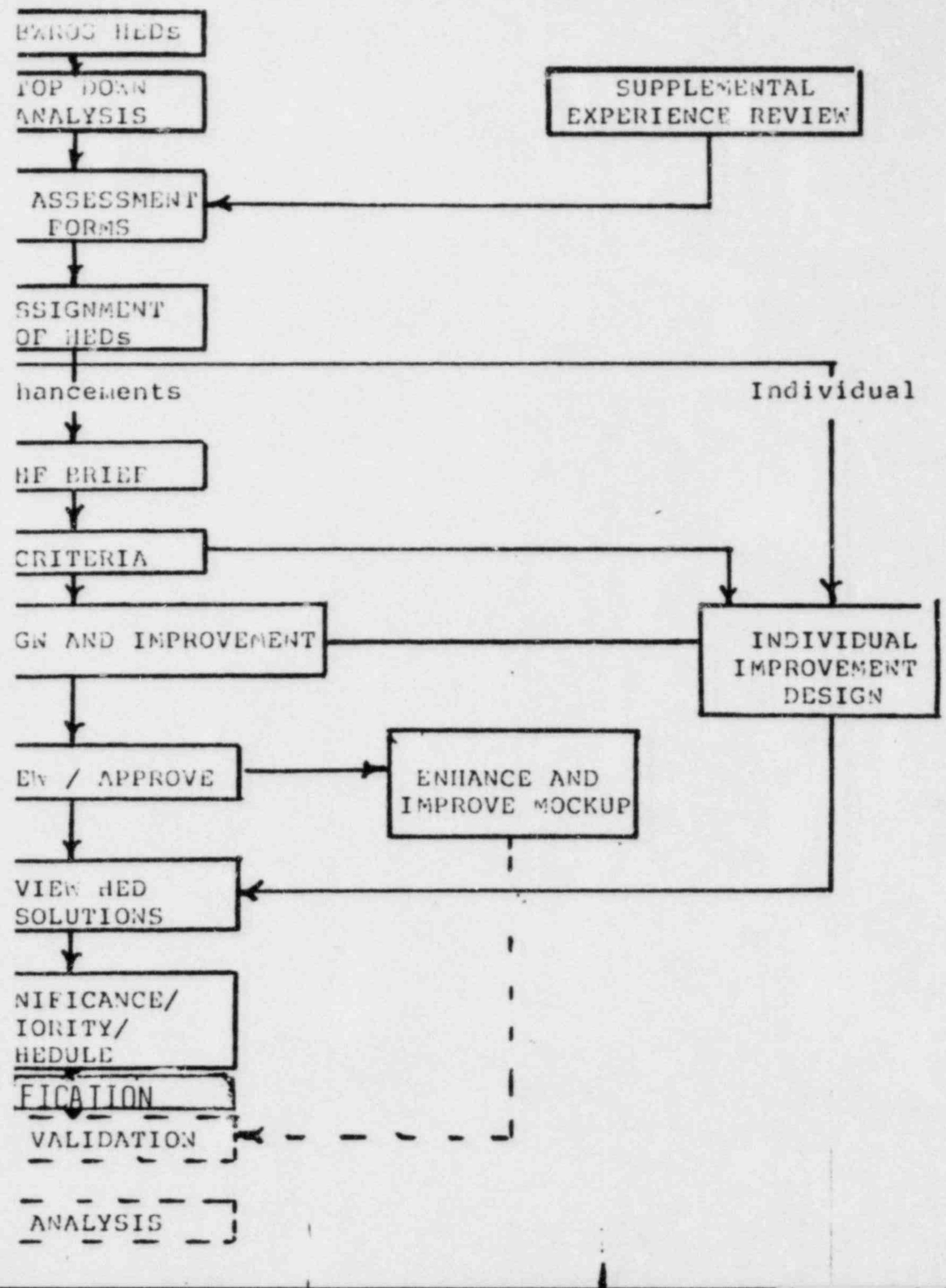
FINAL VALIDATION

The final validation will be accomplished as a walkthrough by a team of operators on the completed mockup in the final intended configuration. The methodology described in NUREG 0700 for validation walkthroughs will be used. A discription of the methodology will be provided with the report of the validation results. This validation will be the last step in the process of verifying that HED resolutions satisfactorily resolve the discrepancies and that they do not conflict with other resolutions or cause new HEDs. This validation will also address the integration of other initiatives of NUREG 0737.

TASK ANALYSIS

A task analysis will be performed as agreed with the NRC and the methodology will follow that described in NUREG 0700. It will be described with the report of the task analysis and verification.

ICS CRDR PROCESS



HUMAN FACTORS BRIEFING

INTRODUCTION

Cain Mutiny - geniouses...................... idiots

In training - very smart people.............. difficult

Design philosophy - plant protects itself....... cookbook

HOW IT HAPPENS NOW

Engineering integration
- control interface
- Correct problems

People side
- CR designed by engineers
- Meet system requirements
- Training - from basic data
- Schematics - from draftsmen

Operator input:
Problems .. experience - op requirements
Personal preferance * conflicting
What they are used to
Constrained input - whats possible

MENTAL WORKLOAD

Collect - what, finding, reading, remembering

Collate - organize, compare, convert, calculate
recall requirements, plot

Analyze
- Deduce system status alignment
- Determine cause of problem
- Determine action

NEED to be TIED TOGETHER

Make the most of what we have

Easy to learn - easy to remember - easy to operate

Thinking in patterns

Schematics
- training schematics *
- panel layout
- actial plant layout

Enhance panels
- emphasize patterns
- mimics as reminders
- relate instruments - functions

Guide eye to right place

Annunciator - patterns many alarms

ATTCH 2

SPECIFICS

Labeling - name leap out   key word
- distractions   words   numbers
- hierarchy labeling

Color - relate functions

Logic - operator logic - engineer logic
- functional - symetrical
- functional - esthetic beauty
- operation - not - conventional appearacne

Meters - easy to use   scales, numbers, bands, key points

INTEGRATING

Spread out   no central location
Team work
Second source   backup   whole picture
CRT   really tie together   not just helpful

Schematics, patterns, labeling, CRT

ENHANCEMENT CRITERIA

This suggested criteria has been prepared for team review and comment. It is intended as a talking paper from which the team can then settle upon the criteria that will be used.

