CONTROL ROOM DESIGN REVIEW
SUMMARY REPORT
HOPE CREEK GENERATING STATION

Prepared for:

Nuclear Regulatory Commission

Prepared by
Essex Corporation for:

Public Service Electric & Gas Company

August 6, 1984

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

1.0 INTRODUCTION

This Summary Report presents results from the detailed Control Room Design Review (CRDR) conducted by Public Service Electric and Gas Company (PSE&G) for Hope Creek Generating Station (HCGS). Background on the CRDR and its relationship to other activities that address human factors in the HCGS control room is descirbed in Section 1.1. The remainder of the introductory section summarizes the scope of work described in this report and the report organization.

1.1 Background

The CRDR is part of a larger effort to ensure the operability of the HCGS control room with full consideration of human factors and full responsiveness to the requirements of Regulatory Guide 1.97 and NUREG-0737 Supplement 1.

In 1977, an Operability Analysis was performed to determine the final layout of the HCGS control panels prior to release for fabrication. A full-scale mockup of the control panels was constructed with movable components magnetically attached to the panel surfaces.

PSE&G assembled a team from General Electric, Bechtel Power Corporation, and the Peach Bottom operations staff to assist in the Operability Analysis. The team walked through Peach Bottom procedures to develop the detailed layout of the HCGS control panels to support effective operations. The layout resulting from this analysis incorporated functional grouping, demarcation, mimicking, and hierarchical labeling as primary considerations.

As the analysis proceeded, changes were immediately incorporated (to the extent practicable) into the mockup, were redlined onto appropriate drawings, and were recorded in a set of notes compiled during the analysis. The evolving mockup was reviewed by panel vendor representatives for constructability. At the end of the analysis, details of the final panel arrangements which evolved on the mockup were recorded on photographs. The photographs, redlined drawings, and notes were the basis for the panel arrangement drawings which were to be submitted to the panel vendor for detailed panel design. A report was written documenting the methodology used, participants, and results of the Operability Analysis. The recommendations from the Operability Analysis are reflected in the "as built" configuration of the control panels.

Upon issuance of NUREG-0700, PSE&G decided that the preliminary design of the Remote Shutdown Panel should be revised to meet NUREG-0700 criteria. This resulted in a redesign of the Remote Shutdown Panel.

Other improvements were identified prior to the CRDR from PSE&G's experience as architect-engineer and operator of Salem. For example, lamp-test capability is provided in the HCGS design, as well as indication of loss of power to vertical indicators and recorders. Regulatory Guide 1.97 requirements for instrumentation design have also been incorporated.

Essex Corporation, PSE&G's human factors consultant, has been consulted throughout the review for comments on control room design changes. For example, PSE&G requested Essex to review the annunciator system layout in the early stages of the CRDR. The analysis was performed to finalize annunciator system layout prior to release for fabrication. This analysis resulted in enhanced functional grouping and prioritization. The revised layout has been implemented in the HCGS control room.

The HCGS control room design is based on advanced control room concepts, making extensive use of computer capabilities to provide the operators with dynamic displays of key parameters and parameter relationships readily available at the work stations via CRTs. Since 1980, PSE&G personnel have participated in Boiling Water Reactor Owners Group (BWROG) efforts to define control room CRT information requirements for a BWR. Since 1983, PSE&G has participated in development of a generic functional analysis of information requirements for a Graphic Display System (GDS) that is being developed by the Electric Power Research Institute (EPRI) and the BWROG. This experience is being utilized in the final development of the computer system and, in particular, in the development of a Safety Parameter Display System (SPDS) for Hope Creek. In addition, generic information requirements from the EPRI-BWROG analysis were used, along with the BWROG generic Emergency Procedure Guidelines (EPGs), in performing the CRDR task analysis. The task analysis is being used in the development of the Procedures Generation Package, further contributing to integration of all of these requirements and activities.

Although fuel load is not scheduled until January 1986, the control room complex was turned over to PSE&G in December 1983. This has allowed the operators to start becoming familiar with the control room at an earlier date than normal for an Near Term Operating License (NTOL) plant.

1.2 Scope of the Summary Report

The HCGS CRDR is being conducted in two stages, in accordance with the schedules for plant construction and other activities being performed in preparation for licensing and operation.

PSE&G initiated the HCGS CRDR at an earlier point in the construction schedule than most other near term operating license (NTOL) plants. This was done so that CRDR recommendations could be implemented in the control room to the fullest extent possible before fuel load. In addition, an early start provided the maximum opportunity for coordination of the CRDR with related activities, including the training of control room operating personnel, response to Regulatory Guide 1.97 requirements, SPDS development, and procedures development as discussed above.

Given the early start, the HCGS CRDR is being conducted in two stages. Some of the CRDR tasks are being deferred until plant construction and system implementation status permit them to be performed more effectively. The following tasks were completed in the first stage:

- Training and orientation of CRDR participants regarding methodologies to be used and Program Plan requirements.
- Operating Experience Review, including LER review and preliminary interviews with operations personnel.
- Displays Survey
- Controls Survey
- Labels and Location Aids Survey
- Annunciator Survey
- Anthropometric Survey
- Conventions Survey
- Maintainability Survey
- Task Analysis
- Verification of control room design adequacy, using the task analysis*
- Validation of control room design to support emergency response requirements, startup, and shutdown.*

Several tasks of the CRDR could not be included in the first stage of review because of the plant's NTOL status. The following activities were deferred for stage two:

- Environmental Surveys
  - Heating, Ventilation, and Air Conditioning (HVAC)
  - Illumination
  - Ambient Noise

*Panel layout and control-displays integration criteria were addressed in verification and validation.

- o Communications Survey
- o Emergency Equipment Survey
- o Computer System Survey
- o Additional interviews with operating personnel to get their input after completion of license training, familiarization with procedures, and experience in the operating control room.

These activities will be performed as plant construction progresses to a point when it is feasible to conduct each activity. The results will be submitted in a CRDR Supplemental Report approximately six months after fuel load.

In addition, complete verification of display characteristics was deferred until plant-specific calculations to convert BWROG EPGs into plant-specific EOPs are completed. This program will be completely described in the EOP Procedures Generation Package. Display verification will be completed as part of the EOP validation program prior to fuel load.

1.3 Organization of the Summary Report

This report is organized as follows. Review tasks and methods are described in section 2.0. A summary of review findings is provided in section 3.0. The process used to assess Human Engineering Discrepancies (HEDs) and define the corrective actions to be taken is described in section 4.0. The schedule for implementation of corrective actions is presented in section 5.0.

There are six appendices to this report. Appendix A describes changes to the Program Plan regarding the Review Plan, Management and Staffing, and Documentation. Appendix B contains summaries of the HEDs generated during the review and their corresponding dispositions. Appendix C contains the list of interview questions used in the Preliminary Operator Interview. Appendix D contains interview results concerning positive design features. Appendix E presents the scenarios used in the validation walk-throughs. An example of the task plans which guided the CRDR data collection processes is provided in Appendix F.

2.0 METHODOLOGY FOR HCGS CONTROL ROOM DESIGN REVIEW

The goal of the control room design review was to determine the extent to which the design of the HCGS control room will support the tasks required of the control room operating personnel. The following methodologies, based on NUREG-0700 guidelines, were applied in the HCGS CRDR:

- o Operating Experience Review
- o Task Analysis
- o Control Room Inventory
- o Control Room Surveys
- o Verification of Task Performance Capabilities
- o Validation of Control Room Design.

2.1 Operating Experience Review

The objective of the operating experience review was to identify control room design features that might contribute to operator performance problems. Because HCGS is not yet operating, the operating history for a comparable plant was examined. Similarly, detailed operator interviews cannot be conducted until the operators have experience in the HCGS control room. However, preliminary structured interviews were conducted during the first phase of the design review as described below.

2.1.1 Review of Licensee Event Reports

Since HCGS is not yet operating, Licensee Event Reports (LERs) of two other BWR units, Peach Bottom 2 and Peach Bottom 3, were reviewed to identify documented problems at Peach Bottom that might be relevant to HCGS. These units, which are operated by Philadelphia Electric Company, contributed to the Hope Creek Control Room Complex Operability Analysis (September 1977). These units were also constructed by the same architect-engineer that constructed the Hope Creek unit.

As discussed in Section 1.0, the HCGS control room incorporates advanced control room concepts to a greater extent than most nuclear power plant control rooms, and is designed with extensive use of the Control Room Integrated Display System (CRIDS) computer system. There is no similar control room to which the HCGS control room can be compared with any degree of high correlation. The functions required for operation of

Peach Bottom are inherently reflected in the HCGS control board design since Peach Bottom procedures were the basis of the 1977 Operability Analysis.

The LER review process began with a set of LERs for Peach Bottom 2 and 3 selected from a larger group of LER abstracts (for 1975-1980) for General Electric plants provided by the Nuclear Safety Information Center of Oak Ridge National Laboratory.

Further filtering of these LERs eliminated LERs not related to control room design, such as improper installation of plant equipment, errors by non-licensed operators in the plant, and plant equipment design problems. This review process resulted in one set of LERs which were attributable largely to procedure design, and another set of LERs attributable largely to "operator error." Although procedures design is not in the scope of this review, the procedural LERs were examined for possible problem elements related to the HCGS control room design.

The overall selection process resulted in a set of LERs which had possible application to the HCGS control room. Based on the abstracts of these LERs, the more detailed LERs themselves were obtained and examined. Three categories of results were found: (1) the problem was not a control room design problem; (2) the problem was already being addressed in other HCGS CRDR tasks; (3) the problem was not appli able because of differences between the HCGS and Peach Bottom control rooms. Therefore, no HEDs were identified as a result of the LER Review.

2.1.2 Operating Personnel Survey

The survey of operating personnel for the HCGS CRDR consists of two parts: a preliminary interview, which was conducted during the first stage of the CRDR; and a second interview, which will be conducted after the plant is operational.

During the HCGS CRDR, at a meeting to discuss NRC comments on the HCGS Program Plan, the Nuclear Regulatory Commission inquired about the degree of operator input into the HCGS CRDR. In response, Public Service Electric & Gas decided to have a preliminary operator interview conducted before the plant becomes operational and to include the results in this summary report. The purpose of this preliminary interview is to supplement, not replace, the more detailed Operating Personnel Survey to be conducted after operating experience is acquired.

It should be noted that the preliminary interviews were conducted before the control room was completed and before training was completed. However, there is an advantage of discussing control room problems with operators during training since they have not yet accommodated to the control room design through experience.

The interviews with 10 members of the operations staff were conducted by human factors specialists experienced in CRDR interviews. Each respondent was interviewed individually and without interruption in a private area near the control panels. Anonymity was provided for by the privacy of the interview area and by the assignment of a coded number to the response form before the interview. After gathering biographical data, instructions for the interview were read to the respondent by the interviewer. The instructions included a brief description of the general control room topics that would be covered during the interview, a general orientation regarding human factors concerns, an acknowledgment that operator training was not yet completed, and an opportunity for the respondent to ask questions before the interview began.

The interview questions, shown in Appendix C, were selected to provide broad coverage of human factors concerns in the control room. The questions covered the areas of control room equipment layout, access to reference material, environment, panel layout, design of controls and displays, annunciators, labeling, CRTs, staff and workload, appropriateness of procedures for this control room, and maintainability.

Two additional questions were more general than the preceding items. They allowed the respondent to address any potential problems not yet mentioned in the interview and to offer suggestions for control room improvements. There were also questions concerning positive design features. The same set of 28 questions was asked of each respondent.

Problems identified in the interviews were written up as HEDs. Positive design features that were identified are summarized in Appendix D.

2.2 System Function and Task Analysis

Objective:

The objective of the system function and task analysis was to determine the information and control requirements associated with control room operator emergency response tasks, in order to allow a systematic analysis of the completeness and adequacy of the control room equipment to support emergency response.

The task analysis provides integration between the CRDR and related efforts — in particular, the development of Emergency Operating Procedures (EOPs) and the development of the Safety Parameter Display System (SPDS):

- The BWR Owner's Group Emergency Procedures Guidelines (EPGs) were the basis for both the CRDR task analysis and EOP development. An NRC memorandum dated May 14, 1984, from S.H. Weiss to Voss A.

Moore entitled "Meeting Summary - Task Analysis Requirements of Supplement 1 to NUREG-0737 - May 4, 1984, Meeting with BWR Owners Group Emergency Procedure Guidelines and Control Room Design Review Committees" stated that the EPGs provide a functional analysis that identifies, at a high level, generic information and control needs.

- The task analysis also used the result of a function-task analysis performed by EPRI and the BWROG to establish generic information requirements for a Graphic Display System (GDS) for emergency response. As a first step in developing the GDS, the contractor identified all information required to execute the EPGs, how each piece of information would be used, and links between specific parameters to support operator decisions. The resulting information requirements are being used in the development of the HCGS SPDS.
- The data from the CRDR task analysis is being used in the preparation of the Emergency Operating Procedures. In addition, analyses performed in the EOP development effort will supplement the CRDR task analysis by providing parameter values and ranges needed to fully establish required instrument characteristics. The EOP verification and validation (V&V) program will assess whether available instruments have appropriate characteristics.

Method:

NRC Staff comments on the HCGS Program Plan for the CRDR identified the methodology for the function and task analysis as the Staff's primary concern. The Staff noted that the description of the methodology provided in the Program Plan did not make it clear that an objective, top-down analysis would be performed. The Staff recommended clarification to ensure that operator information and control requirements would not be derived from the existing instrumentation and controls.

Pursuant to this recommendation, NRC Staff and HCGS staff and consultants met to discuss the task analysis methodology and HCGS submitted a written clarification on April 10, 1984. The following description of the methodology shows the top-down analysis that was performed, as clarified in the discussions at the meeting and in the written submission. The methodology discussed herein is different from the methodology described in the HCGS CRDR Program Plan and reflects modifications made to respond to NRC concerns.

Three documents served as information inputs to the task anlaysis. These were:

- BWROG EPGs.
- HCGS EOPs, which track closely with the EPGs and provide plant specificity. HCGS EOPs are in flowchart form.
- The draft document prepared by the BWROG to define operator information needs for a Graphic Display System (a generic basis for SPDS development).

All three of these documents have the EPGs in common, and all three were used and compared in the task analysis.

The first step in the analysis was the development of a Task Data Form (see Figure 2.1) which was designed to serve two functions. First, the task analysis information was recorded in the top and left side of the form. Then, after the task analysis was completed, the right side of the form was used in the verification process to record specific equipment in the control room, with each entry under "control room component" corresponding to the task requirement specified on the left part of the form.

The next step was for the human factors staff on the CRDR team to develop a thorough familiarity with the HCGS emergency response requirements through review and comparison of EPGs, EOPs, and the draft EPRI/BWROG GDS functional analysis document. This review was conducted with the concurrent input of utility engineering, operations personnel, and the HCGS architect-engineer. Based on this input, the human factors team, which included an Essex senior reactor operator with previous experience in control room supervision and a human factors analyst experienced in nuclear and non-nuclear process control task analysis, developed a statement of the behavioral elements required for each task.

The functional or system objectives to be implemented were recorded in the Step Objective blank. A summary statement of the task required to meet the objective was entered in the Step Title blank. The specific EOP step number corresponding to each task was entered to facilitate cross-referencing between the task analysis and the EOPs. The task was then described in terms of a series of specific behavioral elements required (for instance, to access information or to control a piece of plant equipment — observe flow, adjust valve). The verb describing the behavior was entered in the Action column. When the Action column is combined with the columns to its right (Plant System, Plant Component, Plant Parameter, and State) a sentence structure format results which defines an information requirement or a control requirement. Additional information recorded on the data form included the cue which initiated the task, performance criteria where applicable, and any special comments pertaining to this particular task.

The task analysis as described above was performed on all of the following EPGs and the corresponding HCGS EOPs:

- Reactor Pressure Vessel (RPV) Control
- Containment Control and Drywell Pressure Control
- Radioactivity Release
- Secondary Containment Control

PSE&G — HOPE CREEK GENERATING STATION
TASK DATA FORM

PROCEDURE NAME LEVEL/POWER CONTROL # _____ **PAGE** 4 **OF** 11

STEP # 2.0 CONT'D **STEP TITLE** TERMINATE ALL INJECTIONS INTO RPV EXCEPT BORON & CRD INSERTION **STEP OBJECTIVE** REDUCE POWER

INITIATING CUE POWER > 3% AFTER SCRAM AND RPV LEVEL ABOVE TAF AND EITHER SRV OPEN OR DRYWELL PRESS > 2 PSIG

PERFORMANCE CRITERIA MONITOR RPV WATER LEVEL: IF IT DROPS BELOW -129 INCHES AT ANY TIME DURING THIS STEP, INHIBIT ADS INITIATION **REFERENCES**

COMMENTS

STEP #	WHO TAKES ACTION	ACTION (VERB)	OBJECT OF ACTION					MEANS OF ACTION			COMMUNICATIONS (OTHER PARTY, CONTENT)	HED ID
			PLANT SYSTEM	PLANT COMPONENT	PLANT PARAMETER	STATE	OTHER	CONTROL ROOM COMPONENT TYPE	CONTROL ROOM COMPONENT ID	OTHER		
2.14	NCO2	POSITIONS	CORE SPRAY	PUMPS	PUMP MODE	OFF		CONTROL - LEGEND PUSHBUTTON	BV AP 206 (180) A CV BP 206 (028) B BV CP 206 (181) C CV DP 206 (029) D			
2.15	NCO2	OBSERVES	CORE SPRAY	PUMPS	PUMP MODE	OFF		DISPLAY - LEGEND IND LIGHT	SAME AS ABOVE			
2.16	NCO2	OBSERVES	CORE SPRAY	PUMPS	FLOW	DECREASE TO ZERO		DISPLAY - VERTICAL METER-INDICATOR	BV FI-E21(A601)A (163) A CV FI-E21(A601)B (011) B			

INFORMATION AND CONTROL NEEDS (TASK) — VERIFICATION

Figure 2.1 TASK DATA FORM

- o RPV Water Level Restoration
- o Emergency Depressurization
- o Blow Down Cooling
- o Spray Cooling
- o Alternate Shutdown Cooling
- o RPV Flooding
- o Reactor Level/Power Control.

Radioactivity Release and Secondary Containment Control were added to the list of emergency response functions originally identified in the Program Plan as candidates for task analysis. Analysis of these additional emergency response functions replaced the task analysis of startup or shutdown and significant power change, as originally planned. Both startup and shutdown were examined during validation walk-throughs (see Section 2.6), even though a formal task analysis was not performed.

The primary output of the task analysis was a list of requirements which were later used as a detailed checklist to determine if operator information and control requirements are satisfied by the control room equipment. The operator information and control requirements occur at two levels: at one level the requirement specifies that a direct measure or control of a parameter be present in the control room. At a more detailed level, the requirement may specify, for instance, that changes in the parameter should be observable (as opposed to an on-off indication), and that a certain parameter value or range be present.

The scope of the task analysis described herein focused only on the requirement for the basic presence of the control capability or information. This was necessary since plant-specific parameter values and operating ranges have not yet been finalized. Analysis of specific parameter characteristics will be performed, and suitability of displays in relation to those data will be assessed, as part of the EOP validation program.

2.3 Photomosaics and Control Room Inventory

2.3.1 Photomosaics

Two types of photomosaics were constructed. For the main panels 10C650 and 10C651, color photos were taken of the Hope Creek simulator, developed and assembled. The simulator was photographed due to the inaccessibility of the actual control room.

The simulator photomosaic was compared to the actual control room near the end of the CRDR to record differences between the two. Color mosaics were made of the actual back panels in the control room and actual remote shutdown panel. These mosaics were also compared to the respective panels for any changes that may have occurred during the review process.

HEDs identified from the photomosaics were checked against the current control room design. In some cases discrepancies were found to have been eliminated. Other differences between the photomosaics and the actual design will be addressed in the Supplemental Report.

The photomosaics were used to facilitate the control room surveys, since the control room was under construction. The photomosaics also provide a record of the configuration evaluated.

2.3.2 Control Room Inventory

A Component Report was completed for each component in the control room. The complete set of these forms constitutes a record of the control room inventory on file at PSE&G and available for reference. The primary sources of information for this task were a combination of (1) the mosaics described above and (2) engineering drawings of the panel layout including labeling and instrument numbers.

The Component Report includes the following information:

- Component label
- Associated equipment (e.g. display associated with a control)
- Panel identification
- Component type (a category code--e.g., C-LP for control-legend push-button)
- Instrument number
- Subsystem
- Control modes/display range
- Use of component
- HED identification

The Component Report forms provided a means of managing HED information and backfits. All HEDs associated with a particular component are recorded on the form. For backfit implementation, a cross check will be made to ensure that all changes to a particular component are made efficiently.

Initially it was thought that the component reports might be needed for verification of information and control requirements identified through the task analysis. However, the status of the control room at the time of verification permitted it to be performed in the control room.

2.4 Control Room Surveys

Objective:

The objective of the control room surveys was to examine the control room equipment at a component level in order to identify and record any departures from preferred human engineering practice.

Method:

The control room surveys were based on the application of the criteria from Chapter 6 of NUREG-0700. Surveys conducted in the HCGS CRDR include the following:

- Controls Survey
- Displays Survey
- Labels and Location Aids
- Conventions Survey (as applicable to types of components surveyed — e.g., conventions for displays, controls, mimics)
- Annunciator System Review
- Anthropometrics Survey
- Maintainability Survey
- Panel Layout and Control-Display Integration Review (done in Verification and Validation tasks).

All of the surveys specified in the Program Plan were completed, with the following exceptions:

- Environmental Surveys
  - Heating ventilating and air conditioning (HVAC)
  - Illumination
  - Ambient noise
- Communications Survey
- Emergency Equipment Survey
- Computer System Survey

The environmental surveys and communications survey cannot be done until those systems are installed and operational. The ambient noise and communications surveys should be deferred until the plant is operating. The computer system survey cannot be

done until the design is finalized, implemented, and the necessary documentation is available. These surveys will be scheduled accordingly. They will be documented in the HCGS CRDR Supplemental Report to be delivered approximately six months after fuel load.

A set of standard task plans, developed by Essex Corporation, was used to guide the survey data collection effort. The task plans group the NUREG-0700 criteria according to review topic and the method(s) of data collection most appropriate for each criterion (e.g., some criteria require measurement, some may be applied by observation, others require input from operations personnel). Data collection procedures and forms are included in the task plans. The task plans cover completely all NUREG-0700 requirements, and a criterion-by-criterion crosswalk table between the task plans and NUREG-0700 is available. An example task plan is provided as Appendix F to this report.

All of the NUREG-0700 criteria were applied in accordance with the task plan guidance. The photomosaic mockup was used to the extent possible for the criteria assessed by observation. Measurements, and evaluation of parallax, use of color, and other items that could not be assessed from the mockup, were performed in the control room.

2.5 Verification of Task Performance Capabilities

Objective:

The objective of verification was to determine whether the information and control requirements identified in the task analysis were satisfied by the equipment in the HCGS control room.

Method:

This objective was accomplished by taking the operator information and control requirements from the task analysis to the control room and comparing each requirement to available control room components. For each requirement that was satisfied, the corresponding equipment was identified noting the specific location and unique component number. This information was recorded in the space reserved for equipment identification on the right side of the Task Data Form (see section 2.2 for description of this form). When a requirement was not satisfied, the discrepancy was recorded on an HED form.

The participants in this activity were HCGS operating personnel, a Bechtel engineer, and an operator and human factors engineer from Essex Corporation.

An assumption made for the verification task was that any displays needed to meet emergency response requirements should be hardwired. This was done as a worst-case analysis to assess whether operator information needs would be met in the unlikely event that the plant computer is unavailable. This assumption was also used in the validation walk-through analysis (section 2.6).

In addition to observations from mismatches between task analysis requirements and actual control room equipment, data were also gathered from criteria concerning demand versus status information (e.g., "Does this display indicate solenoid energized or actual valve status?"), panel layout, proximity of related controls and displays, and other aspects of control-display integration. HCGS operating personnel who participated in the verification provided input on any concerns or questions they had about the adequacy of the control room to support their task performance requirements.

2.6 Validation of Control Room Functions

Objective:

Whereas the control room surveys evaluated control room equipment largely on a component basis, the objective of the validation process was to examine the organization of the components and the extent to which they function as an integrated whole to support control room operations.

Method:

The basic method employed for the validation process was a walk-through of the EOPs, Startup, and Shutdown procedures. This method was oriented to observing any conditions or features of the control room which hamper or impede the successful performance of a task. The walk-through was conducted in the HCGS control room.

As in the task analysis and verification process, the validation was conducted on the assumption that only hardwired instruments and controls might be available. The walk-throughs used the same EOPs as were addressed in the task analysis and verification. Before each procedure, a scenario was developed stating assumptions about plant conditions associated with the particular event. These scenarios are described in Appendix E. In some cases a scenario was selected on the basis of a probable high workload sequence in the procedure due to two or more procedures possibly being performed together, or to a special condition in one of the procedures.

The validation walk-throughs were manned by four HCGS operating personnel. They performed the roles of Shift Supervisor, two Nuclear Control Operators, and a Shift

Technical Advisor. Before the walk-throughs were conducted, a briefing was given which included introductions, the purpose of the walk-through with examples of potential human factors problems, and instructions on how the operators could facilitate the data collection. For instance, the panel operators were asked to touch or point directly to each control or display that they would use in the procedure. They were also told that they would be interrupted frequently by the observer team in order to review a particular part of the procedure, or to back up and repeat a part of the procedure.

The observer team consisted of a human factors specialist and an Essex senior reactor operator with previous experience as a shift supervisor. Before the walk-throughs the team had reviewed a set of checklist criteria pertaining to panel layout and control-display relationships. During the walk-throughs, a Walk-Through Checklist Data Form was available for reference (Figure 2.2). This form lists a series of behaviors which might be produced by an operator experiencing difficulty with a procedure on the control panel. These kind of behaviors could provide a cue as to when and possibly where the difficulty was encountered. In addition, traffic patterns of the panel operators were recorded during the procedures as shown in Figure 2.3.

Although the validation process itself was the primary source of the HEDs, discrepancies were also reported on the basis of other observations and general operator comment during the walk-throughs. The HEDs ranged from label problems to control-display separation and absence of instruction.

2.7 Generation of HED Reports

Human engineering discrepancies (HEDs) were identified from all CRDR activities described in Section 2.0, with the exception of the LER Review which revealed no control room design problems that were applicable to HCGS and not otherwise addressed in the CRDR.

An HED Report was prepared for each problem identified. The HED Report defined the problem and described a recommended solution. The solution was specific if possible. If not, the data and/or analysis needed to determine an appropriate solution was indicated. These reports were submitted to the Technical Advisory Team (TAT) for assessment and disposition according to the procedure described in Section 4.0.

HED reports are summarized in Appendix B. All needs for further data and analysis to determine dispositions have been met since the initial HED Reports were prepared and submitted. No outstanding items remain for assessment and disposition.

