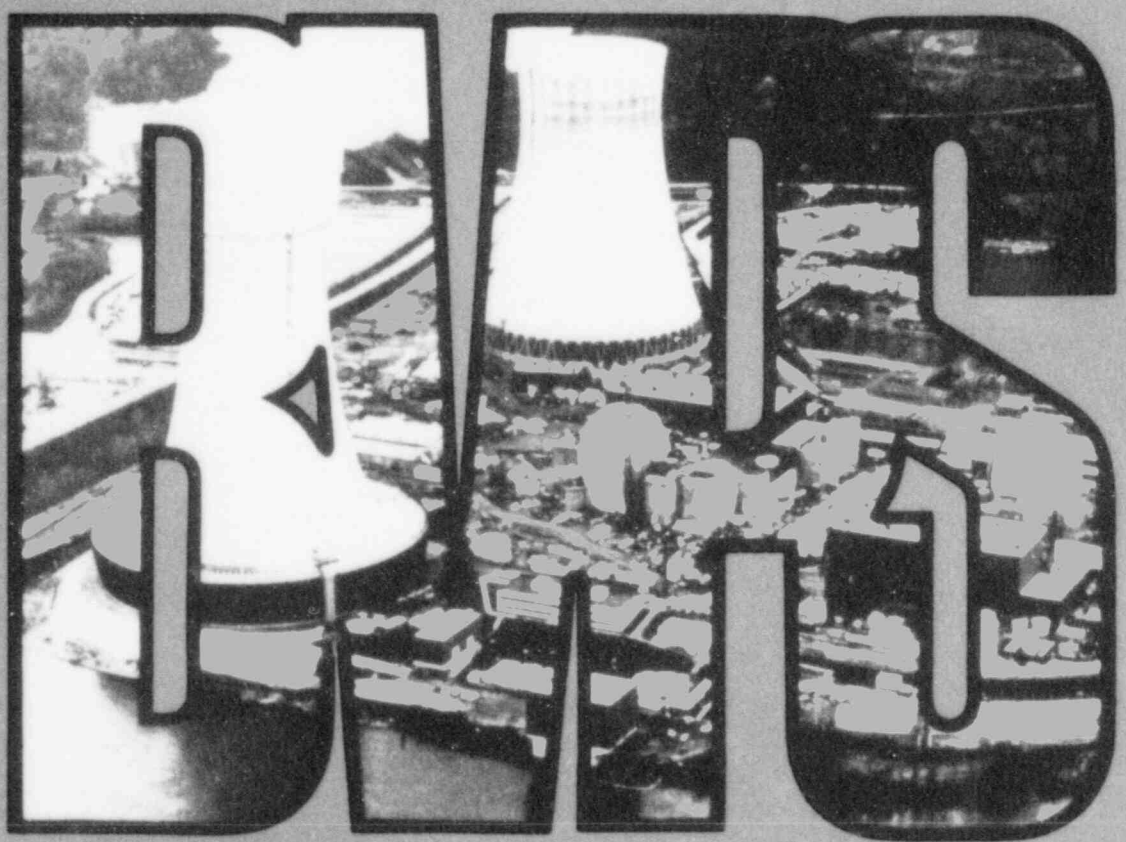
# CONTROL ROOM DESIGN REVIEW

## Summary Report

Volume 1



BEAVER VALLEY POWER STATION UNIT 2

Duquesne Light

# BEAVER VALLEY POWER STATION UNIT - 2

# CONTROL ROOM DESIGN REVIEW

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HUMAN ENGINEERING DISCREPANCIES

# 1.0 INTRODUCTION

Duquesne Light Company (DLC) is the applicant and agent for itself and The Cleveland Electric Illuminating Company, Ohio Edison Company, and The Toledo Edison Company for the operation of the Beaver Valley Power Station, Unit 2 (BVPS-2) (NRC Docket No. 50-412). BVPS-2 will employ a Westinghouse three-loop pressurized water reactor (PWR) with a net electrical output of 836 MWe. BVPS-1, located on the same site, was licensed in January 1976 and also utilizes a Westinghouse three-loop PWR with a net electrical output of 810 MWE.

The Control Building for BVPS is located between Unit 1 and Unit 2 at elevation 735'6". Within the Control Building are the control rooms for each unit. The control rooms are presently separated by a temporary steel reinforced wall. The wall is installed so that Unit 2 construction activities will not hamper Unit 1 operations and to maintain security in the Unit 1 control room. The wall will be removed prior to Unit 2 becoming operational. Until the wall is removed, DLC will not be able to complete some of the surveys involving common control room attributes required by NUREG-0700 (see Section 3.1).

The Control Room Design Review (CRDR) is part of an extensive effort within the nuclear industry and the Nuclear Regulatory Commission (NRC) to evaluate nuclear power plant control rooms, and the operability of emergency operating procedures (EOPs) within the control room. The goals of the CRDR effort were to identify Human Engineering Discrepancies (HEDs) within the context of the existing control room, emergency shutdown panel, and alternate shutdown panel; evaluate the HEDs for their possible impact on the safe operation of the plant; assess whether or not the impact is significant; and provide for adequate disposition of all identified HEDs. In achieving these goals, care was taken to avoid negating the safety characteristics of the existing control room design. Also practical considerations required that any action taken to upgrade the control room use accepted human factors principles.

## 1.1 Overview

This report describes the methodology, findings, assessment, and implementation of the BVPS-2 CRDR. The review was conducted to ensure that the control room and the emergency and alternate shutdown panels would support operation during emergency conditions and to meet the requirements of Item 1.D.1 (Control Room Design Review) of Supplement 1 to NUREG-0737 published by Generic Letter 82-33. Note that the format of this report is not consistent with that presented in Figure 6-1 of the BVPS-2 Program Plan[1]. The present format better organizes and presents the material contained herein. The CRDR effort will be addressed in Chapter 18.0, "Human Factors Engineering," of the FSAR.

[1]Duquesne Light letter no. 2NRC-3-060 to H. Denton from E. J. Woolever, dated August 8, 1983.

The review was conducted in accordance with the BVPS-2 Program Plan. The plan organized the review into four phases: Planning, Review, Assessment and Implementation, and Documentation.

Planning for the review, based on the Program Plan, was crystallized with the generation of a BVPS-2 CRDR Charter (Appendix A) and a set of detailed instructions for each task (Appendix B).

Relying heavily upon the expertise of Human Factors Specialists (HFS), as well as operating personnel, and instrumentation and control systems engineers, the review phase was accomplished for the following tasks in accordance with the established instructions.

- Task 1 - Operating Experience Review
- Task 2 - Control Room Inventory
- Task 3 - Control Room Survey
- Task 4 - System Review and Task Analysis
- Task 5 - Verification of Control Room Functions
- Task 6 - Validation of Control Room Functions

The products of each task (where applicable) were HEDs, which identify discrepancies and, in some cases, provide preliminary resolutions for the discrepancies based upon NUREG-0700 guidelines.

In the assessment and implementation phase, each HED was reviewed in detail by the Core Team and Support Team, at which time final resolutions were agreed upon. The HEDs, with their resolution, were given to the DLC Management Team for disposition. Upon agreement of DLC management, a plan for the implementation of the HED resolutions was generated. The above review phases are further documented within this report.

Section 6.0, "Implementation and Scheduling of Corrective Actions" discusses the time frame for resolving the HEDs identified in this report. Also discussed in Section 6.0 is the intended approach for evaluating those control room characteristics which were unable to be assessed during the course of the BVPS-2 CRDR.

## 1.2 Management and Staffing

This section will identify the CRDR program teams and their associated areas of responsibility. An overview of the CRDR organization is shown in Figure 1-1. The Regulatory Affairs Department (RAD) of the Nuclear Construction Division (NCD) has primary responsibility for the CRDR. The NCD is a division within the Nuclear Group. The Vice President of the Nuclear Group has responsibility for all nuclear related activities (BVPS-1 and -2) at DLC.

## BVPS-2 CRDR ORGANIZATION

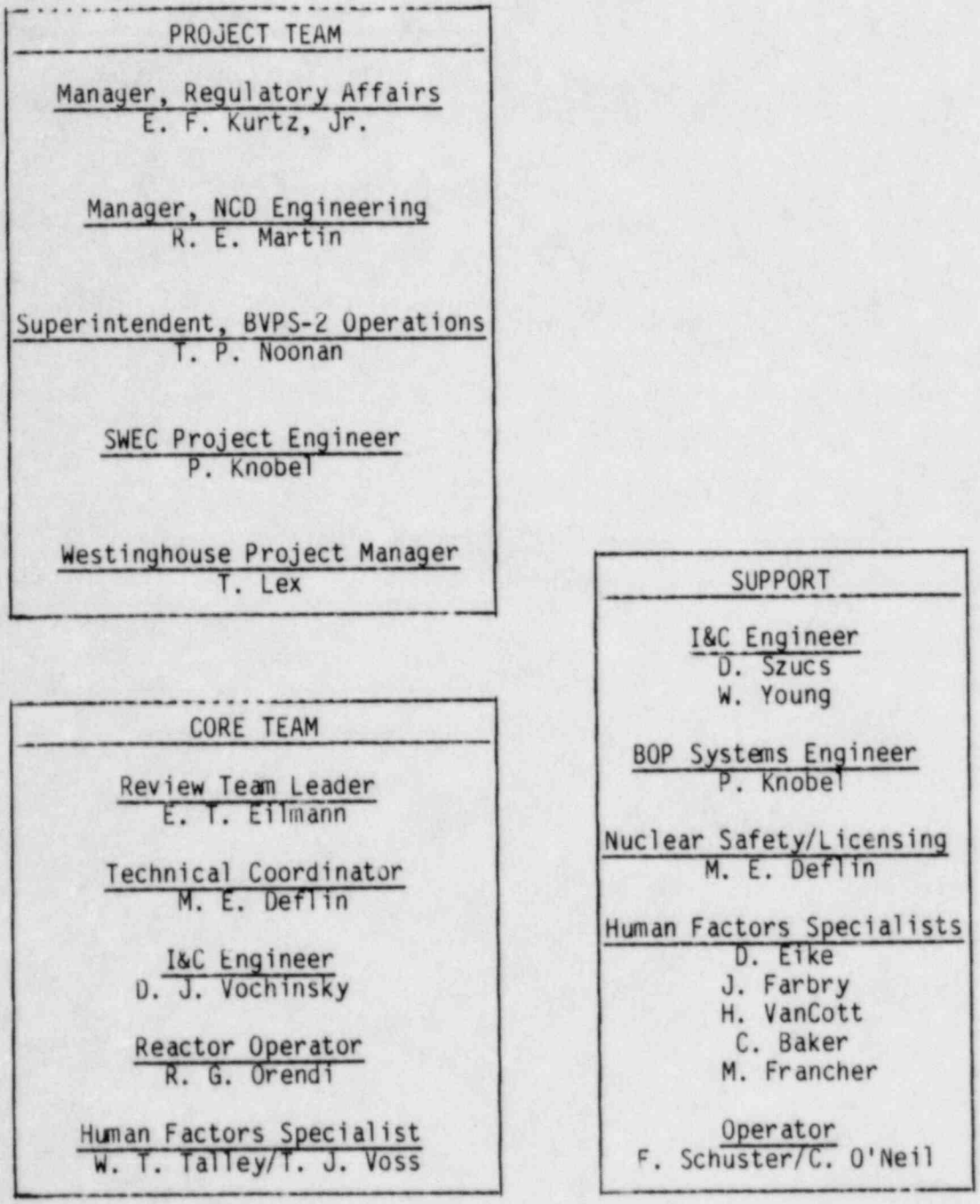


FIGURE 1-1

### 1.2.1 Management Organization

The management function for the CRDR was under DLC NCD Procedure 1.2, "Organization and Responsibilities," and NCD Procedure 2.10, "Engineering Change Control."

The function of management is to:

- approve the Program Plan
- provide the resources necessary for implementation of the CRDR
- review and approve control room recommendations for correction of HEDs
- provide the mechanism for the preparation and submittal of documents to the NRC

### 1.2.2 Project Team

The Project Team provided the overall coordination of the CRDR program. The function of this team was to:

- ensure that the CRDR program was perfonmed in accordance with the DLC Quality Assurance Program
- provide overall support to the CRDR process
- monitor the CRDR process
- ensure that the CRDR objectives and tasks, in relation to other NUREG 0737 efforts, are properly coordinated
- establish and initiate a control room improvement program

### 1.2.3 Core Team

The day-to-day review activities were the responsiblity of the Core Team. The Core Team was responsible for the planning, scheduling, coordinating, and integration of CRDR activities.

### 1.2.4 Core Team Structure

The Core Team is a multidisciplined team of individuals with the wide range of skills necessary to perfonm the design review. The Core Team includes the following personnel:

- Review Team Leader
- Human Factors Specialist
- Reactor Operator (licensed or certified)
- Instrumentation and Control Engineer
- Technical Coordinator

The Core Team was supplemented, as required, by the Support Team. The Support Team helped to address such areas as:

operations, human factors, mechanical engineering, electrical engineering, nuclear engineering, procedures, and licensing/nuclear safety. Resumes of all members of the CRDR organization are maintained in the CRDR files.

1.2.4.1 The Core Team had the Review Team Leader as its key person. This individual provided the administrative and technical direction for the project and has overall responsibility for the project. Access to information and individuals which/who provided useful or necessary input to the team was coordinated by the Review Team Leader.

It was the responsibility of the Review Team Leader to resolve human factors concerns on methodology, technique, review findings, assessment, and HED corrective actions that dissent with the majority opinion of the Core Team.

1.2.4.2 Human Factors Specialist (HFS)

The HFS worked closely with the CRDR organization throughout each phase of the CRDR and shared with the team the human factors technical leadership of the entire CRDR project. This individual is the Essex Human Factors Project Manager.

1.2.4.3 Reactor Operator (RO)

The RO assisted in identifying operator tasks and served as the Core Team expert on the operational constraints for manipulations of plant systems.

1.2.4.4 Instrumentation and Control (I&C) Engineer

The I&C Engineer in conjunction with the Balance-of-Plant (BOP) Systems Engineer assisted in the identification of plant system design features and served as the Core Team expert on the capabilities and limitations of controls and instruments. The I&C specialist and BOP Systems Engineer also provided input to the team during the assessment phase of the review. This individual is the Westinghouse Program Coordinator.

1.2.4.5 Technical Coordinator

The Technical Coordinator acted as the primary contact and liaison between the Project, Core, and Support Teams. He also provided the interface between the CRDR organization and the NRC. The

Technical Coordinator was delegated the authority of the Review Team Leader in cases where the Review Team Leader was unavailable.

## 1.3 Program Plan

The initial step of the CRDR was the preparation of a Program Plan based upon the requirements of Supplement 1 to NUREG-0737 and the guidance contained in NUREG-0700 and NUREG-0801. As described above, the Program Plan addressed the design review activities in four phases:

- Phase I - Planning
- Phase II - Review
- Phase III - Assessment and Implementation
- Phase IV - Documentation

BVPS-2 is currently under construction and the Program Plan was made flexible so that the CRDR tasks would be performed within the framework of the overall schedule for the CRDR, Safety Parameter Display System (SPDS) installation, the Regulatory Guide 1.97 (Rev. 2) survey, and the new EOP implementation.

The Program Plan was submitted to the NRC for review on August 8, 1983, and the NRC staff comments on the plan were returned on January 23, 1984.

In general, the NRC staff stated that the plan did not describe the proposed review program in enough detail to allow them to understand fully how the CRDR objectives would be accomplished. More specifically, the comments were in the following areas:

1. Qualification of review team members and level of involvement in review tasks.

2. HFS involvement in detailed planning.

3. Need for more than one human factors specialist in the many review tasks.

4. Description of the data base and data base management system.

5. Description of the standardized forms/checklists to be used.

6. The necessity to include conventions and standard abbreviations in DLC reference materials.

7. Independence of system review and task analysis (SRTA) from other review tasks.

8. Events to be considered in the SRTA.

9. Event-based vs function-based EOPs.

10. Specific EOPs to be considered in the SRTA.

11. Information and control requirements and characteristics to be determined from SRTA.

12. SRTA methodology.

13. Control room inventory of instrumentation.

14. Control room inventory forms.

15. Verification methodology and tools.

16. Human factors guidelines and criteria to be used in the control room survey.

17. Process for identifying and recording HEDs.

18. State of control room in which survey will be conducted.

19. Implementation schedule for correction of HEDs.

20. HED assessment methodology.

21. Selection of design improvements traceability.

22. Criteria for selection of design improvements.

23. Methodology to ensure that improvements correct the HED without introducing new HEDs.

24. Approach to coordinating the CRDR with other post-TMI activities.

25. Control room modifications resulting from post-TMI actions.

Based on the Program Plan, a CRDR Charter was developed. The Charter describes and organizes the entire CRDR by addressing the following subjects:

- Purpose
- Objectives
- CRDR Organization
- Schedule
- Monthly Report
- Contractor/Subcontractor
- Records
- Final Report Format
- Regulatory Issues

- Audits
- Revisions to Charter
- Document Control
- Instructions

Based on the NRC review, the staff requested an in-progress audit of the BVPS-2 CRDR program. The on-site, in-progress audit was conducted by the staff on July 26 and 27, 1984. The NRC issued the results of that meeting on September 10, 1984 [2], and stated that, with the exception of comment No. 11, all responses were satisfactory to the staff. In a subsequent meeting with the staff on November 20, 1984, further details were presented for the SRTA program which satisfactorily resolved comment No. 11.

The plan was carried out by DLC with the support of Essex Corporation and Westinghouse Electric Corporation. Westinghouse provided the overall technical coordination of the CRDR, administered the human factors contribution of Essex, and provided NSSS instrumentation and control expertise. DLC provided overall CRDR management, operations expertise, and balance of plant instrumentation and control expertise. To maintain consistency between the organizations involved, a set of detailed instructions were developed for each CRDR task. The instructions made all team members cognizant of task responsibilities and objectives. The instructions are discussed in Section 1.4 and are contained in Appendix B.

### 1.3.1 QA Audits

All CRDR work was performed under a Quality Assurance Program. The CRDR work was audited twice by the DLC Quality Assurance Department. Audits were conducted October 2-8, 1984, and August 29-30, 1985. These audits were conducted to ensure that the CRDR work was performed in accordance with the Charter and Instructions contained in Appendices A and B. The audits did not identify any significant findings and all items have been closed.

## 1.4 Review Instructions

The review phase of the CRDR was accomplished in accordance with the following DLC NCD instructions.

[2]Control Room Design Review Audit Summary, from M. Ley to Applicant (DLC), dated September 10, 1984.

| TASK | TITLE | INSTRUCTION NO. |
|---|---|---|
| 1A | LER Review | R 401 A |
| 1B | Control Room Operating Personnel Survey | R 401 B |
| 2 | Control Room Inventory | R 402 |
| 3 | Human Factors Control Room Survey | R 403 |
| 4 | System Review and Task Analysis | R 404 |
| 5 | Verification of Task Performance Capabilities | R 405 |
| 6 | Validation of Control Room Functions | R 406 |
| 7 | Assessment | R 407 |
| 8 | Final Summary Report | R 408 |
| 9 | Human Engineering Discrepancy (HED) Report | R 409 |

1A) LER Review: The intent of the Licensee Event Reports (LER) Review is to review available documentation of operating difficulties and incidents as outlined in plant specific LERs to identify conditions that may cause human performance problems. Since BVPS-2 is under construction, LERs from North Anna Unit 1 and Surry Unit 1 were reviewed for applicability to BVPS-2. In addition, HEDs generated from the BVPS-1 CRDR document review were reviewed for applicability to BVPS-2.

1B) Control Room Operating Personnel Survey: Since BVPS-2 is under construction and there are no Unit 2 trained operators available, BVPS-1 CRDR Operator Survey (using BV-1 operators) HEDs were reviewed for applicability to BVPS-2.

2) Control Room Inventory: An inventory of all instrumentation, controls, and other devices on the main control board, building services control panel, emergency shutdown panel (ESP), and alternate shutdown panel (ASP) was recorded. Approved design documentation as of August 17, 1984, was used as a basis for the inventory and the inventory was compared with the 1/2 scale and full scale main control board photomosaics that were constructed for the CRDR.

3) Human Factors Control Room Survey: Much of the detailed assessment of the control room was conducted through checklist surveys. Surveys entailed the collection of data using preconstructed checklists and taking direct measurements. Since BVPS-2 is under construction and not all design features were available for review, only the following surveys were conducted.

Anthropometrics: analysis of reach and visual access to control room components.