DESIGN OBJECTIVE

The object of any improvement designs is to help the operator. However, each operator represents a different set of characteristics in terms of knowledge, skills, and experience. Therefore it is necessary to define a specific operator that will be the object of design.

Criteria:

From the point of view of safety, the panels must be designed for the least experienced person who will ever be performing operations in the control room.

[Application:

As a minimum, the panels must be designed for:

a. A licensed operator
b. The least experienced possible operator
c. Longest period of elapsed time between being licensed and standing first shift as operator.

It may be desirable to give some consideration to operator trainees. Since there must be a constant flow of new licensed operators, additional information might be included on the board that will aid trainees. This must be limited in order to avoid cluttering the board.]

ENHANCEMENT COVERAGE

While no particular enhancement can be said to directly effect plant safety, the total ease of operation of the control room can have a significant effect on the errors and omission of the operator, and upon his cognitive workload in high stress emergency operations. The identification and correlation of information can directly effect the cognitive workload and therefore the operator's decision making.

Criteria:

1. Safety: Those functions performed under high stress emergency conditions should be supported by panel enhancements that reduce the cognitive workload of the operator.

2. Reliability: Those functions performed under less stressful conditions but could result in degraded plant performance should be enhanced.

ATTCH 3

3. Deliberate Operation: These functions that are performed only under no stress, as deliberate actions do not need enhancement.

PANEL TERMINOLOGY

Terminology refers to the words used on labels and as legends on windows on the panel. The same terminology selected for the panels must be used in the operating procedures.

Criteria:

1. Clarity: The words used must clearly indicate the component and function involved.

2. Meaningful: The words used must be meaningful to the operator without interpretation: they should not be in code.

3. Simplicity: Use as few words as possible consistent with 1 and 2 above.

4. Spoken clarity: Operators must use the terminology in communications, particularly during noisy, high stress periods of emergency operations. The words selected must not be easily confused under these conditions.

5. Operators use names rather than component ID numbers when communicating during emergency operations.

[Application: (Numbers correspond to criteria)

1. There must be enough words to identify a unique system, component, and/or function.

2. The m ning of the word should be easily understood by the operator wi ut interpretation. This means that English words are much pr red to acronyms. An acronym is a code that must be memorized and recalled. An English word is native to the operator's's understanding. Abbreviations should easily suggest the English word being abbreviated.

3. To aid the operator in reading labels and legends quickly, only key words should be used so long as the requirements for clarity and meaningfulness can be met. Unnecessary words should be eliminated. Where possible, hierarchy labeling should be used so that individual labels and legends can omit words that are covered by a hierarchy label.

4. For accurate communications under stress, words should be chosen that will not be confused with other label words. This is particularly applicable to acronyms. For example, LP SI and HP SI tend to be spoken as "lip see" and "hip see". A spoken directive during an emergency operation to stop the "lip see" pumps could be misinterpreted as stop the "hip see" pumps.

The tendency to phoneticly pronounce acronyms is a potential source of serious error.

5. Names on labels should stand out so that the operator can easily and quickly locate the desired instrument. This capability is enhanced by the simplicity of the name, the size of the font, and the lack of any other distractions. Fewer words allows larger fonts. Relocation of component ID numbers on separate labels, subduing ID numbers with lighter and smaller fonts eliminates distractions and allows the eye to more quickly identify the name.]

GROUPING ENHANCEMENTS

Demarcations are used in various forms to group instruments of like functions. When consoles are designed with benchboards primarily containing controls, and vertical boards primarily containing meters, the eye coordination between controls and displays is more difficult than if they were placed immediately adjacent to each other. (This is not intended as a criticism of the design, because every design arrangement has tradeoffs that prevent ideal arrangements.) Emergency operations require rapid and accurate coordination of decision, control, and feedback under stressful conditions. Demarcation enhancements, particularly when done in conjunction with hierarchy labeling, can greatly improve this coordination.

Although grouping on these panels is generally good, groups are in many cases not set off by spaces: that is, one group runs into another without any visual distinction. Because of changes after the original design has been implemented, some instruments are not well located with respect to their related group. In order to highlight a group, some rearrangement might be necessary. Sometimes it is possible to swap like components, if separation criteria can be met, to get better grouping. This eliminates the need to cut new holes and install inserts.

Suggested Criteria

1. Locating instruments: Grouping should help the operator to locate meters and controls quickly and accurately, without resorting to searching labels.

2. Coordination: The operator should be aided in identifying controls and corresponding meters on another part of the panel.

3. Logical arrangements: Instruments should be grouped in logical arrangements that facilitate an understanding of the intent of the group and thereby locating the proper instrument.

[Application:

1. Demarcations for groups will be devised in order to obtain the clearest arrangement using the minimum amount

of swapping and relocation necessary to obtain easily identifiable groups.

2. Groupings will have hierarchy labels and may have subgroup labels where it appears useful. Internal demarcations may be used to differentiate subgroups within groups. Specific controls, particularly emergency controls, will be hilighted within a group or on their own. Labels and color will be used to coordinate meter groups with control groups.

3. Swapping will be used sparingly as necessary to accomplish grouping, and relocations will be used only when necessary to include an instrument within its proper group.]

MIMIC ENHANCEMENTS

The following criteria is suggested for mimics:

1. Simplicity: Mimics should stress simplicity so that they provide the simplest reminder to the operator.

2. rapid scan: Operators should be able to rapidly scan mimics and discern the status, particularly when the systems are performing their primary emergency function.

3. Alignment: The operator should be aided by the mimic in determining proper system lineup.

4. Relationships: The relationships between mimics, where appropriate, should be enhanced by the mimic arrangement.

5. Changes: Enhancements should emphasize improvements to mimic lines and labels, and not change locations of controls and indication unless absolutely necessary.