PSE&G - HOPE CREEK GENERATING STATION
WALKTHROUGH CHECKLIST DATA FORM

Procedure: _____
Step No: _____

TIME

___ 1. Searches

___ 2. Hesitates

___ 3. Rushes

___ 4. Waits

ERROR

___ 5. Incomplete Task

___ 6. Repeats Task

___ 7. Error Observed

ANTHROPOMETRY

___ 8. Walks Long Distances

___ 9. Reaches / Bends

___ 10. Vision is Difficult

GROUP COORDINATION

___ 11. Communication Difficulty

___ 12. Interference Among Operators

OTHER

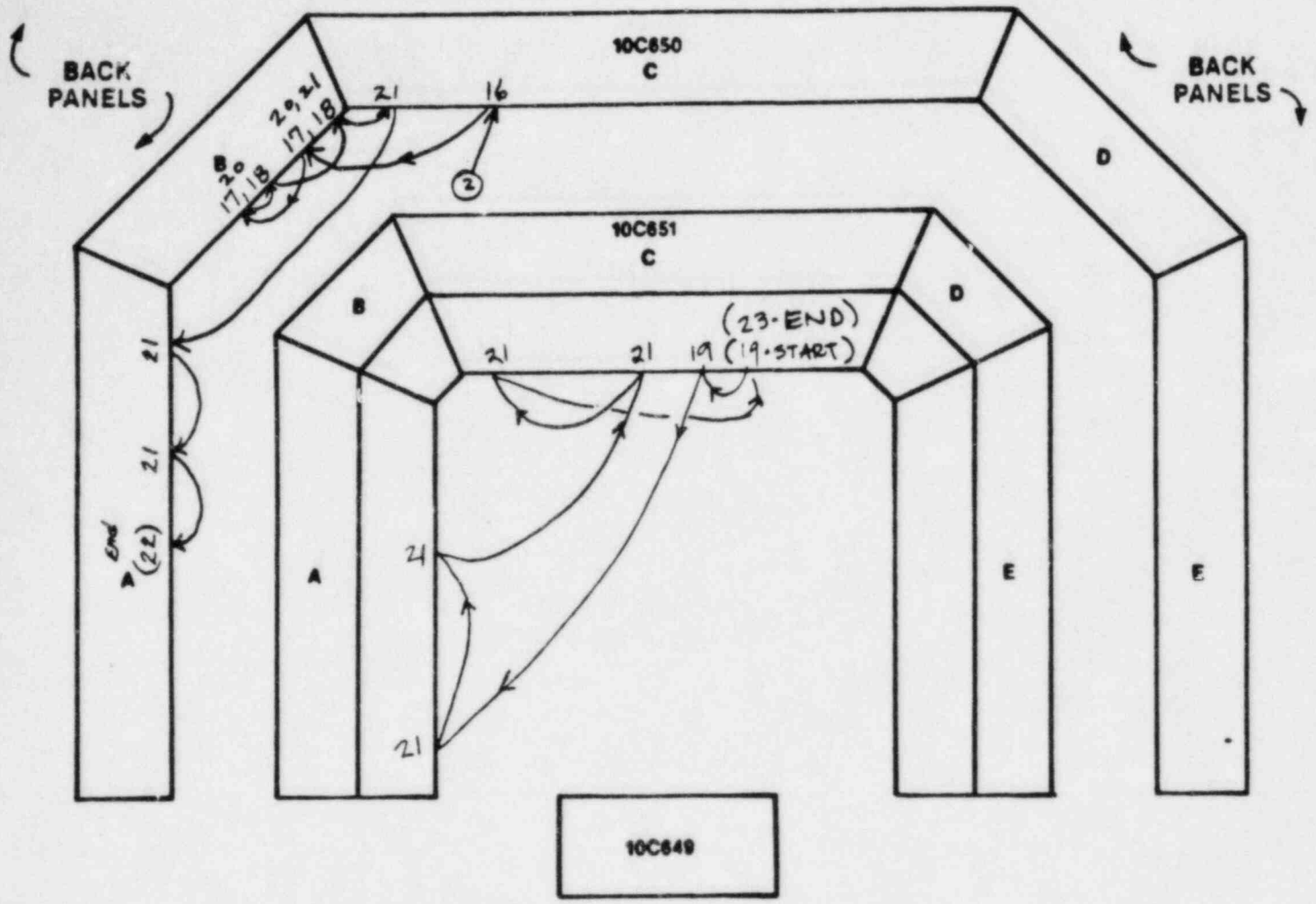
___ 13. High Workload

___ 14. Other

COMMENTS

Figure 2.2 Walk-through Checklist Data Form

PUBLIC SERVICE ELECTRIC & GAS
HOPE CREEK GENERATING STATION
DIAGRAM OF MAIN CONTROL ROOM
OPERATOR TRAFFIC PATTERNS



PROCEDURE TITLE: RPV WATER LEVEL RESTORATION

STEPS: 16

SCENARIO COMMENTS: RPV Level below TAF
Come from step 38 in RX Control (101)

Figure 2.3 Example of Traffic Pattern Diagram

3.0 SUMMARY OF REVIEW FINDINGS

3.1 HED Summary Descriptions

Each of the HEDs observed in the HCGS Control Room Design Review is individually summarized and presented in Appendix B of this report. Each HED description includes a brief summary of the discrepancy, as well as its disposition. If a correction is scheduled for the HED, a general description of the proposed correction is given. If no correction is planned, the reason(s) which support the decision not to correct the HED is stated. The HED category (see Section 4.0) resulting from the assessment process is also specified.

The HED summaries in Appendix B are grouped according to the control room panel on which each HED was observed. HEDs with the group prefix A were recorded in the primary operating area on panels 10C650, 10C651, 10C800, and 10C649. HEDs in Group B were recorded from the Remote Shutdown Panel. The remaining HEDs, Groups C through L, were recorded from the back panels in the control room.

It should be noted that there are only two panels in the back area that will be used by control room operators to control a process. These are the Hydrogen Recombiner Panel and the Fire Protection Panel. The other panels in the back area are primarily used by Instrumentation and Control Technicians. They were reviewed to identify possible substantial design- related problems, although this was beyond the scope of the CRDR objectives and requirements.

3.2 Sources of HEDs

The review processes from which HEDs were generated include the Preliminary Operator Interview; the Control Room Surveys (e.g., Controls Survey, Displays Survey, etc.); the Verification process (using data from the task analysis); and the Validation process.

All of the HEDs in Appendix B are listed in Table 3.1 grouped according to the method by which they were observed. In many cases, an HED was observed by more than one method (e.g., a discrepancy in labeling may have been observed in the Labels Survey and also found from the Preliminary Operator Interview). When each of the observations addressed the same discrepancy, only one HED report was generated in order to reduce confusion and duplication. Each contributing method, however, is indicated on the HED Report form to allow the sorting of HEDs into which methods identified the HED. As a result, an HED number will sometimes appear in more than one methodological grouping in Table 3.1.

Table 3.1

HEDs Grouped According to Method of Observation

METHOD	HEDs*
PRELIM OP INTERVIEW	A1, A22, A24, A26, A30, A31, A32, A44, A47, A48, A57, A58, A69, A78, A127, A132, A133, A134, A135, A136, A137, A138, A139, A140
DISPLAYS	A3, A4, A5, A6, A10, A11, A12, A14, A15, A23, A28, A54, A60, A62, A63, A64, A66, A67, A69, A70, A126, A149, B2, B6, B7, B10, B11, B12, B13, B14, B16, B18, D6, D11, E4, E8, E14, E17, E18, F6, F7, F8, G1, G2, G5, G6, G8, G22, J1, J2, J3, J6, J7, J9, K6, K7, K8, K9, K10, K12, K13, K17, L4, L7, L14
CONTROLS	A4, A13, A16, A17, A20, A22, A24, A61, A68, A73, A77, A79, A96, A131, A146, B8, B15, B17, D1, D7, E5, E10, E12, E13, E19, E20, F3, F4, F5, F14, F15, G4, G7, G21, G24, H1, H2, J5, J10, L1, L3, L5, L12, L13
LABELS/LOC. AIDS	A21, A27, A78, A95, A98, A99, A100, A101, A102, A103, A104, A105, A106, A107, A108, A109, A110, A111, A112, A113, A114, A115, A116, A117, A118, A119, A120, A121, A129, A141, A143, A145, A147,

*Letter prefixes to HED numbers indicate the location of the component(s). (A = primary operating area; B = Remote Shutdown Panel; J = Hydrogen Recombiner Panel; L = Fire Detection Status Cabinet; other letter designations identify test and calibration cabinets in back area.)

Table 3.1 (Continued)

HEDs Grouped According to Method of Observation

METHOD	HEDs
LABELS/LOC. AIDS (Continued)	B1, B3, B4, B5, B9, B19, B20, D2, D3, D4, D5, D10, E1, E2, E3, E6, E7, E9, E11, F1, F2, F9, F11, F12, F13, G3, G9, G10, G11, G12, G13, G14, G15, G16, G19, G20, G23, H3, H5, H6, J4, J8, J11, K1, K2, K3, K4, K5, K11, K14, L2, L6, L10, L11
ANNUNCIATOR	A1, A2, A26, A122, A124, A125, L8, L9
ANTHROPOMETRY	A7, A8, A9, A18, A19, A123, A127, A144, B21, B22, B23, D8, D9, E15, E16, E21, F10, G17, G18, H4, K15, K16, L15, L16, L17
CONVENTIONS	A25, A65, A89, A90, A91, A92, A93, A94, A130,
MAINTAINABILITY	A148
VERIFICATION	A29, A30, A31, A32, A33, A34, A35, A36, A37, A38, A39, A40, A41, A42, A43, A44, A45, A46, A55, A71, A72, A73
VALIDATION (EOP)	A22, A29, A31, A39, A43, A47, A48, A49, A50, A51, A52, A53, A56, A57, A58, A59, A73, A75, A76, A97, A142
VALIDATION (SU/SD)	A31, A32, A48, A49, A50, A52, A80, A81, A82, A83, A84, A85, A86, A87, A88

4.0 ASSESSMENT AND CORRECTION OF DISCREPANCIES

After an HED was identified in the review process, it was submitted to the Technical Advisory Team (TAT) to determine the implications of the discrepancy with regard to possible safety and operational consequences. The TAT had a dual role in the CRDR — to provide guidance during the data collection process, and to participate in HED assessment and disposition as described in the CRDR Program Plan (Section 2.2). This section describes the method by which the safety and operational implications of an HED were assessed, and by which HED dispositions were determined.

4.1 Assessment

The first decision point in the HED assessment process corrects an HED without formally assessing its significance. If this option is not elected, the HED proceeds through the assessment process for category assignment. The assessment process, shown in Figure 4.1, has two basic functions. First, it determines whether an HED should be corrected. Second, it determines when the correction should be implemented. Both decisions are determined by the category assignment of the HED. The categories are defined in Figure 4.2.

The determination of whether an HED should be corrected is a function of the consequences of an error due to the discrepancy and the estimated probability that such an error will occur. HEDs are first examined for whether an important error described in the HED has actually been documented, such as in a Licensee Event Report. (As discussed previously, this category does not presently apply to the HCGS control room since it is not yet operating and no Peach Bottom LERs were judged pertinent to the HCGS control room.)

Next, the HED proceeds to a question which asks whether the consequences of an operator error due to the discrepancy could reduce the margin of plant safety below acceptable levels. This process was necessarily subjective since plant documentation determining acceptable levels was not completely developed. For example, since the HCGS Technical Specifications were not completed at the time of the assessment, the assessment team's experience with similar specifications was used as guidance in evaluating the potential consequences of an HED.

Given that an HED was judged to have potential safety consequences, the likelihood of error was considered. If the likelihood of error was estimated to be very low, the HED was not assigned to Category II but continued through the categorization process.

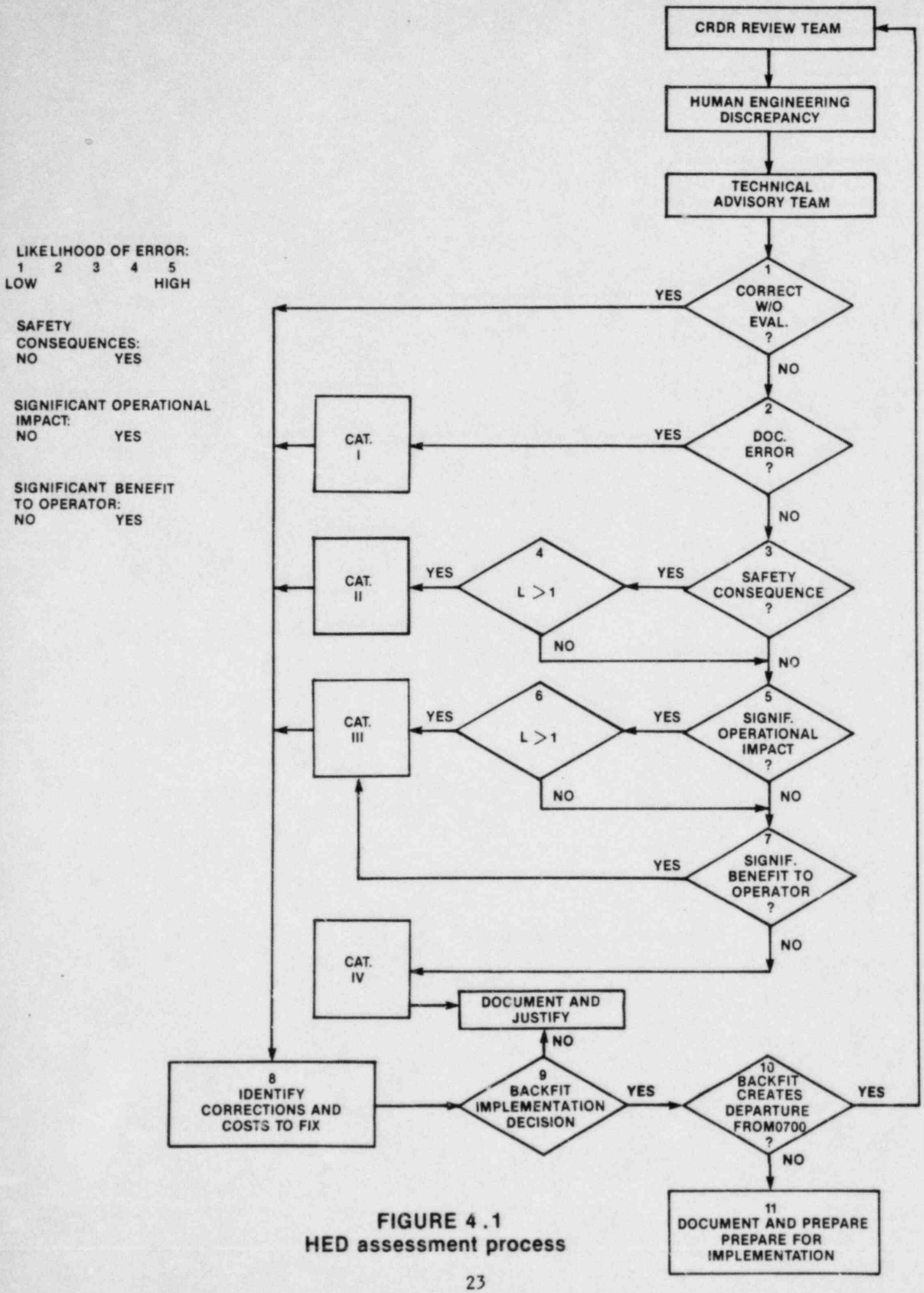


FIGURE 4.1
HED assessment process

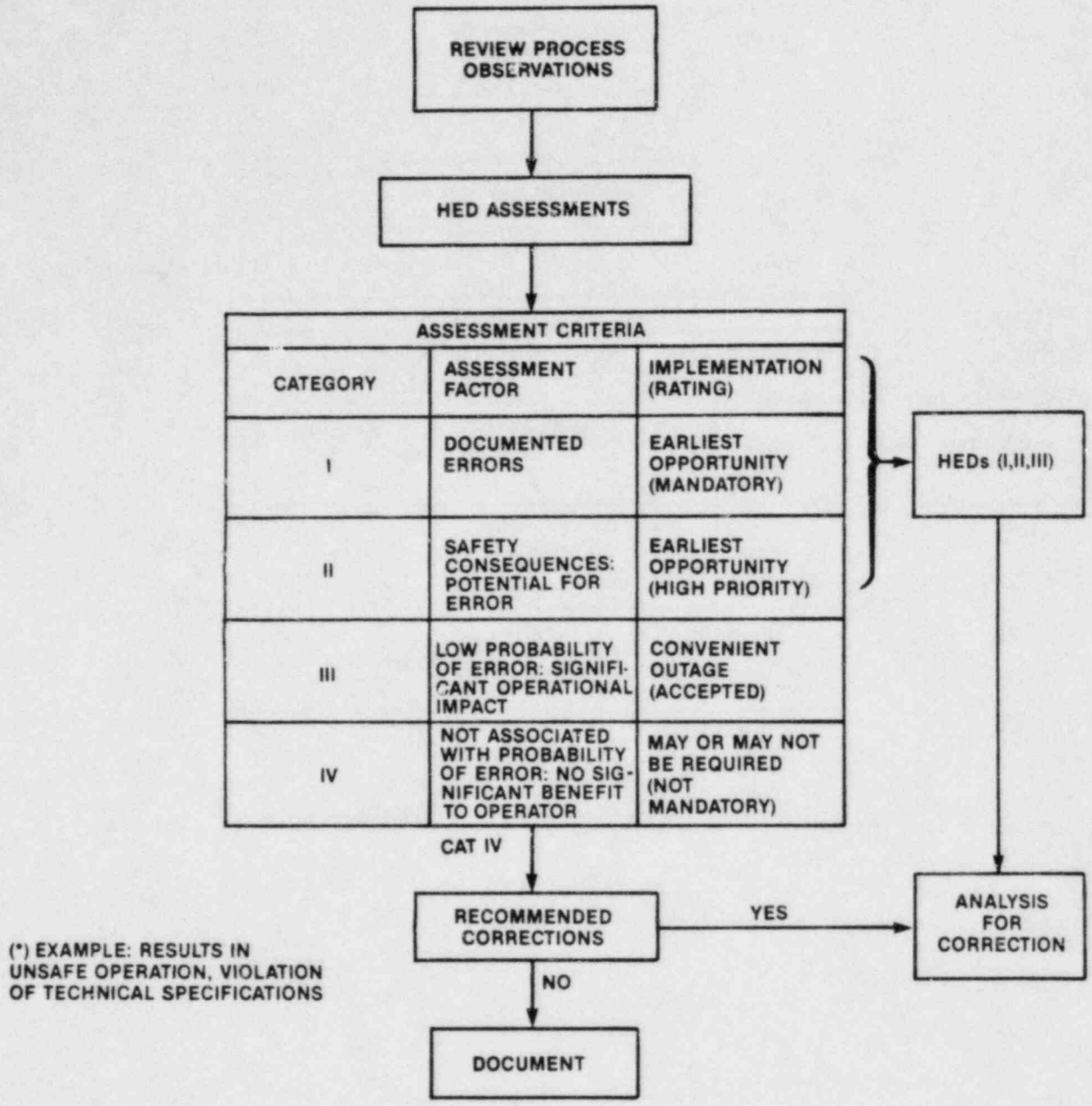


Figure 4.2 HED category guidelines.

HEDS not associated with a likelihood of safety consequences were similarly examined for the likelihood of significant operational impact on plant availability. If the HED was judged to not affect plant availability it was examined to determine whether a correction would provide a significant benefit to the operator. If it did not, the HED was assigned to Category IV in which a correction is not mandatory.

The provision of several categories is an assessment feature most useful to HCGS when it becomes an operating plant. In its present NTOL status, however, the first category is not applicable, and there is no practical difference between the second and third categories since all of the selected corrections will be completed in a relatively brief time frame before the plant is operational. After the assessment team assigned the discrepancy to a category, the HED was examined for an effective correction.

4.2 Correction of Discrepancies and Verification of Corrections

All HEDs which were designated by the assessment process to receive a correction were first examined for the possibility of correction by surface enhancement. HEDs for which surface enhancements were not applicable or sufficient were analyzed for design alternatives.

The assessment process also incorporates a method to verify the appropriateness of the corrections. This has the two primary objectives of determining whether the correction/improvement introduced new discrepancies and if it resolved the existing discrepancy.

4.2.1 Correction by Enhancement

Each HED to be corrected was evaluated to determine if a surface enhancement would provide a resolution to the discrepancy. Some of the enhancements that were considered were the addition, relocation, modification and removal of labels, demarcation, modification of key shapes, the provision of strip chart paper with more than one scale, removal of unused scales on certain types of meter-indicator components, scale redesign, modification of terminology in documents and changing of color on components and mimics.

When the verification process indicated that a discrepancy could be resolved by a surface enhancement, the correction was then verified by the application of appropriate criteria from NUREG-0700 to ensure that new HEDs did not result from the correction and that the old HED had received an effective solution. This HED correction was then placed in implementation planning.

4.2.2 Correction by Design Alternative

When surface enhancements did not provide sufficient resolution to the discrepancy, the discrepancy was submitted to reanalysis for correction by design alternative. Any information which contributed to the HED Report, such as operator interviews or the CR validation process, was reviewed to provide a clear definition of the tasks and functions and operator requirements that might be affected by this discrepancy. Various alternatives were considered, as required, to ensure that an effective and reasonable design solution would be provided. Specific considerations in this process included the verification of the solution and the impact on the existing design, cost and schedule estimates where applicable, and operator training.

This correction process is iterative in that each proposed solution is reviewed in regard to its appropriateness to the discrepancy. The verification process examines the impact on the operator's requirements for each viable alternative and, similar to the enhancement verification method, NUREG-0700 criteria are used to evaluate whether the design alternative resolves the HED and avoids new HEDs. The alternative which is selected is then inserted into implementation planning.

4.2.3 Other Means of Correction

In a few cases, neither enhancement nor design change offered an appropriate solution. In those cases a procedural or training solution was recommended.

5.0 IMPLEMENTATION SCHEDULE OF DESIGN SOLUTIONS

This section describes design changes that have been made or that will be made to improve control room operability and operational safety. Addressed here is the disposition of the HEDs presented in the previous section and the process for implementing the corrections that have been selected for these HEDs. The following discussion includes:

- o A description of improvements initiated at the time of this report
- o A list of the HEDs that are planned to be corrected
- o An implementation schedule for these corrections
- o A list of the HEDs for which no correction is planned
- o The methodology for determining:
  - whether the corrections will resolve the HED
  - if the corrections will result in new HEDs.

5.1 Incorporation of HFE in Design

PSE&G has incorporated HFE throughout the design of HCGS. In addition to the Operability Analysis and the revision of the Remote Shutdown Panel design as discussed earlier, the following steps have been taken.

5.1.1 Experience Based on Salem Design

PSE&G has incorporated design improvements based on their experience as architect-engineer and operator of Salem. Those improvements include a lamp test capability and indication of loss of power to all vertical indicators.

5.1.2 Analysis of Annunciator Tile Arrangement

During the CRDR, PSE&G has taken every opportunity to incorporate good human factors practices into the design process. A primary example of this is analysis of the annunciator system layout.

Early in the CRDR, and prior to submission of the Program Plan, PSE&G asked Essex Corporation to review the HCGS annunciator system layout for functional grouping and prioritization prior to implementation of the design in the control room. As a result of this analysis, the layout of the annunciator system was redesigned to enhance operability.

5.1.3 Development of Abbreviations and Acronyms List for HCGS

A list of standard acronyms and abbreviations was developed as a means of ensuring consistency in control room component labeling, and with training and procedures. Salem and Hope Creek panel, annunciator and procedure abbreviations were reviewed to develop the list. Selection among alternatives was based on frequency of use, label space constraints, and recommended American National Standards Institute Abbreviations (ANSI Y1.1-1972).

5.2 HEDs Proposed for Correction

Table 5.1 lists all of the HEDs for which corrections are planned. The HEDs have been placed in groups of related problems where possible due to the difficulty in correcting one HED without allowing for a related HED. This approach is intended to accomplish two goals: (1) increase the efficiency of the correction process by addressing related problems at the same time, and (2) avoid introducing new HEDs with the correction process by looking at any interaction of related solutions. A brief description of the corrections is found by entry into Appendix B summaries with the HED number.

5.3 HEDs Not Scheduled for Correction

Table 5.2 lists all of the HEDs for which no correction is planned. The rationale for not correcting these HEDs is addressed individually in the Disposition portion of the HED summary description in Appendix B. Most occur on panels in the back area that are not used by control room operators for process control.

5.4 Implementation Schedule for HED Corrections

The implementation schedule for HED corrections is guided, in large part, by the NTOL status of HCGS. One of the advantages of being NTOL is that the planning and implementation of the modifications is not dependent on planned outages associated with the operating plant.

Implementation of HED corrections described in this summary report is planned according to the following schedule:

- The engineering will be completed in December 1984.
- Implementation of the changes will be completed in May 1985, six months prior to fuel load.

Table 5.1

HEDs Scheduled for Correction

METHOD	HEDs
PRELIM OP INTERVIEW	A1, A26, A30, A31, A32, A44, A47, A58, A69, A78, A127, A133, A134, A135, A137
DISPLAYS	A3, A4, A5, A6, A10, A11, A14, A15, A23, A60, A64, A66, A67, A69, B2, B6, B7, B10, B11, B12, B13, B14, B16, J1, J2, J3, K13, L7
CONTROLS	A4, A13, A17, A20, A61, A68, A73, A79, A131, B17, D7, E19
LABELS/LOC. AIDS	A21, A27, A78, A98, A99, A100, A102, A103, A106, A107, A108, A109, A110, A112, A113, A114, A115, A116, A117, A118, A119, A121, A129, A141, A143, B5, B9, B19, D2, D5, E1, E11, G9, G10, G12, G15, G16, G23, H5, L6
ANNUNCIATOR	A1, A2, A26, A124, A125, A128, L9
ANTHROPOMETRY	A9, A127, L15
CONVENTIONS	A25, A65, A90, A91, A92, A130
MAINTAINABILITY	A148

Table 5.1 (Continued)
HEDs Scheduled for Correction

METHOD	HEDs
VERIFICATION	A30, A31, A32, A33, A34, A35, A36, A37, A38, A39, A40, A41, A42, A43, A44, A45, A46, A55, A72, A73
VALIDATION (EOP)	A31, A39, A43, A47, A49, A51, A52, A58, A59, A73, A75
VALIDATION (SU/SD)	A31, A32, A49, A52, A80, A81, A82, A85, A86, A87, A88

Table 5.2

HEDs Not Scheduled for Correction

METHOD	HEDs
PRELIM OP INTERVIEW	A22, A24, A48, A57, A132, A136, A138, A139, A140,
DISPLAYS	A12, A28, A62, A63, A70, A126, A149, B18, D6, D11, E4, E8, E14, E17, E18, F6, F7, F8, G1, G2, G5, G6, G8, G22, J6, J7, J9, K6, K7, K8, K9, K10, K12, K17, L8,
CONTROLS	A16, A22, A24, A77, A96, A146, B8, B15, D1, E5, E10, E12, E13, E20, F3, F4, F5, F14, F15, G4, G7, G21, G24, H1, H2, J5, J10, L1, L3, L5, L12, L13
LABELS/LOC. AIDS	A95, A101, A104, A105, A111, A120, A145, A147, B1, B3, B4, B20, D3, D4, B10, E2, E3, E6, E7, E9, F1, F2, F11, F12, F13, G3, G11, G13, G14, G19, G20, H3, H6, J4, J11, K1, K2, K3, K4, K5, K11, K14, L2, L10, L11
ANNUNCIATOR	A122, L8
ANTHROPOMETRY	A7, A8, A18, A123, A144, B21, B22, B23, D8, D9, E15, E16, E21, F10, G17, G18, H4, K15, K16, L16, L17
CONVENTIONS	A89, A93, A94
VERIFICATION	A29

Table 5.2 (Continued)

HEDs Not Scheduled for Correction

METHOD	HEDs
VALIDATION (EOP)	A22, A29, A48, A50, A53, A56, A57, A76, A97, A142
VALIDATION(SU/SD)	A48, A50, A83, A84

The time period for completion of control room changes was chosen to coordinate with the schedule for finalizing Emergency Operating Procedures. The HCGS Safety Evaluation Report requires that all proposed operating and maintenance procedures must be ready in advance draft form six months prior to fuel load and must be in final form three months prior to fuel load. This is to allow adequate time for operator familiarization with the procedures. To ensure that the procedures are fully consistent with control room component characteristics and labeling, and to support the EOP development schedule, it will be necessary to complete the control room changes on the planned schedule.

6.0 INTEGRATION OF NUREG-0737 SUPPLEMENT 1 INITIATIVES

Public Service Electric and Gas Company is taking a fully integrated approach to meeting the requirements of NUREG-0737 Supplement 1 for Hope Creek Generating Station. The design of instrumentation based on Reg Guide 1.97, SPDS development, development of upgraded EOPs, implementation of the CRDR, and the design of the TSC and EOF are recognized as being highly interrelated and have been managed and coordinated accordingly. Since HCGS is an NTOL, the operator training program has considered new developments from the beginning.

Engineering personnel on the review team are the same individuals responsible for SPDS and Reg Guide 1.97 instrumentation. Operations personnel on the review team are the individuals responsible for development of upgraded emergency procedures. Together, PSE&G personnel assigned to the CRDR also determined TSC and EOP design.

The HCGS SPDS will be based on the BWROG recommendation. The BWROG is using a task anlaysis of the generic EPGs to develop operator information requirements, which will in turn lead to a set of displays. A plant-specific list of those information requirements was heavily used during the task analysis portion of the CRDR as discussed previously. Instrumentation provided to meet Reg Guide 1.97 was considered in the verification of control room adequacy to support task performance requirements. The results of the plant-specific task analysis is being considered in the preparation of the EOPs. The suitability of available instrumentation (ranges, etc.) and control capabilities to meet operator needs will be assessed as part of the EOP V&V program.

7.0 DOCUMENTATION

Documentation of the HCGS CRDR falls into five categories.

- The HCGS CRDR Program Plan
- This HCGS CRDR Summary Report
- A Supplemental HCGS CRDR Report to be submitted within 6 months after fuel load
- The photomosaics
- HED forms, checklists, component sheets, and other data forms used in conduct of the HCGS and maintained in PSE&G Files.

The HCGS CRDR Program Plan was reviewed by the NRC and PSE&G has modified its approach to respond to NRC concerns. Variances from the Program Plan are contained in Appendix A and discussed throughout this Summary Report.

This Summary Report describes all analyses done in the HCGS CRDR to date. Remaining analyses (described in Section 2.1.2 and 2.4) cannot be done at this time due to plant construction status. These remaining analyses will be conducted as soon as completion of the control room makes the data useful. A Supplementary Report documenting the results of these analyses will be submitted to the NRC 6 months after fuel load.

The simulator photomosaics, together with a list of detailed differences between the simulation photomosaic and the actual "as built" control room, form a detailed baseline of the control room configuration as reviewed. Other documentation will be maintained in PSE&G files.