Annunciator Systems: checklist evaluation of annunciator systems; direct measurement of annunciator fonts, signal intensities, etc.

Controls: checklist evaluation of controls

Displays: checklist evaluation of displays

Labels and Location Aids: checklist evaluation of labels and location aids

Computer Systems: checklist evaluation of computer systems

Convention: checklist evaluation of conventions

4) System Review and Task Analysis: The SRTA program systematically evaluated the needs of the control room operations crew in response to emergency tranisients. The SRTA process and documentation was based on the methodology developed by the Westinghouse Owners Group (WOG) and the NRC clarification comments on task analysis provided at the March 29, 1984, meeting (see Appendix E). The SRTA documentation was structured to provide the information required by the control room CRDR team to perform the Verification of Operator Task Performance Capability review phase of the CRDR.

5) Verification of Task Performance Capabilities: The verification of task capabilities was accomplished in two steps: verification of availability and verification of suitability. Verification of availability was conducted using results of the SRTA, the control room inventory, and the BVPS-2 main control board mockup. Operator device requirements for control, indication, and instrumentation, as identified by the SRTA, were compared with the inventory and the main control board mockup to establish availability of the devices. The devices so identified were then evaluated for suitability to the NUREG-0700 Section guidelines using the same data sources and methodology as used for verification of availability.

6) Validation of Control Room Functions: At the BVPS-2 main control mockup, operators performed walk-throughs of the following procedures using validation scenarios developed from the SRTA and comprised of the following BVPS-2 EOPs:

- Start-up from cold shutdown to power operation (5%).
- Load follow from 100% power to 50% power.
- Reactor trip or safety injection (SI).
- SI termination.
- Loss of reactor or secondary coolant.
- Post-LOCA cooldown and depressurization.

- Transfer to cold leg recirculation.
- Transfer to hot let recirculation.
- Faulted steam generator isolation.
- Steam generator tube rupture.
- Post-SGTR cooldown using steam dump.
- Critical safety function status trees.
- Response to nuclear power generation.
- Response to inadequate core cooling.
- Response to loss of secondary heat sink.
- Response to imminent pressurized thermal shock conditions.
- Response to high containment pressure.

During the walk-throughs, the operators identified difficulties and the CRDR team noted any deviations from applicable NUREG-0700 Section 6 guidelines and any concerns or questions. The entire set of walk-throughs was video taped. Using the video tapes, a debriefing was held between the operators and the CRDR team to discuss problems identified during the walk-throughs and to develop the information necessary to generate applicable HEDs.

## 1.5 Documentation and Document Control

Throughout the CRDR program, the design review activities and results were carefully documented. Three categories of documentation were used to support the CRDR: reference documentation, process documentation, and control documentation.

Reference Documentation: A library of reference documents was established to support the CRDR. It contains the following documents.

- Final Safety Analysis Report
- Main Control Board front panel layout drawings
- Main Control Room and Computer Room arrangement drawing
- Main Control Board dimensions drawing
- Main one-line drawings
- Equipment one-line drawings
- One-line power distribution drawings
- Flow diagrams
- ASP layout drawing
- Nameplate engraving lists
- Annunciator window arrangement
- ESP front view drawing
- Building Service Control Panel front view drawing
- Switch contact development drawings
- Logic diagrams

Process Documentation: Data collection and reduction methods were documented for reporting purposes in accordance with instructions listed in Section 1.4, "Review Instructions."

1A) LER Review: LERs from nuclear power plants with similar plant designs were obtained for review. Following screening by the CRDR Core Team, the Operations Start-up Group and the HFS re-reviewed LERs eliminated by the initial screening and documented any discrepancies found.

LER Report Summaries were completed by the Core Team members for LERs remaining after the above screenings. Preliminary HEDs were issued for events relevant to BVPS-2.

1B) Control Room Operating Personnel Survey: Since the BVPS-2 control room was under construction and there were no BVPS-2 trained operators available, the survey was limited to a review of the BVPS-1 HEDs generated from their operator surveys. These Unit 1 HEDs applicable to BVPS-2 were then documented as BVPS-2 HEDs.

2) Control Room Inventory: Inventory information was recorded on individual Inventory Data Sheets for all instrumentation, controls, and other devices on the main control board, the building services control panel, the ESP, and the ASP.

3) Human Factors Control Room Survey: Observation data was collected and recorded using the checklists from the anthropometrics, annunciator systems, controls, displays, labels and location aids, computer systems, and conventions task plans. Problems identified were recorded as preliminary HEDs.

4) Systems Review and Task Analysis: The requirements used to evaluate the control room capability were identified by the development of Element Tables. The primary document developed to organize the data base of Element Tables are the System Sequence Matrices. Instrumentation Requirements Tables were developed to identify and review requirements for individual instruments. Control Requirements Tables were developed to identify and review requirements for individual controls.

5) Verification of Task Performance Capabilities: Every control and instrumentation device identified in the SRTA Element Tables is listed on a Verification of Availability checklist and on a Verification of Suitability checklist (see Figures 4-6 and 4-7). These checklists were used to record the availability and suitability (per NUREG-0700 guidelines) of these devices as required to implement each operator task. Any descrepancies between the required devices and actual control room devices were recorded on preliminary HEDs.

6) Validation of Control Room Functions: The primary documentation used for validation was the BVPS-2 Walk-Through Validation scenario forms. As a minimum, these scenarios cover all of the event sequences suggested by NUREG-0700. All validation walk-throughs were video taped using two cameras: one wide-angle camera showing entire main control board area activity and another camera, with zoom lens, following each walk-through action. The debriefings held following each walk-through were also video taped. As with the other CRDR tasks, any descrepancies found were recorded as preliminary HEDs.

Control Documentation: The primary documentation for control of identified HED, their assessment, and their resolution was the HED form. As each discrepancy was identified by a Core Team or Support Team member, it was recorded on a HED form as a Preliminary HED (PHED). PHEDs were reviewed for completeness and accuracy and signed by the Westinghouse Program Coordinator and the Essex Human Factors Manager to denote acceptance of PHED as a HED. PHEDs due to misinterpreted NUREG-0700 guidelines were discarded. As the HEDs were assessed by the Core Team, each was assigned a priority via a HED Priority Record form and each recommended resolution was assessed using a Reassessment of Probable Error and Deviation form to determine whether the correction satisfactorily resolved the existing discrepancy and whether it would introduce new discrepancies.

All of the above documentation was filed in the CRDR file maintained by the Westinghouse Program Coordinator and transferred to DLC following completion of this report.

## 1.6 Assessment and Disposition of HEDs

Section 5.0 of this report details the assessment and disposition of HEDs generated during the BVPS-2 CRDR. The assessment methodology is contained in Instruction R-407.

## 1.7 Definition of Terms

Control Room Design Review (CRDR): A post-TMI task listed in NUREG-0660, "Task Action Plan Developed as a Result of the TMI-2 Accident," and NUREG-0737, the staff supplement to NUREG-0660, as Task I.D.1.

Control Room Survey: The control room survey is a static verification of the control room performed by comparing the existing control room instrumentation and layout with selected human engineering design criteria, i.e., checking the control room match to the human operator.

Element Tables: A description of the operator tasks per EOP step.

Emergency Operating Procedures (EOPs): Plant procedures directing the operator actions necessary to mitigate the consequences of transients and accidents that cause plant parameters to exceed reactor protection setpoints, engineered safety feature setpoints, or other appropriate technical limits.

Emergency Response Guidelines (ERGs): Guidelines developed from system analysis of transients and accidents that provide sound technical bases for plant-specific EOPs.

Human Engineering Discrepancy (HED): A characteristic of the existing control room that does not comply with human engineering criteria.

Operating Experience Review: The operating experience review screens plant operating documents and operator experience to discover human engineering shortcomings that have or could have caused actual operating problems or near misses in the past.

Priority: A number (1-9) assigned to an HED in the Assessment phase to categorize the HED based on safety importance and operational significance. The logic used to assign priority levels is explained in Instruction R-407.

System Review: The determination of system functions required to meet system goals.

System Sequence Matrix: A table which lists the discrete steps of the EOPs in order of performance and the associated plant systems and subsystems.

Task Analysis: A tool used to delineate system functions and the specific actions that must take place to accomplish those functions. In the CRDR context, task analysis is used to determine the individual tasks that must be completed to allow successful emergency operation. This activity checks the control room match to the EOPs.

Task Plan: A restructuring of all NUREG-0700 guidelines into 15 individual surveys to facilitate data collection, reduction, analysis, and recording. Each Task Plan contains all appropriate guidelines, instructions, and recording forms for measurements, observations, questionnaires/interviews, and document reviews. Task Plan areas are: Workspace, Anthropometrics, Emergency Equipment, HVAC, Illumination, Ambient Noise, Maintainability, Communications, Annunciator Systems, Controls, Displays, Labels and Location Aids, Computer Systems, Conventions, and Verification/Validation. Completed Task Plans for those areas which were able to be evaluated are contained in the CRDR files.

Validation: The process for determining whether the control room operating crew can perform their functions effectively given the control room instrumentation, procedures, and training. In the CRDR context, validation implies a dynamic performance evaluation.

Verification: The process for determining whether instrumentation, controls, and other equipment meet the specific requirements of the emergency tasks performed by operators. The control room survey is a verification activity, checking the control room match to the human operator. In the CRDR context, verification implies a static check of the plant instrumentation and controls against established human engineering criteria.

# 2.0 OPERATING EXPERIENCE REVIEW

A review of operating experiences is required to ensure that problems previously encountered during plant operations and plant start-up are addressed. This phase of the BVPS-2 CRDR consists of two tasks: examination of historical records (2.1) and a survey of control room operating personnel (2.2).

## 2.1 Examination of Available Historical Records

The methodology utilized for this task is contained in DLC NCD Instruction R-401A. DLC NCD Instruction R-401A addresses the specifics of all items contained in the DLC Program Plan.

### 2.1.1 BVPS-1 Document Review

All of the incident reports (IRs) that had been generated at BVPS-1 were reviewed by the BVPS-1 CRDR team. Of the IRs reviewed, 390 were retained and submitted to the BVPS-1 Human Factors Consultant to undergo human factors review. Of the 390 IRs that were reviewed by the BVPS-1 Human Factors Consultant, 133 were retained for further evaluation and disposition by the BVPS-1 CRDR team. Of the 133 IRs that were evaluated and dispositioned by the BVPS-1 CRDR team, 8 HEDs were identified, none of which were found to be applicable to Unit 2.

### 2.1.2 BVPS-2 LER Review

The LERs reviewed were from nuclear power plants with similar designs as that of BVPS-2. These plants were North Anna Unit 1 and Surry Unit 1. The LER Review was conducted in accordance with NCD Instruction R-401A.

A total of 651 LERs were reviewed by the CRDR team. Of the 651 LERs, 212 were initially screened out by the CRDR team. The 212 initially screened LERs were then forwarded to DLC operations and the BVPS-2 HFS for review to ensure that the screened LERs did not contain human error. Of the 212 screened LERs, 12 were returned (11 from operations, 1 from the HFS) for further CRDR Core Team review.

The 12 LERs needing further review plus the remaining 439 previously unscreened LERs were then split up among the CRDR Core Team. Each Core Team member filled out an "LER Report Summary" for each of their assigned LERs. The "LER Report Summaries" were separated into one of the following three categories:

- Corrective action taken terminated the consequences of the event.

- Corrective action taken was adequate but in the judgment of the reviewer, sufficient action was not taken to prevent the recurrence of the problem.

- Corrective action taken was not sufficient in the judgment of the reviewer.

All LERs pertaining to the first category (a total of 314) were forwarded to the HFS to review for possible indications of human error. LERs pertaining to the second and third categories (a total of 137) were held for Core Team review. Of the 314 LERs forwarded to the HFS, 29 were returned for further review by the CRDR Core Team.

Core Team LER review meetings were held to discuss the 166 LERs. Of the 166 LERs that were assessed and dispositioned by the Core Team, 12 HEDs were identified (see Table 2.1.2, "Summary of HEDs from Similar Plant LERs").

## 2.2 Control Room Operating Personnel Survey

Although not a statutory requirement, a Control Room Operating Personnel Survey (CROPS) was included in the scope of the BVPS-2 CRDR and was to be conducted in accordance with NCD Instruction R-401B. However, during the course of the CRDR, there were no operators who had received training on the Unit 2 control boards. The only source of operators for CROPS was Unit 1. Since the Unit 1 CRDR had already conducted operator interviews and questionnaires, the Review Team reviewed HEDs resulting from the Unit 1 survey for applicability to Unit 2. This approach was acceptable based on the degree of similarity of the control boards and to avoid a duplication of effort. The methodology for the Unit 1 survey is contained in Appendix C.

Three of the HEDs generated during the Unit 1 operator survey (BVPS-1 HEDs 52, 116, 157) were found applicable to Unit 2. See Table 7.1 for a description of these HEDs.

**TABLE 2.1.**
**SUMMARY OF HEDs FROM SIMILAR PLANT LERS**

| Virginia Power LERs | LER HEDS BVPS-2 | LER HED Titles (Subjects) | Priority* | Remarks |
|---|---|---|---|---|
| LER 280-81039 | 2***-1101 | Inadvertent opening of Accumulator drain valve | 3 | |
| LER 280-82072 | 2***-1102 | "A" SI Accumulator drained below the T.S. minimum | 3 | |
| LER 280-80002 | 2***-1701 | Failure of effluent flow recorder paper | 5 | |
| LER 280-81054 | 2***-2001 | Increase in storm drain activity due to leaks from stripper feed steam heater | N/A | Not a CRDR problem |
| LER 280-82093 | 2***-2101 | Failure to reset alarm | 1 | High safety importance |
| LER 280-81076 | 2***-2102 | Diesel fire pump fuel oil level less than required | N/A | BVPS-2 has no diesel fire pump |
| LER 280-82020 | 2***-2301 | Loss of boric acid flow to blender and bit recirc flow resulting from mechanical failure on A/B pump suction cross connect | 5 | |
| LER 280-83015 | 2***-4001 | Nitrogen purge removed | 5 | |
| LER 338-78081 | 2***-4002 | Containment bulk average temperature not within T.S. limits | 3 | |
| LER 338-80058 | 2***-4003 | Post accident monitoring hydrogen anayzer failure | 4 | High safety importance |
| LER 280-80016 | 2***-4201 | Incorrect valve opening resulting in inadvertent release of liquid waste test tank | 5 | |
| LER 338-80083 | 2***-4202 | Erroneous pressurizer level transmitter readings | 4 | High safety importance |

*The logic used to assign priorities is explained in Instruction R 407.

# 3.0 CONTROL ROOM SURVEY

The methodology used to conduct the control room surveys at BVPS-2 incorporated a mix of traditional procedures and methods tailored to the specific requirements of the plant per DLC NCD Instruction R-403. The three basic methods employed within each survey were measurements, observations, and documentation reviews. Within the summary tables, these methods are designated by M, O, and D, respectively. Normally, operator interviews are also included in the data collection methodology. However, BVPS-2 as an NTOL under construction did not yet have operators trained on the Unit 2 control boards; therefore, interviews were not conducted. Within each of the methods used, specific procedures were followed to ensure a comprehensive data collection, data reduction, and analysis process. The procedures were organized into a set of standardized task plans.

The survey process was structured into a number of separate tasks, each task involving a specific set of related control room design features. For example, the anthropometrics survey involved consideration of reach and viewing factors for each of the various types of consoles in the control room. This approach, coupled with the standardization of task plan structure, allowed for maximum flexibility during data collection, data reduction, and analysis, and resulted in a standard, well-organized, self-documenting process.

It was not possible to survey all of the control room design features since many were not complete at the time of this CRDR. For this reason, only the sections evaluated will be discussed in the report. Entire sections unable to be surveyed were:

1) Workspace
2) Emergency Equipment
3) HVAC
4) Illumination
5) Ambient Noise
6) Maintainability
7) Communications

All task plans followed the general format of:

1) Introduction (including the objectives)
2) Review Team Selection and Responsibilities
3) Criteria (from NUREG-0700, Section 6.0)
4) Procedures
5) Equipment and Facility Requirements
6) Inputs and Data Forms
7) Outputs and Results
8) Figures and Tables
9) Procedure Exceptions
10) Appendices (as required).

In addition to this general format, the control room survey task plans incorporated a standardized set of appendices that ensured a consistent well-documented process for data collection, analyses, assessment, implementation, and audits (the appendices discussed here are for the task plans; they are not appendices to this report). The appendix structure employed for the task plans was:

Appendix A (Criteria) - This is a compendium of all 0700, Section 6.0 criteria in 0700 paragraph number order that is relevant to that task plan. It was used to summarize the final results.

Appendix B (Data Forms) - This appendix is further divided into the following:

B1 Measurements Data

- B1.1 Linear Measurements (scalar, force, torque, dimensional, air volume, temperature, humidity)
- B1.2 Sound Measurements (noise auditory signals, communications systems auditory response characteristics)
- B1.3 Light Measurements (illumination levels, luminance characteristics, contrast ratios)
- B1.4 Through B1.n "Others" (as required)

B2 Interviews and Questionnaires

- B2.1 Operations
- B2.2 Engineering
- B2.3 Instrumentation and Calibration
- B2.4 Management and Administration
- B2.5 Through B2.n "Others" (as required)

B3 Observation Checklists

B4 Documentation Review Checklists

B5 Analysis Aids for B1 - Measurements

- B5.1 Analysis Aids for B1.1
- B5.2 Analysis Aids for B1.2
- B5.3 Analysis Aids for B1.3

B5.4 Through B5.n "Analysis Aids for B1.4 through B1.n" (as required)

B6 Analysis Aids for B2 - Interviews/Questionnaires

B7 Analysis Aids for B3 - Observation Checklists

B8 Analysis Aids for B4 - Documentation Review Checklists

B9 Additional forms, as required.

## 3.1 Guideline Areas Not Surveyed

Because BVPS-2 was under construction, the sections listed below could not be surveyed during the course of the CRDR. These sections apply to the total control room workspace, which includes the control board areas for both Unit 1 and Unit 2. The following is a list of criteria from NUREG-0700 that will be applied when the temporary wall separating the Unit 1 and Unit 2 control board areas is removed, as discussed in Section 6.0 of this report.

1. Workspace

   Paragraphs 6.1.1.3a through g; 6.1.1.4a through e; 6.1.1.6a and b; 6.1.1.7; 6.1.2.6; 6.1.2.7a through d; 6.1.2.8a through g; 6.1.3.1a and b; 6.1.5.6a and b; and 6.1.5.7.

2. Emergency Equipment

   Paragraphs 6.1.4.1a through i; 6.1.4.2a through e; 6.1.4.3a and b; 6.1.5.4a and b; 6.2.1.8a through c(3); 6.4.1.1d.

3. Heating, Ventilation, and Air Conditioning

   Paragraphs 6.1.5.1a, 6.1.5.1b, 6.1.5.2a, and 6.1.5.2b.

4. Illumination

   Paragraphs 6.1.5.3a(1) through a(9), b through e(2), f, g, and h; 6.1.5.4c.

5. Ambient Noise

   Paragraphs 6.1.5.5a through e.

6. Maintainability

   Paragraph 6.1.1.5a through f, 6.2.1.1b, 6.3.3.1c(1) through (3), 6.4.3.3c(1) through (4), 6.5.3.1a(1) through (3) and c(2), 6.5.4.1e and f.

7. Communications

Paragraphs 6.1.3.1b; 6.2.1.1c(1) and (2); 6.2.1.2a through e; 6.2.1.3a through e; 6.2.1.4a through e; 6.2.1.5a through c; 6.2.1.6a through f; 6.2.1.7a and b; 6.2.1.8a through c; 6.2.2.1a through c; 6.2.2.2a through c; 6.2.2.3a through e; 6.2.2.4a and b; 6.2.2.5a and b; 6.2.2.6a through c; 6.2.2.7a through c.

## 3.2 Anthropometric Survey

This section documents the results of the anthropometrics survey conducted in the main control room, ESP, and ASP at BVPS-2. This review was conducted in accordance with the requirements of NUREG- 0700, as specified in the BVPS-2 DCRDR Program Plan.

### 3.2.1 Objectives

The objectives of the anthropometrics survey were to:

a. Assess the degree to which all stand-up and sit-stand work stations in the control room, ESP, and ASP conform to the criteria in NUREG-0700.

b. Identify and document any features of the work stations that do not conform to the criteria in NUREG-0700.