[Application: (Numbers correspond to criteria)

1. All mimic lines should be as straight as possible. The primary, or primary emergency function of the mimic should be the straightest mimic and should use the most prominent lines.

2. The primary emergency function of the mimic should stand out so that the operator's eye will be guided to the proper section to determine operating status. Secondary or alternative uses of the mimic should be visually subordinated to differentiate them from the primary use. Support functions should be further subordinated, or possibly not mimiced.

3. Mimics should have only the necessary information to aid the operator in making proper alignments when system changes are required.]

COLORS

Colors can be used effectively to help tie similar functions together that are located on different parts of the panel or on different panels. The design of Limerick panels spreads some systems between consoles and vertical panels. Also, some systems are located on more than one console.

Suggested Criteria:

1. Consistent: The use of color should be consistent throughout the control room. However, the same color can have different meanings in different applications so long as the operator will not be confused by the different uses.

2. Color Codes: Colors will not generally be used as specific codes. Colors will not stand alone as the identifier of function but will be used in conjunction with hierarchy labeling and instrument recognition.

3. Color Shading: Systems that have similar functions but require differentiation should have a different shade of the same color.

4. Color Selection: Colors should, as far as possible, be chosen to suggest the system or function they represent.

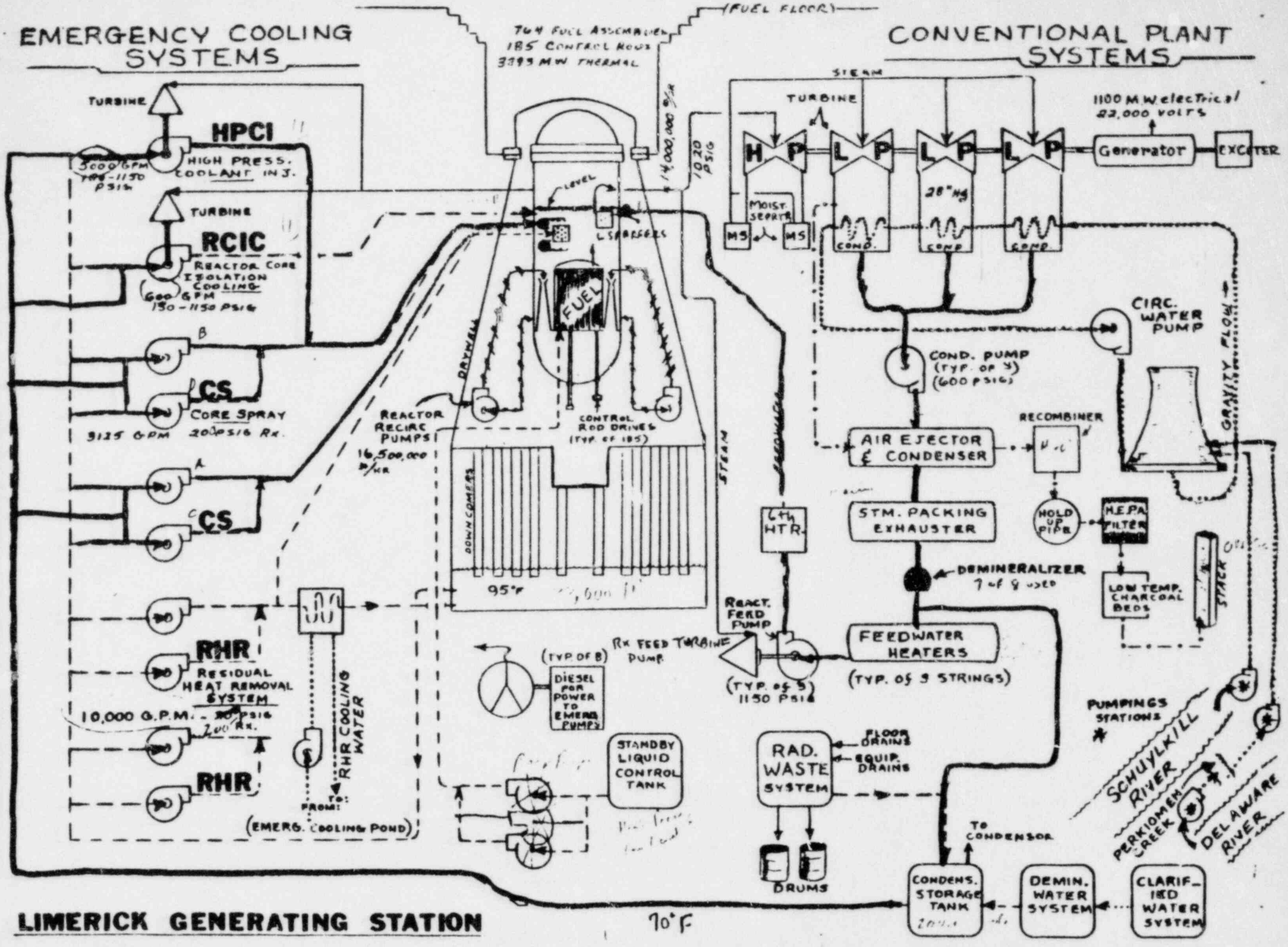
5. CRT Colors: Colors used for systems should be the same colors that will be used on the CRT system diagrams.