APPENDIX A

MODIFICATIONS TO PROGRAM PLAN

SUMMARY OF MODIFICATIONS TO PROGRAM PLAN

The NUREG-0700 guidance concerning CRDR final reports recommends that changes in the overall review plan, management and staffing, and documentation should provide update material only, with reference to the Program Plan. In addition, this requirement was emphasized in our meeting with the NRC to resolve comments on the Program Plan.

Changes in those areas are summarized below:

- o Review Plan
  - The schedule for completing CRDR activities and for reporting was revised. This was done so that the surveys which must be deferred until system implementation is complete or until the unit is operating can be accomplished in one coordinated effort, minimizing interference with other activities. One Supplemental Report will be submitted, approximately six months after fuel load to document the remaining surveys. Additional operator interviews will also be conducted and their results provided in the Supplemental Report.
  - Two additional emergency response sequences were included in task analysis — radioactivity release and secondary containment control. They replace startup/shutdown and operating power change as topics for task analysis. Although a detailed task analysis of the latter was not performed, they were examined in validation walk-throughs. "Significant changes in reactor power" was considered to be encompassed by startup and shutdown.
- o Management and Staffing
  - There was one change in project management personnel. G. H. Brittain replaced K. V. Evans as the Bechtel CRDR Coordinator.
- o Documentation
  - Modifications were made in the HED Report Form.

Revised pages showing the specific changes made are provided in the back of this appendix. The paragraph, page, and figure numbers given correspond to those in the Program Plan.

In addition, there were modifications in two areas of the review procedures. In accordance with the NUREG-0700 guidance, the actual procedures used are described in the main body of this report. The procedural modifications that occurred are summarized below:

- The procedure described in the Review Plan for system function and task analysis was modified to clarify the roles of the BWROG EPGs and the plant-specific EOPs with respect to CRDR task analysis and to separate the identification of operator information and control needs from the existing control room components more clearly. This was done in response to NRC staff comments on the Program Plan. The procedure used is described in Section 2.2 of this report.

  In addition, the determination of specific parameter values and ranges was deferred. The plant-specific analyses needed to provide data concerning the operator information requirements aspect of verification will be completed as part of the development of the Procedures Generation Package. This is also discussed in Section 2.2.

- Related to the above, verification of instrumentation with respect to specific parameter values and ranges was deferred to the procedures validation program.

- The method for assessment of HEDs was clarified, and benefit to operators was added as an assessment consideration. Also, a provision was added to allow for decisions to correct HEDs without assessment. The assessment method as implemented is described in Section 4.0 of this report.

PROGRAM PLAN
PAGE CHANGES

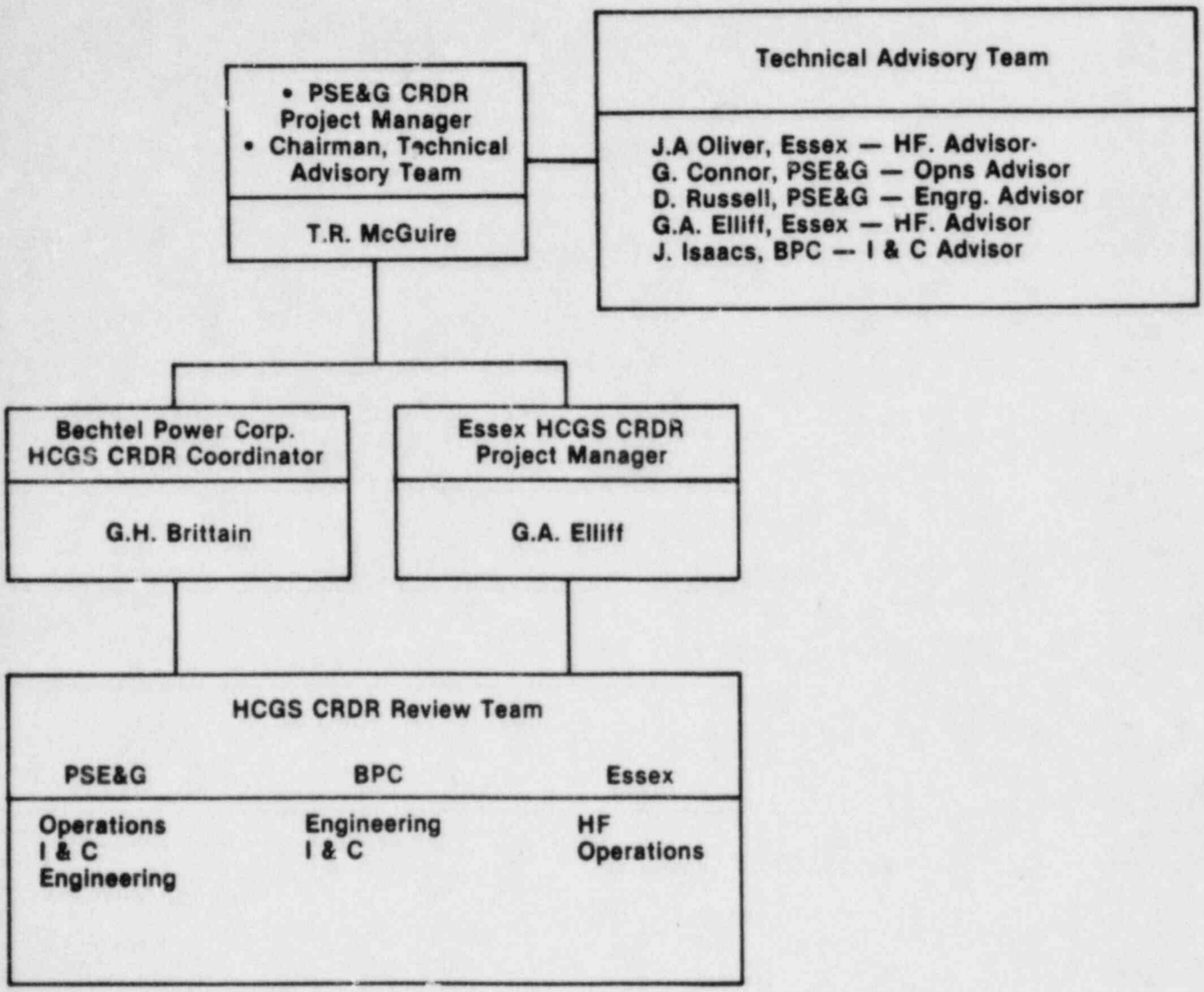


FIGURE 5. HCGS CRDR project management organization

2.2.3 Bechtel Power Corporation HCGS CRDR Coordinator

Bechtel Power Corporation, serving as a consultant to PSE&G, is responible for providing appropriate technical expertise to the HCGS CRDR Team. The Bechtel Power Corporation (BPC) HCGS CRDR Coordinator is responsible for ensuring coordination of all BC activities in support of the HCGS CRDR.

Mr. Gilbert H. Brittain will be the BPC HCGS CRDR Coordinator. Mr. Brittain has been a member of the Bechtel Power Corporation Control Room Design Group for the HCGS since June 1979. He was involved in much of the early design of the Hope Creek control room complex and has been the responsible engineer for that equipment which comprises the main vertical boards and the unit operator's consoles as well as the interfacing d' al logic and analog loop equipment in the control equipment rooms. He also monitored the design of the miscellaneous monitor and communication consoles for the control room and shift superivsor's office as well as the main annunciators. Before working on the Hope Creek generation station he was involved in an advanced control room study for another BWR nuclear plant and was responsible for the control room design.

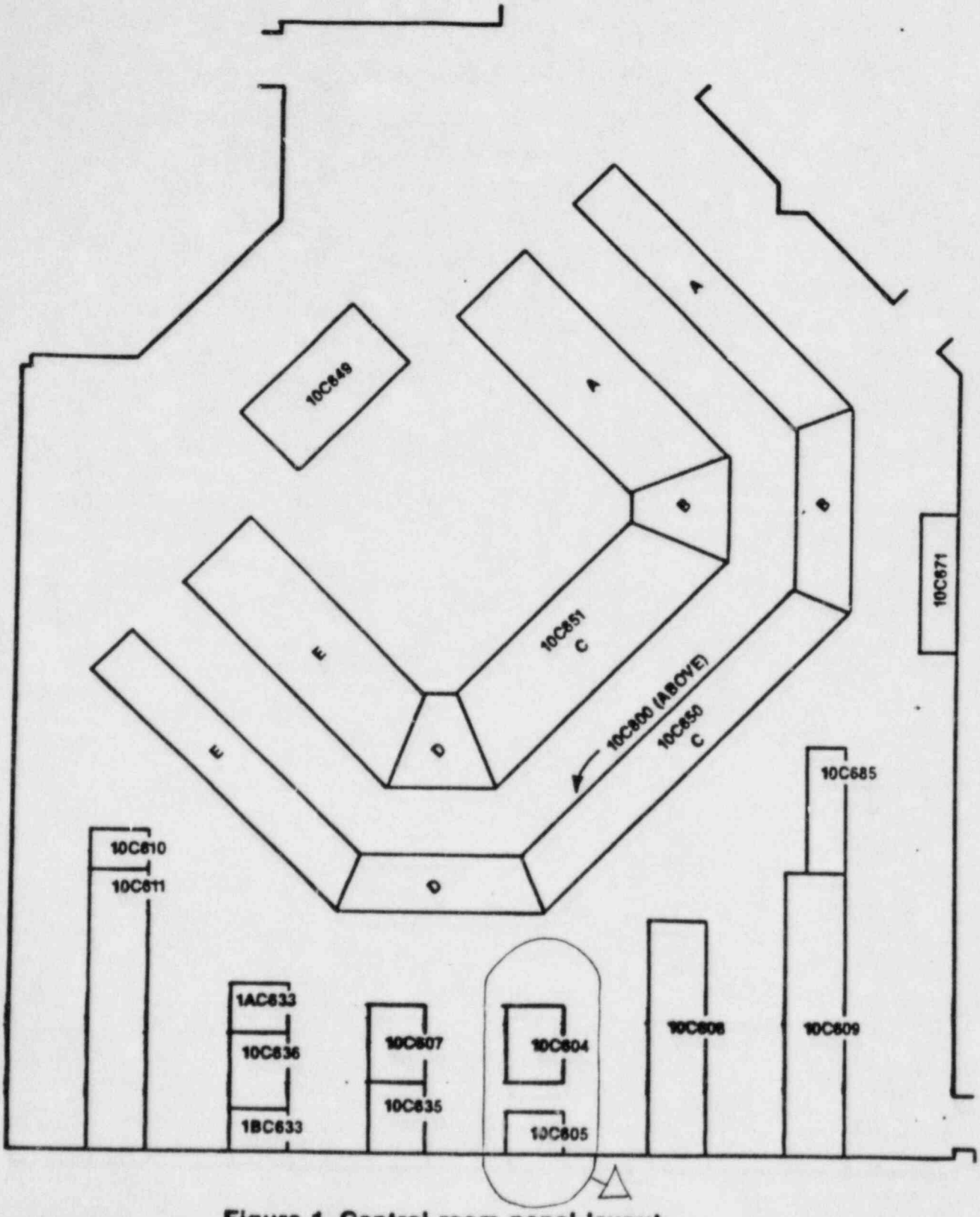


Figure 1. Control room panel layout

Table 1.
Panel identification summary

PANEL NO.	CONTENTS
10C399	REMOTE SHUTDOWN PANEL
10C604	CLASS 1E RADIATION MON. INSTR. CAB.
10C607	TIP CONT. & MON. CABINET
10C609	RPS A/B LOGIC VB
10C610	CONT. ROD TEST INSTR. CAB.
10C611	RPS C/D LOGIC VB
1AC633	POST LOCA H2 RECOMB. A CTRL. CAB.
1BC633	POST LOCA H2 RECOMB. B CTRL. CAB.
10C635	RAD. MONITOR A/B INSTR. CAB.
10C636	RAD. MONITOR C/D INSTR. CAB.
10C649	OPERATORS MONITOR CONSOLE
10C650	MAIN VERTICAL BOARDS
10C651	UNIT OPERATORS CONSOLE
10C671	FIRE DETECTION STATUS CAB.
10C685	COMMUNICATIONS EQUIP. CAB.
10C800	OVERHEAD ANNUNCIATOR PANEL
10C605	SAFETY RELIEF VALVE MONITOR CAB.
10C608	POWER RANGE NEWTRON MONITOR CAB.

ACTIVITY	SCHEDULE
Phase 1 — Project Planning	Completed October 1983
Phase 2 — Surveys	
Control Room Surveys (except as identified below)	October 1983 — March 1984
HVAC, Illumination, Ambient Noise, Communications and Computer System Surveys*	Completed prior to delivery of Supplemental Report
Operator Interviews**	
Phase 3 — Assessment and Design Solutions	December 1983 — June 1984
Phase 4 — Reporting	
Summary Report	Ongoing through July 1984
Supplemental Report	Completed six months after fuel load

* Results to be provided as Supplemental Report.
** Preliminary operator interviews were conducted as part of the CRDR activities presented in this report. Additional interviews will be conducted after a period of operating experience and presented in the Supplemental Report.

Figure 6. HCGS CRDR project milestones

HUMAN ENGINEERING DISCREPANCY REPORT

NO: _____ PLANT-UNIT: _____ DATE: _____

REVIEWER NAME: _____

a) HED TITLE: _____

_____

_____

b) METHOD OF REVIEW: _____

c) ITEMS INVOLVED:

ITEM TYPE	NOMENCLATURE	LOCATION	PHOTO NO.

d) PROBLEM DESCRIPTION:

(NUREG-0700 CRITERION)

e) SPECIFIC OPERATOR ERROR(S) THAT COULD RESULT FROM HED:

f) SUGGESTED BACKFIT

g) ESSEX REVIEW

DATA COLLECTION MGR _____ DATE _____

PROGRAM MGR _____ DATE _____

h) DISPOSITION
ASSESSMENT CATEGORY CODE

EVALUATION COMPLETED
PSE&G PROJECT MGR _____ DATE _____

HUMAN ENGINEERING DISCREPANCY REPORT

HED NO. _____

CONTINUATION SHEET: COMPONENT IDENTIFICATION

COMPONENT

PANEL ZONE NUMBER

4.3.2.2.2 Selection of Event Sequences — The objective of this subtask is to select the event sequences to be analyzed for human interaction in later tasks. These event sequences will reflect the spectrum of plant operations.

1. The event sequences for transient and accident conditions described in NUREG-0660 and NUREG-0737, items I.C.1 and I.C.9, will be addressed through analysis of symptom-based emergency response requirements as defined in the BWROG generic Emergency Procedure Guidelines and other generic and plant-specific technical data.
   - Reactor Pressure Vessel (RPV) Control
   - Containment Control and Drywell Pressure Control
   - RPV Water Level Restoration
   - Emergency Depressurization
   - Blow Down Cooling
   - Spray Cooling
   - Alternate Shutdown Cooling
   - RPV Flooding
   - Reactor Level/Power Control
   - Radioactivity Release
   - Secondary Containment Control
2. Plant startup or shutdown and significant operating power changes (to be addressed in validation walk-throughs, detailed task analysis will not be performed).

APPENDIX B

REVIEW FINDINGS OF THE CONTROL ROOM DESIGN REVIEW FOR HOPE CREEK GENERATING STATION

REVIEW FINDINGS OF THE CONTROL ROOM DESIGN REVIEW FOR HOPE CREEK GENERATING STATION

INTRODUCTION

This appendix presents, in summary form, the HEDs that were observed in the first stage of the Control Room Design Review for Hope Creek Generating Station. Each HED summary provides a brief description of the discrepancy and its disposition as determined during the assessment process. The summaries are presented in groups. HEDs identified with prefix A were observed in the primary operating area of the main control room, group B HEDs were observed from the Remote Shutdown Panel, and the remaining HEDs were observed in the back panel area of the main control room. Each set of HEDs for a given back panel received its own prefix letter due to the variety of panel types.

The location of each panel in the control room is shown in Figure B.1 on the next page. The only panel not shown here is the Remote Shutdown Panel, which is in a separate area away from the Main Control Room. The Primary Operating Area is that space which includes the Operators Monitor Console (10C649), the Main Vertical Boards (10C650), the Unit Operators Console (10C651), and the Overhead Annunciator System (10C800 on top of 10C650). The sub-panels within 10C650 and 10C651 are designated A, B, C, D, and E. In the HED summaries in this appendix, the HED is often indicated by the subpanel letter followed by a prefix. For example, "Bv" represents Subpanel B of the Main Vertical Panel (10C650) and "Bc" represents Subpanel B of the Unit Operators Console (10C651).

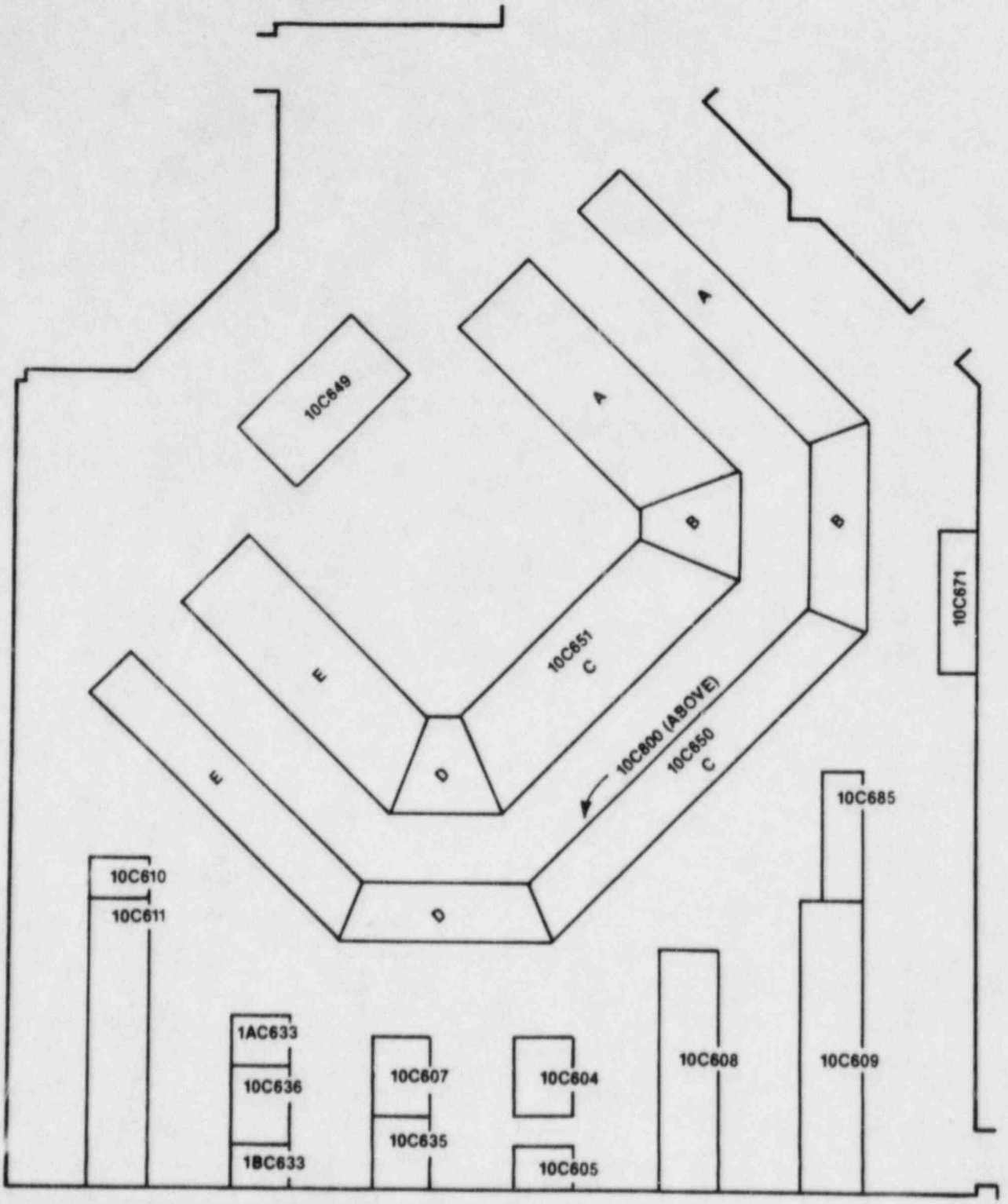


Figure B.1 Control room panel layout

B1. Primary Operating Area

- 10C649 Operators Monitor Console
- 10C650 Main Vertical Boards
- 10C651 Unit Opertors Console
- 10C800 Overhead Annunciator Panel

A1: The horizontal and vertical axes of the annunciator panels are not identified.

Disposition: This HED will be corrected. An alphanumeric designation for all rows and columns in each annunciator panel will be provided.

A2: The annunciator panels do not have component identification labels.

Disposition: This HED will be corrected. An identification label will be provided for each annunciator panel and for CRTs in the annunciator section.

A3: The scales on several of these vertical meters do not have the recommended three levels of graduation marks (e.g., panel Ec, Electrical System).

Disposition: This HED will be corrected. The scale will be redesigned to provide the appropriate levels of graduation marks. Specifications for all scales in the control room have been prepared by Bechtel and approved by the TAT for implementation.

A4: Several legend pushbuttons/legend indicator lights have four lines of lettering (panels Ac, Av, Bv, and Cc). The recommended maximum is three.

Disposition: This HED will be corrected. Message legends with no more than three lines will be provided.

A5: These displays have scales with scale intervals which increase by values other than 1, 2, 5, or multiples thereof (e.g., panels Cv, Dv, Dc).

Disposition: This HED will be corrected by redesigning the scales to provide appropriate intervals. See A3.

A6: There are more than nine graduation marks between the numerals on these meter scales (panels Av - Cv, and Ev).

Disposition: This HED will be corrected. A scale having no more than nine graduation marks between the numerals will be provided. See A3.

A7: These emergency-related controls fall above the maximum recommended height of 53 inches from the floor on vertical panels Av, Bv, Cv, and Dv.

Disposition: A correction is not planned for this HED (Category 4). The controls identified are part of mimics. The mimics are considered to be of greater value to the operators than having all of these controls under the restricted upper limit for emergency controls.

A8: These displays are not within the recommended 41"-70" zone on vertical panels Av - Ev.

Disposition: A correction is not planned for this HED (Category 4). The layout of the vertical panels was done to allow systems to be mimicked. The arrangement of components that are not part of mimics were made in accordance with space constraints associated with the priority on mimics. The primary concern where there was no mimic was to optimize the arrangements with respect to functional groupings and sequence of use. These features are considered to be of greater benefit to the operators than strict adherence to the recommended zone of distance above the floor.

A9: These controls are not within the extended functional reach on the console panels Ac - Ec.

Disposition: This HED will be corrected. The handrail will be moved to reduce the reach distance by approximately 4 inches.

A10: Some scales differentiate between scale graduation marks by line thickness. These types of scale graduations are not different enough to allow easy discrimination between them on panels Ac - Cc, Ec, Av, Bv, Ev.

Disposition: This HED will be corrected by increasing the contrast between the widths of different levels of graduation marks. See A-3.

A11: Numerals are missing at the bottom of these meter scales on panels Ac - Cc, Av, and Bv due to being displaced by units or multiplier labels.

Disposition: This HED will be corrected. The units and multiplier labels will be relocated to a more acceptable location on the meter, and the missing numerals will be included on the scale.

A12: Light lettering is used on a dark label background on these components (on most panels).

Disposition: A correction is not planned for this HED (Category 4). The contrast is adequate. These components are backlit pushbuttons. Light lettering on dark background was intentionally selected to reduce visual noise.

A13: These key-operated switches/legend indicator lights do not have labels for the different key positions on panels Av - Cv, and Cc.

Disposition: This HED will be corrected. All key switches have labels denoting purpose and position except the following three: Cc (172)M, Cc (104)M, 10C649 (032). The first two will have purpose and position labels added. The last one, on 10C649, is associated with the security system and purposely does not have a label.

A14: These trend recorders on panels Av, Cv, and Ev have scales which do not match the scales on the graph paper.

Disposition: This HED will be corrected. Paper matching the recorder scales will be provided.

A15: These meters and pushbutton modules on the console and vertical panel display unnecessary information in the form of manufacturer labels.

Disposition: This HED will be corrected. The manufacturer labels will be removed from these components.

A16: The smallest dimension of these pushbuttons on panels Av - Fv and Cc are about one quarter of an inch less than the recommended three quarter inch dimension.

Disposition: A correction is not planned for this HED (Category 4). Pushbutton size is manufacturer standard. The difference in actual vs recommended dimension is small and is not known to have caused any problem at other plants. In all cases, indicator lights provide a barrier between adjacent pushbuttons.

A17: These pushbutton controls have a pushbutton on the right side of the control which has the term OFF to mean either Bypass or Normal. This results in inconsistent meanings for OFF, an inappropriate term to represent Bypass and Normal, and an OFF control on the right side of the component instead of the conventional left side. (Panels Av - Dv, Cc; see BOP Systems Bypassed; RPS Trip System.)

Disposition: This HED will be corrected. The legends on the pushbuttons will be changed to indicate Bypass or Normal as appropriate.

A18: These controls fall out of the recommended 34 to 70 inches above the floor on panels Av - Ev.

Disposition: A correction is not planned for this HED (Category 4). See A8.

A19: These displays, which require frequent or precise use, do not fall within the recommended 50 to 65 inches above the floor on panels Av - Dv.

Disposition: A correction is not planned for this HED (Category 4). See A8.

A20: These components have a red indicator line on a metal sleeve which is sometimes difficult to see on panels Av - Cv and especially on Cc (Nuclear Steam Supply Shutoff System).

Disposition: This HED will be corrected. The red line will be extended so that it can be seen readily.

A21: These components have an enable function, but the switch positions of the enable selector are not labeled (panels Av - Cv and Cc).

Disposition: This HED will be corrected. Position labels will be added to these components.

A22: It is not clear which Cutler-Hammer controls are associated with throttle valves vs. continuous travel valves and which of these controls are of the momentary vs. maintained type.

Disposition: A correction is not planned for this HED (Category 4). Control room personnel can easily distinguish between the maintained operators and the momentary operators. The momentary operators, (for throttling valves) are labeled with the valve designator and the abbreviation INCR (Increase) and DECR (decrease) on the push button and spring back when released. The maintained operators (operators that remain in the pushed in position when activated) have the valve designator and OPEN or CLOSE inscribed on the push buttons.

A23: The power-on indicator lights of the lower trend recorders (panels Av - Ev) are difficult to see because the line of sight is interrupted by part of the component.

Disposition: This HED will be corrected. An administrative procedure requiring checks of recorder operating status will be implemented.

A24: The RZ pushbutton modules do not have the recommended barrier height of .183" to .25"

Disposition: A correction is not planned for this HED (Category 4). The pushbutton design is manufacturer standard. Barriers are provided to protect against inadvertent actuation of adjacent pushbuttons. In this design, protection against inadvertent actuation is also provided by having to depress the pushbutton $\frac{1}{4}$" before actuation occurs. The barrier is high enough so that the pushbutton cannot inadvertently be depressed $\frac{1}{4}$". Also, there is adequate separation.

A25: The legend indicator lights and legend pushbuttons on the turbine panel (Dc) are not coded to allow discrimination between display or control.

Disposition: This HED will be corrected. The legend indicator lights will be provided with a black background for light letters similar to the other indicator light displays in the RZ modules.

A26: It is difficult to discriminate between red- and amber-colored annunciator tiles when they are lighted under typical control room illumination.

Disposition: This HED will be corrected. Specific solutions are under study.

A27: The present locations of the key position labels on these RZ keylock switches do not provide clear key position information (panels Ac - Cc, Av, Ev).

Disposition: This HED will be corrected. All keys in the control room will be notched on that side of the key which corresponds to the SAFE Or OFF position. The keys cannot be removed unless they are in the SAFE or OFF position. To avoid any operator confusion as to switch position, all existing RZ keylock "ON/OFF" nameplates will be replaced with nameplates that show only the on position.

A28: These vertical meters, mostly on the console sections (e.g., panel Ec), have a certain amount of parallax due to the scales, numerals, and pointers being in different planes.

Disposition: A correction is not planned for this HED (Category 4). The amount of parallax is small (one or two minor graduation marks). Readings to the required degree of accuracy can be obtained by the operator.

A29: Operators are directed to read "Reference Leg Temperature" by the procedure, RPV Flooding. This parameter is not presently available.

Disposition: This HED has been corrected. Two channels of reactor pressure vessel level instrumentation sensing lines have been rerouted such that the drop in elevation of the reference leg in the drywell is minimal. Procedure will be rewritten indicating which channel A&B indicators and recorders are to be used for determining level.

A30: The present page phone arrangement does not extend to the main vertical panels, fire protection panel, or RMS panel. Existing phone cords on the console are too short to allow reasonable coverage of the panel.

Disposition: This HED will be corrected. Three 5 line party pages phones will be added at the rear of the console (one each to sections A, C, & E); the existing 3 page phones on 10C651 will be converted to 5-line party phones like the one on 10C649. Will increase the length of coiled phone cords to 10 to 12 feet for all phones. By opening the rear doors of the vertical boards, the jack stations of the sound powered system will be accessible to technicians/operators at the RMS and Fire Protection panels. All jack stations for sound-powered phones within the vertical boards and console will be interconnected.