### 3.2.2 Scope

The scope of the effort extends to the assessment of the work station design in the main control room at the BVPS-2 using the applicable guidelines as stated in NUREG-0700. The anthropometrics topics evaluated include:

- Stand-up console dimensions
- Sit-stand console dimensions
- Vertical panels
- Operator-display/controls relationships

### 3.2.3 Criteria

The criteria applied in this survey, identified by NUREG-0700 paragraph number, are: paragraphs 6.1.2.2a through g; 6.1.2.3a through h; 6.1.2.4a through c; 6.1.2.5a and b and 6.7.2.3a through f.

The detailed definitions for each criterion are presented in Table 3-2.

### 3.2.4 Method

#### 3.2.4.1 Data Collection

a. Data were collected using the checklist contained in the Anthropometrics Task Plan.

b. Reach and visual envelopes recommended in NUREG-0700 were demarcated on the control boards and visual observations were made of the relative locations of controls and displays. Controls and displays falling outside the recommended envelopes were noted and their item numbers recorded.

c. Where it was necessary to consider the operational characteristics of the component (e.g., Guideline 6.1.2.5.a[1]), cognizant DLC personnel were consulted.

3.2.4.2 Analysis -- Data were analyzed according to the following procedure:

a. All deviations from the criteria were recorded on HED reports. Recorded information included the displays or controls involved, a description of the problem including the NUREG- 0700 paragraph number of the criteria, and a recommended solution.

b. The data collection description was also recorded on the HED form. Where data from two or more sources were contradictory, resolution of the conflict was achieved through data review and discussions with cognizant DLC personnel.

### 3.2.5 Findings

The findings of the anthropometrics survey are presented in Table 3.2 "Anthropometry Survey Findings and HEDs Generated." Overall, 47 criteria were applied to the displays in the BVPS-2 control room, ESP, and ASP. Of the criteria assessed, 17 (36%) were not applicable, 19 (40%) were not violated, and 11 (23%) were violated. A total of 12 HEDs were generated which document all of the 11 criteria which were violated. In general, those HEDs describe instances of controls and displays located too high or too low on the vertical panels or controls not located more than three inches away from the edge of the bench board.

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TABLE 3-2

ANTHROPOMETRY SURVEY FINDINGS & HEDs GENERATED Page 1 of 9

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.1.2.2 STAND-UP CONSOLE DIMENSIONS** | | | | | |
| a. **CONSOLE HEIGHT TO SEE OVER** — When it is necessary for a standing operator to see over the top, console height (with or without annunciator panels) should not exceed 58 inches. | M | YES | | | |
| b. **CONTROL HEIGHT** — (Exhibits 6.1-5 and 6.1-6) | | | | | |
| (1) The highest control on a stand-up console should be within the highest reach of the 5th percentile female without stretching or using a stool, ladder, etc. | M | NO | 2AB*-3024 | 7 | |
| (2) The lowest controls on a stand-up console should be within the lowest reach of the 95th percentile male without bending or stooping. | M | YES | | | |
| c. **BENCHBOARD SLOPE** — The benchboard slope, in conjunction with its depth, should result in all controls being within the reach radius of the 5th percentile female, as illustrated in Exhibit 6.1-6. | M | NO | 2B**-1401 | 7 | |
| d. **CONTROL DISTANCE FROM THE FRONT EDGE OF THE CONSOLE** | | | | | |
| (1) Controls should be set back a minimum of 3 inches from the front edge to protect against accidental activation. | M | NO | 2ES*-3020<br>2B**-1402 | 5<br>5 | |
| (2) No control should be more than 25 inches from the front edge of the console. This accommodates the maximum reach of the 5th percentile female adult as illustrated in Exhibit 6.1-6. | M | NO | 2ES*-1408<br>2B**-1401<br>2AB*-3024 | 7<br>7<br>7 | |

TABLE 3-2

ANTHROPOMETRY SURVEY FINDINGS & HEDs GENERATED Page 2 of 9

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.1.2.2 (Cont'd) | | | | | |
| e. **DISPLAY POSITIONING** — (Exhibit 6.1-7) | | | | | |
| (1) **DISPLAY HEIGHT AND ORIENTATION** | | | | | |
| (a) All displays, including annunciator tiles, should be mounted so that they are within the upper limit of the visual field (75° above the horizontal line of sight) of the 5th percentile female. | M | YES | | | |
| (b) In addition, all displays and annunciators should be mounted so that the angle from the line of sight to the face plane is 45° or greater. The 5th percentile female determines the upper limit. The 95th percentile male determines the lower limit. | M | YES | | | |
| (2) **HORIZONTAL DISPLACEMENT** — The oblique angle from the line of sight to a display located to either side of the working position from which the display must be read should be at least 45°. This includes annunciator tiles, which should be readable from the acknowledge button. (See Exhibit 6.1-8.) | M | NO | 2V**-2116<br>2V**-2120 | 9<br>9 | Covered in TP-3.1 (#6.3.3.5a) |
| f. **LATERAL SPREAD OF CONTROLS AND DISPLAYS** — The operator should be able to perform task sequences at a given work station with minimum respositioning. The amount of operator movement required depends on the arrangement of controls and displays, not simply on the lateral dimensions of the segments of the control board. The maximum lateral spread of controls and displays at a single-operator work station should not exceed 72 inches. | M<br>D | YES | | | |

TABLE 3-2

ANTHROPOMETRY SURVEY FINDINGS & HEDs GENERATED Page 3 of 9

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.1.2.2 (Cont'd) | | | | | |
| g. **FOOT ROOM** — Enough foot room is needed to allow the operator to get close to the board without leaning. A clearance of 4 inches vertically and 4 inches horizontally is recommended. | M | NO | 2B**-1403 | 9 | |
| **6.1.2.3 SIT-DOWN CONSOLE DIMENSIONS** | | | | | |
| a. **CONSOLE HEIGHT TO SEE OVER** | | | | | |
| (1) If the seated operator must see over the console, the console height should be no more than approximately 27 inches above the seat to accommodate the 5th percentile adult female. Assuming seat height adjusted to 18 inches, maximum console height should therefore be 45 inches above the floor. | N/A | N/A | | | No sit down consoles |
| (2) See-over console heights above 45 inches may be acceptable, for example, where the seated operator need only monitor (not read) status lights and annunciators beyond the console, if they are at a suitable distance and height. | N/A | N/A | | | No sit down consoles |
| b. **CONTROL HEIGHT** — All controls on a sit-down console should be within the reach radius of the 5th percentile female. Measurements should be made using seated shoulder height with the shoulder in line with the leading edge of the benchboard. This is illustrated in Exhibit 6.1-9. | N/A | N/A | | | No sit down consoles |
| c. **BENCHBOARD SLOPE** — The benchboard slope, in conjunction with its depth, should be such that all controls are within the functional reach radius of the 5th percentile female (as illustrated in Exhibit 6.1-9) and all displays and markings can be read. | N/A | N/A | | | No sit down consoles |

TABLE 3-2

ANTHROPOMETRY SURVEY FINDINGS & HEDs GENERATED Page 4 of 9

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.1.2.3 (Cont'd) | | | | | |
| d. **CONTROL DISTANCE FROM THE FRONT EDGE OF THE CONSOLE** | | | | | |
| (1) Controls should be set back a minimum of 3 inches from the front edge to protect against accidental activation. | N/A | N/A | | | No sit down consoles |
| (2) Other controls may be mounted as far back as 25 inches from the console edge. This distance accommodates the extended functional reach of the 5th percentile as defined. | N/A | N/A | | | No sit down consoles |
| e. **DISPLAY POSITIONING** | | | | | |
| (1) All displays, including annunciator tiles, should be mounted so that they are within the upper limit of the visual field — 75° above the horizontal line of sight — of the 5th percentile female (see Exhibit 6.1-10). | N/A | N/A | | | No sit down consoles |
| (2) In addition, all displays should be mounted so that the angle from the line of sight to the display face plane is 45° or greater (see Exhibit 6.1-10). The 5th percentile female determines the upper limit. (Practically, there is no lower limit for a plausible sit-down console design.) | N/A | N/A | | | No sit down consoles |
| f. **LATERAL SPREAD OF CONTROLS AND DISPLAYS** — (Exhibit 6.1-11) | | | | | |
| (1) For control and monitoring actions that must occur in sequence, all necessary controls and displays should be within the maximum extended reach and the viewing range of the seated operator from a single reference point. | N/A | N/A | | | No sit down consoles |

TABLE 3-2

ANTHROPOMETRY SURVEY FINDINGS & HEDs GENERATED 

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.1.2.3f (Cont'd) | | | | | |
| (2) For the situation described in item 1, above, and sustained or precise control action, the operator should be able to reach the controls without having to bend/stretch significantly. | N/A | N/A | | | No sit down consoles |
| g. **LEG AND FOOT ROOM** — Sufficient leg and foot room should be provided to enable seated operators to avoid awkward and uncomfortable positions. Exhibit 6.1-12 shows the dimensions involved and gives minimums and ranges necessary to accommodate the 5th to 95th percentiles (as defined in Exhibit 6.1-5). | N/A | N/A | | | No sit down consoles |
| h. **WRITING SPACE ON CONSOLES** — Writing space may be needed by operators working at consoles. | | | | | |
| (1) An area at least 16 inches deep and 24 inches wide is recommended where these dimensions in the total configuration would fit operator reach capabilities. Less space may be adequate considering the frequency and duration of writing requirements at control room consoles. | N/A | N/A | | | No sit down consoles |
| (2) If writing space is provided on the console itself, it should not interfere with viewing and manipulation of controls and displays. | N/A | N/A | | | No sit down consoles |
| (3) If writing is necessary but space on the console is not available, other arrangements such as a nearby desk or table should be provided. | N/A | N/A | | | No sit down consoles |

TABLE 3-2

ANTHROPOMETRY SURVEY FINDINGS & HEDs GENERATED Page 6 of 9

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.1.2.4 SIT-STAND WORK STATIONS** | | | | | |
| a. **CONTROL AND DISPLAY POSITIONING** — The height and lateral limits for controls and displays should conform to the guidelines given for stand-up consoles (Guideline 6.1.2.2). | N/A | N/A | | | No sit-stand stations |
| b. **CHAIR HEIGHT** — The operator should be provided with a high chair so that the seated eye height is approximately the same as standing eye height. | N/A | N/A | | | No sit-stand stations |
| c. **KNEE ROOM** — Knee room and comfortable foot support should be pro vided. | N/A | N/A | | | No sit-stand stations |
| **6.1.2.5 VERTICAL PANELS** | | | | | |
| a. **CONTROL HEIGHT** | | | | | |
| (1) Controls should be placed in an area between 34 inches and 70 inches above the floor. | M | NO | 2VC6-1404 | 9 | |
| (2) Controls requiring precise or frequent operation and emergency controls should be placed in an area between 34 inches and 53 inches above the floor. | M D | NO | 2VC6-1404 | 9 | |
| b. **DISPLAY HEIGHT** | | | | | |
| (1) Displays should be placed in an area between 41 inches and 70 inches above the floor. | M | NO | 2V**-1405 | 5 | |
| | | | 2V**-1407 | - | HED incorrect |
| (2) Displays that must be read frequently or precisely should be placed in an area between 50 inches and 65 inches above the floor. | M | NO | 2V**-1405 | 5 | |
| | | | 2V**-1407 | - | HED incorrect |

TABLE 3-2

ANTHROPOMETRY SURVEY FINDINGS & HEDs GENERATED Page 7 of 9

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.7.2 CATHODE RAY TUBE (CRT) DISPLAYS** | | | | | |
| **6.7.2.3 OPERATOR-DISPLAY RELATIONSHIPS** | | | | | |
| a. **VIEWING DISTANCE** — Viewing distance should be greater than 18 inches. | M | YES | | | |
| b. **VIEWING ANGLE** — The minimum angle between the operator's actual line-of-sight (LOS) as measured from the operator's normal work station, and the plane of the display screen should be 45° or greater in either the horizontal or vertical direction. See Exhibits 6.7-8 and 6.7-10. | M | YES | | | Sit-station CRTs |
| | M | NO | 2V**-1406 | 9 | Vertical panel CRTs |
| c. **SCREEN LOCATION, SEATED OPERATORS** | | | | | |
| (1) CRT displays which require frequent or continuous monitoring, or which may display important (e.g., alarm) information, should be located within the following limits as measured from the normal operator work station (see Exhibit 6.7-9): | M<br>D | YES | | | |
| (a) Horizontal limits — Not more than 35° to the left or right of the operator's straight-ahead LOS. | M<br>D | YES | | | |
| (b) Vertical limits — Not more than 20° above and 40° below the operator's horizontal LOS. | M | YES | | | |
| (2) CRT displays which do not require frequent or continuous monitoring, and which will not display important (e.g., alarm) information, should be located within the following limits. | M | YES | | | |
| (a) Horizontal limits — Not more than 95° to the left or right of the operator's straight-ahead LOS. | M | YES | | | |

TABLE 3-2

ANTHROPOMETRY SURVEY FINDINGS & HEDs GENERATED Page 8 of 9

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.7.2.3c (Cont'd) | | | | | |
| (b) Vertical limits — Not more than 70° above and 90° below the operator's horizontal LOS. | M | YES | | | |
| d. **SCREEN LOCATION, STANDING OPERATORS** | | | | | |
| (1) CRT displays which require frequent or continuous monitoring, or which may display important (e.g., alarm) information, should be located within the following limits as measured from the normal operator work station: | | | | | |
| (a) Horizontal limits — Not more than 35° to the left or right of the operator's straight-ahead LOS. | M D | YES | | | |
| (b) Vertical limits — Not more than 35° above and 25° below the operator's horizontal LOS. | M D | YES | | | |
| (2) CRT displays which do not require frequent or continuous monitoring, and which will not display important (e.g., alarm) information, should be located within the following limits (as measured from normal operator work stations which permit full operator head and eye rotation): | | | | | |
| (a) Horizontal limits — Not more than 95° to the left or right of the operator's straight-ahead LOS. | M | YES | | | |
| (b) Vertical limits — Not more than 85° above and 90° below the operator's horizontal LOS. | M | YES | | | |

TABLE 3-2

ANTHROPOMETRY SURVEY FINDINGS & HEDs GENERATED 

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.7.2.3 (Cont'd) | | | | | |
| e. **MOUNTING IN CONSOLES** — When CRTs are permanently mounted in consoles, the console configuration, dimensions, and type of use (such as seated, sit-stand, or standing) affects the CRT/operator interface. Consoles in which CRTs are installed should conform to the guidelines of Section 6.1.2. | M | YES | | | |
| f. **VISIBILITY OF DATA** — All data and messages on the CRT screen should be within the unobstructed view of an operator at the normal work station. | O | YES | | | |

## 3.3 Annunciator Survey

This section documents the results of the annunciator survey conducted in the main control room at BVPS-2. This review was conducted in accordance with the requirements of NUREG-0700, as specified in the BVPS-2 OCRDR Program Plan.

### 3.3.1 Objectives

The objectives of the annunciator survey were to:

a. Assess the degree to which the annunciator system in the control room conforms to the criteria in NUREG-0700.

b. Identify and document any features of the annunciator system that do not conform to the criteria in NUREG-0700.

### 3.3.2 Scope

The scope of the effort extends to the assessment of the annunciator system design in the main control room at BVPS-2 using the applicable guidelines as stated in NUREG-0700. The topics evaluated include:

- o General system design
- o Alarm parameter selection
- o First out annunciators
- o Prioritization
- o Cleared alarms
- o Signal detection
- o Auditory coding
- o Visual annunicator panels
- o Visual alarm recognition and identification
- o Arrangement of alarm tiles
- o Tile legends
- o Tile readability
- o Annunciator controls.

### 3.3.3 Criteria

The criteria applied in this survey, identified by NUREG-0700 paragraph number, are: 5a paragraphs 6.3.1.1; 6.3.1.2a through d(2); 6.3.1.3a through d; 6.3.1.4a and b; 6.3.1.5a; through b(3); 6.3.2.1a through f; 6.3.2.2a and b; 6.3.3.1a through b(2); 6.3.3.2a through f.(2a) 6.3.3.3a through f; 6.3.3.4a through c; 6.3.3.5a through d(6); 6.3.4.1a through d(2); 6.3.4.2a through c; 6.3.4.3a and b; 6.5.1.6a through d(3); and 6.6.6.2a, b, and c. The detailed definitions for each criterion are presented in Table 3-3.

### 3.3.4 Method

#### 3.3.4.1 Data Collection

a. Data were collected using the checklists contained in the annunciator task plan.

b. Data were collected primarily through measurement and direct observation of the annunciator system in the control room. As necessary, system documentation (e.g., P&IDs, electrical drawings, annunciator design documents) were reviewed to augment and corroborate observations and interviews.

3.3.4.2 Analysis -- Data were analyzed according to the following procedure:

a. All deviations from the criteria were recorded on HED reports. Recorded information included the components or system involved a description of the problem including the NUREG-0700 paragraph number of the criteria, and a recommended solution.

b. The data collection description was also recorded on the HED form. Where data from two or more sources were contradictory, resolution of the conflict was achieved through data review and discussions with cognizant DLC personnel.

c. Upon completion of all analyses, the criteria of the annunciator task plan were annotated to indicate compliance or noncompliance with the criteria.

### 3.3.5 Findings

The findings of the annunciator survey are presented in Table 3.3 "Annunciator Survey Findings and HEDs Generated." Overall, 98 criteria were applied to the annunciator system in the BVPS-2 control room. Since some features of the control room were not complete at the time of the survey, 12 (12%) of the criteria were unable to be assessed (UTA). These criteria include: 6.3.1.2a-(1), (2), b(1), (2), c(2) and d(1), (2); 6.3.1.3a(3); 6.3.3.2c; 6.3.4.1d(2); 6.3.4.3a and b. Of the criteria assessed, 14 (14%) were not applicable, 50 (51%) were not violated, and 22 (22%) were violated. A total of 19 HEDs were generated which document all of the 22 criteria which were not met. In general, those HEDs address auditory signals, annunciator controls, distinctive coding of annunciator tiles, nuisance alarms, alarm messages, multi-input alarms annunciator response procedures, and annunciator tile grouping and prioritization.