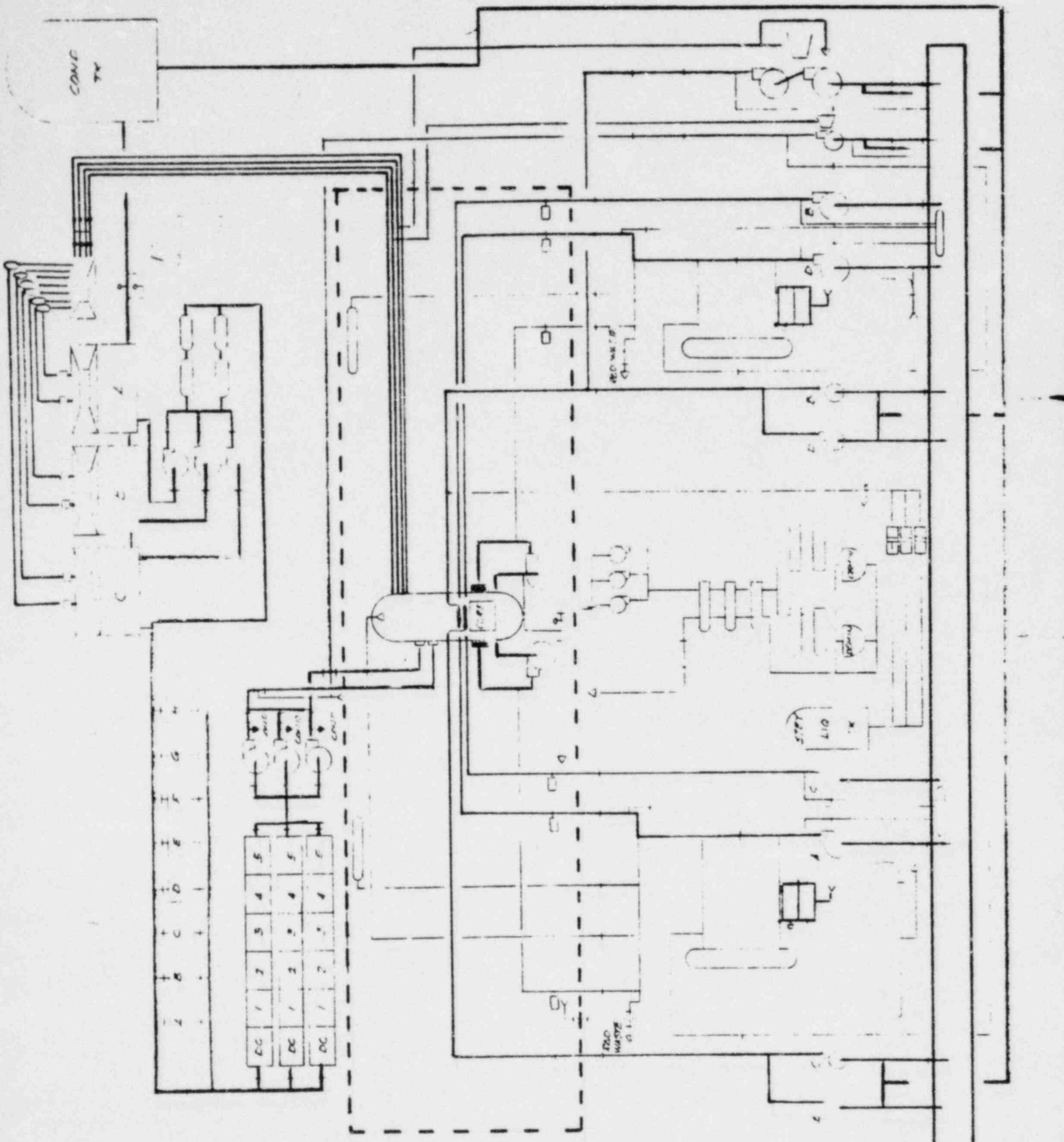
[Application:

1. Colors should be system colors so that system functions can be related by color pads.

2. Colors for mimics can be system color for pads, and use black for mimic lines.

3. Select color shades that blend with panel green.]


EMERGENCY COOLING SYSTEMS
CONVENTIONAL PLANT SYSTEMS
(FUEL FLOOR)
185 CONTROL RODS
3293 MW THERMAL
TURBINE
HPCI
HIGH PRESS. COOLANT INJ.
3000 GPM
PSIG
TURBINE
RCIC
REACTOR CORE ISOLATION COOLING
600 GPM
150 - 1150 PSIG
B
CS
CORE SPRAY
3125 GPM 200 PSIG Rx.
A
C
CS
RHR
RESIDUAL HEAT REMOVAL SYSTEM
10,000 G.P.M.
RHR
RHR COOLING WATER
TO:
FROM:
(EMERG. COOLING POND)
LEVEL
SPARGERS
DRYWELL
FUEL
REACTOR RECIRC PUMPS
16,500,000 #/HR
CONTROL ROD DRIVES (TYP. OF 185)
DOWN COMERS
95°F
14,000,000 #/HR
1020 PSIG
STEAM
FEEDWATER
TURBINE
H P
L P
L P
L P
MOIST. SEPRTR
MS
MS
COND.
COND
COND
28" Hg
Generator
EXCITER
1100 MW electrical
22,000 VOLTS
CIRC. WATER PUMP
GRAVITY FLOW
COND. PUMP (TYP. OF 3) (600 PSIG)
AIR EJECTOR & CONDENSER
RECOMBINER
STM. PACKING EXHAUSTER
HOLD UP PIPE
H.E.P.A. FILTER
DEMINERALIZER
7 of 8 used
LOW TEMP. CHARCOAL BEDS
STACK
6th HTR.
REACT. FEED PUMP
Rx FEED TURBINE PUMP
(TYP. OF 3) 1150 PSIG
FEEDWATER HEATERS
(TYP. OF 3 STRINGS)
(TYP. OF 8)
DIESEL FOR POWER TO EMERG. PUMPS
STANDBY LIQUID CONTROL TANK
RAD. WASTE SYSTEM
FLOOR DRAINS
EQUIP. DRAINS
DRUMS
TO CONDENSOR
CONDENS. STORAGE TANK
DEMIN. WATER SYSTEM
CLARIFIED WATER SYSTEM
PUMPINGS STATIONS
SCHUYLKILL RIVER
PERKIOMEN CREEK
DELAWARE RIVER
LIMERICK GENERATING STATION
70°F
4-29-82



ATTCH 5

NOMENCLATURE FOR CONTROL ROOM (PROPOSED)

This operational nomenclature was developed from the "Limerick Generating Station Abbreviations", Revision 8, August 15, 1983. It is planned that this be used for the improved labeling on the control room panels and remote shutdown panel. The Equipment Name column is derived from the referenced document for items (equipment, systems, etc.) to control room operations with some additions from other listings. The Nomenclature column is the short title to be used for labeling on the control panels. The Abbreviation column corresponds to the adjacent short title for use in the control room where required.