A31: There is no indication for Suppression Chamber Pressure and Drywell Pressure near the spray controls at the RHR system on panel Av. (These parameters are located on panel Ev, however.)

Disposition: This HED will be corrected. Additional indications of these parameters will be added to panel 10C650A.

A32: There is no display for the Reactor Period parameter in the primary operating area of the control room.

Disposition: This HED will be corrected. A display will be located on panel 10C650C.

A33: The procedure for Reactor Control instructs the operator to open the MSIVs. The corresponding MSIV controls on panel Cc do not have an OPEN position label, however.

Disposition: This HED will be corrected. These controls will be relabeled to correspond to the procedure.

A34: The procedure for Reactor Control instructs the operator to "Reset the scram." However, the corresponding RPS trip logic controls (key-operated rotaries on panel Cc) do not have RESET position labels.

Disposition: This HED will be corrected. The present label BYP will be changed to read RESET.

A35: The boron injection pumps for the Standby Liquid Control system are labeled with one number on panel Cc and a different number on the P&IDs.

Disposition: This HED will be corrected. The identification will be changed so that both panel and P&IDs are correct and consistent.

A36: The labeling for two equivalent valve controls in RCIC and HPCI on panel Bv uses inconsistent terms: CV vs. GOV CV; and the distribution of the legend on the two parts of these two controls suggests that there may be two different valves operated by each control.

Disposition: This HED will be corrected. The labels will be changed so that both will read TURB GOV CV open. All of the valve identifications will be placed on the top part of the control instead of being divided between the upper and lower part.

A37: Several trend recorders and vertical meter-indicators on panels Bv and Cv which indicate RPV level are not identified as to which range of the level is being displayed (e.g., Wide Range, Fuel Zone).

Disposition: This HED will be corrected by providing labels which identify the specific range being displayed.

A38: Labeling for the Automatic Depressurization Valve (ADV) groups of pushbuttons and related indicator lights on panel Cv is confusing in relation to associated annunciator tiles and to ADV auto initiation controls and indicator lights. LOGIC is used where CHANNEL should be. LOGIC is not used where it should be used.

Disposition: This HED will be corrected. Appropriate, consistent labeling will be provided.

A39: The appropriate scale for the range or zone monitored by RPV level displays on panel Av (e.g., Wide Range, Fuel Zone, etc.) is not currently installed on at least two displays.

Disposition: The HED will be corrected. All displays relating to RPV water level will be verified for appropriate range/zone and corrected where required.

A40: The Jockey Pumps which feed into the core spray mimics on panels Bv and Cv are not specifically identified.

Disposition: This HED will be corrected. The Jockey Pumps will be identified as to their specific origin in an RHR loop.

A41: The label for this control, HV 3474 on panel Dv, does not agree with the P&ID nomenclature, HV 2069. Also, this legend pushbutton component is represented on the P&ID as a key-operated switch.

Disposition: This HED will be corrected. The valve designation on the control will be changed to HV2069. The P&ID has been corrected to delete the keylock notation.

A42: Jockey Pump Loop D in RHR-B, panel Av, is incorrectly labeled as Jockey Pump A.

Disposition: This HED will be corrected. The label will be changed.

A43: On some of the instruments which indicate RPV level, the Top of Active Fuel (TAF) is shown as zero, while it is shown as approximately -160 on other RPV level indicators.

Disposition: This HED will be corrected. TAF will be identified on all RPV level scales where included in the range of scales.

A44: The HPCI mimic on panel Bv shows flow going out from the Jockey Pump instead of in from the Jockey Pump.

Disposition: This HED will be corrected. The mimic arrowhead will be revised to show flow coming in from the Jockey Pump.

A45: The RHR A and B mimics on panel Av do not show how the Jockey Pumps feed into Loop C and Loop D.

Disposition: This HED will be corrected. The mimic will be modified to show relation of the Jockey Pumps.

A46: The component labeling for these trend recorders for STATION SERVICE WATER on panel Av does not indicate the parameter (e.g, Suction Level) or component (e.g., Pump A).

Disposition: This HED will be corrected. These labels will include the parameter and component identification.

A47: The black vertical, dashed lines on the containment atmosphere mimic on panel Ev are perceived not as flow lines, but as logic lines.

Disposition: This HED will be corrected. On the containment atmosphere mimic, black dashed lines (---) are used to show association of electrical interconnections between valve control switches and miscellaneous control devices such as isolation override switches and flow control station. This mimic will not be changed.

The remaining places where the black dashed mimic is used (containment prepurge clean-up system and various process piping lines leading in to/out of the Suppression Chamber) will be changed to a longer dashed (dashes approximately 3 times present length) green mimic line of the same width as existing dashed black lines.

A48: Some of the component-mimic relationships in the containment atmosphere mimic on panel Ec are unclear/incorrect when compared to the P&ID.

Disposition: No correction is necessary. The mimic is correct and is clear except as noted in A47, which will be corrected. The P&IDs are correct, although somewhat complex. No change, other than as stated for A47, is planned.

A49: These two RHR flow indicators on panel Av are not clear as to whether tube side flow or shell side flow is being displayed.

Disposition: This HED will be corrected. These labels will be made more specific.

A50: The console operator cannot read specific values from the reactor power display on panel Cv.

Disposition: A correction is not necessary. EOP directs operator to verify reactor power less than downscale setpoint. Operator can verify using EPRM downscale indicating lights. In addition, the console operator will obtain the values from the CRT display. In the unlikely event of computer system failure the console operator can request specific readings from the vertical panel operator or other control room personnel if needed.

A51: The key-operated rotary control labeled HI LEVEL SCRAM BYPASS on panel Cc has no position labels.

Disposition: This HED will be corrected. Position labels will be provided for this component.

A52: The component labels for the Feedwater Recirc Flow meters on panel Bc provides the parameter FLOW, but not the system involved.

Disposition: This HED will be corrected. The labels on these components will be modified to read, RECIRC FLOW.

A53: Pressure indication for the Control Rod Drive System used during emergency operating procedures is not available in hardwired indicators at the console (panel Cc).

Disposition: A correction is not planned for this item (Category 4). The information is available from the computer display system.

A54: Several unused scales on vertical indicators and trend recorders have numerical values denoted.

Disposition: This HED will be corrected. The unused numerical scales will be removed.

A55: The legends for the Automatic Depressurization Valve status lights on panel Cv suggests that direct indication of valve status is given when in fact only solenoid status is provided.

Disposition: This HED will be corrected. The legends will be revised to be meaningful and consistent.

A56: The solenoid controls and acoustic monitors for the Automatic Depressurization Valves and Safety Relief Valves on panel Cv are separated by other systems.

Disposition: This HED will not be corrected (Category 4). Information is displayed by plant computer. There are no significant safety impacts, and no significant operator benefits to making a change, even in the unlikely event of computer failure.

A57: There is no hardwired flow indication in the control room for the following systems: Safety Auxiliaries Cooling, Reactor Auxiliaries Cooling, Station Service Water, Condensate Storage and Transfer, Circulating Water, Standby Liquid Control.

Disposition: A correction is not necessary. EOPs direct operators to make decisions based on process conditions, not flow alone. Furthermore, flow for most of these systems is provided by the computer display system. Sufficient secondary indications of flow are available from hardwired instrumentation to meet needs in the unlikely event of computer system failure.

A58: It is possible to inadvertently activate the turbine trip pushbutton on the EHC panel of panel Dc because it is close to the edge of the panel.

Disposition: This HED will be corrected. A protective device will be installed on this pushbutton control.

A59: It is difficult to rapidly determine if all PCIS-related valves have isolated due to a PCIS condition such as a radioactive release because of their distribution on the various control panels.

Disposition: The SPDS will display the status of required isolations. In addition, this HED will be corrected by requiring a procedural verification. Operations will develop a checkoff sheet for verification of all isolations.

A60: These meters on the generator section of panel Ec have multiplier values other than powers of 10 (e.g., X20, X30).

Disposition: This HED will be corrected. These scales will be revised to use powers of 10.

A61: The SAFE or OFF position for these key-operated rotaries is not oriented vertically (most panels, e.g, Cc).

Disposition: This HED will be corrected. All keys in the control room will be notched on that side of the key which corresponds to the SAFE or OFF position. To insert the key, the operator will orient the notch to the SAFE or OFF position label and then place the key into the switch. The keys cannot be removed unless they are in the SAFE or OFF position.

A62: The pointer tip of these multipoint recorders on panel Ev obscures graduation marks on the scale.

Disposition: A correction is not planned for this item (Category 4). These recorders are used for trend information only. Specific values are not read from the recorder.

A63: The pointer tip for these multipoint recorders on panels Bv, Cv, and Ev does not have a simple shape.

Disposition: A correction is not planned for this item (Category 4). See A62.

A64: This trend recorder on panel Ev (STATOR WATER) has four graduation marks between the numerals, but there is only one level or kind of graduation.

Disposition: This HED will be corrected. This scale will be provided with two levels of graduation marks.

A65: The vertical arrangement of the AUTO and MAN pushbuttons is not consistent among the RZ pushbutton modules on the Unit Operators Console (compare Ac, Bc, Cc, and Dc).

Disposition: This HED will be corrected. The RZ modules listed in the component identification sheet for this HED will be revised to locate the "MAN" pushbutton (P/B) atop the "AUTO" P/B.

RZ's at item Nos (026) and (069) will not be changed because: (1) the "auto" and "MAN" P/B are on separate modules; (2) the current layout is sufficiently designed for operator interface; and (3) the association is clear.

A66: The scale multipliers for these meters on panels Av - Ev are difficult to see because they are obscured by the front of the display and/or because they are small.

Disposition: This HED will be corrected. Enlarged multipliers will be placed in a highly visible location on the front of the display.

A67: These displays on panels Av - Ev do not have a parameter label.

Disposition: This HED will be corrected. A parameter label will be provided for these displays.

A68: These controls on panels Ac-Cc and Ec have keys with double rows of teeth. They can be placed in the lock in only one orientation rather than both orientations as recommended.

Disposition: This HED will be corrected. See A61.

A69: There are no zone markings on any of the meters in the primary operating area except on panel Dc.

Disposition: This HED will be corrected. Needs for zone markings will be reviewed by the end of the first year of plant operations. Operating experience is necessary to optimize zone marking.

A70: The numerals on the Generator Shaft Voltage Meter on panel Ev follow the curvature of the scale rather than being in a vertical position.

Disposition: This HED is cancelled. The problem was observed on the simulator, but does not appear in the control room itself.

A71: When using the Containment Control and Drywell Pressure Control procedure during the verification process, it could not be determined how to obtain the Delta T Hc value required by the procedure from the available information.

Disposition: Further analysis of this observation indicates that there is no discrepancy. The Delta T determination is accomplished with the use of a Heat Capacity Temperature Limit curve, and current readings of Reactor Pressure and Suppression Chamber Temperature. The control room provides this information. The procedure for deriving Delta T Hc from these different parameters had not yet been presented during training.

A72: The operator does not have a hard copy of the charts necessary to determine RPV temperature.

Disposition: This HED will be corrected. This will be made available on the CRIDS CRT display.

A73: This key-operated RPS MODE SWITCH on panel Cc has no permanent position labels.

Disposition: This HED will be corrected. The appropriate position labels will be added.

A74: Generator megawatt display is not labeled, panel Dc.

Disposition: This HED will be corrected. Identifying label will be added and the scales will be changed to 0-1200 Mw as required (for both the scale on EHC Panel and item No (020) on V.B. 650E).

A75: To prevent ADS depressurization (e.g., during an emergency procedure), a control must be manipulated every 105 second or less on panel Cv. The operator does not have an easy way to measure the passage of time. This could result either in (1) depressurization, or (2) too-frequent travel to the inhibit control.

Disposition: This HED will be corrected. A modification is being incorporated into the ADS system logic to improve the automation of the system as well as enhance the bypass logic. Included in the modification is a maintained manual inhibit switch that inhibits ADS operation without requiring the operator to repeatedly press the reset pushbutton. There will be two manual inhibit switches (one per division) and these will be located in close proximity to the manual initiate switches.

A76: The emergency procedure, REACTOR CONTROL, instructs the operator to restore Drywell Instrument N2 gas. There is no hardwired display for this parameter in the primary operating area.

Disposition: A correction is unnecessary. The procedure wording has been changed to "restore Drywell Instrument N2 gas if isolated". Isolation status is verified by valve position and compressor operation. Hardwired displays are available for these parameters.

A77: These joystick controls on panel Cc can be placed into nonfunctional positions.

Disposition: A correction is not planned for this HED (Category 4). There is no consequence of a wrong position. These joysticks provide channel selection. Indicator lights provide feedback as to which channel has been selected.

A78: All of the Bailey Rz and Ry components in the control room use magnetic labels which allow easy removal and interchanging of positions.

Disposition: This HED will be corrected. Double-back tape will be used to secure the labels without risk of breakage when they must be removed.

A79: Several key-operated components on panels Av - Dv and Cc have keys which can be inserted with the key teeth pointed down instead of up.

Disposition: This HED will be corrected. See A61.

A80: Operator preferences indicated that the label RECIRC PUMP TRIP (Reactor Recirculation on panel Cc) should be modified to include the abbreviation RPT.

Disposition: This HED will be corrected. The label will be modified to read, RECIRC PUMP TRIP (RPT) BREAKERS.

A81: The scale ranges and/or multipliers for the Feedwater Recirc Flow Meters on panel Bc do not provide the appropriate range for this parameter.

Disposition: This HED will be corrected. This scale will be modified to provide the appropriate range and/or multiplier.

A82: The IN, OUT legend indicator lights on these IRM Detector Selector pushbuttons on panel Cc modules are displays, and thus are not intended to be depressed. Nevertheless, they can be depressed like a control.

Disposition: This HED will be corrected. These components will be modified to prevent depression of the indicator light.

A83: When a turbine bypass valve opens, such as during the startup procedure, the operator does not know it unless a set of indicating lights is being monitored (panel Dc, EHC system).

Disposition: A correction is not planned for this HED (Category 4). During startup and shutdown, the operator will be instructed to monitor indicator lights. An alarm for turbine bypass open would be a nuisance alarm during startup and shutdown.

A84: There are components in the Redundant Reactivity Control System (RRCS) which are presently on panel Dc, although there are related components in systems on panel Cc (e.g., Standby Liquid Control, Feedwater, RPT breakers).

Disposition: No correction is required. Although the RRCS initiates other systems, there is no operational interaction between the RRCS and other systems. The operator does not interface with RRCS and other systems at the same time.

A85: The Full Core Display on panel Cv uses the color red to indicate an alarm condition (e.g., rod DRIFT), and also to indicate that the equipment is energized (e.g., Rod FULL OUT). Although red is conventionally used for both such functions in the control room (i.e., red annunciator alarms, red for pump ON), the two functions seldom converge on the same component as they do here. In this case, the color red appears to have contradictory meanings and may have little effectiveness as a color code.

Disposition: This HED will be corrected. The colors on this display will be modified so that red will serve only an alert or alarm type of function. Red will not be used to indicate activation status of the equipment.

A86: The control rod coordinates on the square legend lights of the Full Core Display matrix are difficult to read from the console.

Disposition: This HED will be corrected. A coordinate system will be provided for the Full Core Display to indicate control rod identification and location. (This correction is to be coordinated with the HED A 87 regarding location of sensor position.)

A87: The small white circles on the Full CORE Display used to indicate sensor position are difficult to see from the reactor control panel.

Disposition: This HED will be corrected. The sensor position circles will be enhanced with a brighter color, possibly orange. This correction also includes additional coordinates to indicate sensor position. (These coordinates are to be integrated with control rod coordinate corrections in HED A 86.)

A88: The use of RED on the Rod Sequence Control System (RSCS) on panel Cc is inconsistent with the use of RED on the Full Core Display.

Disposition: This HED will be corrected. The implementation of the correction for the color discrepancy on the Full Path Display will result in a consistent use of red for the RSCS component and the Full Core Display.

A89: The color codes used in one system are inconsistent with colors used in other systems (e.g., electrical process on panel Ec vs. water or steam processes on such panels as panel Bv).

Disposition: A correction is not planned for this discrepancy (Category 4). There is consistency of color coding within the electrical system. There is also consistency of color coding for all process control systems. In other words, there are two sets of color coding conventions-one for electrical and one for process control. They are in conformance with operator expectations.

A90: The pushbuttons on these four RZ modules (LEVEL CONTROL AIR ISLN, SPLY HDR in the SACS area, panel Ac) do not use conventional color coding. OPEN pushbuttons are colored green instead of red; CLOSED pushbuttons are colored amber instead of green.

Disposition: This HED will be corrected. The documentation required to remove these components has already been initiated at the time of this HED assessment.

A91: The BYP IN OPEN pushbuttons in the RHR systems on panel Av do not use consistent color coding. They are green, whereas open functions use the color red by convention.

Disposition: This HED will be corrected. Red pushbuttons will be substituted for the green ones.

A92: The function of the columns of red and yellow indicators on the Seismic Indicator Panel is not clear. These columns are not labeled.

Disposition: This HED will be corrected. Amber indicates earthquake intensity 67% of operating basis earthquake; red indicates operating basis earthquake. The columns of indicator lights will be labeled accordingly. In addition, a device label will be added on the bezel of the insert above the lights, to read CONTAINMENT FOUNDATION ACCELERATION.

A93: Several TRIP pushbuttons on panels Av and Bv (Aux Boiler, RCIC, HPCI) are colored black. Since a trip serves to deactivate a component, green would appear to be a more appropriate color.

Disposition: No correction is planned for this item (Category 4). Neither green or red is appropriate in this instance. The first three components do have green indicating lights that light when the auxiliary boiler is tripped. Illuminated legend says "OUT OF SERVICE". Black is a nuetral color. The trip buttons for the RCIC and HPCI turbines are in a very obvious location and there is little likelihood of being mistaken for another control.

A94: There are several indicators on panels Av and Ev (RHR, CNTMT ATMOS) which use white to represent an ON condition instead of the conventional red. Similarly the corresponding ON control is black rather than red.

Disposition: No correction is planned for this item (Category 4). The colors used are consistent with HCGS conventions for indicating control modes of the valves operated by the controllers.

A95: The adjacent blue and purple colors on the electrical mimic have low contrast (panel Ec).

Disposition: No correction is planned for this item (Category 4). No controls occur in this portion of the mimic. The distinction in color is made to provide a refinement of information to the operator. Although the contrast is low, the distinction can be seen.

A96: There are several control-display pairs on panels Av (RHR) and Ev (CNTMT ATMOS) labeled ON and OFF which do not use the same color for the related control and display. The displays are white and the controls are black.

Disposition: No correction is planned for this item (Category 4). The colors used are appropriate. However, a more definitive legend will be provided for Ev 093 (CNTMT ATMOS).

A97: The eight IRM channels on panels Cc and Cv are represented by several types of functions (e.g., flow monitoring, range selection, detector selection, strip charts, recorder input). The spatial arrangement and sequence of these components (A, B, . . . , H) varies depending on the particular group. This comment applies similarly to the SRM and APRM components in this area.

Disposition: No correction is planned for this item (Category 4). The arrangement is required for channel separation. The arrangement is logical to operations personnel and the labeling is complete. There is no consequence of incorrect channel selection; the operator has feedback to verify whether the proper channel has been selected.

A98: Two components in the RACS area on panel Ac have the same legend on their label: RACS PUMP RM FLOODED.

Disposition: This HED will be corrected. The necessary identification, Channel A (or B) will be included in the label.

A99: Three Rz modules in the Off Gas System on panel Ac contain the obsolete labels, IN USE LIMIT 2.

Disposition: This HED will be corrected. The documentation required for the removal of these components had already been initiated at the time of this HED assessment.

A100: Some labels use the term DC in an unclear manner on the Feedwater Heaters section of panel Ac (e.g., HTRS 1 & 2/DC).

Disposition: This HED will be corrected. The label will be modified to read HTRS 1 & 2 & DRN CLR.

A101: There are no component labels for these two Rz modules on Panel Bc (i.e., SUCT/DISCHARGE and TURB MODE for REACTOR FEED PUMP C).

Disposition: No correction is necessary. These labels were in place at the time of this HED assessment. This HED, which was based on the simulator photomosaic for which some labels had not yet been installed, was written before the photomosaic had been verified against the actual panel.

A102: These SLC components (PUMP & SQVIB V.) on panel Cc do not discriminate between pumps A & B.

Disposition: This HED will be corrected. The labels will be modified to include the appropriate pump designations.

A103: The labeling for the eight components for IRM SELECT on panel Cc does not allow discrimination between these components.

Disposition: This HED will be corrected. These components will be labeled according to their appropriate channel.

A104: There is no group label for Channel B of the RPS trip system on panel Cc.

Disposition: No correction is necessary. This label was in place at the time of this HED assessment. This HED, which was based on the simulator photomosaic on which some labels had not yet been installed, had been written before the photomosaic had been verified against the actual panel (see Section 2.2.1).

A105: Two subgroup labels appear to have been interchanged on panel Cc. They are SRM B, D and FLOW B, D in the groups RPS TRIP CHANNEL B and SOURCE RANGE NEUTRON MONITORING.

Disposition: No correction is necessary. These labels were in the appropriate location at the time of this HED assessment. This HED, which was based on the simulator photomosaic showing inappropriate label locations, was written before the photomosaic had been verified against the actual panel (see Section 2.2.1).

A106: There are no identification labels for the Rod Select Module and the Rod Sequence Control display on panel Cc.

Disposition: This HED will be corrected. These components will receive identification labels.

A107: Not all of the meters for the EHC panel on panel Dc are identified in the same way. A few meters do not have the typical black letter on white ground above the meter.

Disposition: This HED will be corrected. All meters on this EHC panel will be identified in the same way with a label above the meter.

A108: Some of the component labels in the electrical mimic on panel Ec are incomplete or missing.

Disposition: This HED will be corrected. These components will receive complete labels as required.

A109: These six indicator lights for REGULAR PT and BACKUP PT on panel Ec were not identified according to row and the column labels were ambiguous

Disposition: This HED will be corrected. Column labels and row labels will be provided for these indicator lights.

A110: Several components on this HVAC systems (for the Reactor Bldg. System, panel Ec) have no component labels.

Disposition: This HED will be corrected. These components will receive labels which allow easy discrimination between the components.

A111: Several systems on the vertical panel (RHR, RCIC, HPCI, CSS) include pairs of PUMP ROOM FLOODED indications in the status light matrices. The labels for each element of the pairs are ambiguous in their functional relationship.

Disposition: No correction is necessary. These components had been removed at the time of this assessment. This HED, which had been based on the simulator photomosaic, showing the components described above, was written before the photomosaic had been verified against the actual panel (see Section 2.2.1).

A112: There is no component label for the Full Core Display on panel Cv.

Disposition: This HED will be corrected. An identification label will be provided for this component.

A113: The Four-Rod Display on panel Cv does not have an identification label.

Disposition: This HED will be corrected. This component will receive an identification label.

A114: The eight square yellow indicators labeled BYPASS in the Reactor and Manual Control Indication on panel Cv sections are not clearly labeled with regard to which level they represent.

Disposition: This HED will be corrected. Each of these components will receive a label indicating the appropriate level.

A115: These related strip charts for SRM, IRM, APRM, and RBM parameters on panel Cv are sometimes identified with abbreviations and on other components by complete words. This inconsistency makes it difficult to see and understand the relations between these components.

Disposition: This HED will be corrected. Abbreviations will be provided for each component label.

A116: The Generator Shaft Voltage meter on panel Ev is presently identified only by a number. There is no functional descriptive label.

Disposition: This HED will be corrected. A functional description will be provided in the component label.

A117: Some of the subcomponent labels on the Turbine-Generator Test Panel (panel Ev) were reported to be associated with the wrong components.

Disposition: This HED will be corrected. These labels will be corrected where required. Also, a general identification label for this panel will be provided.

A118: The component labeling for the two Hydrogen-Oxygen Analyzers on panel Ev presently does not allow for discrimination between the two components.

Disposition: This HED will be corrected. Unique identification labels will be provided for these components.

A119: The label CORE MONITOR on the Generator Core Monitor subpanel (panel Ev) does not clearly describe the function of this panel.

Disposition: This HED will be corrected. The label will be changed to read Generator Core Monitor.

A120: The component label WATT HOURS on panel Ev does not describe the parameter or function of the meter.

Disposition: A correction is not necessary for this item. WATT HOURS properly describes the parameter.

A121: The solid horizontal demarcation lines for the Automatic Depressurization Valves on panel Cc divide this system into three sections suggesting incorrectly that there are three systems stacked one on top of another.

Disposition: This HED will be corrected. The solid horizontal demarcation line on top of the valve controls will be removed. The solid horizontal line at the bottom of the valve controls will be changed to a dashed line.

A122: There is no auditory or visual feedback for cleared annunciator alarms.

Disposition: No correction is necessary. An auditory signal is now present to indicate a cleared alarm. Associated with this signal is a flashing annunciator window titled, COMPUTER POINT RETURN TO NORMAL. Corresponding to this window is the CRT warning message which changes color from red to yellow.

A123: The visual angle formed by the operator's line-of-sight and the plane of the annunciator panel is less than 45^{o} for three panels when the operator is standing at the corresponding acknowledge button.

Disposition: A correction is not planned for this HED. The three annuunciator panels in question are only slightly outside the minimum angle and the lettering is large enough that the tiles can be read.

A124: There is at present no administrative procedure controlling annunciator tiles which are on for extended periods. There are no guidelines to determine how these tiles are to be identified.

Disposition: This HED will be reviewed during the first year of operations. The logic will be redesigned to eliminate nuisance alarms. The system out of service log will be reviewed by the operators during shift turnover.

A125: If two or more annunciator tiles are removed at the same time there is no easy way to ensure that the tiles will be replaced in the correct location. Temporary labels are used at present.

Disposition: This HED will be corrected. A procedure will provide instructions that only one window tile will be removed at any one time. In rare cases where it is necessary to remove more than one tile at a time, verification of location will be required prior to reinstallation.

A126: There is not at present an administrative procedure to control the periodic cleaning of labels.

Disposition: A correction is not planned for this HED (Category 4). Ten years of operating experience has shown that dirt accumulation on labels is not a problem in a controlled atmosphere.

A127: An operator seated at the Operators Monitor Console cannot see over the top of the console. It is three inches higher than the recommended maximum.

Disposition: A correction to this HED is being considered (Category 3). A study will be made of the possibility of higher chairs that improve the sightline while maintaining anthropometric criteria. Other sources of plant status include the CRTs on this console and verbal communication between the operator at the console and the operator at the panel. HCGS will commit to adding no permanent fixtures to the top of this console.

A128: The annunciator selector switch on the Operators Monitor Console uses temporary labeling.

Disposition: This HED will be corrected. A permanent label will be provided.

A129: The labels on the annunciator selector switch on the Operators Monitor Console uses numeric designation of panels A-E.

Disposition: This HED will be corrected by providing appropriate permanent labeling.

A130: The colors of telephones on the Operators Monitor Console do not agree with the conventional use of the same colors elsewhere in the control room. Also the three emergency related phones do not have the same color.

Disposition: This HED will be corrected. The color scheme will be changed in accordance with direction from Nuclear Site Protection to be consistent with the telephone colors scheme for Emergency Response Facilities throughout PSE&G.

A131: Labels on pushbuttons and indicator lights can be interchanged among same sized components. Rz bezels can be interchanged.

Disposition: This HED will be corrected. A procedure will provide instructions governing the removal of labels and/or components.

A132: The I&C card on the right side of the display may be facing the wrong direction to facilitate maintenance when the control rod drive display is in use.

Disposition: A correction is not planned for this HED (Category 4). Maintenance will be performed only when operational requirements permit. In that case, the card may be accessed in more than one way. If there is a problem here, it is a maintenance problem to be identified by maintenance personnel.

A133: There is no label to describe the function of the lamp-test pushbuttons on the mini-keyboard.

Disposition: This HED will be corrected. A permanent label will be provided.

A134: The space allotted for tagging procedures on the Operators Monitor Console is not sufficient for the task.

Disposition: This HED will be corrected. There are already plans to install a Tag Regulating and Inquiry System (TRIS) which will reduce the need for table space.

A135: The nomenclature used for switchyard equipment is inconsistent with labels used on the control panel(Ec).

Disposition: This HED will be corrected. The labels in the switchyard will be changed to match those in the control room.

A136: There are several cases in which a control panel component in one system will have the same alphanumeric identifier as a component in another system. For example: "HVF006A" is in CORE SPRAY A and RHR-A, Loop B.

Disposition: A correction is not planned for this HED (Category 4). Clear system labeling and demarcation is provided in the control room so that the components can be distinguished easily. The identifiers are consistent with the valve index and P&IDs. System identifiers are provided on in-plant components and the operators have a job aid that defines those identifiers.

A137: Several labels on Panel Ec and Ev are inappropriate. For example, breaker 10503 on 4.16 KV Bus 10A103 should be 10302, the label H-13 FEED BRKR (which appears on two different breakers under the 4.16 KV Bus) should say FEED BRKR.