TABLE 3-3

ANNUNCIATOR SURVEY FINDINGS & HEDs GENERATED Page 1 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.3.1.1 GENERAL SYSTEM DESIGN** | | | | | |
| Annunciator warning systems are the primary control room interface to immediately alert the operator to out-of-tolerance changes in plant condition. Annunciator warning systems consist of three major subsystems: (a) an auditory alert subsystem, (b) a visual alarm subystem, and (c) an operator response subsystem (see Exhibit 6.3-1). Together, these three subsystems should be designed to provide a preferred operational sequence for annunciator warnings as indicated in Exhibit 6.3.2 | O | NO | 2***-2121 | 9 | Validation, TP-9.2 |
| **6.3.1.2 ALARM PARAMETER SELECTION** | | | | | |
| a. **SET POINTS** — The limits or set points for initiating the annunciator warning system should be established to meet the following goals: | | | | | |
| (1) Alarms should not occur so frequently as to be considered a nuisance by the operators. | UTA | UTA | | | Data not available |
| (2) However, set points should be established to give operators adequate time to respond to the warning condition before a serious problem develops. | UTA | UTA | | | Data not available |
| b. **GENERAL ALARMS** — | | | | | |
| (1) Alarms that require the control room operator to direct an auxiliary operator to a given plant location for specific information should be avoided. | UTA | UTA | | | Data not available |
| (2) If general alarms must be used, they should only be used for conditions that allow adequate time for auxiliary operator action and subsequent control room operator action. | UTA | UTA | | | Data not available |

TABLE 3-3

ANNUNCIATOR SURVEY FINDINGS & HEDs GENERATED Page 2 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.3.1.2 (Cont'd) | | | | | |
| c. **MULTICHANNEL OR SHARED ALARMS —** | | | | | |
| (1) Annunciators with inputs from more than one plant parameter set point should be avoided. Multi-input alarms that summarize single-input annunciators elsewhere in the control room are an exception. | N/A | N/A | | | Individual alarms will be displayed on CRT (next to annunciator panel) |
| (2) Where multi-input annunciators must be used, an alarm printout capability should be provided. The specifics of the alarm should be printed on an alarm typer with sufficient speed and buffer storage to capture all alarm data. | UTA | UTA | | | Data not available |
| (3) A reflash capability should be provided to allow subsequent alarms to activate the auditory alert mechanism and reflash the visual tile even though the first alarm may not have been cleared. | O | YES | | | |
| d. **MULTI-UNIT ALARMS —** | | | | | |
| (1) Alarms for any shared plant systems should be duplicated in all control rooms. | UTA | UTA | | | Data not available |
| (2) When an item of shared equipment is being operated from one control room a status display or signal should be provided in all other control rooms which could potentially control this equipment. | UTA | UTA | | | Data not available |
| **6.3.1.3 FIRST OUT ANNUNCIATORS** | | | | | |
| a. **REACTOR SYSTEM —** | | | | | |
| (1) A separate first out panel should be provided for the reactor system. | O | NO | 2VA5-2103 | 5 | |

TABLE 3-3
ANNUNCIATOR SURVEY FINDINGS & HEDs GENERATED Page 3 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.3.1.3a (Cont'd)** | | | | | |
| (2) The first out panel should consist of separate annunciator tiles for each of the automatic reactor trip functions. | O | NO | 2VA5-2104 | - | HED incorrect |
| (3) In the event of a reactor trip, the tile associated with the event should illuminate, and no other. | UTA | UTA | | | Data not available |
| b. **TURBINE-GENERATOR SYSTEM** — A separate first out panel, similar in function to the reactor system panel, is recommended. | O | NO | 2VA5-2103 | 5 | |
| c. **POSITION** — First out panels should be located directly above the main control work station for the system. | O | YES | | | |
| d. **APPLICATION** — First out annun ciators should conform to the general auditory, visual, and operator response guidelines of this section. | O | YES | 2VA5-2104 | - | HED incorrect |
| **6.3.1.4 PRIORITIZATION** | | | | | |
| A. **LEVELS OF PRIORITY** — | | | | | |
| (1) Prioritization should be accom plished using a relatively small (2-4) number of priority levels. | O | NO | 2V**-2115 | 7 | |
| (2) Prioritization should be based on a continuum of importance, severity, or need for operator action in one or more dimensions, e.g., likelihood of reactor trip, release of radiation. Exhibit 6.3-3 provides an example of prioritization based on three levels of prioritization.. | N/A | N/A | | | No priorization |

TABLE 3-3

ANNUNCIATOR SURVEY FINDINGS & HEDs GENERATED Page 4 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.3.1.4 (Cont'd) | | | | | |
| b. **PRIORITY CODING —** | | | | | |
| (1) Some method for coding the visual signals for the various priority levels should be employed. Acceptable methods for priority coding include color, position, shape, or symbolic coding. | N/A | N/A | | | No priority coding |
| (2) Auditory signal coding for priority level is also appropriate. See Guideline 6.2.2.3 for recommended coding techniques. | N/A | N/A | | | No priority coding |
| **6.3.1.5 CLEARED ALARMS** | | | | | |
| a. **AUDITORY SIGNAL —** Cleared alarms should have a dedicated, distinctive audible signal which should be of finite duration. | O | YES | | | |
| b. **VISUAL SIGNAL —** The individual tile should have one of the following: | | | | | |
| (1) A special flash rate (twice or one-half the normal flash rate is preferred, to allow discrimination), or | N/A | N/A | | | See (3) below |
| (2) Reduced brightness, or | N/A | N/A | | | See (3) below |
| (3) A special color, consistent with the overall control room color coding scheme, produced by a differently colored bulb behind the tile. | O | YES | | | |
| **6.3.2.1 SIGNAL DETECTION** | | | | | |
| a. **INTENSITY —** The signal should be such that operators can reliably discern the signal above the ambient control room noise. A nominal value of 10 dB(A) above average ambient noise is generally adequate. | M | YES | | | |

TABLE 3-3

ANNUNCIATOR SURVEY FINDINGS & HEDs GENERATED Page 5 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.3.2.1 (Cont'd) | | | | | |
| b. **CONTROL** — Signal intensity, if adjustable, should be controlled by administrative procedure. | O | YES | | | Procedure to be written |
| c. **LIMITS** — The signal should capture the operator's attention but should not cause irritation or a startled reaction. | O | YES | | | |
| d. **DETECTION** — Each auditory signal should be adjusted to result in approximately equal detection levels at normal operator work stations in the primary operating area. | O | YES | | | |
| e. **RESET** — The annunciator auditory alert mechanism should automatically reset when it has been silenced. | O | YES | | | |
| f. **IDENTIFICATION** — The operator should be able to identify the work station or the system where the auditory alert signal originated. Separate auditory signals at each work station within the primary operating area are recommended. | O | YES | | | |
| **6.3.2.2 AUDITORY CODING** | | | | | |
| a. **LOCALIZATION** | | | | | |
| (1) Auditory coding techniques should be used when the operator work station associated with the alarm is not in the primary operating area. | N/A | N/A | | | Auditory coding not used |
| (2) Coded signals from a single audio source should not be used to identify individual work stations within the primary operating area. | O | YES | | | |
| b. **PRIORITIZATION** — Coding may be used to indicate alarm priority. (See Guideline 6.3.1.4.) | N/A | N/A | | | Auditory coding not used |

TABLE 3-3

ANNUNCIATOR SURVEY FINDINGS & HEDs GENERATED Page 6 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.3.3.1 VISUAL ANNUNCIATOR PANELS** | | | | | |
| a. **LOCATION** — Visual alarm panels should be located above the related controls and displays which are required for corrective or diagnostic action in response to the alarm. (See Exhibit 6.3-4.) | O | YES | | | |
| b. **LABELING**— | | | | | |
| (1) Each panel should be identified by a label above the panel. | O | YES | | | |
| (2) Panel identification label height should be consistent with a subtended visual angle of a least 15 minutes when viewed from a central position within the primary operating area. | M | YES | | | |
| **6.3.3.2 VISUAL ALARM RECOG AND IDENT** | | | | | |
| a. **FLASHING** — The specific tile(s) on an annunciator panel should use flashing illumination to indicate an alarm condition. | O | YES | | | |
| b. **FLASH RATE** — Flash rates should be from three to five flashes per second with approximately equal on and off times. | M | YES | | | |
| c. **FLASHER FAILURE** — In case of flasher failure of an alarmed tile, the tile light should illuminate and burn steadily. | UTA | UTA | | | Data not available |
| d. **CONTRAST DETECTABILITY** — There should be high enough contrast between alarming and steady-on tiles, and between illuminated and nonilluminated tiles, so that operators in a normally illuminated control room have no problem discriminating alarming, steady-on, and steady-off visual tiles. | O | YES | | | |

TABLE 3-3
ANNUNCIATOR SURVEY FINDINGS & HEDs GENERATED Page 7 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.3.3.2 (Cont'd) | | | | | |
| e. **"DARK" ANNUNCIATOR PANELS** — A "dark" annunciator panel concept should be used. This means that under normal operating conditions no annunciators would be illuminated; all of the visual tiles of the annunciator panels would be "dark." | O | YES | | | |
| f. **EXTENDED DURATION ILLUMINATION** — If an annunciator tile must be "ON" for an extended period during normal operations (e.g., during equipment repair or replacement), it should be: | | | | | |
| (1) Distinctively coded for positive recognition during this period, and | N/A | N/A | | | Procedure to be written |
| (2) Controlled by administravie procedures. | O D | YES | | | Procedure to be written |
| **6.3.3.3 ARRANGEMENT OF VISUAL ALARM TILES** | | | | | |
| a. **MATRIX ORGANIZATION** — Visual alarms should be organized as a matrix of visual alarm tiles within each annunciator panel. | O | YES | | | |
| b. **FUNCTIONAL GROUPING** — Visual alarm tiles should be grouped by function or system within each annunciator panel. For example area radiation alarms should be grouped on one panel, not spread throughout the control room. | D | YES | | | |
| c. **LABELING OR AXES** — | | | | | |
| (1) The vertical and horizontal axes of annunciator panels should be labeled with alphanumerics for ready coordinate designation of a particular visual tile. | O | YES | | | |

TABLE 3-3

ANNUNCIATOR SURVEY FINDINGS & HEDs GENERATED Page 8 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.3.3.3c (Cont'd)** | | | | | |
| (2) Coordinate designation is preferred on the left and top sides of the annunciator panel. | O | NO | 2V**-2105 | 9 | |
| (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. | O | YES | | | |
| d. **PATTERN RECOGNITION —** | | | | | |
| (1) The number of alarm tiles and the matrix density should be kept low (a maximum of 50 tiles per matrix is suggested). | O | NO | 2V**-2106 | 7 | |
| (2) Tiles within an annunciator panel matrix should be grouped by subsystem, function, or other logical organization. | D | YES | | | |
| e. **OUT-OF-SERVICE ALARMS** — Cues for prompt recognition of an out-of-service annunciator should be designed into the system. | D | YES | | | |
| f. **BLANK TILES** — Blank or unused annunciator tiles should not be illumi nated (except during annunciator testing) | O | YES | 2BSP-2107 | 5 | HED Incorrect |
| **6.3.3.4 VISUAL TILE LEGENDS** | | | | | |
| a. **UNAMBIGUOUS** — Annunciator visual tile legends should be specific and unambiguous. Wording should be in concise, short messages. | O | NO | 2V**-2108 | 7 | |
| b. **SINGULARITY** — Alarms which refer the operator to another, more detailed annunciator panel located outside the primary operating area should be minimized. | D | YES | | | |

TABLE 3-3

ANNUNCIATOR SURVEY FINDINGS & HEDs GENERATED Page 9 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.3.3.4 (Cont'd)** | | | | | |
| c. **SPECIFICITY** — Tile legends should address specific conditions; for example, do not use one alarm for HIGH-LOW, TEMPERATURE-PRESSURE. | O<br>D | NO | 2V**-2109 | 7 | |
| **6.3.3.5 VISUAL TILE READABILITY** | | | | | |
| a. **DISTANCE** — The operator should be able to read all the annunciator tiles from the position at the work station where the annunciator acknowledge control is located. | | | | | |
| (1) Letter height should subtend a minimum visual angle of 15 minutes, or .004 x viewing distance. The preferred visual angle is 20 minutes, or .006 x viewing distance. | M | NO | 2V**-2116<br>2V**-2120 | 9<br>9 | |
| (2) Letter height should be identical for all tiles, based on the maximum viewing distance. Separate calculations should be made for stand-up and sit-down work stations. | M | YES | | | |
| b. **TYPE STYLE** — The size and style of lettering should meet the following: | | | | | |
| (1) Type styles should be simple. | O | YES | | | |
| (2) Type styles should be consistent on all visual tiles. | O | YES | | | |
| (3) Only upper-case type should be used on visual tiles. | O | YES | | | |
| c. **LEGEND CONTRAST** — Legends should provide high contrast with the tile background. | | | | | |
| (1) Legends should be engraved. | O | NO | 2VC*-2110 | 7 | |
| (2) Legends should be dark lettering on a light background. | O | YES | | | |

TABLE 3-3

ANNUNCIATOR SURVEY FINDINGS & HEDs GENERATED Page 10 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.3.3.5 (Cont'd) | | | | | |
| d. **LETTER DIMENSIONS AND SPACING —** | | | | | |
| (1) Stroke-width-to-character-height ratio should be between 1:6 and 1:8. | M | NO | 2V**-2112 | 7 | |
| (2) Letter width-to-height ratio should be between 1:1 and 3:5. | M | YES | | | |
| (3) Numeral width-to-height ratio should be 3:5. | M | YES | | | |
| (4) Minimum space between characters should be one stroke width. | M | YES | | | |
| (5) Minimum space between words should be the width of one char acter. | M | NO | 2V**-2113 | 7 | |
| (6) Minimum space between lines should be one-half the character height. | M | NO | 2V**-2114 | 7 | |
| **6.3.4.1 CONTROLS (See Exhibit 6.3-5.)** | | | | | |
| a. **SILENCE —** | | | | | |
| (1) Each set of operator response controls should include a silence control. | O | YES | | | |
| (2) It should be possible to silence an auditory alert signal from any set of annunciator response controls in the primary operting area. | O | YES | | | |
| b. **ACKNOWLEDGE** | | | | | |
| (1) A control should be provided to terminate the flashing of a visual tile and have it continue at steady illumination until the alarm is cleared. | O | YES | | | |

TABLE 3-3

ANNUNCIATOR SURVEY FINDINGS & HEDs GENERATED Page 11 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.3.4.1 (Cont'd) | | | | | |
| (2) Acknowledgement should be possible only at the work station where the alarm originated. | D | YES | | | |
| c. **RESET** | | | | | |
| (1) If an automatic cleared alarm feature is not provided, a control should be provided to reset the system after an alarm has cleared. | O | YES | | | |
| (2) The reset control should silence any audible signal indicating clearance and should extinguish tile illumination. | D | YES | | | |
| (3) The reset control should be effective only at the work station for the annunciator panel where the alarm initiated. | D | YES | | | |
| d. **TEST** | | | | | |
| (1) A control to test the auditory signal and flashing illumination of all tiles in a panel should be provided. | O | YES | | | |
| (2) Periodic testing of annunciators should be required and controlled by administrative procedure. | UTA | UTA | | | Data not available |
| **6.3.4.2 CONTROL SET DESIGN** | | | | | |
| a. **POSITIONING OF REPETITIVE GROUPS** — Repetitive groups of annunciator controls should have the same arrangement and relative location at different work stations. This is to facilitate "blind" reaching. | O | NO | 2B**-2117 | 7 | |
| b. **CONTROL CODING** — Annunciator response controls should be coded for easy recognition using techniques such as: | | | | | |

TABLE 3-3
ANNUNCIATOR SURVEY FINDINGS & HEDs GENERATED Page 12 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.3.4.2b. (Cont'd)** | | | | | |
| (1) Color coding; | N/A | N/A | | | No color coding |
| (2) color shading the group of annunciator controls; | O | NO | 2B**-2118 | 7 | |
| (3) demarcating the group of annun ciator controls; or | O | NO | 2B**-2118 | 7 | |
| (4) shape coding, particularly the silence control. (See Exhibitor 6.3-5, Example 2.) | O | NO | 2B**-2118 | 7 | |
| c. **NONDEFEATABLE CONTROLS** — Annunciator control designs should not allow the operator to defeat the control. For example, some pushbuttons used for annunciator silencing and acknowledgement can be held down by inserting a coin in the ring around the pushbutton. This undesirable design feature should be eliminated. | O | NO | 2B**-2119 | 9 | |
| **6.3.4.3 ANNNUCIATOR RESPONSE PROCEDURES** | | | | | |
| a. **AVAILABILITY** — Annunciator response procedures should be available in the control room. | UTA | UTA | | | Data not available |
| b. **INDEXING** — Annunciator response procedures should be indexed by panel indentification and annunciator tile coordinates. | UTA | UTA | | | Data not available |
| **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. | O | YES | | | |

TABLE 3-3

ANNUNCIATOR SURVEY FINDINGS & HEDs GENERATED Page 13 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.5.1.6 (Cont'd) | | | | | |
| b. **NUMBER OF COLORS —** | | | | | |
| (1) The number of colors used for coding should be kept to the minimum needed for providing sufficient information. | O | YES | | | |
| (2) The number of colors used for coding should not exceed 11. | O | YES | | | |
| c. **MEANING OF COLORS —** | | | | | |
| (1) The meaning attached to a particular color should be narrowly defined. | O | YES | | | |
| (2) Red, green, and 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 tolarance. 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. | O | YES | | | |
| d. **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 | O | YES | | | |

TABLE 3-3

ANNUNCIATOR SURVEY FINDINGS & HEDs GENERATED Page 14 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.5.1.6d(1) (Cont'd) | | | | | |
| with earlier colors in the list. The first 9 colors have been selected so as to yield satisfactory contrast for red-green-deficient as well as color-normal observers. The remaining 13 colors are useful only for color-normal observers. | | | | | |
| (2) Colors selected for coding should contrast well with the background on which they appear. | O | YES | | | |
| (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. | O | YES | | | |
| **6.6.6.2 DEMARCATION** | | | | | |
| a. **USE** — Lines of demarcation can be used to: | | | | | |
| (1) Enclose functionally related displays. | D | NO | 2V**-2111 | 7 | |
| (2) Enclose functionally related controls | N/A | N/A | | | Visually distinctive grouping used |
| (3) Group related controls and displays. | N/A | N/A | | | |
| b. **CONTRAST** — Lines of demarcation should be visually distinctive from the panel background. | N/A | N/A | | | No demarcation used |
| c. **PERMANENCE** — Lines of demarcation should be permanently attached. | N/A | N/A | | | No demarcation used |

## 3.4 Controls Survey

This section documents the results of the controls survey conducted in the main control room, ESP, and ASP at BVPS-2. This review was conducted in accordance with the requirements of NUREG-0700, as specified in the BVPS-2 DCRDR Program Plan.

### 3.4.1 Objectives

The objectives of the displays survey were to:

a. Assess the degree to which all controls in the control room, ESP, and ASP conform to the criteria in NUREG-0700.

b. Identify and document any features of the controls that do not conform to the criteria in NUREG-0700.

### 3.4.2 Scope

The scope of the effort extends to the assessment of the control design in the main control room, ESP, and ASP at BVPS-2 using the applicable guidelines as stated in NUREG-0700. The control topics evaluated include:

- o General principles of control design
- o Prevention of accidental activation
- o Direction of movement
- o Coding of controls
- o Pushbutton design
- o Round pushbuttons
- o Legend pushbuttons
- o Rotary selector controls
- o J-Handle controls
- o Continuous adjustment rotary controls
- o Thumbwheels
- o Slide switches
- o Toggle switches
- o Separation of controls.

Several NUREG-0700 guidelines appropriate to controls are being considered as part of task analysis, and verification and validation activities. These have, therefore, been incorporated into the verification and validation evaluation reports.

### 3.4.3 Criteria

The criteria applied in this survey, identified by NUREG-0700 paragraph number, are: paragraphs 6.4.1.1a(1) through c(2) and e(1) through e(3); 6.4.1.2a through g; 6.4.2.1a through h; 6.4.2.2c(1) through c(4), e, f(1) and f(3); 6.4.3.1b and c; 6.4.3.2a through d; 6.4.3.3.b(1), through (5) and d(1) through e(5); 6.4.4.1a; 6.4.4.2a and b; 6.4.4.3a through g(3); 6.4.4.4a

through e(5); 6.4.4.5a through f; 6.4.5.1a through d(2)(e); 6.4.5.2a through b(2); 6.4.5.3a through c(6); 6.4.5.4a(1) through e(4); 6.5.1.6a through c(2) and e(1) through e(3); and 6.8.3.1a through c. The detailed definitions for each criterion are presented in Table 3-4.

### 3.4.4 Method

#### 3.4.4.1 Data Collection

a. Data were collected using the checklists contained in the Controls Task Plan.

b. The majority of the data were collected through direct observation of controls in the control room. As necessary, measurements were made of the physical characteristics (e.g., size, separation, displacement of the controls).

3.4.4.2 Analysis -- Data were analyzed according to the following procedure:

a. All deviations from the criteria were recorded on HED reports. Recorded information included the control or controls involved (e.g., rotary controls, pushbuttons, J-Handle controls, etc.), a description of the problem including the NUREG-0700 paragraph number of the criteria, and a recommended solution.

b. The data collection description was also recorded on the HED form. Where data from two or more sources were contradictory, resolution of the conflict was achieved through data review and discussions with cognizant DLC personnel.

c. Upon completion of all analyses, the criteria of the controls task plan were annotated to indicate compliance or noncompliance with the criteria.

### 3.4.5 Findings

The findings of the controls survey are presented in Table 3.4 "Controls Survey Findings and HEDs Generated." Overall, 143 criteria were applied to the controls in the BVPS-2 control room, ESP, and ASP. Since some features of the control room were not complete at the time of the survey, three (2%) of the criteria were unable to be assessed. These criteria include: 6.4.1.2d(2) and f; and 6.4.4.3e. Of the criteria assessed, 45 (31%) were not applicable, 76 (53%) were not violated, and 19 (13%) were violated. A total of 21 HEDs were generated which document all of

the 19 criteria which were not met. In general, those HEDs describe instances of accidental activiation of controls, inconsistent direction of movement, pushbutton resistance, and control separation.