NOMENCLATURE FOR CONTROL ROOM (PROPOSAL)

EQUIPMENT NAME	NOMENCLATURE	ABBREVIATION
Accumulator	Accumulator	ACCUM
Aftercooler	Aftercooler	AFT CLR
Air Conditioning	Air Conditioning	A/C
Alternate Rod Insertion	Alternate Insertion	ALT INSERT
Alternating Current	Alternating Current	A/C
Analyzer	Analyzer	ANAL
And	And	&
Annunciators	Annunciators	ANNUN
Area Radiation Monitor	Area Radiation	ARA RAD
Atmospheric	Atmospheric	ATMOS
Automatic	Automatic	AUTO
Automatic Depressurization System	Automatic Depressurization	AUTO DEPRESS
Auxiliary	Auxiliary	AUX
Average Power Range Monitor	Power Range	PWR RNG
Backwash	Backwash	B/W
Battery	Battery	BATT
Bearing	Bearing	BRG
Bleeder Trip Valve	Bleeder Trip	BLLD TRP
Block	Block	BLK
Board	Board	BRD
Boiler	Boiler	BLR
Boiling Water Reactor	Boiling Water Reactor	BWR
Breaker	Breaker	BKR
Building	Building	BLDG

EQUIPMENT NAME	NOMENCLATURE	ABBREVIATION
Bypass Valve	Bypass	BYP
Cathode Ray Tube Screen	Screen	SCRN
Computer	Computer	CMPTR
Centrifuge	Centrifuge	CENT
Chemical	Chemical	CHEM
Chilled Water	Chilled Water	CH WTR
Chiller	Chiller	CHLR
Chlorine	Chlorine	C12
Circuit Breaker	Breaker	BKR
Circulating	Circulating	CIRC
Circulating Water	Circulating Water	CIRC WTR
Clean Radwaste	Clean Radwaste	CLN RAD WST
Closed	Closed	CLSD
Closed and Locked	Closed and Locked	CLS & LK
Collection or Collector	Collection or Collector	COLL
Combined Intermediate Valve	Intermediate Valve	INT VLV
Compartment	Compartment	COMPT
Compressed or Compressor	Compressed or Compressor	COMP
Condensate	Condensate	COND
Condensate Storage Tank	Condensate Tank	COND TK
Control	Control	CONT
Control Rod Drive	Rod Drive	RD DRV
Control Station	Control Station	CONT STA
Control Switch	Control Switch	CONT SW

EQUIPMENT NAME	NOMENCLATURE	ABBREVIATION
Containment	Containment (see Note 1)	CTMT
Containment Atmospheric Dilution System	Containment Dilution	CTMT DIL
Continuous Air Monitor	Air Monitor	AIR MON
Cooler	Cooler	CLR
Cooling	Cooling	CLG
Cooling Tower	Cooling Tower	CLG TWR
Core Spray	Core Spray	COR SPRY
Core Standby Cooling Systems	Standby Cooling	STBY CLG
Coupling	Coupling	COUP
Cycle	Cycle	CYC
Deaerator	Deaerator	DEA
Deminerlizer	Deminerlizer	DEMIN
Demineralized Water Storage Tank	Demineralized Water Tank	DEMIN WTR TK
Detector	Detector	DET
Diesel Generator	Diesel Generator	D/G
Differential or Difference	Differential or Difference	DIFF
Differential Pressure or Delta P	Differential Pressure or Delta P	DP or P
Direct Current	Direct Current	DC
Dirty Radwaste	Dirty Radwaste	DIRT RAD WST
Discharge	Discharge	DISCH
Disconnect Switch	Disconnect Switch	DISC SW
Division	Division	DIV
Drain	Drain	DRN

EQUIPMENT NAME	NOMENCLATURE	ABBREVIATION
Drywell	Drywell	D/W
Ejector	Ejector	EJC
Electro Hydraulic Control	Electro Hydraulic Control	EHC
Emergency	Emergency	EMRG
Emergency Core Cooling System	Emergency Core Cooling	EMRG CORE CLG
Emergency Service Water	Emergency Service Water	EMRG SERV WTR
Enclosure	Enclosure	ENCL
Engine	Engine	ENG
Equalizer or Equalizing	Equalizer or Equalizing	EQUAL
Equipment	Equipment	EQP
Equipment Drain Collection Tank	Equipment Drain Tank	EQP DRN TK
Evaporator	Evaporator	EVAP
Exciter	Exciter	EXC
Exhaust or Exhauster	Exhaust or Exhauster	EXH
Exponential - Negative (e.g. 10 to the negative 6th power = 10N6)	Exponential - Negative	_N_
Exponential - Positive (e.g. 10 to the plus 6th power - 10P6)	Exponential - Positive	_P_
Extraction	Extraction	EXT
Feed	Feed	FD
Feeder	Feeder	FDR
Field	Field	FLD
Fifth	Fifth	5th
Filter	Filter	FILT
Filter Demineralizer	Demineralizer	DEMIN

EQUIPMENT NAME	NOMENCLATURE	ABBREVIATION
First	First	1st
Floor	Floor	FLR
Floor Drain Collection Tank	Floor Drain Tank	FLR DRN TK
Fourth	Fourth	4th
Fuel Pool	Fuel Pool	FUL PL
Generator	Generator	GEN
Gland Seal Condenser	Seal Condenser	SEL COND
Governor	Governor	GOV
Ground	Ground	GRD
Ground Switch	Ground Switch	GRD SW
Group	Group	GRP
Header	Header	HDR
Heat	Heat	HT
Heater	Heater	HTR
Heating	Heating	HTC
Heat, Ventilation, Air Conditioning	Heat, Ventilation Air Conditioning	HT,VENT,A/C
Heat Exchanger	Heat Exchanger	HTX
Hertz	Hertz	HZ
High Pressure	High Pressure	HP
High Pressure Coolant Injection	Coolant Injection	HP INJ
Hydraulic	Hydraulic	HYD
Hydraulic Control Unit	Hydraulic Unit	HYD UNT
Hydrogen	Hydrogen	H2
Hydrogen Analyzer	Hygrogen Analyzer	H2 ANAL
Hydrostatic	Hydrostatic	HYDRO