Disposition: This HED will be corrected. Appropriate labels will be provided.

A138: A few of the EOP charts mounted on the foam core panels are rather large and may be cumbersome to use.

Disposition: No correction is necessary. The size of EOP charts is not considered a problem. They are to be used by the Shift Supervisor who will direct the actions of other control room personnel. This HED was generated based on a comment by an operator who did not understand that only the shift supervisor would be using the EOP.

A139: The main vertical panel (10C650) does not have general acknowledge controls like the five pushbuttons on the Unit Operators Console.

Disposition: A correction is not necessary. The absence of acknowledge controls on the vertical panels is intentional. Alarm acknowledgement is to be managed from the Unit Operators Console.

A140: During tag-out activities, it is easy to overlook the step of placing a plastic tag-out cover over the affected component.

Disposition: A correction is not necessary. The plastic covers are not part of the tagging system. They do not provide block points. They are provided as a convenience to the operators to give information such as who requested the tagout and the reason.

A141: The component labels for the two trend recorders on the Operators Monitor Console do not identify them as CRIDS components. (They are grouped with an NSSS CRT).

Disposition: This HED will be corrected by providing a new label such as CRIDS TREND RECORDER 1.

A142: The two CRIDS computer trend recorders are not grouped with the CRIDS CRT, but with the NSSS CRT which is several feet away.

Disposition: A correction is not planned for this HED (Category 4). No safety significance or operating difficulty is associated with this HED.

A143: The two CRTs on the Operators Monitor Console are not labeled with regard to the CRIDS function in one case and to the NSSS function in the other case.

Disposition: This HED will be corrected. An appropriate label for each CRT will be provided.

A144: An operator sitting at the workspace area midway between the two CRTs at the Operators Monitor Console has a poor viewing angle to the CRTs.

Disposition: A correction is not planned for this HED (Category 4). Operator tasks at the Operators Monitor Console allow movement as necessary to obtain precise data. The tasks performed at this station have to do with documentation and reporting, not critical monitoring for emergency response.

A145: The warning indicator lights on the Operators Monitor Console have white letters on a red background.

Disposition: A correction is not planned for this HED (Category 4). The contrast between the label and background affords good legibility.

A146: The pushbuttons on this telephone unit are one quarter inch less than the recommended three-quarter inch dimension.

Disposition: A correction is not planned for this HED (Category 4). The probability of the finger slipping off the button is very low. Also this component is a manufacturer standard.

A147: This key operated rotary switch has no component label.

Disposition: A correction is not appropriate for this HED (Category 4). Absence of label is intentional due to interface with security system.

A148: Expendable items, spare parts and special replacement tools are not available in the control room with the exception of bulbs.

Disposition: This item will be evaluated after the plant is operating.

A149: The two trend recorders on the Operators Monitor Console can be programmed to display different trends. However, the operator cannot identify the trend and related information (units, range) from the trend recorder itself.

Disposition: A correction is not necssary. There is a specific display used to select parameters and pens. The operator reads the information from this display. The operator records the information on the chart if a historical record is needed.

Remote Shutdown Panel (10C399)

B1: The color red is used to indicate both process flow in the mimic and also for demarcation lines, e.i., it is not used consistently.

Disposition: No correction is planned (Category 4). The mimic highlights transfer switches.

B2: The scales on these meters are missing a number.

Disposition: This HED will be corrected. All relevant numbers will be provided for this scale.

B3: This label is placed beside rather than above the component.

Disposition: A correction is not planned for this HED (Category 4). The association is clear.

B4: The large mimic on this panel has process lines which sometimes overlap or cross each other, but do not intersect.

Disposition: A correction is not planned for this HED. The HED was written based on a photomosaic of the RSD. Examination of the RSD itself shows that the mimic employs generous use of space between its elements so as to minimize crowding of the overlap points. There is a low probability of an error due to misreading of the mimic.

B5: The mimic line leading to the Condensate Storage tank is incomplete.

Disposition: The HED will be corrected. The mimic line will be completed.

B6: The scale on this recorder does not match the graph paper scale.

Disposition: This HED will be corrected. Graph paper will be obtained to match the recorder scale.

B7: These legend indicator lights (RBVS supply and exhaust) use the control term CLOSE rather than the display term CLOSED.

Disposition: This HED will be corrected. The term CLOSED will be used on these displays.

B8: The recommended minimum size of a pushbutton is 3/4". The smallest dimension for these pushbuttons is 1/2".

Disposition: A correction is not planned for this HED (Category 4). See A16.

B9: The unit label on these scales is too small to be easily seen and read.

Disposition: This HED will be corrected. Enlarged labels will be placed in a highly visible location on the front of the display.

B10: These legend indicator lights for the Diesel Generator section use the terms TRIP and CLOSED rather than the conventional START and STOP. It is not clear whether the lights refer to the diesel generators themselves or to the breakers.

Disposition: This HED will be corrected. Since it is the status of the diesel generator breaker being indicated, the indicating light legends shall read: 52-40107 CLOSED/1AG400 BRKR TRIP. This is typical for all four diesel generators and their respective breakers. The main nameplate will be revised to read:

DIESEL GENERATOR BRKR STATUS.

B11: There are more than nine graduation marks between these numbers (FUEL POOL COOLING & PUMPS). This scale has 19 marks between numbers.

Disposition: This HED will be corrected. The scale and numbers will be modified to allow no more than nine graduation marks between numbers.

B12: The graduation on this indicator (FUEL POOL COOLING PUMPS) divide the space between the intermediate graduations into four spaces rather than the conventional five space.

Dispositon: This HED will be corrected. A scale will be provided with values which increase by values of 1, 2, 5, or a power of 10. See A3.

B13: It is difficult to discriminate between the major and minor marks on both scales of the RECIRC PUMP vertical meter.

Disposition: This HED will be corrected by providing good contrast between line weights of the different kinds of graduation marks. See A3.

B14: None of the scales use zones to indicate normal/abnormal ranges.

Disposition: This HED will be corrected. See A69.

B15: These Cutler-Hammer and Bailey RZ pushbuttons do not follow the recommendation of having a barrier between the pushbutton of .183" to .25" high.

Disposition: A correction is not planned for this HED (Category 4). See A24.

B16: These components display unnecessary information in the form of manufacturer's labels.

Disposition: This HED will be corrected. These labels will be removed or covered.

B17: Several meter indicators on this panel have at least one and sometimes two nonfunctional scales on the face of the component.

Disposition: This HED will be corrected. The nonfunctional scales will be removed.

B18: These vertical meters have a certain amount of parallax due to the scales, numerals, and pointers being in different places.

Disposition: A correction is not planned for this HED (Category 4). See A28.

B19: These indicating recorders do not have labeling which identifies the parameter being measured.

Disposition: This HED will be corrected. Parameter labels will be provided.

B20: These components have light lettering on dark background.

Disposition: A correction is not planned for this HED (Category 4). The contrast is adequate. See also A126.

B21: These displays are outside the recommended limits of 41-70 inches above the floor.

Disposition: No correction is planned for this HED (Category 4). See A8.

B22: These controls (legend pushbuttons and two rotary selector switches) are outside the limits of 34-53 inches above the floor recommended for emergency controls.

Disposition: No correction is planned for this HED (Category 4). See A8.

B23: These legend pushbutton controls are outside the recommended limits of 41-70 inches above the floor.

Disposition: No correction is planned for this HED (Category 4). See A8.

Class 1E Radiation Monitoring (10C604)

This panel was not installed at the time of the review.

B4. Safety Relief Valve Monitor Cabinet (10C605)

D1: The OFF and ON positions for this rotary switch are reversed from the conventional OFF on the left and ON on the right (D1).

Disposition: A correction is not planned for this HED (Category 4). The control panel is used by I&C Technicians. No error or user difficulty is likely.

D2: This key-operated rotary switch does not have an identifying component label.

Disposition: This HED will be corrected. A component label will be provided for this control.

D3: This descriptive label is placed below the panel components rather than above them.

Disposition: A correction is not planned for this HED (Category 4). This panel is used primarily by I&C Technicians. The association is clear. Low probability of error.

D4: The labels for the toggle positions (i.e., A, B) are inconsistent with the corresponding component labels (e.g., E, F).

Disposition: No correction (Category 4). The association provided by the component label is clear.

D5: The two labels indicating MAIN FRAME POWER SUPPLY are inappropriate for this panel.

Disposition: This HED will be corrected. The labels will be removed.

D6: Nonrequired information in the form of manufacturer's labels appear several times on this panel.

Disposition: A correction is not planned for this HED (Category 4). See D1.

D7: The control labeled TEST does not serve any function for this panel, and it is not connected to any equipment.

Disposition: This HED will be corrected. The switch will be removed.

D8: These displays (a set of simple indicator lights and one digital display) are somewhat higher than the recommended 70-inch height limit.

Disposition: A correction is not planned for this HED (Category 4). These components are used by I&C Technicians. No user difficulty is anticipated; a stool will be available in the back panel area if needed. See D3.

D9: Four toggle switch controls are above the recommended 70-inch height limit.

Disposition: A correction is not planned for this HED (Category 4). See D3.

D10: Label does not conform to size recommendations for hierarchical labeling. Major system/panel label has smaller lettering than subsystem or component labels.

Disposition: A correction is not planned for this HED (Category 4). See D3.

D11: Position of Open and Closed indications on this simple indicator light is reverse of norm ("closed" is above "open").

Dispositon: A correction is not planned for this HED (Category 4). See D3.

B5. TIP Control and Monitor Cabinet (10C607)

E1: There is no panel ID number indicated on this panel.

Disposition: This HED will be corrected. A label having the PSE&G numerical identifier and functional description will be provided.

E2: The component labels are midway between components, making it difficult in some cases to associate the label with the corresponding component.

Dispositon: A correction is not planned for this HED (Category 4). See D3.

E3: These subsystem labels are smaller rather than larger than the component labels.

Disposition: A correction is not planned for this HED (Category 4). See D3.

E4: Position of "OPEN" and "CLOSED" indicators is reversed from population stereotype.

Disposition: No correction is planned for this HED (Category 4). The association is clear. See D3.

E5: The DOWN and UP control positions for this toggle switch are contrary to convention.

Disposition: A correction is not planned for this HED (Category 4). See D3.

E6: These component labels are below rather than above their component.

Disposition: A correction is not planned for this HED (Category 4). See D3.

E7: These component labels have lettering height the same as, instead of larger than, the position labels.

Dispositon: A correction is not planned for this HED (Category 4). See D3.

E8: This horizontal meter has no parameter or unit label.

Disposition: A correction is not necessary. This display is used by I&C Technicians with special paper appropriate for its use. The problem identified is not a problem to I&C. Units are provided. In addition, see D3.

E9: These labels use light lettering on a dark background.

Disposition: A correction is not planned for this HED (Category 4). The contrast is adequate. See also A129.

E10: The contrast between these black controls and the black background is weak.

Disposition: A correction is not planned for this HED (Category 4). The controls are rotary selectors with white position markers. Position indication on the panel is white. The pointer position can be determined readily. See D3.

E11: These components have no component identification label.

Disposition: This HED will be corrected. Labels will be added.

E12: These rotary selector switches are smaller than the recommended diameter.

Disposition: A correction is not planned for this HED (Category 4). The size is adequate. See D3.

E13: These pushbuttons are slightly smaller in diameter than the recommended size.

Disposition: A correction is not planned for this HED (Category 4). The size is adquate. See D3.

E14: The numerals on the %POWER/VOLTS meter on the FLUX PROBING MONITOR component follow the curvature of the scale rather than being in a vertical position.

Disposition: A correction is not planned for this HED (Category 4). The curvature of the scale is small enough that an error in reading the scale is unlikely and there should be no extra time required.

E15: These controls are located below the recommended 34-inch limit.

Disposition: A correction is not planned for this HED (Category 4). See D3.

E16: These displays are located below the recommended 41-inch limit.

Disposition: A correction is not planned for this HED (Category 4). See D3.

E17: This horizontal meter has intermediate graduation marks longer than the major graduation marks.

Disposition: A correction is not planned for this HED (Category 4). See D3.

E18: There are 24 graduation marks between the numerals on this vertical meter.

Disposition: A correction is not planned for this HED (Category 4). See D3.

E19: The key for this switch is inserted with the teeth down.

Disposition: This HED will be corrected. Switches will be reoriented.

E20: The OFF (or MONITOR) position of this key-operated switch is not oriented vertically.

Disposition: A correction is not planned for this HED (Category 4). See D3.

E21: These controls are located outside the recommended limits of 34-53 inches above the floor for frequently used controls, emergency controls, or those requiring precise adjustment.

Disposition: This is not an HED. The controls identified do not fit under the definition for placement within the restricted zone of 34-53 inches above the floor. See also D3.

Power Range Neutron Monitor Cabinet (10C608)

F1: Labels are above the components they describe.

Disposition: A correction is not planned for this HED (Category 4). The association is clear and labelling is consistent across the panel. See D3.

F2: Labels are located to the side of components.

Disposition: A correction is not planned for this HED (Category 4). There is not room to move the labels. Association is clear. See D3.

F3: These rotary switches are less than one inch in length or diameter.

Disposition: A correction is not planned for this HED (Category 4). The switches serve an I&C test function and are not frequently used. The size is adequate for function. See also D3.

F4: Pushbutton controls are not slip resistant and not concave as recommended for simple pushbuttons.

Disposition: A correction is not planned for this HED (Category 4). See D3.

F5: The diameter of these pushbuttons is .125. Recommended diameter is .375.

Disposition: A correction is not planned for this HED (Category 4). See D3.

F6: There are no zone markings on these circular meters.

Disposition: A correction is not necessary. Zone marking is not appropriate.

F7: These meters have more than nine graduation marks between numerals.

Disposition: A correction is not planned for this HED (Category 4). The graduations are appropriate for the functional use. See D3.

F8: The numerals on each of the 10 curvilinear scales on this panel follow the curvature of the scale rather than being in a vertical orientation.

Disposition: A correction is not planned for this HED (Category 4). The curvature of the scale is small enough that an error in reading the scale is unlikely and there should be no extra time required. See D3.

F9: The Power Range Neutron Monitor Cabinet is not identified by either a functional description or an ID number.

Disposition: This HED will be corrected. Label will be added.

F10: Displays (simple indicator lights) are located above the recommended 70-inch height limit.

Disposition: A correction is not planned for this HED (Category 4). See D3.

F11: Component labels on this cabinet have light lettering on dark ground.

Disposition: A correction is not planned for this HED (Category 4). The contrast is adequate. See also A126.

F12: Labels do not conform to size recommendations for hierarchical labeling. Group labels are about equal in height to component labels.

Disposition: A correction is not planned for this HED (Category 4). See D3.

F13: Component label (LPRM) is located between two sets of position labels.

Disposition: A correction is not planned for this HED (Category 4). The association is clear to the users. See also D3.

F14: The contrast between these black controls and the blackground is weak.

Disposition: A correction is not planned for this HED (Category 4). Control shape and white position markings on the panel allow control position to be determined readily. See D3.

F15: Related components are separated. Also in one case order appears questionable.

Disposition: A correction is not planned for this HED (Category 4). See D3.

Reactor Protection System Cabinets (10C609, 10C611)

G1: Meters on each of these panels do not have zone markings.

Disposition: A correction is not appropriate.

G2: Manufacturer labels are on the face of several displays on these panels and may result in slightly increased search time.

Disposition: A correction is not planned for this HED (Category 4). See D3.

G3: Several component labels on this panel are placed below rather than above their related components.

Disposition: A correction is not planned for this HED (Category 4). The association is clear. See also D3.

G4: These simple pushbuttons have a diameter of 3/16 of an inch; the recommended diameter is 3/8 of an inch.

Disposition: A correction is not planned for this HED (Category 4). See D3.

G5: Display scale and pointer design and placement result in parallax potential. Readings could have an error factor of two to three graduation marks.

Disposition: A correction is not planned for this HED (Category 4). The technician will use a voltmeter; precise reading of this scale is not required. See D3.

G6: Meter scales with five or more graduation marks between numerals should be provided with three levels of graduation. These meters have only two levels of graduation.

Disposition: A correction is not planned for this HED (Category 4). See D3 and G5.

G7: These toggle switches have switch arm length less than the recommended $\frac{1}{2}$ inch.

Disposition: A correction is not planned for this HED (Category 4). See D3.

G8: Those vertical meters have as many as 14 graduation marks between numerals. They may require more time to read for this reason.

Disposition: A correction is not planned for this HED (Category 4). See D3 and G6.

G9: Labeling appears to be incorrect or inconsistent. Component lables use the terms "Div A" and "Div B," while the major system lables use "Div 1" and "Div 2."

Disposition: This HED will be corrected. Labels will be revised.

G10: The main label that identifies the panel is inconsistent with the corresponding label on the engineering drawing.

Disposition: This HED will be corrected. Modification will be made to ensure that labels and drawings are consistent.

G11: Label appears to be incorrect. The label reads "Inboard Valve Control Logic Status." Should "Inboard" be changed to "Outboard"?

Disposition: This is not an HED. The label is correct.

G12: Labeling of indicator lights that provide identical information on different panels is inconsistent.

Disposition: This HED will be corrected. The labeling will be changed to be consistent.

G13: Label does not conform to size recommendations for hierarchical labeling.

Disposition: A correction is not planned for this HED (Category 4). See D3.

G14: The SECONDS label and portions of the graduation marks on these ISOLATION TIMERS are obscured by the wide pointer on the timer.

Disposition: A correction is not planned for this HED (Category 4). See D3.

G15: These components are identified only by serial number.

Disposition: This HED will be corrected. Functional labeling will be provided.

G16: System and Logic labels vary in completeness. Inconsistency and, in some cases, insufficient information could cause confusion.

Disposition: This HED will be corrected. Complete and consistent labeling will be provided.

G17: These toggle switch controls are outside the recommended zone of 34-70 inches above the floor.

Disposition: A correction is not planned for this HED (Category 4). See D3.

G18: These displays are not within the recommended zone 41-70 inches above the floor.

Disposition: A correction is not planned for this HED (Category 4). See D3.

G19: Labels have light lettering on dark background.

Disposition: A correction is not planned for this HED (Category 4). The contrast is adequate. See also A126. See D3.

G20: Label is curved.

Disposition: A correction is not planned for this HED (Category 4). See D3.

G21: The Normal position on these key operated switches is not vertical position.

Disposition: A correction is not planned for this HED. The switch positions are clearly identified. See also D3.

G22: To set this timer, the switch has to be turned counter-clockwise, contrary to population stereotype.

Disposition: A correction is not planned for this HED (Category 4). See D3.

G23: RPS Div 1 and 3 panel and RPS Div 2 and 4 panel are located in different aisles. RAD MON A and B panel is similarly separated from RAD MON C and D. Labeling of panels is not adequate to make it easy to locate the panels.

Disposition: This HED will be corrected. A label will be put on the end of each cabinet in the back area to provide complete identification by name and cabinet number readable from the aisles.

G24: Identical components (key-operated switches) are arranged in different sequence on two panels.

Disposition: This HED has already been corrected. Sequence is identical.

Control Rod Test Instrument Cabinet (10C610)

H1: Rod scram timing test jack array is labeled at bottom. Because of the large number of jacks, this does not allow easy identification of those near the top.

Disposition: A correction is not planned for this HED (Category 4). See D3.

H2: Large array (H1 above) has no demarcation lines to aid in locating specific points.

Disposition: A correction is not planned for this HED (Category 4). See D3.

H3: Labels are below the components they describe.

Disposition: A correction is not planned for this HED (Category 4). The association is clear. See also D3.

H4: These simple indicator lights are not within the recommended zone of 41-70 inches above the floor.

Disposition: A correction is not planned for this HED (Category 4). See D3.

H5: This group of components has no group label. Panel layout suggests that they are part of the Control Rod Test System but they are not. Also, an unrelated component appears to be part of the group.

Disposition: This HED will be corrected by proper labeling and demarcation.

H6: The numerical identifier on the cabinet (H11-P610) does not match the PSE&G identification system (10C610).

Disposition: A correction is not planned for this HED (Category 4). The cabinets can be distinguished by the numerical suffixes, which are consistent. Also, labeling is to be provided on the end of each cabinet that identifies it by name as well as number (see G23). See D3.

Post LOCA H_2 Recombiner Control Cabinets A and B (1AC633)

J1: The horizontal meter for REAC CHAMBER TEMP CONTROL does not indicate whether degrees Centigrade or degrees Fahrenheit is being monitored.

Disposition: This discrepancy will be corrected by placing the correct label near the scale.

J2: There is no units label for the INLET VALVE FLOW meter and the RECOMBINER TOTAL FLOW meter.

Disposition: This discrepancy will be corrected by placing the appropriate label near the scale.

J3: Legends on three of the annunciator/legend indicator lights do not provide sufficient information. For example, window TE-1 says INLET TEMP but it does not specify whether the temperature is above or below the set point.

Disposition: The legends on the indicated windows will be changed to provide more specific information.

J4: White lettering on a black background is present on a portion of the annunciator panel and the temperature control component.

Disposition: A correction is not planned for this HED (Category 4). The contrast is adequate. See also A129.

J5: The key for each of the key-operated rotary controls must enter horizontally rather than with the teeth pointed up.

Disposition: A correction is not planned for this HED (Category 4). The valve position is clear and feedback is provided.

J6: The lettering for the component labels of the indicator lights is the same size as the position labels (CLOSED, OPEN) instead of 25% larger.

Disposition: A correction is not planned for this HED (Category 4). The labels are clearly readable and associations are clear. Error likelihood is judged to be negligible.

J7: The function of the three dark arrowheads on the INLET VALVE FLOW meter and the RECOMBINER TOTAL FLOW meter is not clear. If the arrows indicate zones, the type of zone still needs to be specified.

Disposition: A correction is not planned for this HED (Category 4). The arrowheads mark calibration points for I&C. The procedure for operational use of this component requires operators to establish flow at a specific value. See D3.

J8: There is no unique identifier on the front of the two recombiner panels to allow discrimination between cabinet A and cabinet B. These cabinets do not have the numerical identifier found on other cabinets.

Disposition: A unique, numerical identifier will be provided for each of the two cabinets to supplement the present panel label.

J9: Because the INLET VALVE control and its directly related INLET VALVE FLOW meter are arranged the same way as the adjacent RECIRC VALVE control and RECOMBINER TOTAL FLOW meter, the operator may assume that changes in the Total Flow meter shows a direct indication of Recirc. control adjustments when Total Flow is actually a combination of Recirc. flow and another flow.

Disposition: A discrepancy is not involved here. Although the plant configuration of these two control-display pairs is different, the two control-display pairs function similarly (i.e., an adjustment in the recirc. control receives direct feedback from the total flow meter). Also, each of these components is labeled appropriately.

J10: There is low contrast between the rotary selector switch and the panel background.

Disposition: A correction is not planned for this HED (Category 4). See D3.

J11: Labels for the three pushbuttons on the annunciator panel are below these controls and are thus obscured by the operation of these controls.

Disposition: A correction is not planned for this HED (Category 4). The association between labels and components is clear. Operator uses labels to select, not operate pushbutton.

Radiation Monitoring Instrument Cabinets, A/B and C/D (10C635 and 10C636)

K1: The numerical identifiers used to identify these two cabinets (H11-P635 and H11-P636) use a different numbering system from the typical PSE & G identification system used on most of the other cabinets (e.g., 10C635, 10C636).

Disposition: A correction is not planned for this item. The cabinets can be distinguished by the numerical suffixes, which are consistent. Also, labeling is to be provided on the end of each cabinet that identifies it by name as well as number (see G23).

K2: Several component labels (e.g., Channel A, IRM) lie midway between similar components; this delays association between label and related component.

Disposition: A correction is not planned for this item (Category 4). See D3.

K3: Several component labels (e.g., Channel A, SRM; Channel A, IRM) have letter heights which are the same size or smaller, rather than larger, than position labels for the rotary controls and indicator labels.

Disposition: A correction is not planned for this HED (Category 4). See D3.

K4: Many of the labels for rotaries and indicator lights are below, rather than above, the component.

Disposition: A correction is not planned for this HED (Category 4). The association is clear. See also D3.

K5: The rotary switches do not have component labels.

Disposition: A correction is not planned for this HED (Category 4). See D3.

K6: The pointers on the circular meters cover the scale numbers at certain pointer positions.

Disposition: A correction is not planned for this HED (Category 4). The numbers can be read. See D3.

K7: There is no parameter label for these circular meters on the CHANNEL A - CHANNEL F components.

Disposition: A correction is not necessary. The component label is adequate. See D3.

K8: There is no specific identification of the units being measured on these circular meters on the CHANNEL A - CHANNEL F components. The label shown on these meters is UNITS.

Disposition: A correction is not necessary. The current use of the UNITS label represents an industry standard for BWR plants. See D3.

K9: The IRM circular meters have two levels or types of graduation marks for the red scale, even though there are more than five marks between the numbers.

Disposition: A correction is not planned for this HED (Category 4). See D3.

K10: Much of the labeling on these panels is composed of white letters on a dark background.

Disposition: A correction is not planned for this HED (Category 4). The contrast is adequate. See also D3.

K11: There is low contrast between the black rotary controls on these panels and the dark background.

Disposition: A correction is not planned for this HED (Category 4). See D3.

K12: Nonrequired information in the form of manufacturer's labels appears several times on this panel.

Disposition: A correction is not planned for this HED (Category 4). See D3.

K13: The RADIATION LEVEL meters for Main Steam have no zone coding for the scale.

Disposition: Decisions on zone markings will be made after sufficient plant experience has developed to specify appropriate zone limits. See A69.

K14: There are no position labels on several of the RESET or TRIP RESET rotary switches.

Disposition: No correction is planned (Category 4). No mistake is possible. See D3.

K15: The controls for the Main Steam Line, Radiation Monitoring A and B subpanels are a few inches below the recommended 34" minimum height from floor.

Disposition: A correction is not planned for this HED (Category 4). The position of these controls is highly unlikely to cause any difficulty. The cabinet is used by I&C Technicians. See D3.

K16: The displays for the Main Steam Line, Radiation Monitoring A and B subpanels are below the recommended 41" minimum height from floor.

Disposition: A correction is not planned for this HED (Category 4). See D3.

K17: Colors of indicator lights are inconsistent on 10C635 and between that cabinet and 10C636.

Disposition: This HED has been corrected.

Fire Detection Status Cabinet (10C671)

L1: There are nine pairs of controls on this panel which are randomly distributed rather than placed in subgroups.

Disposition: This HED is no longer relevant to this cabinet because it has been determined that these controls are not necessary for this cabinet. Design modifications have been initiated to remove these components.

L2: Clutter on labels distracts from their unique identifying symbols.

Disposition: A correction is not planned for this HED (Category 4). Error likelihood is low. See D3.

L3: Contiguous legend pushbuttons are not separated by barriers.

Disposition: A correction is not planned for this HED (Category 4). Error likelihood is low. See D3.

L4: System 2 on pushbutton is located above System 1 pushbutton.

Disposition: A correction is not planned for this HED (Category 4). Error likelihood is low. See D3.

L5: Color coding of simple indicator light and legend pushbutton is inconsistent with coding elsewhere on this cabinet and in the control room.

Disposition: A correction is not planned for this HED (Category 4). Error likelihood is low. See D3.

L6: Labeling of control and associated display is inconsistent. The control uses "System 2" and "System 1." The display uses "System A" and "System B."

Disposition: This HED will be corrected. Consistent labeling will be provided.

L7: Pump controls and pump discharge pressure display are separated by five rows of components. The relationship is not evident.

Disposition: This HED will be corrected. The controls will be moved to a position near the display.

L8: Annunciator panel designated "Loop 1" is grouped with "Loop 2" panels.

Disposition: A correction is not planned for this HED (Category 4). Error likelihood is low. See D3.

L9: There is presently no way to read or interpret the annunciator messages on this panel since each annunciator element is identified only by an alphanumeric code.

Disposition: This HED may not represent a discrepancy since a CRT and printer are to be installed near the Fire Protection Panel. The added equipment will provide messages corresponding to the annunciator alphanumeric location code.

L10: There is no group label to show the relationship between these sets of components.

Disposition: A correction is not planned for this HED (Category 4). Error likelihood is low. See D3.

L11: Labels are placed to the side of components.

Disposition: A correction is not planned for this HED (Category 4). Error likelihood is low. See D3.

L12: The smallest dimension of these rectangular pushbuttons is 5/8 inch rather than the recommended 3/4 inch.

Disposition: A correction is not planned for this HED (Category 4). Error likelihood is low. See D3.

L13: Rocker switch is black against a black background. Control position may not be readily perceived.

Disposition: A correction is not planned for this HED (Category 4). Error likelihood is low. See D3.

L14: Labels have white lettering on red or black background.

Disposition: A correction is not planned for this HED (Category 4). The contrast is adequate. See also A126.

L15: Controls are above the height limit of 53 inches recommended for emergency controls.

Disposition: This HED will be corrected. The controls will be moved to below the recommended limit.