TABLE 3-4

**CONTROLS SURVEY FINDINGS & HEDs GENERATED** 

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.4.1.1 GENERAL PRINCIPLES** | | | | | |
| a. **ADEQUACY —** | | | | | |
| (1) It should provide a sufficient range of control. | D | NO | 2AB*-3207 | 5 | |
| | | | 2ES2-3208 | 5 | |
| | | | 2BB1-3013 | 7 | HED Incorrect |
| | | | 2BA*-3014 | 9 | Valid., TP-9.2 |
| | | | 2***-3018 | 8 | Verif., TP-9.2 |
| | | | 2BC2-3019 | 8 | Verif., TP-9.2 |
| | | | 2BA4-3205 | 8 | Verif., TP-9.2 |
| | | | 2B**-3206 | 6 | Verif., TP.9-2 |
| (2) It should be easily adjusted with the required level of precision. | D | NO | 2BC3-3025 | 7 | |
| b. **ECONOMY —** | | | | | |
| (1) There should be a good reason to require a control for the function concerned. | D | YES | | | |
| (2) Duplication of controls should not occur, except for a specific reason. | D | YES | | | |
| (3) The precision and range of a control should not greatly exceed the need. | D | YES | | | |
| (4) Selected controls should be economic of space. | O | YES | | | |
| c. **HUMAN SUITABILITY —** | | | | | |
| (1) Each control should be recognizable in terms of its function. | O | NO | 2ES4-3023 | 5 | |
| (2) Each control should be of the type normally anticipated for the operation concerned. This means conforming to operator expectations, matching to other controls for the same function, and generally conforming to conventional practice. | O | NO | 2ES4-3023 | 5 | |

TABLE 3-4
CONTROLS SURVEY FINDINGS & HEDs GENERATED Page 2 of 18

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.4.1.1 (Cont'd)** | | | | | |
| c. **DURABILITY —** | | | | | |
| (1) Broken, chipped, or crumbled control surfaces should not ordinarily occur. | O | NO | 2BA*-3201 | 8 | |
| (2) Control knobs or handles should not rotate, slip, or move loosely on their shafts. | I | YES | | | |
| (3) No internal wear or breakage should occur which alters the "feel" or other sensory feedback of a control. Controls should not develop internal looseness, binding, or backlash. | N/A | N/A | | | Controls are unused |
| **6.4.1.2 PREVENTION OF ACCIDENTAL ACTIVATION** | | | | | |
| a. **PROPER LOCATION** — Controls should be located and oriented so that the operator is not likely to strike or move them accidentally in any sequence of control movements. | O | YES | | | |
| b. **FIXED PROTECTIVE STRUCTURES —** | | | | | |
| (1) Controls may be recessed, shielded, or otherwise surrounded by physical barriers. (See Exhibit 6.4-1) | O | YES | | | |
| (2) The control should be entirely contained within the envelope described by the recess or barrier. | O | YES | | | |
| c. **MOVABLE COVERS OR GUARDS —** | | | | | |
| (1) Controls may be covered or guarded with movable (e.g., hinged) barriers. (See Exhibit 6.4-2) | N/A | N/A | | | Not on panel |
| (2) Safety or lock wires should not be used. | N/A | N/A | | | Not on panel |

TABLE 3-4
CONTROLS SURVEY FINDINGS & HEDs GENERATED Page 3 of 18

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.4.1.2 (Cont'd)** | | | | | |
| (3) When the guard is in the open position, it should not interfere with the operation of the guarded control or other adjacent controls. | N/A | N/A | | | Not on panel |
| d. **INTERLOCKING CONTROLS** — Controls may be provided with interlocks so that: | | | | | |
| (1) Extra movement is required (e.g., a side movement out of a detent position or a pull-to-engage clutch). | O | YES | | | |
| (2) Prior operation of a related or locking control is required. | UTA | UTA | | | Data not available |
| e. **RESISTANCE TO MOVEMENT** — Controls should be provided with resistance (e.g., friction or spring-loading), so that distinct or sustained effort is required for activation. | O | YES | | | |
| f. **SEQUENTIAL ACTIVATION** — When a strict sequential activation is necessary, controls should be provided with locks to prevent the controls from passing through a position. Further movement should require a new control action. | UTA | UTA | | | Data not available |
| g. **CHOICE OF ACTION** — Rotary action controls should be used in situations where linear or pushbutton controls would be subject to inadvertent activation, and fixed protective structures are impractical or inappropriate. | O | YES | | | |
| **6.4.2.1 DIRECTION OF MOVEMENT** | | | | | |
| To minimize operator error, control movements should conform to the following population stereotypes (for U.S. population only): | | | | | |
| a. **ON, START, RUN, OR OPEN** — Up, right, forward, clockwise, or pull. | O | NO | 2B**-3403 | 7 | |

TABLE 3-4

CONTROLS SURVEY FINDINGS & HEDs GENERATED Page 4 of 18

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.4.2.1 (Cont'd)** | | | | | |
| b. **OFF, STOP, CLOSE** — Down, left, backward, counterclockwise, or push. | O | NO | 2B**-3403 | 7 | |
| c. **RIGHT (AS A FUNCTION)** — Clockwise or right. | O | YES | | | |
| d. **LEFT (AS A FUNCTION)** — Counter-clockwise or left. | O | YES | | | |
| e. **RAISE** — Up. | O | YES | | | |
| f. **LOWER** — Down. | O | YES | | | |
| g. **INCREASE** — Forward, up, right, or clockwise. | O | NO | 2BB2-3301 | 5 | High safety importance Valid., TP-9.2 |
| h. **DECREASE** — Backward, down, left, or counterclockwise. | O | NO | 2BB2-3301 | 5 | High safety importance Valid., TP-9.2 |
| **6.4.2.2 CODING OF CONTROLS** | | | | | |
| c. **SIZE CODING** | | | | | |
| (1) No more than three different sizes of controls should be used for discrimination by absolute size. | N/A | N/A | | | Size coding not used |
| (2) Controls used for performing the same function on different items of equipment should be the same size. | O | YES | | | |
| (3) When knob diameter is used as a coding parameter, differences between diameters should be at least 0.5 inch. | N/A | N/A | | | Diameter coding Not used |
| (4) When knob thickness is a coding parameter, differences between thicknesses should be at least 0.4 inch. | N/A | N/A | | | Thickness coding not used |

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CONTROLS SURVEY FINDINGS & HEDs GENERATED Page 5 of 18

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.4.2.2 (Cont'd)** | | | | | |
| e. **ROTATING KNOB SHAPE OPTIONS** — Rotating knob controls for different types of control actions should be distinguishable by sight and touch and not easily confused with each other. Exhibits 6.4-4 through 6.4-6 give examples of 15 suitable knob designs developed for three major classes of knobs, each class intended for a different purpose: multiple rotation, fractional rotation, and detent positioning. | O | YES | | | |
| f. **COLOR CODING** | | | | | |
| (1) Color coding should follow the recommendations of Guideline 6.5.1.6. | O | YES | | | |
| (3) The color of the control should contrast with the panel background. (See Guideline 6.1.5.6.e) | O | YES | | | |
| **6.4.3.1 PUSHBUTTON DESIGN PRINCIPLES** | | | | | |
| b. **INDICATION OF ACTIVATION** — To ensure that the operator knows that a pushbutton has been pressed far enough for activation, a positive indication should be provided in the form of a snap feel, an audible click, or an integral light. | O | YES | | | |
| c. **PUSHBUTTON SURFACE** — For best operation, the surface of a pushbutton should offer slip resistance, or be concave. | O | YES | | | |
| **6.4.3.2 ROUND PUSHBUTTONS (See Exhibit 6.4-7)** | | | | | |
| a. Diameter (D), for fingertip operation (inches) | | | | | |
| (1) Unguarded and nonrecessed push buttons<br>Minimum 0.385 | M | YES | | | |

TABLE 3-4
CONTROLS SURVEY FINDINGS & HEDs GENERATED Page 6 of 18

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.4.3.2a (Cont'd)** | | | | | |
| (2) Guarded or recessed pushbuttons Minimum 0.75 | N/A | N/A | | | No such equipment |
| b. Diameter (D), for thumb or heel of hand operation (inches) Minimum 0.75 | M | YES | | | |
| c. Displacement (A), for thumb or finger operation (inches) Minimum 0.125 | M | YES | | | |
| d. Resistance (R), for fingertip operation (ounces) Minimum 10 Maximum 40 | M | YES | | | |
| **6.4.3.3 LEGEND PUSHBUTTONS** | | | | | |
| b. **LEGEND** | | | | | |
| (1) The legend should be readable under ambient light conditions, with or without internal illumination. | O | YES | | | |
| (2) The illuminated condition should be clearly recognizable under the highest predicted ambient light condition and should be at least 10% brighter than the surrounding panel. | O | YES | | | |
| (3) Legend lettering and contrast should conform to recommendations for legend lights (Guideline 6.5.3.3). | N/A | N/A | | | Covered in TP 5.1 (see 6.5.3.3) |
| (4) The legend message should be specific, unambiguous, and concise. | O | YES | | | |
| (5) The legend message should contain no more than three lines of lettering. | O | NO | 2BC2-3401 | 9 | |

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CONTROLS SURVEY FINDINGS & HEDs GENERATED Page 7 of 18

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.4.3.3 (Cont'd)** | | | | | |
| d. **BARRIERS** | | | | | |
| (1) Barriers should be used when legend pushbuttons are contiguous. | O | NO | 2BC2-3402 | 7 | |
| (2) Barriers should have rounded edges. | N/A | N/A | | | No barriers used |
| e. **LEGEND PUSHBUTTON DIMENSIONS** — For maximum effectiveness of legend pushbutton controls, the following dimensions should be used (see Exhibit 6.4.8): | | | | | |
| (1) Size (S) (inches)<br>Minimum 0.75<br>Maximum 1.5 | M | YES | | | |
| (2) Displacement (A) (inches)<br>Minimum 0 (touch plate)<br>Minimum 0.125 (all others)<br>Maximum 0.250 | M | YES | | | |
| (3) Barrier width ($B_w$) (inches)<br>Minimum 0.125 | M | YES | 2VC8-3404 | 9 | HED Incorrect |
| (4) Barrier depth ($B_d$) (inches)<br>Minimum 0.183<br>Maximum 0.250 | M | YES | | | |
| (5) Resistance (ounces)<br>Minimum 10 (except touch plate)<br>Maximum 40 | M | YES | | | |
| **6.4.4.1 ROTARY CONTROL DESIGN PRINCIPLES** | | | | | |
| a. **DIRECTION OF ACTIVATION** — Rotary control settings should increase in value with a clockwise rotation. | O | YES | | | |
| **6.4.4.2 J-HANDLES** | | | | | |
| a. **HIGH-TORQUE DESIGNS** — J-handles should conform to dimensions as follows (see Exhibit 6.4-9): | | | | | |
| (1) Length (L) (inches)<br>Minimum 3.75<br>Optimum 4.0 | M | YES | | | |

TABLE 3-4
CONTROLS SURVEY FINDINGS & HEDs GENERATED Page 8 of 18

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.4.4.2a (Cont'd)** | | | | | |
| (2) Clearance (C) (inches)<br>Minimum 1.0<br>Optimum 2.0 | M | YES | | | |
| b. **LOW-TORQUE DESIGNS** — For certain purposes, smaller scale J-handles may be used. In such cases the handle proportion usually has a flattened or flared tip for finger placement, and the clearance between handle and panel surface can be less. | O | YES | | | |
| **6.4.4.3 KEY-OPERATED CONTROLS** | | | | | |
| a. **USE** — Key-operated controls should be used when system requirements dictate that the function being controlled should be secured against activation by unauthorized personnel. If key-oerated controls cannot be justified in terms of security, they are probably not necessary and should ot be used. Key-operated switches should not be used solely as a means of shape coding. | D | NO | 2BB*-3015 | 5 | Valid., TP-9.2 |
| b. **TEETH: SINGLE ROW** — Keys with a single row of teeth should be inserted into the lock with the teeth pointing up or forward. | O | NO | 2BC2-3202 | 9 | |
| c. **TEETH: DOUBLE ROW** — If keys have teeth on both edges, they should fit the lock with either side up or forward. | N/A | N/A | | | |
| d. **ON-OFF ORIENTATION** — Locks should be oriented so that the switch is OFF (or SAFE) when the key is in the vertical position. | O | NO | 2BC2-3203 | 9 | |
| e. **KEY REMOVAL** — Operators should not normally be able to remove the key from the lock unless the switch is turned to the OFF or SAFE position. | UTA | UTA | | | Data not available |
| f. **LABELING** — Control positions should be labeled. | O | YES | | | |

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CONTROLS SURVEY FINDINGS & HEDs GENERATED Page 9 of 18

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.4.4.3 (Cont'd) | | | | | |
| g. **KEY-OPERATED CONTROL DIMENSIONS** — The following dimensions should be used for key-operated controls (see Exhibit 6.4-10). | | | | | |
| (1) Displacement (A) (degrees)<br>Minimum 80°<br>Maximum 90° | M | NO | 2BC2-3901 | 9 | |
| (2) Height (H) (inches)<br>Minimum 0.5<br>Maximum 3.0 | M | YES | | | |
| (3) Resistance (inch/pounds)<br>Minimum 1.0<br>Maximum 6.0 | N/A | N/A | | | Data not available |
| **6.4.4.4 CONTINUOUS ADJUSTMENT ROTARY CONTROLS** — To ensure precise control along a continuous variable, continuous adjustment rotary controls are appropriate. | | | | | |
| a. **KNOBS** — Knobs for continuous adjustment controls should be round in shape, with knurled or serrated edges. | O | YES | | | |
| b. **POSITION INDICATION** — When an indication of position is desirable, the pointer configurations shown in Exhibit 6.4-11 may be used. Where more accuracy is required, a line should be engraved (and filled with contrasting pigment) both on top and down the side of the pointer, as shown on the knob at the bottom of the exhibit. | O | YES | | | |
| c. **DIMENSIONS** | | | | | |
| (1) Fingertip grasp knobs should conform to the following dimensions: | | | | | |
| (a) Height (inches)<br>Minimum 0.5<br>Maximum 1.0 | N/A | N/A | | | No such equipment |

TABLE 3-4
CONTROLS SURVEY FINDINGS & HEDs GENERATED Page 10 of 18

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.4.4.4c (Cont'd)** | | | | | |
| (b) Diameter (inches)<br>Minimum 0.375<br>Maximum 4.0 | N/A | N/A | | | No such equipment |
| (2) Thumb and forefinger encircled knobs should conform to the following dimensions:<br>Diameter (inches)<br>Minimum 1.0<br>Maximum 3.0 | N/A | N/A | | | No such equipment |
| d. **TORQUE** — Knob torque should be within the range of 4.5 to 6.0 inch/ounces. | N/A | N/A | | | No problem controlling |
| e. **CONTINUOUS ADJUSTMENT ROTARY CONTROLS WITH KNOB SKIRTS** — If knob skirts are used, such controls should conform to approximately the following dimensions. See Exhibit 6.4-12. | | | | | |
| (1) Skirt diameter ($D_S$): 2.0 inches. | M | NO | 2***-3001 | 9 | |
| (2) Skirt height ($H_S$): 0.25 inch. | M | YES | | | |
| (3) Finger stop diameter ($D_F$): 1.25 inches. | M | YES | | | |
| (4) Finger stop height ($H_F$) plus rotary knob height ($H_K$): total 0.75 inch. | M | YES | | | |
| (5) Knob diameter ($D_K$): 0.75 inch. | M | YES | | | |
| **6.4.4.5 ROTARY SELECTOR CONTROLS** | | | | | |
| a. **SELECTION** — Rotary selector controls should be used when three or more detented positions are required, and may be used for two-detented position operation. | O | YES | | | |

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CONTROLS SURVEY FINDINGS & HEDs GENERATED Page 11 of 18

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.4.4.5 (Cont'd) | | | | | |
| b. **POSITIONING** | | | | | |
| (1) To ensure proper positioning of a discrete rotary control, detents should be provided at each control position. | O | YES | | | |
| (2) It should not be possible to position a control between detented positions. | O | YES | | | |
| (3) A maximum of 24 positions should be used on a rotary selector control. | O | YES | | | |
| (4) To minimize the possibility of placing a rotary selector control in an unused position, stops should be provided at the limits of the control range. | O | YES | | | |
| c. **READABILITY** — To maximize read ability, rotary controls should have a moving pointer and fixed position settings. | N/A | N/A | | | No scales |
| d. **POSITION INDICATION** | | | | | |
| (1) Position indication should be provided. Desirable alternatives are: | | | | | |
| (a) Illuminated indicator lights, | O | YES | | | |
| (b) A line engraved both on the top of the knob and down the side, or | N/A | N/A | | | None in CR |
| (c) A pointer shape. | O | YES | | | |
| (2) It should not be possible to confuse the position of the knob in reference to position markers on the panel. To minimize the problem of parallax, pointers on knobs should be mounted close to the settings to which they point. | O | YES | | | |

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CONTROLS SURVEY FINDINGS & HEDs GENERATED 

| GUIDELINE | METHOD | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.4.4.5 (Cont'd)** | | | | | |
| e. **DIMENSIONS** — Recommended dimensions for rotary selector switches are as follows (see Exhibit 6.4-13): | | | | | |
| (1) Length (L) (inches) Minimum 1.0 | M | YES | | | |
| (2) Width (W) (inches) Maximum 1.0 | M | YES | | | |
| (3) Diameter (D) (inches) Minimum 1.0 | M | YES | | | |
| (4) Depth (H) (inches) Minimum 0.625 | M | YES | | | |
| (5) Resistance (inch/pounds) Minimum 1.0 Maximum 6.0 | M | YES | | | |
| f. **MOMENTARY CONTACT ROTARY SELECTOR CONTROLS** — Knobs for spring-loaded momentary contact rotary selector controls should be large enough to be easily held against the spring torque, without fatigue, for as long as necessary to accomplish the control action. | O | YES | | | |
| **6.4.5.1 THUMBWHEELS** | | | | | |
| a. **VISIBILITY** — To minimize error, thumbwheel readouts should be visible from the thumbwheel operating position. | O | YES | | | |
| b. **CODING** — If the thumbwheel is used as an input device, the OFF, zero, or normal position should be coded to facilitate visual recognition of status. | N/A | N/A | | | No such equipment |
| c. **CONTINUOUS ADJUSTMENT THUMBWHEELS** — The dimensions of thumbwheel controls which permit continuous adjustment (not stepped or detented) should be as follows: | | | | | |
| (1) At least 1 inch of the wheel should be exposed to permit easy manipulation. | N/A | N/A | | | No such equipment |

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CONTROLS SURVEY FINDINGS & HEDs GENERATED Page 13 of 18

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.4.5.1c (Cont'd)** | | | | | |
| (2) Resistance should be between 3 and 6 ounces. | N/A | N/A | | | No such equipment |
| (3) If the thumbwheel has an OFF position, a detent should be provided for feedback at that point. | N/A | N/A | | | No such equipment |
| d. **DISCRETE SETTING (STEPPED) THUMBWHEELS** | | | | | |
| (1) Thumbwheel controls which have discrete settings should be detented between positions. The control should snap into each position, and resist intermediate or uncertain settings. | O | YES | | | |
| (2) Discrete thumbwheel controls should conform to the following specifications. (See Exhibit 6.4-14) | | | | | |
| (a) Diameter (D) (inches)<br>Minimum 1.5<br>Maximum 2.5 | M | YES | | | |
| (b) Trough distance (L) (inches)<br>Minimum 0.45<br>Maximum 0.75 | M | YES | | | |
| (c) Width (W) (inches)<br>Minimum 0.1 | M | YES | | | |
| (d) Depth (H) (inches)<br>Minimum 0.125<br>Maximum 0.5 | M | YES | | | |
| (e) Resistance (ounces)<br>Minimum 6<br>Maximum 20 | M | YES | | | |
| **6.4.5.2 SLIDE SWITCHES** | | | | | |
| a. **SURFACE** — The surface of slide switches should be serrated or knurled. | N/A | N/A | | | Not on panel |
| b. **DIMENSIONS** — Slide switches should conform to approximately the following dimensions. See Exhibit 6.4-15. | | | | | |

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CONTROLS SURVEY FINDINGS & HEDs GENERATED Page 14 of 18

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.4.5.2b (Cont'd) | | | | | |
| (1) Thickness (T): 0.25 inch. | N/A | N/A | | | |
| (2) Length (L): 1.0 inch. | N/A | N/A | | | Not on panel |
| **6.4.5.3 TOGGLE SWITCHES** | | | | | |
| a. **POSITIONING** — To minimize the possibility of inadvertent activation or setting between control positions, toggle switches should have an elastic resistance that increases as the control is moved and drops as the switch snaps into position. | N/A | N/A | | | Not on panel |
| b. **FEEDBACK** — Toggle switches should emit an audible click, or provide some other source of feedback on activation. | N/A | N/A | | | Not on panel |
| c. **DIMENSIONS** — To ensure the most effective use, toggle switches should conform to the following dimensions. See Exhibit 6.4-16. | | | | | |
| (1) Arm length (L), for use by one finger (inches)<br>Minimum 0.5<br>Maximum 2.0 | N/A | N/A | | | Not on panel |
| (2) Tip diameter (D) (inches)<br>Minimum 0.125<br>Maximum 1.0 | N/A | N/A | | | Not on panel |
| (3) Resistance (small switch) (ounces)<br>Minimum 10<br>Maximum 16 | N/A | N/A | | | Not on panel |
| (4) Resistance (large switch) (ounces)<br>Minimum 10<br>Maximum 40 | N/A | N/A | | | Not on panel |
| (5) Displacement (A), two position (degrees)<br>Minimum 30<br>Maximum 120 | N/A | N/A | | | Not on panel |