EQUIPMENT NAME	NOMENCLATURE	ABBREVIATION
Inboard	Inboard	INBD
Information	Information	INFO
Injection	Injection	INJ
Inoperative	Inoperative	INOP
Instrument	Instrument	INST
Intermediate Range Monitor	Intermediate Range	INT RNG
Intermediate Stop Valve	Intermediate Stop	INT STOP
Iso Phase	Iso Phase	ISO
Isolate, Isolation	Isolate, Isolation	ISOL
Kilowatt	Kilowatt	KW
Kilovars	Kilovars	KVAR
Kilovolts	Kilovolts	KV
Kilovolt - Amperes	Kilovolt - Amperes	KVA
Liquid	Liquid	LIQ
Locked	Locked	LK
Local Power Range Monitor	Local Power	LOCAL PWR
Loose Parts Monitoring System	Loose Parts	(None)
Loss of Coolant Accident	Loss of Coolant Accident	LOCA
Low Pressure	Low Pressure	LP
Low Pressure Coolant Injection	Low Pressure Injection	LP INJ
Machine	Machine	MACH
Main Control Room	Control Room	CONT RM
Main Generator	Main Generator	GEN
Main Steam Isolation Valve	Main Steam Isolation	MN STM ISOL

EQUIPMENT NAME	NOMENCLATURE	ABBREVIATION
Main Steam Line	Main Steam	MN STM
Main Stop Valve	Stop Valve	STOP VLV
Make-up	Make-up	M/U
Manual	Manual	MAN
Maximum	Maximum	MAX
Mechanical	Mechanical	MECH
Megavar	Megavar	MVAR
Megawatt	Megawatt	MW
Minimum	Minimum	MIN
Mode Switch	Mode Switch	M/S
Moisture Separator	Moisture Separator	MOIST SEP
Motor	Motor	MTR
Monitor	Monitor	MON
Motor Control Center	Motor Control Center	MCC
Motor - Generator	Motor - Generator	M/G
Neutral	Neutral	NEUT
Nitrogen	Nitrogen	N2
Normal Waste	Normal Waste	NORM WST
Non-Regenerative Heat Exchanger	Non-Regenerative Heat Exchanger	NON REGEN HTX
Off Gas	Off Gas	(None)
Oily Waste	Oily Waste	OIL WST
Open	Open	OPN
Outboard	Outboard	OUTBD
Out of Service	Out of Service	OUT/SERV
Overload	Overload	OVLD
Oxygen	Oxygen	O2

EQUIPMENT NAME	NOMENCLATURE	ABBREVIATION
Oxygen Analyzer	Oxygen Analyzer	O2 ANAL
Perkiomen Make-up	Perkiomen Make-up	PERK M/U
Point	Point	PT
Position	Position	POS
Potential Transformer	Potential Transformer	POT XFMR
Pounds Per Square Inch Absolute	Pounds Per Square Inch Absolute	PSIA
Pounds Per Square Inch	Pounds Per Square Inch	PSI
Pounds Per Square Inch Gage	Pounds Per Square Inch Gage	PSIG
Power of Hydronium Ion	Power of Hydronium Ion	pH
Preheater	Preheater	PRE HTR
Pressure	Pressure	PRESS
Pressure Control Valve	Pressure Control	PRESS CONT
Pressure Reducing Valve	Pressure Reducing	PRESS REDUC
Process Computer System	Process Computer	PROS CMPTR
Pull to Lock	Pull to Lock	PULL/LOCK
Pump	Pump	PMP
Radiation or Radioactive	Radiation or Radioactive	RAD
Radioactive Waste	Radioactive Waste	RAD WST
Reactive KVA	Reactive KVA	KVAR
Reactor	Reactor	RX
Reactor Enclosure Isolation Cooling System	Reactor Enclosure Isolation Cooling	RX ENCL ISOL CLG
Containment Cooling Water	Containment Cooling Water	CTMT CLG WTR
Reactor Feed Pump	Feed Pump	FD PMP

EQUIPMENT NAME	NOMENCLATURE	ABBREVIATION
Reactor Feed Pump Turbine	Feed Turbine	FD TURB
Reactor Water Clean-up System	Clean Up	CLNUP
Reactor Pressure Vessel	Reactor	RX
Recirculation System	Recirculation	RECIRC
Recombiner	Recombiner	RECOMB
Reducer	Reducer	REDCR
Refuel	Refuel	REFL
Refueling Water Storage Tank	Refueling Water Tank	REFL WTR TK
Refrigeration	Refrigeration	REFRIG
Refueling	Refueling	REFULL
Regulator	Regulator	REG
Removed	Removed	RMVD
Reservoir	Reservoir	RESV
Residual Heat Removal System	Residual Heat	RESD HT
Residual Heat Removal Service Water	Residual Heat Service Water	RESD HT SERV WTR
Return	Return	RET
Revolutions Per Minute	Revolutions Per Minute	RPM
Rod Block Monitor	Rod Block	ROD BLK
Rod Minimizer	Rod Minimizer	ROD MIN
Rod Position Information System	Rod Position	ROD POS
Rod Sequence Control System	Rod Sequence	ROD SEQ
Rod Worth Minimizer	Rod Minimizer	ROD MIN