L16: Controls are below the recommended lower limit of 34 inches.

Disposition: A correction is not planned for this HED (Category 4). See D3.

L17: Displays are not within the recommended zone of 41-70 inches above the floor.

Disposition: A correction is not planned for this HED (Category 4). Error likelihood is low. See D3.

APPENDIX C

PRELIMINARY OPERATOR INTERVIEW

PRELIMINARY OPERATOR INTERVIEW

This appendix contains the cover sheet for the interview form and a list of the questions asked during the interview. Each question originally appeared at the top of a page, leaving the rest of the sheet for recording of the respondent's comments by the interviewer.

Form No: _____

Date: _____

INTERVIEW FORM

HOPE CREEK GENERATING STATION
CONTROL ROOM DESIGN REVIEW

1. Have you experienced any problems in viewing control and display panels from desks and consoles placed in the primary operating area?

2. Are there any features of the equipment and/or furniture layout in the control room that you find particularly bothersome?

3. Are there any problems in accessing or retrieving procedures or reference materials?

4. Describe the primary features of the control room equipment arrangement which you expect to be particularly effective in supporting control room operations.

5. Have you experienced any problems with the environmental conditions of the control room workspace? This includes:
   - discomfort due to humidity or temperature
   - lighting which is too bright, too dim, or which has too much glare

6. Have you ever experienced any difficulties communicating between any two points in the control room? If so, has this caused any difficulties in performing your job?

7. Which component systems are arranged especially well on the control panel? Describe the positive features of those systems.

8. Which systems do you consider to be difficult or confusing to operate? Why? Give an example of an incident in which there was difficulty in operating the system.

9. Are there any controls or displays which are difficult to locate even after you have used them a few times? If yes, please explain.

10. Are there any controls and/or displays which, in your opinion, should be on the main panels or back panels which are not there at this time?

11. Describe any displays which have an unclear or awkward relation to its associated control.

12. Have you experienced any problems reading any displays located on the control panels? If yes, please explain.

13. Have you experienced any problems operating any controls located on the control panels? If yes, please explain.

14. Can you think of any examples for any of the following occurrences?
    - activation of the wrong control
    - inadvertent activation of a control
    - incorrect activation of a control

    Why did this happen?
    Which system/panel was involved?
    How and when was the mistake discovered?
    What was (or could have been) the consequence?
    What would you recommend to prevent a recurrence of this problem?

15. Did you ever make an error while performing a task in training because of problems with the existing design of a control or display? If yes, please explain.

16. Are there any features of the annunciator, caution, or off-normal status system which are difficult to understand or use? If yes, please explain.

17. Describe any features of the annunciator warning system that you feel could result in inefficient or erroneous fault isolation.

18. Which features of the annunciator warning system promise to be particularly effective?

19. Describe components which are inappropriately or inadequately labeled.

20. To the extent that you have had any training or other experience with the CRT display system, which aspects of it do you consider to be awkward, cumbersome, or difficult to use in locating and using important system data?

21. Which features of the CRT display system do you consider to be especially useful or effective?

22. Have you experienced any problems performing a task involving the control or monitoring of plant equipment due to a requirement to perform several tasks concurrently? If yes, please explain.

23. Are there sufficient control room personnel on duty and do their job responsibilities allow prompt response to an abnormal situation?

24. Are there other conditions in which the workload requirements would cause difficulty in promptly responding to an abnormal situation? If yes, please explain.

25. Have you experienced any situations in which part of an operating procedure (e.g., EOP, Start-up,...) seemed inappropriate for the design of this control room?

26. Describe any problems that may exist with preventive maintenance, fault isolation capability, or corrective maintenance for the control room equipment.

27. Describe any other areas in the control room design or layout that you have had problems with.

28. What kind of changes would you recommend to improve the operator's capability to recognize and control normal and abnormal plant operating conditions?

APPENDIX D

POSITIVE DESIGN FEATURES IDENTIFIED IN PRELIMINARY INTERVIEWS

Number of Respondents	Positive Design Features Noted	Reasons/Comments
6	Aural alarm feature of the annunciator system.	The various tones associated with the five sections of the main control board facilitate information retrieval. Tones selected are easily discriminable.
5	Large size of annunciator windows.	The labels (nomenclature) are essy to read.
2	"Ring back" feature of annunciator system.	Will reflash even while holding "ACK" pushbutton. (One respondent liked feature, but was not sure whether it is used.)
1	Generic annunciator alarms, which are fewer in number and require less configuring.	In theory, by limiting the number of files, one can isolate the source more quickly, clear the overheads, and bring the problem down to specific controls/displays on the MCB.
1	The individual acknowledge feature built into each section of the 651 console.	
1	Having the mini-annunciator (flash) built into bezel controls.	
3	Full-core display (RX protection system layout), especially the extra indicator light that gives the operator additional information regarding the status of particular core locations.	
4	Rod control mechanism.	Convenient location. One-pushbutton as opposed to two-pushbutton activation.
1	Cut-out at 651-C.	Enables operator to sit during rod withdrawals.

Number of Respondents	Positive Design Features Noted	Reasons/Comments
1	Location of pens at the right hand side of trend recorders.	Design allows operator to track trends without the need to remove the glass cover to access the trend on the take-up reel.
1	"OVLD/PWR FAIL" indicators.	Their large size makes them easier to see than the conventional white dots used on most other designs.
1	Pushbuttons on Bailey process controllers on vertical boards.	Their larger size.
6	Use of CRTS (CRIDS).	They can hold a lot of information (P&ID and system); they minimize panel clutter. The large number of CRTs on all panels facilitates information retrieval. One respondent liked having CRTs at the 649 desk.
2	"Mimic"/"P&ID" feature of the CRIDS system.	
5	"Poking" feature of CRT system (light pen).	One can position the cursor on a component in the system display, push the button or the light pen, and display changes showing a display dedicated to component features. One respondent mentioned being able to call up addressable points to monitor.
1	White frame surrounding poke points on CRT system.	This feature makes it easy to identify selectable parameters.

Number of Respondents	Positive Design Features Noted	Reasons/Comments
1	Use of different colors on CRT displays.	
1	Menu used on CRT system. Mimic of large-case keyboard on CRT.	To call up displays at the 651 console, one need only call up the menu, position the cursor on the appropriate key/display, and push a button.
1	Concept of Period indication being displayed automatically on the CRT when power changes.	This is more accurate and faster than the trend recorder.
1	Good contrast and color saturation on CRT displays.	
1	CRTs	Respondent believes that formats will appear automatically on CRTs, contingent upon plant status/trouble, etc., and that this is a good feature.
2	Speed at which the CRT system will update parameter values — about every five seconds.	
1	Layout of bezel controls in the mimic.	
9	Mimics used on Electrical Distribution and ECC panels.	Of these nine respondents, one mentioned only the ECCS and one only the switchyard. One respondent said the electrical distribution mimic is better than the ECCS.
1	Mimics on the 650 panels.	
1	Mimics, in general.	
2	Console design, i.e., nested horseshoes.	Respondents said this feature gives them a good "feeling"; they know what's "happening" in the plant.

Number of Respondents	Positive Design Features Noted	Reasons/Comments
3	Good location of all systems and subsystems on panels.	
5	Good location of all controls and displays within systems.	One respondent referred specifically to the ECCS system, e.g., RHR; one referred to Section C of 651 E Condensate (Feedwater System); and two respondents mentioned the switchyard on the 651 console.
1	The ready room concept.	One can readily assess personnel availability.
1	Location of, and continuity within, the feedwater system.	
1	Rheostat to control overhead lighting levels.	
1	Out-of-service annunciators associated with ECCS system (e.g., "HPCI OUT OF SERVICE").	
1	Actual load listing directly on labels associated with switchyard components.	

APPENDIX E

SCENARIOS FOR VALIDATION WALK-THROUGHS

SCENARIOS FOR VALIDATION WALK-THROUGHS

This appendix describes the scenarios employed in the EOP walk-throughs for the Validation of Control Room Functions. The alphanumeric identifier of each scenario was usually based on the number of the EOP in which the scenario began. Each scenario describes the assumptions about plant conditions, the procedures and corresponding steps involved in the scenario, and comments describing where the scenario begins and at which points other procedures become involved.

SCENARIO: 101-A

Drywell pressure above 2 psig.

Procedure(s) and Steps in Scenario:

101: Reactor Control (1, 5-7, 25-34)

102: Containment Control and Drywell Pressure Control (42-50)

202: Emergency Depressurization (1-10)

Comments:

This scenario begins in Procedure 101, Step 1. It includes entry conditions for Procedure 101 and 101. This scenario continues at Step 47 in Procedure 102, where it is assumed that Suppression Chamber Pressure can not be maintained below 28 psig. Thus at Step 47 in Procedure 102, operators were directed to Procedure 202, Step 1. As a result, operators were performing steps concurrently in three procedures.

SCENARIO: 101-B

Group isolation RC/P and RC/L performed concurrently.

Procedure(s) and Steps in Scenario:

101: Reactor Control (2-7, 25-41)

Comments:

This scenario begins in Procedure 101, Step 2.

SCENARIO: 101-C

RVP water level below 36 in. or unknown. Water level cannot be maintained.

Procedure(s) and Steps in Scenario:

101: Reactor Control (3-7, 35-41)

201: RPV Water Level Restoration (1- 4, 5, 6,-11, 12-15, 16-23C, 24-28)

203: Blowdown in Cooling (1-4)

204: Spray Cooling (0-3)

Comments:

This scenario begins in Procedure 101, Step 3. Step 38 in Procedure 101 directs operators to enter Procedure 201 at Step 1. Each of the following five conditions were examined in Procedure 201.

1. RPV water level increasing in conjunction with:
   a) High RPV pressure
   b) Intermediate RPV pressure
   c) Low RPV Pressure

2. RPV water level decreasing in conjunction with:
   a) High or intermediate RPV pressure
   b) Low RPV pressure

SCENARIO: 101-D

Assume reactor SCRAM power > 3%, RC/Q and RC/P performed concurrently.

Procedure(s) and Steps in Scenario

101: Reactor Control (4-7, 8-24, 25-34)

Comments:

This scenario begins at Procedure 101, Step 4.

SCENARIO: 101-E

Existing SCRAM conditions and power > 3%

Procedure(s) and Steps in Scenario

101: Reactor Control (4-7, 8-24)

207: Level/Power Control (1-10)

Comments:

This scenario begins at Procedure 101, Step 4. Step 18B of Procedure 101 directs the operators to enter Procedure 207 and perform these steps concurrently beginning at Step 1 of the latter procedure. Additional portions of Procedure 101 were also walked through and discussed with the operators (i.e., Steps 15, 42-46, 47-67).

SCENARIO: 102-A

Suppression chamber water above 95°F.

Procedure(s) and Steps in Scenario:

102: Containment Control and Drywell Pressure Control (1-19)

100: SCRAM (1-14)

Comments:

This scenario begins in Procedure 102, Step 1. Step 9 of Procedure 102 directs the operators to enter Procedure 100 and perform these steps concurrently.

SCENARIO: 102-B

Suppression chamber water level outside 12'-2"-12'-6" limit. Condensate transfer system will be used for makeup to the suppression chamber.

Procedure(s) and Steps in Scenario:

102: Containment Control and Drywell Pressure Control (20-32)

Comments:

This scenario begins in Procedure 102, Step 20.

SCENARIO: 102-C

Drywell temperature above 125°F.

Procedure(s) and Steps in Scenario:

102: Containment Control and Drywell Pressure Control (33-41)

Comments:

This scenario begins in Procedure 102, Step 33. In this train the operator is directed to Procedures 100 and 202, which were covered in a different scenario.

SCENARIO: 205

This scenario assumes that the operators were in the Post Scram Restoration Procedure 099 and, at Step 27 in 099, were directed to Alternate Shutdown Cooling Procedure 205.

Procedure(s) and Steps in Scenario:

205: Alternate Shutdown Cooling (1-15)

Comments:

This scenario begins in Procedure 099, Step 27.

SCENARO: 206-A

RPV level cannot be determined at Step 4 in Procedure 206, RPV Flooding.

Procedure(s) and Steps in Scenario:

206: RPV Flooding (1-6)

Comments:

This scenario begins in Procedure 206, Step 1.

SCENARIO: 206-B

RPV level can be determined at Step 4 in Procedure 206, RPV Flooding.

Procedure(s) and Steps in Scenario:

206: RPV Flooding (4-18)

Comments:

This scenario begins in Procedure 206, Step 4.

APPENDIX F

EXAMPLE OF TASK PLANS USED TO GUIDE SURVEY DATA COLLECTION

(Task Plan is bound separately.)

HUMAN FACTORS TASK PLAN
FOR THE
LABELS AND LOCATION AIDS

The

Essex Corporation
333 North Fairfax Street
Alexandria, Virginia 22314
(703) 548-4500

Approved for Use: Walter T. Talley (Signature) 15 May, 1983 (Date)

Walter T. Talley Project Manager, PCS Department
(Printed Name and Title)

RECORD OF REVISIONS

Rev. No.	Rev. Date	Description

TABLE OF CONTENTS

APPENDICES

LABELS AND LOCATION AIDS

1.0 OBJECTIVES

a. To examine the readability and usability of labeling in the control room according to NUREG-0700 criteria.

b. To assess the design and use of location aids in the control room according to NUREG-0700 criteria.

c. To identify and document any cases where labels and location aids do not conform to the criteria of NUREG-0700.

2.0 REVIEW TEAM SELECTION AND RESPONSIBILITIES

a. A human factors specialist is required to implement the data collections procedure, and to record, reduce, analyze and report the data.

b. Reactor operators and operational personnel are required to supply information on an as-needed basis.

3.0 CRITERIA

The criteria are from NUREG-0700, paragraphs 6.3.3.3c.(3), 6.5.1.6a through 6.5.1.63(3), 6.6.1.1, 6.6.1.2a. and b., 6.6.2.1a. through f., 6.6.2.2a. and b., 6.6.2.3a. and b., 6.6.2.4a. through d., 6.6.3.1a. through e., 6.6.3.5, 6.6.3.6, 6.6.3.7a. and b., 6.6.3.8a., b., and c., 6.6.5.1a. through h., 6.6.5.2a. and b., 6.6.6.2a., b., and c., 6.6..3, 6.6.6.4a. and b., and 6.8.3.2d (see Appendix A).

4.0 PROCEDURES

4.1 General Instructions

4.1.1 Preparation and Conduct of Procedures

a. Prior to conduct of this task, ensure that all required data forms, plant documentation, engineering drawings, equipment, and materials are available. Ensure that permission has been obtained for all required access to the control room or other plant areas.

b. Record all exceptions, deviations, or changes to these procedures in Section 9.0 of this Task Plan. Number each entry sequentially, starting with 1. Include an explanation (technical justification as to why the exception, deviation, or change was made).

4.1.2 Task Plan Critique

Upon completion of this task, fill out the Task Plan Critique contained in Appendix D. Submit the completed critique to your supervisor or project manager.

4.2 Data Collection

a. Data are collected using various methods and procedures consisting of measurements, observations, interviews and questionnaires, and document reviews. Appendix C illustrates the distribution of the criteria for the various methods.

b. Measurements and observations should be made for all items contained on the measurements data forms and observations checklists contained in Appendix B.

c. The operator questionnaire (Appendix B) should be administered to at least 50 percent of the licensed reactor operators for the plant. Administration may be conducted singly or in a group, but should be proctored or monitored.

d. Plant documentation should be reviewed to verify the item listed in the Document Review Checklist in Appendix B. The required plant documents include:

1. Administrative Procedures relevant to labels and location aids
2. Plant Operating Procedures.

e. This task plan does not address consistency of terms, abbreviations, and acronyms across all types of labels. Control room labeling consistency is evaluated in the Conventions Task Plan, TP-8.1.

4.3 Analysis

a. All deviations from criteria shall be recorded on Human Engineering Discrepancy (HED) reports (Appendix B). Recorded information shall include labels and/or components involved (e.g., "label name" — component it describes, component name without label, etc.), a description of the problem including the NUREG-0700 paragraph number of the criteria, and a recommended solution.

b. Data collection method(s) shall also be recorded on the HED form. Where data from two or more sources are contradictory, resolution of the conflict through data review and client interview shall be made.

c. Use the analysis aids from Appendix B for all data reductions and analysis. Upon completion of all analyses, ensure that the criteria in Appendix A are properly annotated (as specified in the analysis aids).

d. Submit the completed task plan to your immediate supervisor for review. Upon project management approval, initiate Task Report 3.1.

5.0 EQUIPMENT AND FACILITY REQUIREMENTS

a. Access to panels, consoles, and work stations in the control room.

b. Photographic mosaic.

c. Graphic arts comparator and/or small machinist's scale.

d. Tape measure.

6.0 INPUTS AND DATA FORMS

a. Criteria list (Appendix A).

b. The following from Appendix B:

1. Measurements Data Forms
2. Questionnaire
3. Observations Checklist
4. Documentation Review Checklist
5. Analysis Aids
6. HED Report Forms.

c. Criteria Matrix (Appendix C).

d. Task Plan Critique Form (Appendix D).

e. Standard Abbreviations and Acronyn List from Conventions Task Plan (TP-8.1).

7.0 OUTPUTS AND RESULTS

a. Completed HEDs.

b. Completed Task Report.

8.0 FIGURES AND TABLES

None.

9.0 PROCEDURE EXCEPTIONS

The following exceptions, deviations, and changes were made to these procedures during the task (include a statement of justification on each item):

APPENDIX A
CRITERIA

APPENDIX A
CRITERIA

N/A	YES	NO	COMMENTS

6.3.3.3 ARRANGEMENT OF VISUAL ALARM TILES

c. LABELING OF AXES

(1) The vertical and horizontal axes of annunciator panels should be labeled with alphanumerics for ready coordinate designation of a particular visual tile.

(2) Coordinate designation is preferred on the left and top sides of the annunciator panel.

(3) Letter height for coordinate designation should be consistent with a subtended visual angle of at least 15 minutes as viewed from a central position within the primary operating area.

6.5.1.6 COLOR CODING

a. REDUNDANCY -- In all applications of color coding, color should provide redundant information. That is, the pertinent information should be available from some other cue in addition to color.

b. NUMBER OF COLORS

(1) The number of colors used for coding should be kept to the minimum needed for providing sufficient information.

(2) The number of colors used for coding should not exceed 11.

c. MEANING OF COLORS

(1) The meaning attached to a particular color should be narrowly defined.

N/A	YES	NO	COMMENTS

6.5.1.6c. (CONT'D)

(2) Red, green, amber (yellow) should be reserved for the following uses:

Red: unsafe, danger, immediate operator action required, or an indication that a critical parameter is out of tolerance.

Green: safe, no operator action required, or an indication that a parameter is within tolerance.

Amber (yellow): hazard (potentially unsafe), caution, attention required, or an indication that a marginal value or parameter exists.

d. CONSISTENCY OF MEANING

(3) The meaning of a particular color should remain the same both within and among the various systems to which it is applied.

e. PRINCIPLES OF COLOR SELECTION

(1) The primary principle which should be applied in selecting colors for coding purposes which do not have the immediate safety implications of red, green, and amber is to ensure that each color is recognized as different from any other. Exhibit 6.5-7 lists 22 colors of maximum contrast. Each successive color has been selected so that it will contrast maximally with the color just preceding it and satisfactorily with earlier colors in the list. The first 9 colors have been selected so as to yield saftisfactory contrast for red-green-deficient as well as color-normal observers. The remaining 13 colors are useful only for color-normal observers.

APPENDIX A
CRITERIA

N/A	YES	NO	COMMENTS

6.5.1.6e. (CONT'D)

(2) Colors selected for coding should contrast well with the background on which they appear.

(3) Ambient lighting in the area in which color coding is used will influence the apparent color of the coded element (especially for surface colors). Each color selected for coding should be evaluated under all illumination conditions under which it is used.

6.6.1.1 NEED FOR LABELING

Controls, displays, and other equipment items that must be located, identified, or manipulated should be appropriately and clearly labeled to permit rapid and accurate human performance.

6.6.1.2 HIERARCHICAL SCHEME

To reduce confusion, operator search time, and redundancy, a hierarchical labeling scheme should be used. (See Exhibit 6.6-1.)

a. RANKING

(1) Major labels should be used to identify major systems or operator work stations.

(2) Subordinate labels should be used to identify subsystems or functional groups.

(3) Component labels should be used to identify each discrete panel or console element.

(4) Labels should not repeat information contained in higher-level labels.

APPENDIX A
CRITERIA

N/A	YES	NO	COMMENTS

6.6.1.2 (CONT'D)

b. **LETTER GRADATIONS** — Labels should be graduated in letter size such that:

(1) System/work station labels are about 25% larger than

(2) Subsystem/functional group labels which are about 25% larger than

(3) Component labels which are about 25% larger than

(4) Control position identifiers.

6.6.2.1 PLACEMENT

a. **NORMAL PLACEMENT** — Labels should be placed above the panel element(s) they describe.

b. **PANEL LABELING** — The placement of labels on control panels should conform to the guidance shown in Exhibit 6.6-1.

c. **VISIBILITY ENHANCEMENT** — Labels of elements located above eye level should be positioned to ensure label visibility.

d. **PROXIMITY** — Labels should be placed close to the panel element. See Exhibit 6.6-2.

e. **LABELS ON CONTROLS** — Labels should not appear on the control itself when an adjustment or manipulation is required that causes the operator's hand to obscure the label for an extended time period.

6.6.2.2 MOUNTING

a. **INTEGRITY**— Label should be mounted in such a way as to preclude accidental removal.

APPENDIX A
CRITERIA

N/A	YES	NO	COMMENTS

6.6.2.2 (CONT'D)

b. SURFACE — Labels should be mounted on a flat surface.

6.6.2.3 SPATIAL ORIENTATION

a. HORIZONTAL ORIENTATION

(1) Labels should be oriented horizontally so that they may be read quickly and easily from left to right.

(2) Although not normally recommended, vertical orientation may be used only where space is limited.

b. CURVED PATTERNS — Curved patterns of labeling should be avoided. See Exhibit 6.6-5.

6.6.2.4 VISIBILITY

a. OTHER INFORMATION SOURCES — Labels should not cover any other information source. They should not detract from or obscure figures or scales which must be read by the operator.

b. CONCEALMENT — Labels should not be covered or obscured by other units in the equipment assembly.

c. CONTROLS — Labels should be visible to the operator during control actuation.

d. CLEANING — Administrative procedures should be in place for the periodic cleaning of labels.

6.6.3.1 KINDS OF INFORMATION

a. PRIMARY FUNCTION — Labels should describe the function of equipment items.

APPENDIX A
CRITERIA

N/A	YES	NO	COMMENTS

6.6.3.1 (CONT'D)

b. **CLARITY** — Instructions should be clear.

c. **DIRECT** — Instructions should be direct.

d. **MEANING** — Words should be used that have a commonly accepted meaning for all intended users.

e. **TECHNICAL TERMS** — Unusual technical terms should be avoided.

f. **SPELLING** — Words should be correctly spelled.

6.6.3.3 CONSISTENCY

b. **INTERNAL CONSISTENCY** — Labels should be consistent within and across pieces of equipment in their use of words, acronyms, abbreviations, and part/system numbers. See Exhibit 6.6-6.

c. **CONSISTENCY WITH PROCEDURES** — There should be no mismatch between nomenclature used in procedures and that printed on the labels.

6.6.3.4 SYMBOLS

a. **MEANING** — Abstract symbols should be used only if they have a commonly accepted meaning for all intended users (e.g., %).

b. **DISTINGUISHABILITY** — Symbols should be unique and distinguishable from each other.

c. **STANDARD** — A commonly accepted standard configuration should be used.

d. **CONSISTENCY** — Symbols should be consistently used within and across panels.

N/A	YES	NO	COMMENTS

6.6.3.4 (CONT'D)

e. **ROMAN NUMERALS** — Use of Roman numerals should be avoided.

6.6.3.5 BREVITY

Brevity should not be stressed if the results will be unfamiliar to operating personnel. Words on labels should be concise and still convey the intended meaning. See Exhibit 6.6-7.

6.6.3.6 SIMILARITY

Words and abbreviations of similar appearance should be avoided where an error in interpretation could result. When labels containing similar words, abbreviations, or acronyms are located in close proximity to each other, different words should be selected or means of coding should be used to reduce the probability of selecting the wrong control or reading the wrong display. See Exhibit 6.6-8.

6.6.3.7 FUNCTIONAL GROUPS

a. **FUNCTIONAL RELATIONSHIP** — Labels should be used to identify functionally grouped controls or displays.

b. **LOCATION** — Labels should be located above the functional groups they identify.

6.6.3.8 CONTROL POSTION LABELING

a. **POSITION** — All discrete functional control positons should be identified.

b. **DIRECTION** — Direction of motion (increase, decrease) should be identified for continuous motion rotary controls.

c. **VISIBILITY** — Control position information should be visible to the operator during operation of the control.

APPENDIX A
CRITERIA

N/A	YES	NO	COMMENTS

6.6.3.9 ACCESS OPENING, DANGER, WARNING, AND SAFETY INSTRUCTION LABELING

a. **ACCESS OPENING LABELS** — Each access opening used by control room operators should be labeled to identify the function of items accessible through it.

b. **DANGER, WARNING, AND SAFETY INSTRUCTION LABELS** — All danger, warning, and safety instruction labels should be in accordance with appropriate safety standards.

6.6.4.1 READABILITY

a. **CHARACTER HEIGHT**

(1) Character height should subtend a visual angle of 15 minutes as a minimum, or 0.004 x viewing distance. A visual angle of 20 minutes, or 0.006 x viewing distance, is preferred.

(2) Letter height should be identical for all labels within the same hierarchical level, based on the maximum viewing distance.

b. **CONTRAST**

(1) To ensure adequate contrast and prevent loss of readability because of dirt, dark characters should be provided on a light background.

(2) If color print is used for coding purposes, it should conform to the established color coding scheme for the control room. (See Guideline 6.5.1.6.) Colors should be chosen for maximum contrast against the label background. Exhibit 6.6-9 rates various color combinations in terms of relative legibility.

APPENDIX A
CRITERIA

N/A	YES	NO	COMMENTS

6.6.4.2 STYLE (Exhibits 6.5-1 and 6.5-2)

a. **CHARACTER SELECTION**

(1) Labels should be prepared in capital letters.

(2) The design of letters and numerals should be simple and without flourishes or serifs.

b. **CHARACTER WIDTH**

(1) Letter width-to-height ratio should be between 1:1 and 3:5.

(2) Numeral width-to-height ratio should be 3:5 except for the numeral "4" which should be one stroke width wider and the numeral "1" which should be one stroke in width.

c. **STROKE WIDTH** — Stroke width-to-character height ratio should be between 1:6 and 1:8.

d. **SPACING**

(1) The minimum space between characters should be one stroke width.

(2) The minimum space between words should be one character width.

(3) The minimum space between lines should be one-half of the character height.

6.6.5.1 USE OF TEMPORARY LABELS

a. **NECESSITY** — Temporary labels should be used only when necessary.

b. **HUMAN FACTORS PRACTICES** — Temporary labels should conform to good human engineering principles.

APPENDIX A
CRITERIA

N/A	YES	NO	COMMENTS

6.6.5.1 (CONT'D)

c. **VISIBILITY** — Temporary labels should not obscure prior permanent labels unless the old label is to be replaced.

d. **IDENTIFICATION** — Tag-out labels should clearly identify out-of-service components and equipment.

e. **MOUNTING** — Tag-outs should be securely affixed.

f. **OBSCURATION** — Tag-outs should not obscure the label associated with the nonoperable device.

g. **ACTIVATION** — Tag-outs should be designed to physically prevent actuation of a control.

h. **ADJACENT DEVICES** — Tag-outs should not obscure any adjacent devices or their associated labels.

6.6.5.2 CONTROL OF TEMPORARY LABELS

a. **ADMINISTRATIVE PROCEDURES** — The use of temporary labels should be administratively controlled.

b. **REVIEW PROCEDURES** — A review procedure should be in place that will result in a determination of:

(1) when temporary labels are needed;

(2) how they will be used;

(3) their content (given human engineering requirements);

(4) their installation;

(5) the impact of their use on other system equipment (e.g., annunciators, mimics);

N/A	YES	NO	COMMENTS

6.6.5.2b. (CONT'D)

(6) documentation requirements;

(7) retraining requirements;

(8) their periodic review; and

(9) their removal.

6.6.6.2 DEMARCATION (See Exhibit 6.8-1)

a. USE — Lines of demarcation can be used to:

(1) Enclose functionally related displays.

(2) Enclose functionally related controls.

(3) Group related controls and displays.

b. CONTRAST — Lines of demarcation should be visually distinctive from the panel background.

c. PERMANENCE — Lines of demarcation should be permanently attached.

6.6.6.3 COLOR

Color should be dedicated to specific functions or conditions throughout the control room in order for the code to elicit the expected operator response. The color coding scheme should be used consistently throughout the control room. Refer to Guideline 6.5.1.6 for specific recommendations on the use of color.