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| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.4.5.3c (Cont'd)** | | | | | |
| (6) Displacement (A), three position (degrees between settings)<br>Minimum 18<br>Maximum 60<br>Optimum 25 | N/A | N/A | | | Not on panel |
| **6.4.5.4 ROCKER SWITCHES** | N/A | N/A | | | Not on panel |
| a. **ORIENTATION** — Rocker switches should ordinarily be oriented vertically. | | | | | |
| (1) Activation of the upper part should control the ON or INCREASE function. | N/A | N/A | | | Not on panel |
| (2) Horizontal orientation should be used only when the location of the controlled function or equipment requires it. | N/A | N/A | | | Not on panel |
| b. **INDICATION OF ACTIVATION** | | | | | |
| (1) Activation should be indicated by a snap feel, an audible click, or an integral light. | N/A | N/A | | | Not on panel |
| (2) In the ON position, the top of the switch should be flush with the panel surface. | N/A | N/A | | | Not on panel |
| c. **RESISTANCE** | | | | | |
| (1) Control resistance should gradually increase, then drop to zero when the control snaps into position. | N/A | N/A | | | Not on panel |
| (2) This resistance should preclude the switch being placed between positions. | N/A | N/A | | | Not on panel |
| d. **INADVERTENT ACTIVATION** — If it controls a critical function, the switch should be protected by channel guards or other means to prevent inadvertent activation. | N/A | N/A | | | Not on panel |

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| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.4.5.4 (Cont'd)** | | | | | |
| e. **ROCKER SWITCH DIMENSIONS** — (see Exhibit 6.4-17): | N/A | N/A | | | Not on panel |
| (1) Width (W) (inches)<br>Minimum 0.75<br>Maximum 1.5 | | | | | |
| (2) Resistance (ounces)<br>Minimum 10<br>Maximum 40 | N/A | N/A | | | Not on panel |
| (3) Displacement, two-position switches (A) (degrees)<br>Minimum 30<br>Maximum 120 | N/A | N/A | | | Not on panel |
| (4) Displacement, three-position switches (A) (degrees)<br>Minimum 18<br>Maximum 60<br>Optimum 25 | N/A | N/A | | | Not on panel |
| **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. | O | YES | | | |
| b. **NUMBER OF COLORS** | | | | | |
| (1) The number of colors used for coding should be kept to the minimum needed for providing sufficient information. | O | YES | | | |
| (2) The number of colors used for coding should not exceed 11. | O | YES | | | |
| c. **MEANING OF COLORS** | | | | | |
| (1) The meaning attached to a particular color should be narrowly defined. | O | YES | | | |

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CONTROLS SURVEY FINDINGS & HEDs GENERATED Page 17 of 18

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.5.1.6c (Cont'd)** | | | | | |
| (2) Red, green, and 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. | O | YES | | | |
| Green: safe, no operator action required, or an indication that a parameter is within tolerance. | O | NO | 2BC2-3405 | 7 | Conventions, TP-8.1 |
| Amber (yellow): hazard (potentially unsafe), caution, attention required, or an indication that a marginal value or parameter exists. | O | YES | | | |
| **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 safey 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 satisfactory contrast for red-green-deficient as well as color-normal observers. The remaining 13 colors are useful only for color-normal observers. | O | YES | | | |
| (2) Colors selected for coding should contrast well with the background on which they appear. | O | YES | | | |

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| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.5.1.6e (Cont'd)** | | | | | |
| (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. | O | YES | | | |
| **6.8.3.1 SEPARATION OF CONTROLS** | | | | | |
| Recommended minimum control separation distances are shown in Exhibits 6.8-2 and 6.8-3. In most cases, control room operations will require greater separation. The function requirements that should be considered are: | | | | | |
| a. **ACCESS** — Control access should not be impeded by any position of an adjacent control. | O | NO | 2BC3-3025 | 8 | |
| b. **INADVERTENT ACTUATION** — Control actuation should not result in advertent actuation of an adjacent control. | O | YES | | | |
| c. **SIMULTANEOUS ACTUATION** — Simultaneously actuation of adjacent controls (where required) should be possible. | O | YES | | | |

## 3.5 Displays Survey

This section documents the results of the displays survey conducted in the main control room, ESP, and ASP at BVPS-2. This review was conducted in accordance with the requirements of NUREG-0700, as specified in the BVPS-2 DCRDR Program Plan.

### 3.5.1 Objectives

The objectives of the displays survey were to:

a. Assess the degree to which all displays in the control room, ESP, and ASP conform to the criteria in NUREG-0700.

b. Identify and document any features of the displays that do not conform to the criteria in NUREG-0700.

### 3.5.2 Scope

The scope of the effort extends to the assessment of the display design in the main control room, ESP, and ASP at BVPS-2 using the applicable guidelines as stated in NUREG-0700. The display topics evaluated include:

- Display failure
- Usability of displayed values
- Readability
- Printing on the display face
- Scale markings
- Coding
- Display movement
- Scale pointers
- Zone markings
- Light indicators (legend and simple)
- Legend design
- Trend recorders.

CRT displays are evaluated as part of the computer survey. Several NUREG-0700 guidelines appropriate to displays are addressed as part of task analysis and task verification and validation activities. These guidelines have been incorporated into the verification and validation evaluation reports.

### 3.5.3 Criteria

The criteria applied in this survey, identified by NUREG-0700 paragraph number, are: paragraphs 6.5.1.1f; 6.5.1.2d(1) through e; 6.5.1.3a through c(1) and d(1) through d(6); 6.5.1.4a(1) through f; 6.5.1.5a through c and e and f; 6.5.1.6a through c(2) and e(1) through e(3); 6.5.2.1a through c; 6.5.2.2a(1) through c; 6.5.2.3a through c; 6.5.2.4a through c(3); 6.5.2.5; 6.5.3.1b,

c(1) and d; 6.5.3.2a(1), a(3), and b; 6.5.3.3a(1) through b(7); 6.5.4.1a through d and g through k; 6.5.4.2a(1) through b(4); 6.5.5.1a(1) through c(2); and 6.5.5.2a(1) through c.

The detailed definitions for each criterion are presented in Table 3-5.

### 3.5.4 Method

#### 3.5.4.1 Data Collection

a. Data were collected using the checklists from the Displays Task Plan.

b. Data were collected primarily through direct observation of displays in the control room. As necessary, measurements were made of the physical characteristics (e.g., character size, height-to-width ratios, etc.) of control room displays. Where guidelines refer to consistency with operating procedures (e.g., 6.5.1.4.e), preliminary EOPs were reviewed.

c. Data were recorded on the appropriate forms.

3.5.4.2 Analysis -- Data were analyzed according to the following procedure:

a. All deviations from the criteria were recorded on HED reports. Recorded information included the instrument or instruments involved (e.g., legend lights, meters, chart recorders, etc.), a description of the problem including the NUREG-0700 paragraph number of the criteria, and a recommended solution.

b. The data collection method was also recorded on the HED form. Where data from two or more sources were contradictory, resolution of the conflict was achieved through data review and discussions with cognizant DLC personnel.

c. Upon completion of all analyses, the criteria of the displays task plan were annotated to indicate compliance or noncompliance with the criteria.

### 3.5.5 Findings

The findings of the displays survey are presented in Table 3.5 "Displays Survey Findings and HEDs Generated." A total of 107 criteria were applied to the displays in the BVPS-2 control room,

ESP, and ASP. Since some features of the control room were not complete at the time of the survey; nine (8%) of the criteria were unable to be assessed. These criteria included: 6.5.3.1b and d; 6.5.4.1a, b, h, and i; 6.5.5.1.c(1); and 6.5.5.2b and c. Of the criteria assessed, 9 (8%) were not applicable, 60 (56%) were not violated, and 29 (27%) were violated. A total of 27 HEDs were generated which document all of the 29 criteria which were not met. In general, those HEDs address display labeling, readability, adequacy of information presentation and methods of information presentation.

TABLE 3-5

DISPLAYS SURVEY FINDINGS & HEDs GENERATED Page 1 of 15

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.5.1.1 INFORMATION TO BE DISPLAYED** | | | | | |
| f. **DISPLAY FAILURE** — When panel instruments, such as meters, fail or become inoperative, the failure should be apparent to the operator (e.g., through off-scale indication). | O | YES | | | |
| **6.5.1.2 USABILITY OF DISLAYED VALUES** | | | | | |
| d. **SCALE RANGE** — Scales should be selected to: | | | | | |
| (1) Span the expected range of operational parameters, or | O | YES | | | |
| (2) Employ appropriate scale ranging techniques, or | O | YES | | | |
| (3) Be supported by auxiliary wide-range instruments. | O | YES | | | |
| e. **SCALE SIZE** — Scale ranges may be expanded (or contracted) by multiplying or dividing indicated scale values by powers of ten. All such scales should be clearly marked as to whether the indicated values should be multiplied or divided, and the factor involved (e.g., 10, 100, 1000). | O | YES | | | |
| **6.5.1.3 READABILITY** | | | | | |
| a. **CHARACTER HEIGHT** — Character height should subtend a minimum visual angle of 15 minutes, or 0.004 x viewing distance. The preferred visual angle is 20 minutes, or 0.006 x viewing distances. | M | NO | 2***-2303 | 9 | |
| b. **TYPE STYLE** — Exhibits 6.5-1 and 6.5-2 present two recommended sets of characters, character size and style should meet the following: | | | | | |
| (1) Type styles should be simple. | O | YES | | | |
| (2) Type styles should be consistent. | O | YES | | | |

TABLE 3-5

DISPLAYS SURVEY FINDINGS & HEDs GENERATED Page 2 of 15

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.5.1.3b (Cont'd)** | | | | | |
| (3) Only upper-case letters should be used. | O | YES | | | |
| c. **CONTRAST** — Highest contrast is provided by black and white. | | | | | |
| (1) Visual displays should normally contain black markings on a white background. | O | NO | 2VC8-2205<br>2VC7-2401 | 7<br>9 | |
| d. **CHARACTER DIMENSIONS AND SPACING** — | | | | | |
| (1) Stroke-width-to-character-height ratios should be between 1:6 and 1:8. | M | NO | 2***-2002 | 5 | |
| (2) Letter width-to-height ratios should be between 1:1 and 3:5. | M | NO | 2***-2002 | 5 | |
| (3) Numeral width-to-height ratios should be 3:5. | M | NO | 2***-2002 | 5 | |
| (4) Minimum space between characters should be one stroke width. | M | NO | 2***-2002 | 5 | |
| (5) Minimum space between words should be the width of one character. | M | YES | | | |
| (6) Minimum space between lines should be on-half the character height. | M | YES | | | |
| **6.5.1.4 PRINTING ON THE DISPLAY FACE** | | | | | |
| a. **PROVISION OF NEEDED MESSAGE** — If any information is required to use the display, it must be provided close enough to the scale so that the scale and the message are clearly associated. The message may be communicated: | | | | | |
| (1) By printing on the display face. | O | NO | 2***-2204 | 8 | |
| (2) By an appropriate label adjacent to the display. | O | YES | | | |

TABLE 3-5

DISPLAYS SURVEY FINDINGS & HEDs GENERATED Page 3 of 15

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.5.1.4 (Cont'd)** | | | | | |
| b. **AVOIDANCE OF EXTRANEOUS ITEMS** — Categories of information not needed in using the display should be avoided (e.g., patent notices, manufacturer's trademark or address). | O | NO | 2B**-2206 | 9 | |
| c. **BREVITY** — To avoid distraction and interference with the needed essential markings, messages should be written as briefly as clarity permits. | O | YES | | | |
| d. **ABBREVIATIONS** — Only standard and commonly accepted abbreviations should be used. | D | NO | 2V**-1111 | 8 | Conventions, TP-8.1 |
| e. **CONSISTENCY WITH PROCEDURES** — The printed message should use the same terms as the procedures in display identification, parameter identification, and units displayed. | D<br>O | NO | 2***-3018 | 8 | Verification, TP-9.2 |
| f. **INDICATION OF TRANSFORMATIONS NEEDED** — Where necessary to multiply or divide the displayed readings by powers of 10 to determine quantitative value, the operation required and result derived must be clearly indicated. | O | YES | | | |
| **6.5.1.5 SCALE MARKINGS** | | | | | |
| a. **USE OF GRADUATIONS** — Scales for quantitative reading should be provided with graduations consistent with the progression of their numerals. | O | YES | | | |
| (1) No more than 9 graduations should separate numerals. | O | NO | 2***-2208 | 7 | |
| (2) Major and minor graduations should be used if there are up to four graduations between numerals. | O | YES | | | |
| (3) Major, intermediate, and minor graduation should be used if there are five or more graduations between numerals. | O | NO | 2***-2203 | 6 | |

TABLE 3-5

DISPLAYS SURVEY FINDINGS & HEDs GENERATED Page 4 of 15

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.5.1.5 (Cont'd)** | | | | | |
| b. **GRADUATION HEIGHT** — Graduation heights as a function of viewing distance should be: | M | NO | 2***-2003 | 9 | |
| c. **VALUES INDICATED BY UNIT GRADUATIONS** — Successive values indicated by unit graduations should be one of those shown below or those values multiplied by some power of 10. | O | NO | 2VC7-2201<br>2VC5-2405 | 9<br>7 | Valid., TP-9.2 |
| e. **LINEAR VS LOGARITHMIC SCALES** — Logarithmic scales should be avoided unless needed to display a large range of values. | D | NO | 2VC6-2218 | 5 | Valid., TP-9.2 |
| f. **MULTISCALE INDICATORS** — Multiscale indicators (i.e., single pointer, multiple scales) should be avoided unless they can be justified as of operational benefit, and precautions are taken to avoid operator confusion. | O | NO | 2*C*-2217 | 9 | Verif., TP-9.2 |
| **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. | O | YES | | | |

TABLE 3-5

DISPLAYS SURVEY FINDINGS & HEDs GENERATED Page 5 of 15

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.5.1.6 (Cont'd) | | | | | |
| b. **NUMBER OF COLORS —** | | | | | |
| (1) The number of colors used for coding should be kept to the minimum needed for providing sufficient information. | O | YES | | | |
| (2) The number of colors used for coding should not exceed 11. | O | YES | | | |
| c. **MEANING OF COLORS** | | | | | |
| (1) The meaning attached to a particular color should be narrowly defined. | O | YES | | | |
| (2) Red, green, and 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. | O | YES | | | |
| Green: safe, no operator action required, or an indication that a parameter is within tolerance. | O | YES | | | |
| Amber (yellow): hazard (potentially unsafe), caution, attention required, or an indication that a marginal value of parameter exists. | O | YES | | | |

TABLE 3-5

DISPLAYS SURVEY FINDINGS & HEDs GENERATED Page 6 of 15

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.5.1.6 (Cont'd) | | | | | |
| e. **PRINCIPLES OF COLOR SELECTION** | | | | | |
| (1) The primary principle which should be applied in selecting colors for coding purposes which do not have the imemdiate 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 satisfactory contrast for red-green-deficient as well as color-normal observers. The remaining 13 colors are useful only for color-normal observers. | O | YES | | | |
| (2) Colors selected for coding should contrast well with the background on which they appear. | O | YES | | | |
| (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. | O | YES | | | |
| **6.5.2.1 DIRECTIONALITY OF MOVEMENT AND NUMBERING WITH FIXED-SCALE AND MOVING-POINTER METERS** | | | | | |
| a. **CIRCULAR SCALES** — Scale values should increase with clockwise movement of the pointer as in Exhibit 6.5-8. | O | YES | | | |
| b. **VERTICAL STRAIGHT SCALES** — Scale values should increase with upward movement of the pointer as in Exhibit 6.5-9. | O | YES | | | |

TABLE 3-5

DISPLAYS SURVEY FINDINGS & HEDs GENERATED Page 7 of 15

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.5.2.1 (Cont'd) | | | | | |
| c. **HORIZONTAL STRAIGHT SCALES** — Scale values should increase with pointer movement to the right as in Exhbit 6.5-10. | O | YES | | | |
| **6.5.2.2 POINTERS** | | | | | |
| a. **POINTER TIP FORM** — | | | | | |
| (1) Pointer tips should be simple. Examples of preferred and non-preferred types are given in Exhibit 6.5-11. | O | NO | 2V**-2202 | 9 | |
| (2) Pointer tips should be selected to minimize concealment of scale graduation marks or numerals. (See Exhibit 6.58.) | O | NO | 2***-2209 | 9 | |
| b. **POINTER POSITIONING RELATIVE TO SCALE** -- | | | | | |
| (1) Pointer tip should extend to within about 1/16 inch of (but not overlap) the smallest graduation marks on the scale. (See Exhibits 6.5-8, -9,-10.) | M | YES | | | |
| (2) Pointers should be mounted to avoid parallax errors. | O | YES | | | |
| c. **POINTER VISIBILITY** — Pointer/background contrast and pointer size should be adequate to permit rapid recognition of pointer position. | O | NO | 2***-2210 | 8 | |
| **6.5.2.3 ZONE MARKING** (Exhibit 6.5-12) | | | | | See Verification TP-9.2, HED # 2***-2220 |
| a. Zone markings should be conspicuous and distinctively different for different zones. | N/A | N/A | | | No zone coding |
| b. Zone marking should not interfere with reading of quantitative markings. | N/A | N/A | | | No zone coding |
| c. If color is used for coding, color should be related to meaning as given in Guideline 6.5.1.6.c. | N/A | N/A | | | No zone coding |

TABLE 3-5

DISPLAYS SURVEY FINDINGS & HEDs GENERATED Page 8 of 15

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.5.2.4 ORIENTATION OF MARKINGS ON FIXED-SCALE METERS** | | | | | |
| a. **NUMERAL ORIENTATION** — Individual numerals on any type of fixed scale should be vertical (see Exhibit 6.5-13). This holds true for circular as well as linear scales. | O | NO | 2BC3-2207 | 9 | |
| b. **ZERO-POINT ORIENTATION** — | | | | | |
| (1) Where pointer movement is more than 360°, the zero point should be located at the 12 o'clock position. | N/A | N/A | | | No such scales |
| (2) Where positive and negative values are displayed around a zero or null position, the zero or null point should be located at the 12 o'clock position. | O | YES | | | |
| c. **END-POINT INDICATION ON PARTIAL-REVOLUTION SCALES** — | | | | | |
| (1) Where the scale covers less than a full rotation of the pointer, scale end-points should be indicated by a break in scale (see Exhibit 6.5-13). | O | YES | | | |
| (2) The break should be at least one numbered interval in length. | O | YES | | | |
| (3) The break should be oriented at the 6 o'clock position. | O | YES | | | |
| **6.5.2.5 MOVING-SCALE METERS** | | | | | |
| Moving-scale fixed-pointer meters are infrequently seen in nuclear power plant control rooms. They should be avoided in favor of the more effective fixed-scale moving-pointer types. | N/A | N/A | | | No such equipment |

TABLE 3-5

DISPLAYS SURVEY FINDINGS & HEDs GENERATED 

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.5.3.1 CHARACTERISTICS AND PROBLEMS OF LIGHT INDICATORS** | | | | | |
| b. **PRECAUTIONS TO ASSURE UNAMBIGUOUS SENSING BY OPERATORS** — Lights should not appear to be glowing when in fact they are off, or vice versa. To that end, ambient light sources should be selected, located, or controlled to avoid reflections or refractions. (See Guideline 6.1.5.3.) | UTA | UTA | | | Data not available |
| c. **PRECAUTIONS TO AVOID MISINTERPRETATION** — | | | | | |
| (1) System/equipment status should be inferred by illuminated indicators, and never by the absence of illumination. | O | NO | 2BB2-2309 | 7 | Valid., TP-9.2 |
| d. **USE AS ALERTING INDICATORS** — Alerting the operator to unfavorable status should be a function of the annunciator system and not assigned to light indicators. | UTA | UTA | | | Data not available |
| **6.5.3.2 DESIGN AND USE OF NONLEGEND LIGHT INDICATORS** | | | | | |
| a. **IDENTIFICATION OF MEANING** — | | | | | |
| (1) Where meaning is not apparent, labeling must be provided close to the light indicator showing the message intended by its glowing. | O | YES | | | |
| (3) The color of the light should be clearly identifiable. | O | YES | | | |
| b. **LIGHT INTENSITY** — The illuminated indicator should be at least 10% greater in light intensity than the surrounding panel (as measured by a spot photometer). | O | YES | | | |