EQUIPMENT NAME	NOMENCLATURE	ABBREVIATION
Room	Room	RM
Safeguard	Safeguard	SFGD
Safety Relief Valve	Safety	SFTY
Saturated	Saturated	SAT
Schuylkill Make-Up	Schuylkill Make-up	SCHUYL M/U
Seal	Seal	(None)
Second	Second	2nd
Secondary	Secondary	SEC
Section	Section	SECT
Selector	Selector	SEL
Separator	Separat)r	SEP
Sequence	Sequence	SEQ
Service	Service	SERV
Service Water	Service Water	SERV WTR or SW
Shut Down	Shut Down	S/D
Sixth	Sixth	6th
Source Range Monitor	Source Range	SORC RNG
Stage	Stage	STG
Standby Gas Treatment	Standby Gas	STBY GAS
Standby Liquid Control	Standby Liquid	STBY LIQ
Start Up	Start Up	S/U
Station	Station	STA
Steam	Steam	STM
Steam Jet Air Ejector	Air Ejector	AIR EJC
Steam Packing Exhauster	Steam Packing Exhauster	STM PAK EXH

EQUIPMENT NAME	NOMENCLATURE	ABBREVIATION
Steam Seal Evaporator	Steam Seal Evaporator	STM SEAL EVAP
Strainer	Strainer	STRN
Suction	Suction	SUCT
Supervisory	Supervisory	SUPV
Suppression Pool	Suppression Pool	SUPP POOL
Switch	Switch	SW
Synchroscope	Synchroscope	SYNC
System	System	SYS
Tank	Tank	TK
Temperature	Temperature	TEMP
Temperature Control Valve	Temperature Control	TEMP CONT
Third	Third	3rd
Throttle	Throttle	THROT
Tower	Tower	TWR
Transfer	Transfer	TRANS
Transformer	Transformer	XFMR
Traversing In-Core Probe	Core Probe	COR PROB
Turbine	Turbine	TURB
Main Turbine Bypass Valve	Turbine Bypass	TURB BY
Turbine Enclosure Cooling Water	Turbine Cooling Water	TURB CLG WTR
Turbine Generator	Turbine Generator	TURB GEN or T/G
Turning Gear	Turning Gear	TURN GEAR
Ultrasonic	Ultrasonic	ULTSNC
Unit #1	Unit #1	U/1

EQUIPMENT NAME	NOMENCLATURE	ABBREVIATION
Unit #2	Unit #2	U/2
Vacuum	Vacuum	VAC
Valve	Valve	VLV
Vapor or Vaporizing	Vapor or Vaporizing	VAP
Ventilation	Ventilation	VENT
Vibration Monitoring System	Vibration Monitoring	VIB MON
Waste	Waste	WST
Water	Water	WTR
Yard	Yard	YD

Note 1. "Containment" will refer to the combined Drywell and Supression Pool bounda ies, i.e. the primary containment.

SPECIAL PARAMETER ABBREVIATIONS FOR METERS

Temperature	T
Pressure	P
Flow	F
Level	L
Valve Position	POS
Differential Pressure	ΔP
Amps	A
Volts	V
Watts	W

ASSESS IMPACT UPON OPERATOR'S ABILITY TO PERFORM

Each HED must be assessed based upon its potential for causing error by operators, and therefor the resulting potential impact upon safety. The following descriptions identify the more common categories and causes of human error, but the team is not limited to only these items in its considerations.

This list is intended to help team members in evaluating the potential significance and seriousness of a HED to cause operator error. The significance can best be determined by the combined professional judgement of the team representing different areas of expertise. Each member should make his own judgement, and then the team should review the several viewpoints and obtain a consensus. If no consensus can be obtained, the team will vote. The significance and seriousness of an individual HED should also be considered for possible interactions with other HEDs as well as individually. The resulting statement of significance and seriousness of the HED will then be used to determine the consequences of errors with respect to safety. Finally, the overall priority of the HED will be determined by applying the criteria of the four priority statements.

The list is divided into three major categories. Subcategories list the areas of performance that make up each category. In turn, each area of performance lists typical contributors to degraded performance. In evaluating the impact of a discrepancy, any one cause may have a major impact or it may have a very minor impact. Minor impacts in more than one area of performance, however, may combine to cause a discrepancy to have a greater impact on operator performance. When major categories combine, there is a potential for greater seriousness.

A. PHYSICAL PERFORMANCE

1. Reduction of effectiveness of the operator's body and mind caused by:

   a. Undue fatigue:

      (1) Duration of operation
      (2) Frequency of demands
      (3) Environmental conditions

   b. Discomfort:

      (1) Working conditions
      (2) Resting conditions

   c. Injury

2. Restriction of the operator's ability to perform:

   a. Control suitability

   b. Availability

B. SENSORY/PERCEPTUAL PERFORMANCE

1. Reduction in visual sensing:

   a. Visibility of instrument or information:

      (1) Meters and controls

      (2) Labels and legends

      (3) Scales and units

      (4) Displays

   b. Readability of information:

      (1) Labels and legends

      (2) Scales and units

      (3) Displays

   c. Visual distractions:

      (1) Cluttered presentations

      (2) Lack of differentiation

      (3) Excessive information

2. Impairment of audio reception:

   a. Audibility

   b. Noise level

3. Perception of information received visually or audibly:

   a. Identification of information sought:

      (1) Easily recognizable

      (2) Differentiated from other information

      (3) Expected location or arrangement

   b. Understandable information:

      (1) Terminology succinct

      (2) Useful form

C. MENTAL PERFORMANCE

1. The degree of stress:

   a. Rapidity of response required

   b. Severity of situation (emergency procedure)

   c. Accuracy of response required

2. The tendency to cause confusion:

   a. Misleading information or arrangement

   b. Complexity:

      (1) manipulations

      (2) Displays

      (3) Procedures

3. Mental workload:

   a. The degree of information collection requirements:

      (1) Proximity to operator's location

      (2) Organization for easy identification

   b. Correlation of information:

      (1) Status of systems/components

      (2) Alignment of systems

      (3) Effects of one system on another

   c. Mental manipulations:

      (1) Recall of detailed information

      (2) Perform calculations

      (3) Transposition/conversion of units

   d. Evaluation and decision:

      (1) Effective guidance

      (2) Sequential or parallel

4. Coordination with others in or outside control room:

   a. Absence/remote location of information or controls

   b. Delay of feedback information

   c. Interaction with other systems

Methodology

BWR OWNERS GROUP

CONTROL ROOM DESIGN REVIEW PROGRAM

DEVELOPMENT AND METHODOLOGY

8/1/81

ATTCH 8

specific procedures based upon these guidelines are not yet available, the analyses performed provide much useful information on the adequacy of present control room instrumentation and the ability of the operator to respond in accordance with the Guidelines within the framework of existing control room design. As such, they serve as a valuable method of integrating procedure and control room upgrade efforts. More detailed analyses are expected to be performed at the time actual plant specific procedures are prepared.