	N/A	YES	NO	COMMENTS
6.6.6.4 USE OF MIMICS				
a. **COLOR**				
(1) Flow paths should be color coded. Colors should be selected in conformance with Guidelines 6.5.1.6.				
(2) The mimic colors should be discriminably different from each other.				
(3) There should be adequate contrast between the mimic colors and the panel.				
(4) Mimic lines depicting flow of the same contents (e.g., steam, water, electricity) should be color coded the same throughout the control room.				
(5) No more than 4 mimic lines of the same color should run in parallel if the operator must quickly identify any one of the lines.				
b. **MIMIC LINES**				
(1) Differential line widths may be used to code flow paths (e.g., significance, volume, level).				
(2) Overlapping of mimic lines should be avoided.				
(3) Flow directions should be clearly indicated by distinctive arrowheads.				
(4) All mimic origin points should be labeled or begin at labeled components.				
(5) All mimic destination or terminal points should be labeled or end at labeled components.				
(6) Component representations on mimic lines should be identified.				

N/A	YES	NO	COMMENTS

6.8.3.4 (CONT'D)

c. SYMBOLS

(1) Graphic symbols should be readily understood and commonly used.

(2) Symbols should be used consistently.

6.8.3.2 STRINGS OR CLUSTERS OF SIMILAR COMPONENTS

d. LARGE MATRICES

(1) Large matrices of similar components should have the coordinate axes labeled for identification of any single component within the grid. The left and top sides of the matrix should be used for labeling (see Exhibit 6.8-6).

(2) Large matrices should be subdivided by appropriate demarcation.

APPENDIX A
CRITERIA

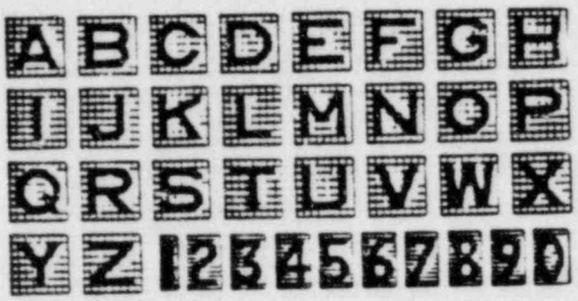


Exhibit 6.5-1. A recommended set of characters (from U.S. Military Specification MIL-M-18012B).

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z
0 1 2 3 4 5 6 7 8 9

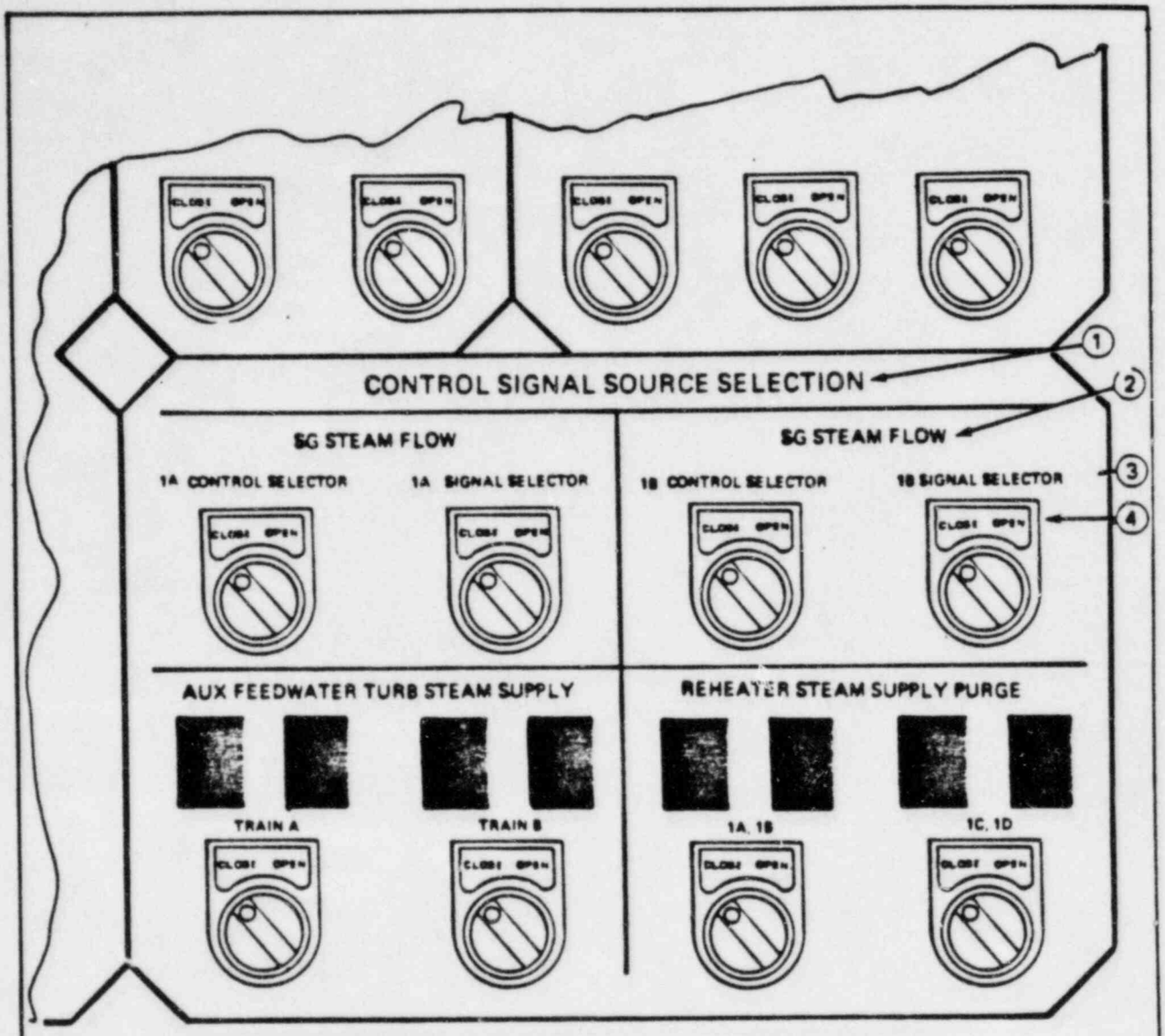
Exhibit 6.5-2. A recommended set of characters (from U.S. Military Standard MS-33558 (ASG)).

APPENDIX A
CRITERIA

Color Serial or selection number	General color name	ISCC-NBS centroid number	ISCC-NBS color-name (abbreviation)	Munsell renotation of ISCC-NBS Centroid Color
1	white	263	white	2.5PB 9.5/0.2
2	black	267	black	N 0.8/
3	yellow	82	v.Y	3.3Y 8.0/14.3
4	purple	218	s.P	8.5P 4.3/9.2
5	orange	48	v.O	4.1YR 6.5/15.0
6	light blue	180	v.l.B	2.7PB 7.9/6.0
7	red	11	v.R	5.0R 3.9/15.4
8	buff	90	gy.Y	4.4Y 7.2/3.8
9	gray	265	med. Gy	3.3GY 5.4/0.1
10	green	139	v.G	3.2G 4.9/11.1
11	purplish pink	247	s.pPk	5.6RP 6.8/9.0
12	blue	178	s.B	2.9PB 4.1/10.4
13	yellowish pink	26	s.yPk	8.4R 7.0/9.5
14	violet	207	s.V	0.2P 3.7/10.1
15	orange yellow	66	v.OY	8.6YR 7.3/15.2
16	purplish red	255	s.pR	7.3RP 4.4/11.4
17	greenish yellow	97	v.gY	9.1Y 8.2/12.0
18	reddish brown	40	s.rBr	0.3YR 3.1/9.9
19	yellow green	115	v.YG	5.4GY 6.8/11.2
20	yellowish brown	75	deep yBr	8.8YR 3.1/5.0
21	reddish orange	34	v.rO	9.8R 5.4/14.5
22	olive green	126	d.OlG	8.0GY 2.2/3.6

Exhibit 6.5-7. Twenty-two colors of maximum contrast (from Kelly, 1965).

APPENDIX A
CRITERIA



Label Designation	Location
1. System/workstation label	Centered near top edge of panel
2. Subsystem/functional label	Centered near top of subsection
3. Component label	Above component display or control
4. Control position indicator	Near control

Exhibit 6.6-1. Example of good panel labeling (numerals correspond to numbered items in table).

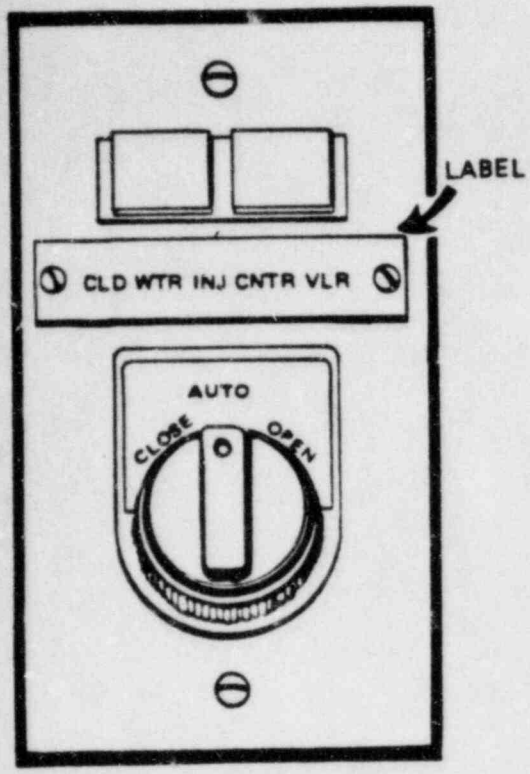


Exhibit 6.6-2. Label in close proximity to panel element.

Exhibit 6.6-5. Poor practice: Curved pattern.

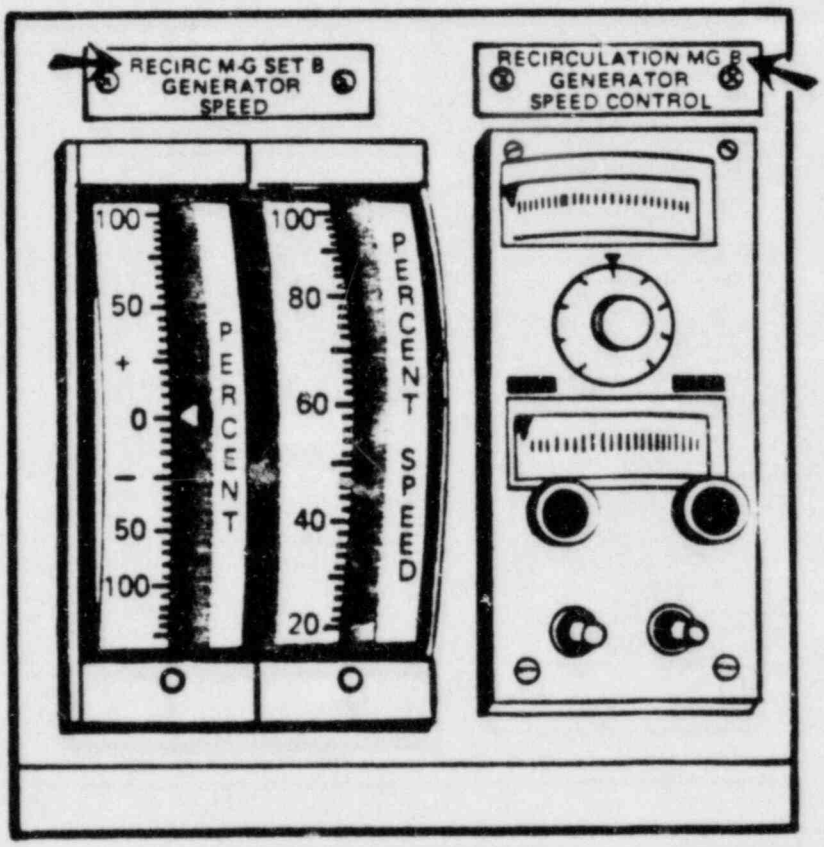


Exhibit 6.6-6. Inconsistent labeling.

APPENDIX A
CRITERIA

24 VDC SWITCHBOARD	24 VOLT DIRECT CURRENT SWITCHBOARD
PREFERRED	NON-PREFERRED

Exhibit 6.6-7. Labeling brevity.

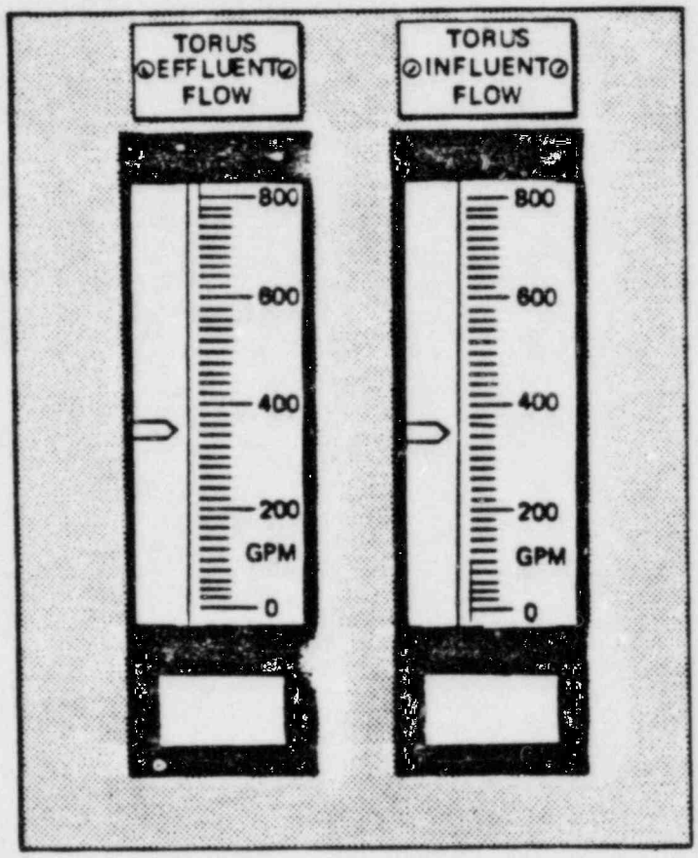


Exhibit 6.6-8. Labels are too similar.

Legibility Rating	Color Combination
Very good	Black letters on white background
Good	Black on yellow Dark blue on white Grass green on white
Fair	Red on white Red on yellow White on black
Poor	Green on red Red on green Orange on black Orange on white

Exhibit 6.6-9. Relative legibility of color combinations.

APPENDIX A
CRITERIA

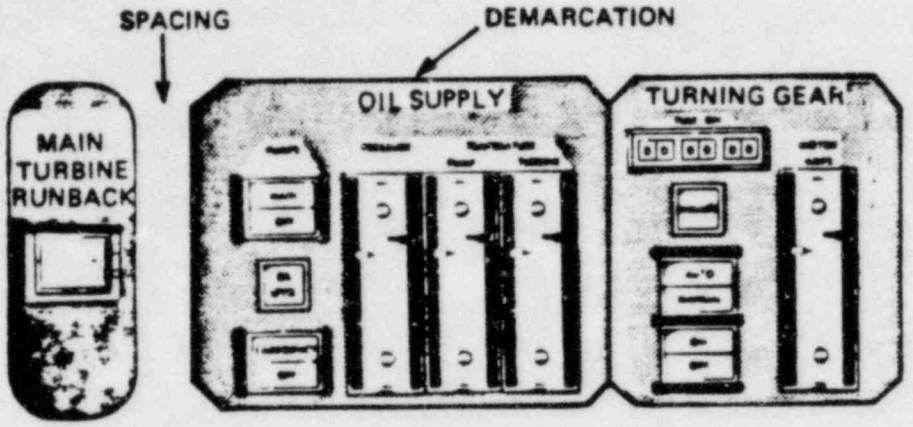


Exhibit 6.8-1. Separation of functional groups by spacing and demarcation.

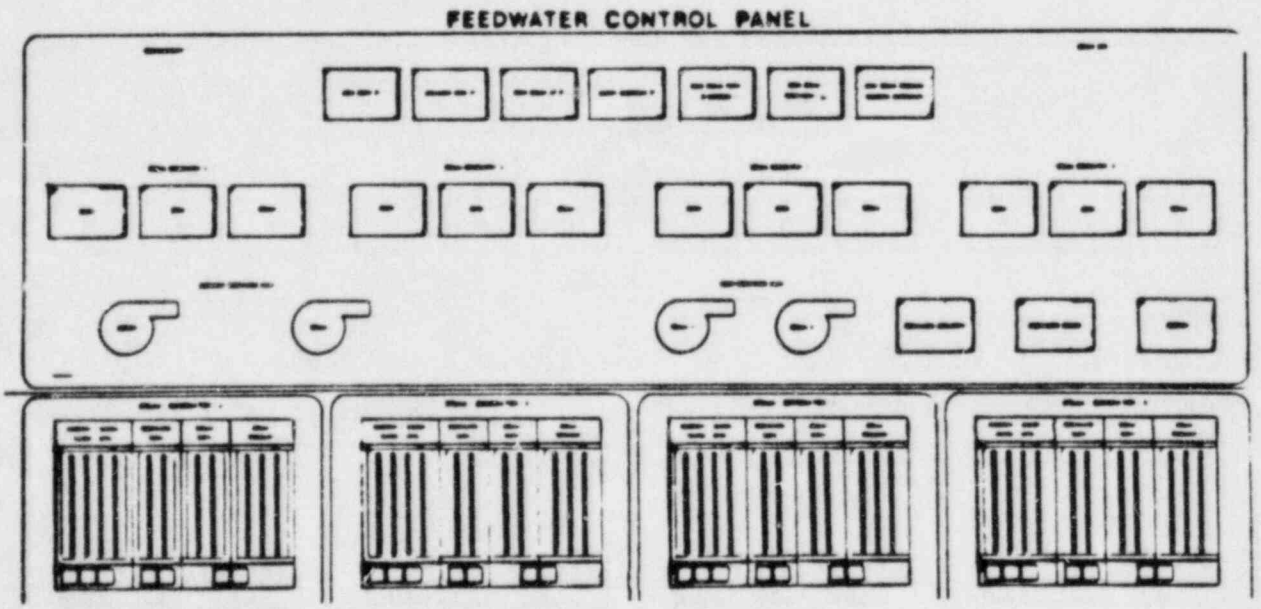


Exhibit 6.8-5. Long strings of components should be broken by spacing or demarcation.

APPENDIX A
CRITERIA

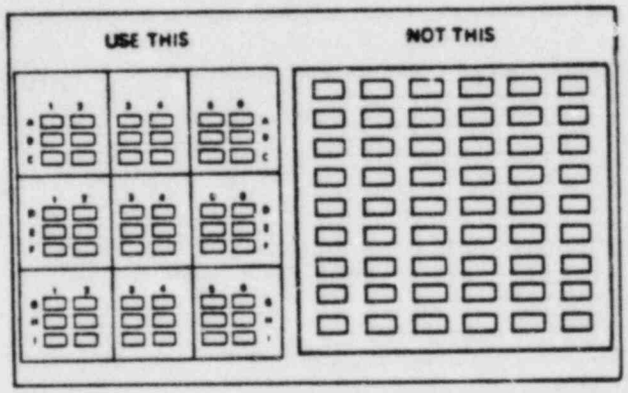


Exhibit 6.8-6. Coordinate axes of grid should be labeled, and appropriate delineation used to subdivide the matrix.

APPENDIX B
DATA FORMS

APPENDIX B
DATA FORMS

TABLE OF CONTENTS

LABELS AND LOCATION AIDS

APPENDIX B1.1
MEASUREMENTS DATA

1. LINEAR MEASUREMENTS.

1.1 Readability and Discriminability — 6.3.3.3c(3), 6.6.4.1a(1), 6.6.4.1a(2), and 6.6.4.2b through 6.6.4.2d.

a. Obtain a copy of Data Form 1.1 for one sample of each different size of all System/Work Station labels, all Subsystem/Functional Group labels, all Component labels, all Control Position labels, and all Legend Light labels.

b. For each sample label, record all required label identification information on Data From 1.1, Part 1.

c. Using a graphics comparator, a card comparator, or a machinist's scale, measure the following for each label sample and record the measurements on Data Form 1.1, Part 2:

1) Character height for letters, numerals other than 1 and 4, and numerals 1 and 4

2) Character width for letters, numerals other than 1 and 4, and numerals 1 and 4

3) Character stroke width

4) Space between characters

5) Space between words

6) Space between lines.

LABELS AND LOCATION AIDS

APPENDIX B1.1
MEASUREMENTS DATA

DATA FORM 1.1

Part 1

LABEL CONTENT: _____

_____ _____

LABEL TYPE (check one and also record the contents of each label that is heirarchically related to and above the type checked):

☐ SYSTEM/ WORK STA ☐ SUBSYS/ FUNCT GP ☐ COMPONENT ☐ CONTROL POSITION ☐ LEGEND LIGHT

RELATED LABELS:

System/Work Station: _____

Subsystem/Functional Group: _____

Component: _____

Part 2

1) Character Height for:
   a) Letters _____
   b) Numerals other than 1 and 4 _____
   c) Numerals 1 and 4 _____
2) Character Width for:
   a) Letters _____
   b) Numerals other than 1 and 4 _____
   c) Numerals 1 and 4 _____
3) Character Stroke Width _____
4) Space Between Characters _____
5) Space Between Words _____
6) Space Between Lines _____

THIS BLOCK FOR USE IN ANALYSES | C_-_ | H_-_ |

LABELS AND LOCATION AIDS

APPENDIX B1.1
MEASUREMENTS DATA

2. SOUND MEASUREMENTS — **Not required.**

APPENDIX B1.1
MEASUREMENTS DATA

3. LIGHT MEASUREMENTS — **Not required.**

APPENDIX B2
OPERATOR INTERVIEW/QUESTIONNAIRE

INSTRUCTIONS

1. The following are questions concerning the general layout, functional organization, and operational considerations in your control room. Most of the questions will require a YES or NO answer, with some additional information.

2. When you have comments or suggestions, use the space provided below each question. If you need additional room, use the backs of the sheets.

3. If you do not understand a question, please ask the monitor for clarification.

4. Please answer all of the questions as completely as possible.

5. If any questions do not apply to your control room, please mark them N/A.

6. Take as much time as you need to complete the questionnaire.

7. All of your answers and your biographical information will be kept in the strictest confidence and will be used to aid in the performance of the detailed control room design review.

PLEASE BEGIN

APPENDIX B2
OPERATOR INTERVIEW/QUESTIONNAIRE

BIOGRAPHICAL DATA:

Name: _____ Age: _____

Sex: _____ Height: _____ Weight: _____

Current Position/Title: _____

1. Do you have a current reactor operator's license? YES _____ NO _____
2. Amount of licensed experience at this plant: _____
3. Total amount licensed experience: _____
4. Related experience and amount (example: operator-trainee, Hodge NPP Unit 1, 1 yr.):

5. Education:
   a. Highest level attained: _____ _____
   b. Specialized Schools or courses (list):

6. Military experience:

LABELS AND LOCATION AIDS

APPENDIX B2
OPERATOR INTERVIEW/QUESTIONNAIRE

1. Are color coded labels and location aids supported by additional cues (e.g., shape or functional nomenclature) which designate their meaning; that is, can you determine all you need to know without the color? YES NO

2. Do you know of any unnecessary label color coding? YES NO

3. Is the meaning attached to each color coded label narrowly defined and reserved only for that color? YES NO

4. Are all meanings attached to any colors used in color coded labels standard to your control room conventions, with the colors red, green, and amber reserved for the following uses:

   a. Red: unsafe, danger, immediate operator action required, or an indication that a critical parameter is out of tolerance? YES NO

   b. Green: safe, no operator action required, or an indication that a parameter is within tolerance? YES NO

   c. Amber (yellow): hazard (potentially unsafe), caution, attention required, or an indication that a marginal value or parameter exists? YES NO

APPENDIX B2
OPERATOR INTERVIEW/QUESTIONNAIRE

5. Are the meanings assigned to particular colors consistent across all applications within the control room, including panel surfaces, signal lights and CRTs? YES NO

6. Are any label colors used for coding difficult to tell apart? YES NO

7. Are controls, displays, and other equipment items appropriately and clearly labeled to enable rapid and accurate location, identification, and manipulation (if applicable)? YES NO

8. Are labels pertinent to control actuation visible during actuation? YES NO

9. Are labels periodically cleaned as a maintenance procedure? YES NO

10. Do labels describe the primary function of equipment items? YES NO

11. Do the words employed in the label express exactly what action is intended, if action is necessary? YES NO

LABELS AND LOCATION AIDS

APPENDIX B2
OPERATOR INTERVIEW/QUESTIONNAIRE

12.	Are instructions on labels clear and direct?	YES	NO
13.	Do words have a commonly accepted meaning for all users?	YES	NO
14.	Are there any unusual technical terms used in labels?	YES	NO
15.	Are there any symbols (e.g., abstract symbols like %) which have uncommon meanings?	YES	NO
16.	Are symbols used in a commonly accepted standard configuration?	YES	NO
17.	Is the use of temporary labels restricted to only necessary situations (e.g., need to replace a damaged, dropped, or changed label while a permanent one is made)?	YES	NO
18.	Does the method used for "tagging-out" a control prevent actuation of the control?	YES	NO

APPENDIX B2
OPERATOR INTERVIEW/QUESTIONNAIRE

19. Is there any place in the control room where mimic lines are difficult to distinguish quickly due to similarity in color and/or placement in a parallel configuration. YES NO

APPENDIX B3
OBSERVATIONS CHECKLIST

INSTRUCTIONS

1. Using the attached checklist, make all the noted observations.
2. Record all necessary information in the comments column to justify an N/A check and to detail a NO check.
3. Ensure that all comments for NO checks include component, instrument, panel, equipment, etc., identification and location information.
4. Initiate HED reports on all NO checks per the directions contained in the checklist analysis aids.

APPENDIX B3
OBSERVATIONS CHECKLIST

	N/A	YES	NO	COMMENTS
1. The number of colors used for coding should not exeed 11. — 6.5.1.6b.(2) & e.(1).				
2. The color used for coding any label should contrast well with the panel background — 6.5.1.6e.(2).				
3. Any given color used for label coding should be recognizable from all other label code colors for all illumination conditions — 6.5.1.6e(3).				
4. A hierarchical labeling scheme should be used and ranked in the following fashion — 6.6.1.2:				
5. Major labels should identify major systems or operator work stations — 6.6.1.2a.(1).				
6. Subordinate labels should identify subsystems or functional groups — 6.6.1.2a.(2).				

LABELS AND LOCATION AIDS

APPENDIX B3
OBSERVATIONS CHECKLIST

	N/A	YES	NO	COMMENTS
7. Component labels should identify each discrete panel or console element —6.6.1.2a.(3).				
8. Labels should not repeat information contained in higher-level labels — 6.6.1.2a.(4).				
9. Labels should be placed above the panel element(s) they describe — 6.6.2.1a.				
10. The placement of labels on control panels should conform to the recommendations shown in Appendix A, Exhibit 6.6-1. — 6.6.2.1b.				
11. Labels for elements located above eye level should be positioned to ensure label visibility — 6.6.2.1c.				

APPENDIX B3
OBSERVATIONS CHECKLIST

	N/A	YES	NO	COMMENTS
12. Labels should be placed close to the panel element as shown in Appendix A, Exhibit 6.6-2. — 6.6.2.1d.				
13. Adjacent labels should be separated by sufficient space so that they are not read as one continuous label (see Appendix A, Exhibits 6.6-3 and 6.6-4) — 6.6.2.1f.				
14. Labels should be mounted in such a way as to preclude accidental removal — 6.6.2.2a.				
15. Labels should be mounted on a flat surface — 6.6.2.2b.				
16. Labels should be oriented horizontally so that they may be read quickly and easily from left to right — 6.6.2.3a.(1)				
17. Although not normally recommended, vertical orientation may be used only where space is limited — 6.6.2.3a.(2)				

APPENDIX B3
OBSERVATIONS CHECKLIST

	N/A	YES	NO	COMMENTS
18. Curved patterns of labeling should be avoided (see Appendix A, Exhibit 6.6-5) — 6.6.2.3b.				
19. Labels should not cover any other information source. They should not detract from or obscure figures or scales which must be read by the operator — 6.6.2.4a.				
20. Labels should not be covered or obscured by other units in the equipment assembly — 6.6.2.4b.				
21. Labels should describe the function of equipment items — 6.6.3.1a.				
22. If needed for clarity, engineering characteristics or nomenclature may be described in labels — 6.6.3.1b.				
23. The words employed in the label should express exactly what action is intended — 6.6.3.2a.				

APPENDIX B3
OBSERVATIONS CHECKLIST

	N/A	YES	NO	COMMENTS
24. Labeled instructions should be clear — 6.6.3.2b.				
25. Labeled instructions should be direct — 6.6.3.2c.				
26. The use of unusual technical terms should be avoided on labels — 6.6.3.2e.				
27. Words on labels should be correctly spelled — 6.6.3.2f.				
28. Labels should be consistent within and across pieces of equipment in their use of words, acronyms, abbreviations, and part/system numbers — 6.6.3.3b.				
29. Symbols used in labels should be unique and distinguishable from each other — 6.6.3.4b.				