TABLE 3-5

DISPLAYS SURVEY FINDINGS & HEDs GENERATED Page 10 of 15

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.5.3.3 DESIGN AND USE OF LEGEND LIGHT INDICATORS** | | | | | |
| a. **VISIBILITY FACTORS —** | | | | | |
| (1) Light intensity of the illuminated indicators should be at least 10% greater than the surrounding panel (as measured by a spot photometer). | O | YES | | | |
| (2) Legends should be legible under ambient illumination with indicator lights off. | O | NO | 2B**-2302 | 7 | |
| (3) Legend lettering should contrast well with background under both ambient and transilluminated lighting. | O | NO | 2B**-2304 | 7 | |
| b. **LEGEND DESIGN** | | | | | |
| (1) General legend design should be consistent throughout the control room. | O | YES | | | |
| (2) Lettering should be simple, and should follow Guideline 6.5 1.3 for style and size. | M<br>O | YES | | | |
| (3) Symbolic legends should be clear and unambiguous as to their meaning. | O | YES | | | |
| (4) Text should be short, concise, and unambiguous. | O | YES | | | |
| (5) Legend messages should contain no more than three lines of text. | O | NO | 2***-2305 | 9 | |
| (6) Nomenclature and abbreviations should be standard, and consistent with usage throughout the control room and in the procedures. | D | NO | 2***-1111 | 8 | Conventions, TP-8.1 |
| (7) Legends should be worded to tell the status indicated by glowing of the light. | O | YES | | | |

TABLE 3-5

DISPLAYS SURVEY FINDINGS & HEDs GENERATED Page 11 of 15

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.5.4.1 GENERAL CHARACTERISTICS OF GRAPHIC RECORDERS** | | | | | |
| a. **QUALITY OF EXPENDABLE MATERIALS** — Pens, inks, and paper should be of a quality to provide clear, distinct, and reliable marking. For example, ink should not clog pens or smudge on the paper. | UTA | UTA | | | Data not available |
| b. **SCALE COMPATIBILITY** — Scales printed on the recording paper should be the same as the scales shown on the recorder. | UTA | UTA | | | Data not available |
| c. **SCALE DESIGN** — Recorder scales should be numbered and marked according to the general principles of scale graduation (Guideline 6.5.1.5), with number style and dimensions according to Guidelines 6.5.1.3 and 6.5.1.4. | O | NO | 2B**-2206<br>2VC7-2201<br>2***-2208<br>2VC5-2405 | 9<br>9<br>7<br>7 | <br><br><br>Valid, TP-9.2 |
| d. **PAPER TAKEUP AND CUTOFF** — A takeup spool should be provided to receive completed recordings. On most instruments this is provided as an inherent part of the design. Also, means should be provided for tearing off completed records for storage. | O | YES | | | |
| g. **USE** — As a general rule, recorders should be used to record trend information and material which may be needed for later reference. | D | YES | | | |
| h. **PLACEMENT OF RECORDERS** — As devices which must be verified and attended by the operator, graphic recorders should in principle be located within the primary operating area rather than on back panels. | UTA | UTA | | | Data not available |
| i. **PAPER-SPEED ADJUSTABILITY** — Not only should high p[illegible] option be provided to run ou[illegible] for detachment, but a selec[illegible] lower speeds should be available to permit adjustment of the time scale so that rate-of-change information can be indicated. | UTA | UTA | | | Data not available |

TABLE 3-5

DISPLAYS SURVEY FINDINGS & HEDs GENERATED Page 12 of 15

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.5.4.1 (Cont'd) | | | | | |
| j. **ANNOTATION** — It should be convenient to annotate recordings with date and time markings, with paper speed if varied from normal, with parameter identification, or with any other relevant information. | O | YES | | | |
| k. **VISIBILITY** — Recorder design should ensure that all data will be visible through the window of the recorder and not require open-door operation to expose it. | O | YES | | | |
| **6.5.4.2 SPECIFIC RECORDER TYPES** | | | | | |
| a. **CONTINUOUS RECORDERS** — | | | | | |
| (1) LABELING — Labels should identify the parameters recorded. With multiple-pen recorders, parameters should be listed in the order of the associated scales on the recorder. | O | YES | | | |
| (2) INK COLORS — Each pen should use a different colored ink to permit channel identification from line color. Colors selected should be distinctively different and should afford good contrast with the paper. | O | YES | | | |
| b. **DISCRETE RECORDERS** — | | | | | |
| (1) CHANNEL OVERLOAD — The recorder should not be loaded beyond its designed channel capacity because this adds complexity to the analysis and prolongs sampling cycle time. | D | YES | | | |
| (2) CHANNEL IDENTIFICATION ON INSTRUMENT — Discrete recorders should be equipped to display an easily viewed manner the channel being plotted. Viewing from odd and inconvenient angles should not be imposed. | D | YES | | | |

TABLE 3-5

DISPLAYS SURVEY FINDINGS & HEDs GENERATED Page 13 of 15

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.5.4.2b (Cont'd)** | | | | | |
| (3) CHANNEL IDENTIFICATION ON RECORDING — Number-printing mechanism should be designed and maintained to provide clear, sharp, and small numbering to avoid crowding of data and consequent analysis problems. | UTA | UTA | | | |
| (4) CHANNEL SELECTION CAPABILITY — Provision should be made to select any single channel for immediate display without awaiting completion of a sampling cycle. | D | YES | | | No such equipment |
| **6.5.5.1 DRUM-TYPE COUNTERS** | | | | | |
| **a. NUMERICAL PRESENTATION FACTORS —** | | | | | |
| (1) ORIENTATION — Multidigit numbers formed by several counter drums should be read horizontally from left to right (see Exhibit 6.5-14). | O | YES | | | |
| (2) WIDTH-HEIGHT RATIO — To compensate for the distortion imposed by the curved surface of the drum, counter numerals should reflect a width-height ratio of 1:1, not 3:5 as recommended for numerals and other displays. | M | YES | | | |
| (3) GROUPING OF NUMERALS — If more than four digits are required, they should be grouped and the groupings separated as appropriate by commas, by a decimal point, or by additional space (see Exhibit 6.5-15). | O | NO | 2BA4-2502 | 7 | |
| (4) CONTRAST — The color of the numerals and of the background should be chosen to yield high contrast. Black numerals on white drum surface is recommended. | O | NO | 2B**-2503 | 9 | |

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DISPLAYS SURVEY FINDINGS & HEDs GENERATED Page 14 of 15

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.5.5.1a (Cont'd)** | | | | | |
| (5) DRUM FINISH — The surface of the drums and surrounding areas should have a matte finish to minimize glare. | O | YES | | | |
| b. **MOUNTING —** | | | | | |
| (1) Drum-type counters are clearly readable only within a viewing angle that is more restrictive than for most displays. Accordingly, they should be mounted perpendicular to the operator's line of sight. | O | YES | | | |
| (2) Counters should be mounted as close as possible to the panel surface to minimize shadows and maximize viewing angle. | O | YES | | | |
| (3) The window should be sized to allow no more than one digit per drum to appear in the window at any one time. | O | YES | | | |
| c. **DRUM MOVEMENT —** | | | | | |
| (1) Numbers should change by snap action rather than through continuous movement. | D | YES | | | |
| (2) The counter drums should move upward with increasing values. | | NO | 2BB?-2501 | 9 | |
| **6.5.5.2 ELECTRONIC COUNTERS** | | | | | |
| a. **NUMERICAL PRESENTATION FACTORS —** | | | | | |
| (1) ORIENTATION — Multidigit counters should be oriented to read horizontally from left to right. | O | YES | | | |

TABLE 3-5

DISPLAYS SURVEY FINDINGS & HEDs GENERATED Page 15 of 15

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.5.5.2a** (Cont'd) | | | | | |
| (2) CHARACTER STYLE — Simple character fonts should be used. Styles using variable stroke widths, slanted characters, etc., should be avoided. | M | YES | | | |
| (3) NUMERAL HEIGHT — Numerals should be of such a height as to subtend a visual angle of 15 minutes from the farthest anticipated viewing distance. | M | YES | | | |
| (4) WIDTH-TO-HEIGHT RATIO — Width-to-heigh ratio of numerals should be approximately 3:5. | M | YES | | | |
| (5) SPACING — Horizontal spacing between numerals should be between one-quarter and one-half the numeral width. | M | YES | | | |
| b. **RATE OF CHANGE** — Numerals should not follow each other faster than two per second when the operator is expected to read the numerals consecutively. | UTA | UTA | | | Data not available |
| c. **CONTRAST** — Character-to-background contrast ratio should be between 15:1 minimum and 20:1 preferred. | UTA | UTA | | | Data not available |

## 3.6 Labels and Location Aids Survey

This section documents the results of the labels and location aids survey conducted in the main control room, ESP, and ASP at BVPS-2. This review was conducted in accordance with the requirements of NUREG-0700, as specified in the BVPS-2 DCRDR Program Plan.

### 3.6.1 Objectives

The objectives of the labels and location aids survey were to:

a. Assess the degree to which all labels and location aids in the control room, ESP, and ASP conform to the criteria in NUREG-0700.

b. Identify and document any features of the labels and location aids that do not conform to the criteria in NUREG-0700.

### 3.6.2 Scope

The scope of the effort extends to the assessment of the labels and location aids in the main control room, ESP, and ASP at BVPS-2 using the applicable guidelines as stated in NUREG-0700. The topics evaluated include:

- Labeling of annunciator panels
- Color coding of labels
- Need for labeling
- Hierarchical labeling
- Placement of labels
- Mounting of labels
- Spatial orientation of labels
- Label visibility
- Label content
- Word selection
- Consistency
- Symbols
- Control position labeling
- Label readability
- Temporary labels
- Demarcation
- Mimics.

### 3.6.3 Criteria

The criteria applied in this survey, identified by NUREG-0700 paragraph number, are: paragraphs 6.3.3.3c(1) through (3); 6.5.1.6a through e; 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 b; 6.6.3.2a through f; 6.6.3.3b and c; 6.6.3.4a through

e; 6.6.3.5; 6.6.3.6, 6.6.3.7a and b; 6.6.3.8a through c; 6.6.3.9a and b; 6.6.4.1a and b; 6.6.4.2a through d; 6.6.5.1a through h; 6.6.5.2a and b; 6.6.6.2a through c; 6.6.6.3; 6.6.6.4a through c; and 6.8.3.2d.

The detailed definitions for each criterion are presented in Table 3.6.

3.6.4 Method

3.6.4.1 Data Collection

a. Data were collected using the checklists from the Labels and Location Aids Task Plan.

b. Data were collected primarily through review of the preliminary labeling list and direct observation of the control room labeling. When possible, measurements were made of the physical characteristics (e.g., character size and separation, height-to-width ratios, etc.) of the control room labels. For those guidelines related to consistency with operating procedures (e.g., 6.6.3.3.c), preliminary EOPs were reviewed.

c. Data were recorded on the appropriate data collection forms.

3.6.4.2 Analysis -- Data were analyzed according to the following procedure:

a. All deviations from the criteria were recorded on HED reports. Recorded information included the labels involved, a description of the problem including the NUREG-0700 paragraph number of the criteria, and a recommended solution.

b. The data collection method was also recorded on the HED form. Where data from two or more sources were contradictory, resolution of the conflict was achieved through data review and discussions with cognizant DLC personnel.

c. Upon completion of all analyses, the criteria of the labels task plan were annotated to indicate compliance or noncompliance with the criteria.

3.6.5 Findings

The findings of the labels and location aids survey are presented in Table 3-6 "Labels Survey Findings and HEDs Generated." Overall

115 criteria were applied to the labels and location aids in the BVPS-2 control room, ESP, and ASP. Since some features of the control room were not complete at the time of the survey, 34 (30%) of the criteria were unable to be assessed. These criteria included: 6.5.1.6e(3); 6.6.2.2a; 6.6.2.4d; 6.6.3.2f; 6.6.3.3c; 6.6.3.9b; 6.6.4.1a; 6.6.4.2a through d; 6.6.5.1a through h; 6.6.5.2a and b. Of the criteria assessed, 11 (10%) were not applicable, 49 (43%) were not violated, and 21 (18%) were violated. A total of 20 HEDs were generated which document all of the 21 criteria which were not met. In general, those HEDs address label content, lack of a hierarchical labeling scheme, nonstandard abbreviations, readability of labels, and lack of demarcation.

TABLE 3-6

LABELS SURVEY FINDINGS & HEDs GENERATED Page 1 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **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. | O | YES | | | |
| (2) Coordinate designation is preferred on the left and top sides of the annunciator panel. | O | NO | 2V**-2105 | 9 | Annunciators TP-3.1 |
| (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. | M | YES | | | |
| **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. | O | YES | | | |
| b. **NUMBER OF COLORS** | | | | | |
| (1) The number of colors used for coding should be kept to the minimum needed for providing sufficient information. | O | YES | | | |
| (2) The number of colors used for coding should not exceed 11. | O | YES | | | |
| c. **MEANING OF COLORS** | | | | | |
| (1) The meaning attached to a particular color should be narrowly defined. | O | YES | | | |

TABLE 3-6
LABELS SURVEY FINDINGS & HEDs GENERATED Page 2 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.5.1.6c. (Cont'd) | | | | | |
| (2) Red, green, amber (yellow) should be reserved for the following uses: | | | | | |
| Red: unsafe, danger, immed iate operator action required, or an indication that a critical parameter is out of tolerance. | O | YES | | | |
| Green: safe, no operator action required, or an indi-cation that a parameter is within tolerance. | O | YES | | | |
| Amber (yellow): hazard (potentially unsafe), caution, attention required, or an indi-cation that a marginal value or parameter exists. | O | YES | | | |
| 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. | O | YES | | | |
| 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. | O | YES | | | |

TABLE 3-6

LABELS SURVEY FINDINGS & HEDs GENERATED Page 3 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.5.1.6e. (Cont'd)** | | | | | |
| (2) Colors selected for coding should contrast well with the background on which they appear. | O | YES | | | |
| (3) Ambient lighting in the area 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. | UTA | UTA | | | Data not available |
| **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. | D | NO | 2***-1113 | 5 | Verif.. TP-9.2 |
| | | | 2***-1117 | 5 | Verif., TP-9.2 |
| **6.6.1.2 HIERARCHICAL SCHEME** | | | | | |
| To reduce confusion, operator search time, and redundancy, a hierarchical labeling should be used. (See Exhibit 6.6-1.) | O | NO | 2***-1103 | 5 | |
| **a. RANKING** | | | | | |
| (1) Major labels should be used to identify major systems or operator work stations. | O | NO | 2***-1103 | 5 | |
| (2) Subordinate labels should be used to identify subsystems or functional groups. | O | NO | 2***-1103 | 5 | |
| (3) Component labels should be used to identify each discrete panel or console element. | D | YES | | | |
| (4) Labels should not repeat information contained in higher-level labels. | N/A | N/A | | | No such equipment |

TABLE 3-6

LABELS SURVEY FINDINGS & HEDs GENERATED Page 4 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 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 | N/A | N/A | | | No hierarchial labels |
| (2) Subsystem/functional group labels which are about 25% larger than | N/A | N/A | | | |
| (3) Component labels which are about 25% larger than | N/A | N/A | | | |
| (4) Control position identifiers. | N/A | N/A | | | |
| **6.6.2.1 PLACEMENT** | | | | | |
| a. **NORMAL PLACEMENT** — Labels should be placed above the panel element(s) they describe. | O | NO | 2B**-1104<br>2ES*-1118 | 9<br>9 | |
| b. **PANEL LABELING** — The placement of labels on control panels should conform to the guidance shown in Exhibit 6.6-1. | N/A | N/A | | | No such labeling |
| c. **VISIBILITY ENHANCEMENT** — Labels of elements located above eye level should be positioned to ensure label visibility. | O | YES | | | |
| d. **PROXIMITY** — Labels should be placed close to the panel element. See Exhibit 6.6-2. | O | YES | | | |
| 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. | O | YES | | | |
| f. **ADJACENT LABELS** --Adjacent labels should be separated by sufficient space so that they are not read as one continuous label. See Exhibits 6.6-3 and 6.6-4. | O | YES | | | |

TABLE 3-6

LABELS SURVEY FINDINGS & HEDs GENERATED Page 5 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.6.2.2 MOUNTING** | | | | | |
| a. **INTEGRITY** — Label should be mounted in such a way as to preclude accidental removal. | UTA | UTA | | | Permanent labels not yet installed |
| b. **SURFACE** — Labels should be mounted on a flat surface. | O | YES | | | |
| **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. | O | YES | | | |
| (2) Although not normally recommended, vertical orientation may be used only where space is limited. | O | YES | | | |
| b. **CURVED PATTERNS** — Curved patterns of labeling should be avoided. See Exhibit 6.6-5. | O | YES | | | |
| **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. | O | YES | | | |
| b. **CONCEALMENT** — Labels should not be covered or obscured by other units in the equipment assembly. | O | YES | | | |
| c. **CONTROLS** — Labels should be visible to the operator during control actuation. | O | YES | | | |
| d. **CLEANING** — Administrative procedures should be in place for the periodic cleaning of labels. | UTA | UTA | | | |

TABLE 3-6
LABELS SURVEY FINDINGS & HEDs GENERATED Page 6 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.6.3.1 KINDS OF INFORMATION** | | | | | |
| a. **PRIMARY FUNCTION** — Labels should describe the function of equipment items. | O | NO | 2***-1115 | 7 | Validation, TP-9.2 |
| b. **SECONDARY FUNCTION** --If needed for clarity, engineering characteristics or nomenclature may also be described. | O | YES | | | |
| **6.6.3.2 WORD SELECTION** | | | | | |
| a. **INTENDED ACTION** --The words employed in the label should express exactly what action is intended. | D | NO | 2***-1115<br>2VB2-2404<br>2BA4-3016 | 7<br>8<br>8 | Valid., TP-9.2<br>Valid., TP-9.2<br>Valid., TP-9.2 |
| b. **CLARITY** — Instructions should be clear. | D | YES | | | |
| c. **DIRECT** — Instructions should be direct. | D | YES | | | |
| d. **MEANING** — Words should be used that have a commonly accepted meaning for all intended users. | D | YES | | | |
| e. **TECHNICAL TERMS** — Unusual technical terms should be avoided. | D | YES | | | |
| f. **SPELLING** — Words should be correctly spelled. | UTA | UTA | | | Permanent labels not yet installed |
| **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. | O | NO | 2***-1111 | 8 | Conventions, TP-8.1 |

TABLE 3-6

LABELS SURVEY FINDINGS & HEDs GENERATED Page 7 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.6.3.3 (Cont'd) | | | | | |
| c. **CONSISTENCY WITH PROCEDURES** — There should be no mismatch between nomenclature used in procedures and that printed on the labels. | D | YES | | | Procedures to use standarized MCB nomen. |
| **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., %). | O | YES | | | |
| b. **DISTINGUISHABILITY** — Symbols should be unique and distinguishable from each other. | O | YES | | | |
| c. **STANDARD** — A commonly accepted standard configuration should be used. | O | YES | | | |
| d. **CONSISTENCY** — Symbols should be consistently used within and across panels. | O | YES | | | |
| e. **ROMAN NUMERALS** — Use of Roman numerals should be avoided. | O | YES | | | |
| **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. | O | YES | | | |
| **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. | O | NO | 2ES*-1120 | 6 | |

TABLE 3-6

LABELS SURVEY FINDINGS & HEDs GENERATED Page 8 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.6.3.7 FUNCTIONAL GROUPS** | | | | | |
| a. **FUNCTIONAL RELATIONSHIP** — Labels should be used to identify functionally grouped controls or displays. | O | NO | 2***-1105 | 5 | |
| b. **LOCATION** — Labels should be located above the functional groups they identify. | O | NO | 2***-1105 | 5 | |
| **6.6.3.8 CONTROL POSTION LABELING** | | | | | |
| a. **POSITION** — All discrete functional control positons should be identified. | O | YES | | | |
| b. **DIRECTION** — Direction of motion (increase, decrease) should be identified for continuous motion rotary controls. | O | YES | | | |
| c. **VISIBILITY** — Control position information should be visible to the operator during operation of the control. | O | NO | 2B**-3204 | 7 | |
| **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. | N/A | N/A | | | No such equipment |
| b. **DANGER, WARNING, AND SAFETY INSTRUCTION LABELS** — All danger, warning, and safety instruction labels should be in accordance with appropriate safety standards. | UTA | UTA | | | Permanent labels not yet installed |
| **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. | UTA | UTA | | | Permanent labels not yet installed |