5.2 Evaluation Methods

An in-depth analysis of control room design requires review of every panel containing controls and displays normally used by operators, including auxiliary and back panels. Evaluations are therefore performed on a panel-by-panel basis, checklist Sections A, B, and C being completed separately for every panel.

Each checklist item is evaluated by means of two numerical ratings: (1) a "compliance factor" indicating the degree to which the panel under consideration complies with that criterion, and (2) a "potential for error factor" representing the relative likelihood that non-compliance with that checklist item could cause or contribute to operator error.

A graded system of compliance evaluations is employed because a simple yes/no judgement of design compliance with a given human factors standard may provide only limited information when a wide spectrum of actual design effectiveness is possible. Therefore, each panel is rated on a scale of one to four for each checklist item. "One" indicates full compliance with a given criterion on the panel being reviewed, "two" indicates that the criterion has been "mostly" complied with, "three" indicates "somewhat" compliance, and "four" indicates total non-compliance. A "zero" signifies that the criterion is not applicable to that panel.

The "potential for error factor" has been preassigned for each checklist item, based on the work of a task force consisting of approximately thirty General Electric and utility engineers from a wide variety of disciplines. Each item was independently evaluated by each task force member, based upon his own knowledge and experience. From this data base, a final value was assigned based upon the statistical frequency distribution of the ratings.

Each rating factor was reviewed and approved by the Control Room Improvements Committee of the BWR Owners Group. The resulting factors ranged from one to three, "three" indicating "high" potential for operator error, "two" a "moderate" potential, and "one" a "low" potential for causing or contributing to operator error.

These two rating factors, the degree of compliance assigned by the survey team, and the predetermined potential for error, are multiplied together to obtain a final Evaluation Product. These Evaluation Products are then utilized in forming preliminary prioritization recommendations for control room enhancements (see Figure 6). Final corrective action will be determined in an item-by-item review of these suggested areas, addressing safety significance of the components and systems involved, frequency of use and the consequences of required operator retraining.

5.3 Survey Teams

The BWR Owners Group Control Room Design Review is intended to be performed by inter-utility review teams composed of members with expertise in a variety of disciplines.

Four such teams have currently been formed, each typically consisting of representatives from three or four utilities with backgrounds in operations, control and instrumentation or engineering, a human factors consultant and a General Electric engineer. The host utility provides additional support as required in the areas of computers, operations, engineering, maintenance, and training. The resulting team structure thus includes expertise in all necessary fields. One utility employee is designated as the "team leader," responsible for scheduling the review and coordinating review team activities. Individual team member responsibilities are listed in Table V.

DETERMINATION OF SAFETY SIGNIFICANCE

In assigning the safety significance of a HED found to be significant, the combined judgement of the team is needed in consideration of the specific condition caused by the HED or a combination of HEDs. The team members should consider the following:

1. HEDs that cause errors on systems that directly effect safety such as:

   a. Engineered safety features

   b. Reactor protection system

   c. Containment isolation

   d. Emergency core cooling systems and their support systems

   e. Systems for monitoring the course of accidents or the availability of safety related systems

   f. Reactor control systems

   g. Off gas isolation systems

2. The potential for violation of technical specifications.

3. HEDs that are known to have caused errors that will lead to unsafe operation.

4. HEDs that could cause the inadvertant activation or deactivation of a safety related system or system needed to safely shutdown the plant.

Assessment Form shown in Figure 4. This will be primarily a human factors analysis, assisted by appropriate technical experts. A summary top-down analysis of the control room panels will be conducted to identify the context of the HEDs and to understand their specific meanings. Upon completion of this analysis, the normal assessment of HEDs will be performed, and the HED Assessment form completed.

4.3.2 PRIORITY EVALUATION CRITERIA

Human engineering discrepancies identified during the control room survey and the supplementary review will be evaluated according to their safety significance. This will be judged mainly on their potential to affect emergency operation adversely. The following four categories of priorities have been designed so a consensus from the team as to which category each HED should be assigned can be reached.

<u>Priority 1 (High Safety Significance)</u>

HEDs that are documented or judged likely to adversely affect the management of emergency conditions by the control room operators. This priority includes all HEDs that have high safety significance that could result in unsafe operation, any that have resulted in unsafe operation, as well as any that could result in errors of serious consequences. (0801 Cat.IA,B,C, Cat.IIA, Cat.III.)

<u>Priority 2 (Low Safety Significance)</u>

HEDs that have caused problems or appear likely to cause problems during normal and off-normal operations that could not result in unsafe operations. (0801 Cat.ID, Cat.IIB,C.)

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. This priority includes HEDs that are individually of minor consequence, but in combination with other HEDs or other conditions could degrade operator effectiveness under stress.

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 operation. This priority includes all HEDs that do not fit into any of the above categories.

4.3.3 DESIGN IMPROVEMENTS

4.3.3.1 PANEL ENHANCEMENTS

It has been experienced throughout the industry that large numbers of HEDs can be corrected through panel enhancements, including labeling and swapping of like components. More specifically, enhancements include a number of techniques that involve surface improvements, such as demarcation lines, shading, and improved labeling. Also included in the enhancement category is the technique of component swapping. This involves changing the location of a control or indicator with a like unit within the same panel, usually within the same grouping. Swapping involves simple exchanges of locations without the need for panel modifications. In some cases, this technique can greatly improve