APPENDIX B3
OBSERVATIONS CHECKLIST

	N/A	YES	NO	COMMENTS
30. Symbols should be consistently used within and across panels — 6.6.3.4d.				
31. Use of Roman numerals on labels should be avoided — 6.6.3.4e.				
32. Words and abbreviations of similar appearance should be avoided where an error in interpretation could result. When labels containing similar words, abbreviations, or acronyms are located in close proximity to each other, different words should be selected or means of coding should be used to reduce the probability of selecting the wrong control or reading the wrong display — 6.6.3.6.				
33. Labels should be used to identify functionally grouped controls or displays — 6.6.3.7a.				
34. Labels should be located above the functional groups they identify — 6.6.3.7b.				

APPENDIX B3
OBSERVATIONS CHECKLIST

	N/A	YES	NO	COMMENTS
35. All discrete functional control positions should be identified — 6.6.3.8a.				
36. Direction of motion (increase, decrease) should be identified for continuous motion rotary controls — 6.6.3.8b.				
37. Each access opening used by control room operators should be labeled to identify the function of items accessible through it — 6.6.3.9a.				
38. All danger, warning, and safety instruction labels should be in accordance with appropriate safety standards — 6.6.3.9b.				
39. To ensure adequate contrast and prevent loss of readability because of dirt, dark characters should be provided on a light background — 6.6.4.1b.(1).				
40. If color print is used for coding purposes, it should conform to the established color coding scheme for the control room — 6.6.4.1b.(2).				

APPENDIX B3
OBSERVATIONS CHECKLIST

	N/A	YES	NO	COMMENTS
40. (Cont'd) Colors should be chosen for maximum contrast against the label background. (See Appendix A, Exhibit 6.6-9 for ratings of various color combinations in terms of relative legibility) — 6.6.4.1b.(2).				
41. Labels should be prepared in capital letters — 6.6.4.2a.(1).				
42. The design of letters and numerals should be simple and without flourishes or serifs — 6.6.4.2a.(2).				
43. Temporary labels should be used only when necessary — 6.6.5.1a.				
44. Temporary labels should conform to good human engineering principles — 6.6.5.1b.				
45. Temporary labels should not obscure prior permanent labels unless the old label is to be replaced — 6.6.5.1c.				

APPENDIX B3
OBSERVATIONS CHECKLIST

	N/A	YES	NO	COMMENTS
46. Tag-out labels should clearly identify out-of-service components and equipment — 6.6.5.1d.				
47. Tag-outs should be securely affixed — 6.6.5.1e.				
48. Tag-outs should not obscure the label associated with the nonoperable device — 6.6.5.1f.				
49. Tag-outs should not obscure any adjacent devices or their associated labels — 6.6.5.1h.				
50. Lines of demarcations are used to enclose functionally related displays — 6.6.6.2a.(1).				
51. Lines of demarcation are used to enclose functionally related controls — 6.6.62a.(2).				

APPENDIX B3
OBSERVATIONS CHECKLIST

	N/A	YES	NO	COMMENTS
52. Lines of demarcation are used to enclose group related controls and displays — 6.6.6.2a.(3)				
53. Lines of demarcation should be visually distinctive from the panel background — 6.6.6.2b.				
54. Lines of demarcation should be permanently attached — 6.6.6.2c.				
55. Flow paths should be color coded. Colors should be selected in conformance with Guideline 6.5.1.6 — 6.6.6.4a.(1).				
56. The mimic colors should be discriminably different from each other — 6.6.6.4a.(2).				
57. There should be adequate contrast between the mimic colors and the panel.				

APPENDIX B3
OBSERVATIONS CHECKLIST

	N/A	YES	NO	COMMENTS
58. If differential line widths are used for mimic lines, they should be used to code flow paths (e.g., significance, volume, level) — 6.6.6.4b.(1).				
59. Overlapping of mimic lines should be avoided — 6.6.6.4b.(2).				
60. Flow directions should be clearly indicated by distinctive arrow-heads — 6.6.6.4b.(3).				
61. All mimic origin points should be labeled or begin at labeled components — 6.6.6.4b.(4).				
62. All mimic destination or terminal points should be labeled or end at labeled components — 6.6.64b.(5).				
63. Component representations on mimic lines should be identified — 6.6.6.4b.(6).				

APPENDIX B3
OBSERVATIONS CHECKLIST

	N/A	YES	NO	COMMENTS
64. Large matrices of similar components should have the coordinate axes labeled for identification of any single component within the grid. The left and top sides of the matrix should be used for labeling (see Appendix A, Exhibit 6.8-6) — 6.8.3.2d.(1)				
65. Large matrices should be subdivided by appropriate demarcation — 6.8.3.2d.(2).				

LABELS AND LOCATION AIDS

APPENDIX B4
DOCUMENTATION REVIEW CHECKLIST

INSTRUCTIONS

1. Collect the results from the following SFTA Review Report and review them for the information contained in the attached checklist:

2. Ensure that all comments for NO checks include component, instrument, panel, equipment, etc., identification and local information.

3. Initiate HED reports on all NO checks per the directions contained in the checklist analysis aids.

APPENDIX B4
DOCUMENTATION REVIEW CHECKLIST

	N/A	YES	NO	COMMENTS
1. PLANT ADMINISTRATIVE PROCEDURES				
a. Periodic cleaning of labels should be required by administrative procedures — 6.6.2.4d.				
b. The use of temporary labels should be administratively controlled — 6.6.5.2a.				
c. A review procedure should require the determination of the necessity for temporary labels — 6.6.5.2b.(1)				
d. A review procedure should require the determination of how temporay labels will be used — 6.6.5.2b.(2).				
e. A review procedure should determine the content of temporary labels (given human engineering requirements) — 6.6.5.2b.(3).				

APPENDIX B4
DOCUMENTATION REVIEW CHECKLIST

	N/A	YES	NO	COMMENTS
f. A review procedure should govern the installation of temporary labels — 6.6.5.2b(4).				
g. A review procedure should require the determination of the impact of temporary labels on other system quipment (e.g., annunciators, mimics) — 6.6.5.2b.(5).				
h. A review procedure should require the determination of the need for documentation requirements as a result of the use of temporary labels — 6.6.5.2b.(6).				
i. A review procedure should require the determination of retraining requirements as a result of the use of temporary labels — 6.6.5.2b.(7).				
j. A review procedure should be established for the periodic evaluation (as to the need for) of temporary labels and their removal (if needed) — 6.6.5.2b.(8) and (9).				

APPENDIX B4
DOCUMENTATION REVIEW CHECKLIST

	N/A	YES	NO	COMMENTS
2. PLANT OPERATING PROCEDURES				
a. There should be no mismatch between nomenclature used in procedures and that printed on the labels. If references to specific labels are made in operating procedures, the label should be refered to verbatum.				

LABELS AND LOCATION AIDS

APPENDIX B5.1
MEASUREMENTS ANALYSIS

1. LINEAR MEASUREMENTS

1.1 General Analysis Procedures.

Two separate analyses are performed on the linear measurements data. The first analysis examines the physical characterisitcs of letter and numerals that can have an effect upon label readability. The second analysis examines the character size relationship between heirarchical label sets which can have an effect upon the discriminability of one label from another.

1.2 Readability Analysis Procedures

a. Obtain copies of all completed data forms from Appendix B1.1.

b. Obtain a copy of Analysis Form 1.2 for each completed data form.

c. Transcribe onto Analysis Form 1.2 the label type, label content, and character heights from Data Form 1.1

d. Calculate the following values from the data recorded on Data Form 1.1 for each sample label and record the calculations on Analysis Form 1.2:

1) Character width-to-height ratios for:

a) Letters

b) Numerals other than 1 and 4

c) Numberals 1 and 4.

2) Stroke width-to-character height ratio.

e. Transcribe the following data from Data Form 1.1 onto Analysis Form 1.2:

1) Space between characters

2) Space between words

3) Space between lines.

f. Calculate the minimum character height required using the maximum viewing distance data from the Anthropometrics Task Plan, TP-1.2. Minimum character height is 0.004 times the maximum viewing distance. Enter this calculated height on all analysis forms.

APPENDIX B5.1
MEASUREMENTS ANALYSIS

1. LINEAR MEASUREMENTS (Cont.)

1.2 Readability Analysis Procedures (Cont.)

g. Compare all calculated ratios and measurements to the required values listed in (or calculated from) the appropriate criteria from Appendix A and perform the following:

1) For all data which meets the specified values, check the YES column for the appropriate criteria in Appendix A.

2) For all data which do not meet the specified values, circle the discrepant value(s), record the correct value(s) in the SHLD BE column, and enter the appropriate NUREG-0700 criterion in the CRITERIA column on the analysis form. Generate an HED report for each heirarchical label that is discrepant and attach copies of the appropriate analysis and data froms to the report. Check the NO column and enter the HED number(s) in the COMMENTS column for the appropriate criteria in Appendix A. Note that for modular components where the component label and the position label are engraved on the same piece of material, it is beneficial to combine the control position label discrepancies with their related component label discrepancies on the same HED report.

1.3 Discriminability Analysis Procedures.

1.3.1 Character Height Consistency Analysis. Character height should be identical for all labels within the same heirarchical level (NUREG-0700, para. 6.6.4.1a).

a. Sort all data forms into stacks such that each stack represents a different heirarchical level. Number each data form in the block provided in the following manner:

1) Use code number C1 for the System/Work Station stack and number each data form sequentially from C1-1 through C1-n.

2) Use the following codes for the remaining stacks:

a) C2 for Subsystem/Functional Groups

b) C3 for Components

c) C4 for Control Positions

d) C5 for Legend Lights.

APPENDIX B5.1
MEASUREMENTS ANALYSIS

1. LINEAR MEASUREMENTS (Cont.)

1.2 Discriminability Analysis Procedures (Cont.)

1.3.1 Character Height Consistency Analysis. (Cont.)

b. Obtain one copy of Analysis Form 1.3.1 and record the character height from each data form for each heirarchical stack in the spaces provided on the form.

c. Compare the character heights across all sample labels for each heirarchical level and perform the following:

1) If all character heights in each heirarchical level are consistent, find cirterion 6.6.4.1a(2) in Appendix A and check the YES column.

2) If any character height is different from the character heights on the other labels of the same heirarchical level perform the following:

a) Circle the discrepant value and obtain a copy of the related data form(s).

b) Generate an HED report for each heirarchical level that is discrepant. Attach a copy of the analysis from and copies of the related data forms to the HED report.

c) Check the NO column for cirterion 6.6.4.1a(2) in Appendix A and record the HED number(s) in the COMMENTS column.

1.3.2 Heirarchical Discriminability Analysis. Labels should be graduated in size such that the character size in each level of heirarchical labeling is approximately 25% larger than the character size in the labeling directly below (NUREG-0700, para. 6.6.1.2b). Do not include legend lights in this analysis.

a. Sort all data forms into stacks such that each stack represents a different sample of a heirarchical set of labels. Number each data form in the following manner:

1) Use code number H1 for the first sample set and number each data form sequentially from H1-1 to H1-n.

2) Use code numbers H2 through Hn for the remaining sample sets.

APPENDIX B5.1
MEASUREMENTS ANALYSIS

1. LINEAR MEASUREMENTS (Cont.)

1.3 Discriminability Analysis Procedures (Cont.)

1.3.2 Heirarchical Discriminability Analysis (Cont.)

b. Obtain one copy of Analysis Form 1.3.2 for each sample set of labels and record the character size from each heirarchical label within a sample set on that set's analysis form.

c. Form the Readability Analysis (para. 1.2) determine if the lowest heirarchical label character height meets the minimum height criterion for the viewing distance. If it does, calculate the minimum height that each label's character height should be based on the following formula:

$$1.25 \times \begin{matrix}\text{character height on} \\ \text{label directly below}\end{matrix} = \begin{matrix}\text{minimum} \\ \text{height}\end{matrix}$$

If the height of the lowest level label's characters do not meet the minimum character height criterion, use the minimum character height criterion and calculate the minimum height that each label's characters should be using this same formula.

d. For each sample set of labels compare the actual character height with the minimum character height criterion for that heirarchical level and perform the following:

1) If all character heights for all levels of labels in all sample sets meet or exceed their respective minimum height criteria, find criteria 6.6.1.2b(1) through 6.6.1.2b(4) in Appendix A and check the YES column.

2) If any character height does not meet or exceed its criterion, perform the following:

a) Circle the discrepant value(s) and obtain copies of the related data form(s).

b) Generate and HED report for each sample set that is discrepant. Attach a copy of the analysis form and copies of the related data forms to the HED report.

c) Check the NO column for the appropriate criterion in Appendix A and record the HED number(s) in the COMMENTS column for that criterion.

LABELS AND LOCATION AIDS

APPENDIX B5.1
MEASUREMENTS ANALYSIS

ANALYSIS FORM 1.2
READABILITY

LABEL CONTENT: _____

_____

LABEL TYPE: _____

		Value	Shld Be	Criteria
1)	Character Heights for:			
	a) Letters			
	b) Numerals other than 1 and 4			
	c) Numerals 1 and 4			
2)	Character Width-to-Height Ratios			
	a) Letters			
	b) Numerals other than 1 and 4			
	c) Numerals 1 and 4			
3)	Stroke Width-to-Character Height Ratio			
4)	Space Between Characters			
5)	Space Between Words			
6)	Space Between Lines			

LABELS AND LOCATION AIDS

APPENDIX B5.1
MEASUREMENTS ANALYSIS

ANALYSIS FORM 1.3.1
CHARACTER HEIGHT CONSISTENCY

	STACK SEQUENCE NUMBER CHARACTER HEIGHT						
	-1	-2	-3	-4	-5	-6	-7
STACK C1 SYSTEM/WORK STATION							
STACK C2 SUBSYSTEM/ FUNCT GROUP							
STACK C3 COMPONENT							
STACK C4 CONTROL POSITION							

LABELS AND LOCATION AIDS

APPENDIX B5.1
MEASUREMENTS ANALYSIS

ANALYSIS FORM 1.3.2

HEIRARCHICAL DISCRIMINABILITY

HEIRARCHICAL LABEL SAMPLE SET NUMBER N _____

	ACTUAL HEIGHT	MINIMUM HEIGHT	CRITERIA
SYSTEM/WORK STATION:	_____	_____	_____
SUBSYSTEM/FUNCTIONAL GROUP:	_____	_____	_____
COMPONENT:	_____	_____	_____
CONTROL POSITION:	_____	_____	_____

APPENDIX B5.2
MEASUREMENTS ANALYSIS

2. SOUND MEASURMENTS - **Not required.**

LABELS AND LOCATION AIDS

APPENDIX B5.3
MEASUREMENTS ANALYSIS

3. LIGHT MEASURMENTS - **Not required.**

APPENDIX B6
OPERATOR INTEVIEW/QUESTIONNAIRE ANALYSIS

1. GENERAL

   a. Review all questionnaires for completeness of biographical information and question responses.

   b. Delete incomplete and unusable questionnaires from the data base. If required by contract, reschedule these questionnaires for correction/completeness.

   c. When the data base assembly is complete perform the analysis, below.

2. BIOGRAPHICAL DATA

   a. Assemble biographical data and determine ranges and distributions for all relevant dimensions.

   b. Using appropriate statistics, determine the distribution (or its approximation) for this data.

3. RESPONSE DATA

   a. Summarize all responses and determine percent frequency response for each negative answer.

   b. Obtain the control copy of Appendix A - Criteria from the Conventions Task Plan (TP-8.1) for use in the next steps.

   c. For each positive answer, check the YES column for that criteria in Appendix A of this task plan. Do the same in the Conventions Task Plan Appendix A for criteria 6.5.1.6b(2) and c(2).

   d. Also add the data collection code number, TP-6.1B6n (with n the question number), in the REMARKS column of the Conventions Task Plan Appendix A.

   e. For each negative answer, initiate Preliminary HEDs (PHEDs) for discrepancy review. Record response frequency data, 0700 criteria number, and data collection code number on each PHED.

   f. The 0700 criteria numbers are contained in List 3b.

   g. For each negative answer, check the NO column and record the data collection code number and PHED number in the REMARKS column for the appropriate criteria in Appendix A of this task plan. Do the same for the Conventions Task Plan Appendix A for the criteria listed in c, above.

   h. Submit all PHEDs to your immediate supervisor.

   i. Subsequent verification, validation, and disposition of all PHEDs will be conducted per TP-10.1 (HED Review Procedure).

APPENDIX B6
OPERATOR INTEVIEW/QUESTIONNAIRE ANALYSIS

List 1b

1. 6.5.1.6a.
2. 6.5.1.6b.(1)
3. 6.5.1.6c.(1) & 6.6.6.3
4. 6.5.1.6c.(2) & 6.6.6.3
5. 6.5.1.6d (all) & 6.6.6.3
6. 6.5.1.6e.(1)
7. 6.6.1.1
8. 6.6.2.1e., 6.6.2.4c., & 6.6.3.8c.
9. 6.6.2.4.d.
10. 6.6.3.1a.
11. 6.6.3.2a.
12. 6.6.3.2b. & c.
13. 6.6.3.2d. & 6.6.3.5
14. 6.6.3.2e.
15. 6.6.3.4a.
16. 6.6.3.4c.
17. 6.6.5.1a.
18. 6.6.5.1g.
19. 6.6.6.4a.(5)

LABELS AND LOCATION AIDS

APPENDIX B7
OBSERVATIONS ANALYSIS

1. For each checklist item checked YES, also check the YES column for that criteria in Appendix A and enter the date collection code number, TP-4.1B3.n (where n is the checklist item number) in the COMMENTS column.

2. For each checklist item checked NO, initiate an HED report. Enter the HED report number in the COMMENTS column of the checklist for that item. Include all necessary information on the HED report concerning identification of the discrepancy and the criteria (checklist item) not met.

3. Find the appropriate criterion or criteria in Appendix A from the reference number in the checklist item. Check the NO column and enter the HED number and the data collection code number in the COMMENTS column for that criterion or criteria.

4. Cordinate the analysis of the following checklist items with the indicated questionnaire answers:

Checklist Item No.	Questionnaire Answer Number	Appendix A Criteria
21	10	6.6.3.1a.
23	11	6.6.3.2a.
24	12	6.6.3.2b.
25	12	6.6.3.2c.
26	14	6.6.3.2e.
43	17	6.6.5.1a.

LABELS AND LOCATION AIDS

APPENDIX B8
DOCUMENTATION REVIEW ANALYSIS

1. For each checklist item checked YES, also check the YES column for the appropriate criteria in Appendix A. Enter the data collection code number TP-6.1B4n (n is the checklist item number) in the COMMENTS column.

2. For each checklist item checked NO, initiate an HED report. Enter the HED report number in the COMMENTS column of the checklist for that item. Include all necessary information on the HED report concerning identification of the discrepancy and the criteria (checklist item) not met.

3. Find the appropriate criterion or criteria in Appendix A from the reference number in the checklist item. Check the NO column and enter the HED number and the data collection code number in the COMMENTS column for that criterion or criteria.

4. When reviewing task report data, do not initiate duplicate HED reports. When an HED report has already been initiated for a specific discrepancy during the condut of another task, update that HED report with the relevant information from this task data. Also update and cross-reference the criteria lists in Appendix A of both sets of task documentation.

5. Coordinate the analysis of the following checklist items with the indicated questionnaire answers:

Checklist Item No.	Questionnaire Answer Number	Appendix A Criteria
1a	9	6.6.2.4d.

APPENDIX B9
HUMAN ENGINEERING DISCREPANCY (HED) REPORT

_____
PLANT/UNIT

ORIGINATOR: _____ HED NO.: _____

VALIDATED BY: _____ DATE: _____

a) HED TITLE: _____

_____

b) ITEMS INVOLVED:

c) PROBLEM DESCRIPTION AND 0700 PARA. NUMBER:

d) DATA COLLECTION DESCRIPTION AND CODE NUMBER:

e) SPECIFIC HUMAN ERROR(s):

APPENDIX B9
HED REPORT (CONTINUED)

_____ HED NO.: _____
PLANT/UNIT

f) SUGGESTED BACKFIT:

g) REVIEW AND DISPOSITION:

APPENDIX C

CRITERIA MATRIX

APPENDIX C
CRITERIA MATRIX

Criteria Distributed Across Data Collection Methods

Notes:

1. The following codes apply to the matrix columns:

   M - Measurement (instruments and/or measuring devices required)

   O - Observations (observation notes taken)

   I - Interview/Questionnaire (generally a structured interview unless otherwise specified)

   D - Document Review (documentation review to include engineering drawings, CWDs, etc.)

   A - Auditory Criteria

   V - Visual Criteria

   C - Controls Criteria (physical characteristics)

   L - Location/Arrangement Criteria

   P - General Physical

   F - Functional Criteria (usually requires some operational data for verification)

2. Data sources listed are suggested. Alternatives should be used when those listed are not available or are not adequate.

LABELS AND LOCATION AIDS

APPENDIX C
CRITERIA MATRIX

CRITERIA NUREG-0700 para number	Crit type	DATA COLLECTION METHODS M	O	I	D	SUGGESTED DATA SOURCES	REMARKS
6.3.3.3c.(3)	V	X				Pnl, Or	6.3.3.3a through f in TP-3.1; 6.3.3.3b and d(2) also in SFTA
6.5.1.6a	F			X		OPS	(See Note 1)
b(1)	L			X			(See Note 1)
b(2)	L		X				(See Notes 1 & 2)
c(1)	F			X		OPS	(See Note 1)
c(2)	F			X			(See Notes 1 & 2)
d(1)	L		N/A				in TP-8.1 (Conv)
d(2)	L		N/A				in TP-8.1 (Conv)
d(3)	F						in TP-8.1 (Conv)
e(1)	L		X			Pnl	(See Note 1)
e(2)	L		X			Pnl	(See Note 1)
e(3)	L		X			Pnl	(See Note 1)
6.6.1.1	V			X		Pnl, OPS	
6.6.1.2a.(1)	VF		X			Pnl, OPS	
a.(2)	VF		X			Pnl, OPS	
a.(3)	VF		X			Pnl, OPS	
a.(4)	V		X			Pnl, OPS	
b.(1)	V	X				Pnl, OPS	
b.(2)	V	X				Pnl, OPS	
b.(3)	V	X				Pnl, OPS	
b.(4)	V	X				Pnl, OPS	

Notes:

1. These criteria also in the following task plans:
   a. TP-3.1, Annunciator System Review
   b. TP-4.1, Controls Survey
   c. TP-5.1, Displays Survey
   d. TP-7.1, Computers
   e. RP-9.0, SFTA Review Plan (P/O TP-9.9, CR Function Validation)

2. These criteria also in TP-8.1, Conventions.

APPENDIX C
CRITERIA MATRIX

CRITERIA		DATA COLLECTION METHODS				SUGGESTED	
NUREG-0700 para number	Crit type	M	O	I	D	DATA SOURCES	REMARKS
6.6.2.1 a.	L		X			Pnl, OPS	
b.	L		X			Pnl, OPS	
c.	VL		X			Pnl, OPS	
d.	L		X			Pnl, OPS	
e.	L			X		Pnl, OPS	
f.	VL		X			Pnl, OPS	
6.6.2.2 a.	F		X			Pnl, OPS	
b.	F		X			Pnl, OPS	
6.6.2.3 a.(1)	VL		X			Pnl, OPS	
a.(2)	V		X			Pnl, OPS	
b.	L		X			Pnl, OPS	
6.6.2.4 a.	VL		X			Pnl, OPS	
b.	V		X			Pnl, OPS	
c.	VF			X		Pnl, OPS	
d.	F			X	X	Pnl, OPS, Proc Docum	
6.6.3.1 a.	F		X	X		Pnl, OPS	
b.	F		X				
6.6.3.2 a.	F		X	X		Pnl, OPS	
b.	F		X	X		Pnl, OPS	
c.	F		X	X		Pnl, OPS	
d.	F			X		Pnl, OPS	
e.	F		X	X		Pnl, OPS	
f.	V		X			Pnl, OPS	
6.6.3.3 b.	V		X			Pnl, OPS	6.6.3.3a. in TP-8.1
c.	V				X	Pnl, OPS Proc Docum	
6.6.3.4 a.	F			X		Pnl, OPS	
b.	V		X			Pnl, OPS	
c.	V			X		Pnl, OPS	
d.	V		X			Pnl, OPS	
e.	V		X			Pnl, OPS	
6.6.3.5	VF			X		Pnl, OPS	

APPENDIX C
CRITERIA MATRIX

CRITERIA		DATA COLLECTION METHODS				SUGGESTED	
NUREG-0700 para number	Crit type	M	O	I	D	DATA SOURCES	REMARKS
6.6.3.6	VF		X			Pnl, OPS	
6.6.3.7 a.	F		X			Pnl, OPS	
b.	L		X			Pnl, OPS	
6.6.3.8 a.	VF		X			Pnl, OPS	
b.	VF		X			Pnl, OPS	
c.	VF			X		Pnl, OPS	
6.6.3.9 a.	F		X			Pnl, OPS	
b.	VF		X			Pnl, OPS	
6.6.4.1 a.(1)	V	X				Pnl, OPS	
a.(2)	V	X				Pnl, OPS	
b.(1)	V		X			Pnl, OPS	
b.(2)	V		X			Pnl, OPS	
6.6.4.2 a.(1)	V		X			Pnl, OPS	
a.(2)	V		X			Pnl, OPS	
b.(1)	V	X				Pnl, OPS	
b.(2)	V	X				Pnl, OPS	
c.	V	X				Pnl, OPS	
d.(1)	V	X				Pnl, OPS	
d.(2)	V	X				Pnl, OPS	
d.(3)	V	X				Pnl, OPS	
6.6.5.1 a.	F		X	X		Pnl, OPS	
b.	VF		X			Pnl, OPS	
c.	V		X			Pnl, OPS	
d.	VF		X			Pnl, OPS	
e.	F		X			Pnl, OPS	
f.	V		X			Pnl, OPS	
g.	F			X		Pnl, OPS	
h.	V		X			Pnl, OPS	

APPENDIX C
CRITERIA MATRIX

CRITERIA		DATA COLLECTION METHODS				SUGGESTED	
NUREG-0700 para number	Crit type	M	O	I	D	DATA SOURCES	REMARKS
6.6.5.2 a.	F				X	Pnl, OPS, Proc Docum	
b.(1)	F				X	Pnl, OPS, Proc Docum	
b.(2)	F				X	Pnl, OPS, Proc Docum	
b.(3)	F				X	Pnl, OPS, Proc Docum	
b.(4)	F				X	Pnl, OPS, Proc Docum	
b.(5)	F				X	Pnl, OPS, Proc Docum	
b.(6)	F				X	Panl, OPS, Proc Docum	
b.(7)	F				X	Panl, OPS, Proc Docum	
b.(8)	F				X	Pnl, OPS, Proc Docum	
b.(9)	F				X	Pnl, OPS, Proc Docum	
6.6.6.2 a.(1)	F		X			Pnl, OPS	6.6.6.2 a., b. and c. also in TP-3.1
a.(2)	F		X			Pnl, OPS	
a.(3)	F		X			Pnl, OPS	
b.	V		X			Pnl, OPS	
c.	VF			X		Pnl, OPS	
6.6.6.3	VF			X		Pnl, OPS	
6.6.6.4 a.(1)	VF		X			Pnl, OPS	6.6.6.4a.(4) and a.(5) in TP-8.1
a.(2)	V		X			Pnl, OPS	
a.(3)	V		X			Pnl, OPS	
a.(4)	V		X			Pnl, OPS	
a.(5)	VL		X			Pnl, OPS	
b.(1)	VF		X			Pnl, OPS	
b.(2)	F		X			Pnl, OPS	
b.(3)	VF		X			Pnl, OPS	
b.(4)	VF		X			Pnl, OPS	
b.(5)	VF		X			Pnl, OPS	
b.(6)	VF		X			Pnl, OPS	6.6.6.4c.(1) and c.(2) in TP-8.1

APPENDIX C
CRITERIA MATRIX

CRITERIA		DATA COLLECTION METHODS				SUGGESTED	
NUREG-0700 para number	Crit type	M	O	I	D	DATA SOURCES	REMARKS
6.8.3.2d.(1)	V		X			Pnl, OPS	6.8.3.2a., b., and c. in SFTA; 6.8.3.2b. and c. also in TP-8.1

APPENDIX D

TASK PLAN CRITIQUE

APPENDIX D
TASK PLAN CRITIQUE

INSTRUCTIONS

1. Attach a copy of Section 4.0.
2. Fill in the required information and answer all questions.
3. Explain all NO answers in detail.
4. When complete, turn in to your immediate supervisor.

1. Name of Respondent: _____
2. Name of Plant: _____
3. Date of Survey: _____
4. Were all of the criteria correct and appropriate for this task (do not explain criteria that were N/A because System/CR did not have that design feature)? YES NO
5. Did the task plan instructions present the easiest and best methodology for performing the assessment? YES NO
6. Were the data collection forms adequate? YES NO