TABLE 3-6
LABELS SURVEY FINDINGS & HEDs GENERATED Page 9 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.6.4.1a (Cont'd)** | | | | | |
| (2) Letter height should be identical for all labels within the same hierarchical level, based on the maximum viewing distance. | UTA | UTA | | | Permanent labels not yet installed |
| b. **CONTRAST** | | | | | |
| (1) To ensure adequate contrast and prevent loss of readability because of dirt, dark characters should be provided on a light background. | O | NO | 2***-1106 | 9 | |
| (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. | N/A | N/A | | | No such print |
| **6.6.4.2 STYLE (Exhibits 6.5-1 and 6.5-2)** | | | | | |
| a. **CHARACTER SELECTION** | | | | | |
| (1) Labels should be prepared in capital letters. | UTA | UTA | | | Permanent labels not yet installed |
| (2) The design of letters and numerals should be simple and without flourishes or serifs. | UTA | UTA | | | Permanent labels not yet installed |
| b. **CHARACTER WIDTH** | | | | | |
| (1) Letter width-to-height ratio should be between 1:1 and 3:5. | UTA | UTA | | | Permanent labels not yet installed |
| (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. | UTA | UTA | | | Permanent labels not yet installed |

TABLE 3-6
LABELS SURVEY FINDINGS & HEDs GENERATED Page 10 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.6.4.2 (Cont'd) | | | | | |
| c. **STROKE WIDTH** — Stroke width-to-character height ratio should be between 1:6 and 1:8. | UTA | UTA | | | Permanent labels not yet installed |
| d. **SPACING** | | | | | |
| (1) The minimum space between characters should be one stroke width. | UTA | UTA | | | Permanent labels not yet installed |
| (2) The minimum space between words should be one character width. | UTA | UTA | | | Permanent labels not yet installed |
| (3) The minimum space between lines should be one-half of the character height. | UTA | UTA | | | Permanent labels not yet installed |
| **6.6.5.1 USE OF TEMPORARY LABELS** | | | | | |
| a. **NECESSITY** — Temporary labels should be used only when necessary. | UTA | UTA | | | Data not available |
| b. **HUMAN FACTORS PRACTICES** — Temporary labels should conform to good human engineering principles. | UTA | UTA | | | Data not available |
| c. **VISIBILITY** — Temporary labels should not obscure prior permanent labels unless the old label is to be replaced. | UTA | UTA | | | Data not available |
| d. **IDENTIFICATION** — Tag-out labels should clearly identify out-of-service components and equipment. | UTA | UTA | | | Data not available |
| e. **MOUNTING** — Tag-outs should be securely affixed. | UTA | UTA | | | Data not available |
| f. **OBSCURATION** — Tag-outs should not obscure the label associated with the nonoperable device. | UTA | UTA | | | Data not available |
| g. **ACTIVATION** — Tag-outs should be designed to physically prevent actuation of a control. | UTA | UTA | | | Data not available |

TABLE 3-6

LABELS SURVEY FINDINGS & HEDs GENERATED 

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.6.5.1 (Cont'd) | | | | | |
| h. **ADJACENT DEVICES** — Tag-outs should not obscure any adjacent devices or their associated labels. | UTA | UTA | | | Data not available |
| **6.6.5.2 CONTROL OF TEMPORARY LABELS** | | | | | |
| a. **ADMINISTRATIVE PROCEDURES** — The use of temporary labels should be administratively controlled. | UTA | UTA | | | Administrative procedures not yet written |
| b. **REVIEW PROCEDURES** — A review procedure should be in place that will result in a determination of: | | | | | |
| (1) when temporary labels are needed; | UTA | UTA | | | Administrative procedures not yet written |
| (2) how they will be used; | UTA | UTA | | | Administrative procedures not yet written |
| (3) their content (given human engineering requirements); | UTA | UTA | | | Administrative procedures not yet written |
| (4) their installation; | UTA | UTA | | | Administrative procedures not yet written |
| (5) the impact of their use on other system equipment (e.g., annunciators, mimics); | UTA | UTA | | | Administrative procedures not yet written |
| (6) documentation requirements; | UTA | UTA | | | Administrative procedures not yet written |

TABLE 3-6

LABELS SURVEY FINDINGS & HEDs GENERATED Page 12 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.6.5.2b. (Cont'd)** | | | | | |
| (7) retraining requirements; | UTA | UTA | | | Administrative procedures not yet written |
| (8) their periodic review; and | UTA | UTA | | | Administrative procedures not yet written |
| (9) their removal. | UTA | UTA | | | Administrative procedures not yet written |
| **6.6.6.2 DEMARCATION (See Exhibit 6.8-1)** | | | | | |
| a. **USE** — Lines of demarcation can be used to: | O | NO | 2ES1-1119 | 6 | |
| | | | 2AB*-1121 | 7 | |
| (1) Enclose functionally related displays. | O | NO | 2***-1107 | 6 | |
| (2) Enclose functionally related controls. | O | NO | 2***-1108 | 6 | |
| (3) Group related controls and displays. | O | NO | 2***-1107 | 6 | |
| | | | 2***-1108 | 6 | |
| b. **CONTRAST** — Lines of demarcation should be visually distinctive from the panel background. | N/A | N/A | | | No demarcation lines |
| c. **PERMANENCE** — Lines of demarcation should be permanently attached. | N/A | N/A | | | No demarcation lines |

TABLE 3-6

LABELS SURVEY FINDINGS & HEDs GENERATED Page 13 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **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. | O | NO | 2***-1116 | 5 | Valid, TP-9.2 |
| **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. | O | YES | | | |
| (2) The mimic colors should be discriminably different from each other. | O | YES | | | |
| (3) There should be adequate contrast between the mimic colors and the panel. | O | YES | | | |
| (4) Mimic lines depicting flow of the same contents (e.g., steam, water, electricity) should be color coded the same throughout the control room. | O | YES | | | |
| (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. | O | YES | | | |
| b. **MIMIC LINES** | | | | | |
| (1) Differential line widths may be used to code flow paths (e.g., significance, volume, level). | N/A | N/A | | | Differential line widths not used |
| (2) Overlapping of mimic lines should be avoided. | O | YES | | | |
| (3) Flow directions should be clearly indicated by distinctive arrowheads. | O | YES | | | |

TABLE 3-6

LABELS SURVEY FINDINGS & HEDs GENERATED Page 14 of 14

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.6.6.4b (Cont'd)** | | | | | |
| (4) All mimic origin points should be labeled or begin at labeled components. | O | YES | | | |
| (5) All mimic destination or terminal points should be labeled or end at labeled components. | O | YES | | | |
| (6) Component representations on mimic lines should be identified. | O | YES | | | |
| c. **SYMBOLS** | | | | | |
| (1) Graphic symbols should be readily understood and commonly used. | O | YES | | | |
| (2) Symbols should be used consistently. | O | YES | | | |
| **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). | O | NO | 2***-1109 | 9 | |
| (2) Large matrices should be subdivided by appropriate demarcation. | O | NO | 2***-1110 | 9 | |

## 3.7 Computer System Survey

This section documents the results of the computer systems conducted in the main control room at BVPS-2. This review was conducted in accordance with the requirements of NUREG-0700, as specified in the BVPS-2 DCRDR Program Plan.

### 3.7.1 Objectives

The objectives of the computer systems survey were to:

a. Assess the degree to which the computer system in the control room conforms to the criteria in NUREG-0700.

b. Identify and document any features of the computer system that do not conform to the criteria in NUREG-0700.

### 3.7.2 Scope

The scope of the effort extends to the assessment of the computer systems design in the main control room at BVPS-2 using the applicable guidelines as stated in NUREG-0700. The scope consists of the following, although many of the topics could not be evaluated since many features of the control room computer system were not complete at the time of the survey.

- Software security
- Operator/computer dialogue
- Prompting and structuring
- Keyboards
- Computer function controls
- Other control devices
- Computer response time
- Access aids
- CRT display characteristics
- Symbol and character size
- Operator-display relationships
- Data presentation format
- Screen layout and structuring
- Messages
- Graphic coding and highlighting
- Multiple-page considerations
- Printer characteristics
- Alarm messages
- Graph and table requirements.

### 3.7.3 Criteria

The criteria applied in this survey, identified by NUREG-0700 paragraph number, are: paragraphs 6.5.1.6d(2), 6.7.1.1a through d, 6.7.1.2a through d, 6.7.1.3a through e, 6.7.1.4a through i, 6.7.1.5a through d, 6.7.1.6a through d, 6.7.1.7a and b, 6.7.1.8a

and b, 6.7.2.1a through h, 6.7.2.2a through g, 6.7.2.3a through f, 6.7.2.4a through q, 6.7.2.5a through n, 6.7.2.6a through l, 6.7.2.7a through m, 6.7.2.8a through e, 6.7.3.1a through f, 6.7.3.2a through f, 6.7.3.3a through d.

The detailed definitions for each criterion are presented in Table 3-7.

### 3.7.4 Method

#### 3.7.4.1 Data Collection

a. Data were collected using the checklists contained in the Computer System Task Plan. Data were collected primarily through measurement and review of system documentation, including hardware specifications.

b. All pertinent observations were recorded on the appropriate data forms.

3.7.4.2 Analysis -- Data were analyzed according to the following procedure:

a. All deviations from the criteria were recorded on HED reports. Recorded information included the items involved, a description of the problem including the NUREG-0700 paragraph number of the criteria, and a recommended solution.

b. The data collection method was also recorded on the HED form. Where data from two or more sources were contradictory, resolution of the conflict was achieved through data review and discussions with cognizant plant personnel.

c. Upon completion of all analyses, the criteria of the computer system task plan were annotated to indicate compliance or noncompliance with the criteria.

### 3.7.5 Findings

The findings of the computer systems survey are presented in Table 3.7 "Computer Survey Findings and HEDs Generated." Overall, 228 criteria were applied to the computer system in the BVPS-2 control room. Since many features of the control room computer system were not complete at the time of the survey the vast majority of criteria, 212 (93%) were unable to be assessed. These criteria included: 6.5.1.6d(2), 6.7.1.1a through d, 6.7.1.2a through d, 6.7.1.3a through e, 6.7.1.4a c, d, e(1) and (2), f, h, and i, 6.7.1.5a through d, 6.7.1.6a through d,

6.7.1.7a and b, 6.7.1.8a and b, 6.7.2.1a and d through h, 6.7.2.2a, b(1) and c through g, 6.7.2.4a through q, 6.7.2.5a through n, 6.7.2.6a and b, 6.7.2.7a through m, 6.7.2.8a through e, 6.7.3.1a(2) through f, 6.7.3.2a through f, 6.7.3.3a through d. Of the criteria assessed, 14 (6%) were not violated, and 2 (1%) were violated. A total of 2 HEDs were generated which document the 2 criteria which were not met.

TABLE 3-7

COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 1 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.5.1.6 COLOR CODING** | | | | | |
| d. **CONSISTENCY OF MEANING** | | | | | |
| (2) The meaning of a particular color should remain the same whether applied to panel surfaces or projected in signal lights or on CRTs. | UTA | UTA | | | Data not available |
| **6.7.1.1 SOFTWARE SECURITY** | | | | | |
| a. **AUTHORIZATION** — The system should include positive protection provisions to ensure that only properly authorized personnel can make changes (by entry, deletion, or alteration). | UTA | UTA | | | Data not available |
| b. **SECURE STORAGE** — At least one copy of the current operating software should be stored in a secure remote location. | UTA | UTA | | | Data not available |
| c. **EDITING** — When characters, words, or phrases are to be inserted, such items should first be collected and displayed on a buffer area of the screen, and then collectively inserted by one operator command. | UTA | UTA | | | Data not available |
| d. **ACKNOWLEDGEMENT** — Before any operator requests are processed that would result in permanent changes to existing data, the computer system should require operator acknowledgement. | UTA | UTA | | | Data not available |
| **6.7.1.2 OPERATOR/COMPUTER DIALOGUE** | | | | | |
| a. **LANGUAGE CHARACTERISTICS** | | | | | |
| (1) Dialogue should be based on the operator's point of view, not the programmer's. | UTA | UTA | | | Data not available |
| (2) Dialogue should be logical. | UTA | UTA | | | Data not available |
| (3) Dialogue should be used in a consistent manner. | UTA | UTA | | | Data not available |

TABLE 3-7

COMPUTER SURVEY FINDINGS & HEDs GENERATED 

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.7.1.2a (Cont'd)** | | | | | |
| (4) Dialogue should reflect the vocabulary and syntax of the expected user population. | UTA | UTA | | | Data not available |
| (5) Input words (e.g., keywords) should approximate real words. | UTA | UTA | | | Data not available |
| (6) Dialogue should require an explicit command in order to terminate an interaction. | UTA | UTA | | | Data not available |
| b. **ENTRY LENGTH** — Individual input words which must be typed should not exceed 7 characters. | UTA | UTA | | | Data not available |
| c. **ABBREVIATIONS** | | | | | |
| (1) Abbreviations should be used whenever possible to minimize operator input requirements. | UTA | UTA | | | Data not available |
| (2) If the operator is using a synonym or abbreviation for a system command name, the computer system should use the same synonym or abbreviation when referring to that command in messages, prompts, etc., to the operator. | UTA | UTA | | | Data not available |
| (3) The use of abbreviations or contractions for output text should be avoided. | UTA | UTA | | | Data not available |
| d. **ERROR AVOIDANCE** — Operator inputs, responses, or actions which could significantly degrade computer system or plant performance should not be dependent on a single keystroke. | UTA | UTA | | | Data not available |
| **6.7.1.3 PROMPTING AND STRUCTURING** | | | | | |
| a. **OPERATOR REQUESTS** — The computer system should contain prompting and structuring features by which an operator can request additional information. | UTA | UTA | | | Data not available |

TABLE 3-7

COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 3 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.7.1.3a (Cont'd) | | | | | |
| b. **CORRECTION OF DATA** — The computer system should contain prompting and structuring features by which an operator can request corrected information when an error is detected. | UTA | UTA | | | Data not available |
| c. **MODE/FILE DISPLAY** — The computer system should display the mode designation and the file(s) being processed. | UTA | UTA | | | Data not available |
| d. **SPECIFIC ERROR CORRECTION** — The computer system should permit correction of individual errors without requiring re-entry of correctly entered data. | UTA | UTA | | | Data not available |
| e. **ENTRY FILE** — The computer system should contain a sequential file of operator entries, available upon operator request. | UTA | UTA | | | Data not available |
| **6.7.1.4 DATA ENTRY — KEYBOARDS** | | | | | |
| a. **ALPHANUMERIC KEYBOARD ARRANGEMENT** — Keyboards that combine alphabetic and numeric functions on a single keyboard should conform to the standard "QWERTY" arrangement. See Exhibit 6.7.-1. | UTA | UTA | | | Data not available |
| b. **NUMERIC KEYBOARD ARRANGEMENT** — The configuration of a keyboard used to enter solely numeric data should be a 3x3+1 matrix, either "telephone" style or "calculator" style. see Exhibit 6.7-2. | D | YES | | | |
| c. **USE OF MULTIPLE KEYBOARDS** — If there is more than one computer system keyboard in a control room, the alphanumeric and/or numeric-only key configuration should be the same in all cases. | UTA | UTA | | | Data not available |
| d. **KEY MEASUREMENTS** — To maximize the effectiveness of keyboards, key dimensions and separation should be as illustrated (see Exhibit 6.7-3). | UTA | UTA | | | Data not available |

TABLE 3-7
COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 4 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.7.1.4 (Cont'd) | | | | | |
| e. **KEY DISPLACEMENT AND RESISTANCE** — To provide positive key movement feedback to the operator, and to reduce inadvertent activation of keys, | | | | | Data not available |
| (1) Key displacement should be as shown in Exhibit 6.7-4. | UTA | UTA | | | Data not available |
| (2) Key resistance should be as shown in Exhibit 6.7-4. | UTA | UTA | | | Data not available |
| f. **POSITIVE INDICATION** — To provide positive key actuation feedback to the operator, a definite indication should be provided (e.g., snap, feel, audible click, release of resistance). | UTA | UTA | | | Data not available |
| g. **KEYBOARD SLOPE** — Keyboards should have a slope between 15° and 25° from the horizontal (see Exhibit 6.7-5). | M D | NO | 2C1C-0301 | 9 | |
| h. **VISUAL FEEDBACK** — Data being entered via keyboards should be displayed as it is keyed. | UTA | UTA | | | Data not available |
| i. **RELEVANT KEYS** — The presence of nonrelevant keys, such as those that might be used by programmer personnel, adds to keyboard complexity and induces operator errors. Control room keyboards should contain only those keys which are used by operators. | UTA | UTA | | | Data not available |
| **6.7.1.5 COMPUTER FUNCTION CONTROLS** | | | | | |
| a. **CONTROL DESIGN** — When dedicated controls are used for selection of computer or display functions or modes, the design of the controls should conform to the appropriate guidelines specified in Section 6.4, Controls. | UTA | UTA | | | Data not available |

TABLE 3-7

COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 5 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.7.1.5 (Cont'd) | | | | | |
| b. **LABELING AND NOMENCLATURE** – Terms, nomenclature, and abbreviations used on function controls should be the same as or consistent with the terms, nomenclature, and abbreviations of the computer function which is selected or displayed. | UTA | UTA | | | Data not available |
| c. **MASTER CONTROL** — When CRTs are subject to operation by centrally located master controls, a positive indication should be provided: | UTA | UTA | | | Data not available |
| (1) At the master-control location to identify those displays under local or master control. | UTA | UTA | | | Data not available |
| (2) At the individual CRT to indicate whether the display is under master or local control. | UTA | UTA | | | Data not available |
| d. **FUNCTION CONTROLS** | | | | | |
| (1) When dedicated controls are used to initiate/activate functions, the keys should be grouped together. | UTA | UTA | | | Data not available |
| (2) Function controls should be easily distinguished from other types of keys on the computer console. | UTA | UTA | | | Data not available |
| (3) Each function control should be clearly labeled to indicate its function to the operator. | UTA | UTA | | | Data not available |
| (4) If multiple computer consoles exist in the control room, the design and layout of the function controls should be consistent for all consoles. | UTA | UTA | | | Data not available |

TABLE 3-7
COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 6 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.7.1.5d (Cont'd)** | | | | | |
| (5) When function keys are included with an alphanumeric keyboard, the function keys should be physically separate. (Avoid multiple-mode keyboards which utilize the same keys for both alphanumerics and functions by using "shift" keys or mode selection controls.) | UTA | UTA | | | Data not available |
| **6.7.1.6 OTHER CONTROL DEVICES** | | | | | |
| a. **LOCATION** — The control devices should be operable from the location where the operator is most likely to need to interact with the computer (e.g., keyboard, computer console, display screen). | UTA | UTA | | | Data not available |
| b. **SPEED** — The control device should provide rapid positioning of cursors or selection of choices. | UTA | UTA | | | Data not available |
| c. **ACCURACY** — Device or method accuracy should be commensurate with the functions to be served. | UTA | UTA | | | Data not available |
| d. **DISPLACEMENT** — Control design should allow the operator freedom of movement to perform other duties. | UTA | UTA | | | Data not available |
| **6.7.1.7 COMPUTER RESPONSE TIME TO OPERATOR QUERIES** | | | | | |
| a. **MAXIMIZE RESPONSE TIMES** — The computer system should provide the correct response to each type of query within the recommended response times listed in Exhibit 6.7-6. | UTA | UTA | | | Data not available |
| b. **RESPONSE DELAY MESSAGES** — When response time for any query exceeds 3 seconds, a delay message should be presented to maintain the operator's attention and to confirm normal computer operation. (See also Guideline 6.7.2.6.) | UTA | UTA | | | Data not available |

TABLE 3-7

COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 7 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.7.1.8 ACCESS AIDS** | | | | | |
| **a. COMPUTER SYSTEM PROCEDURES** | | | | | |
| (1) A compute set of computer system operating procedures and contingency procedures should be available in the control room. | UTA | UTA | | | Data not available |
| (2) Procedures should be prepared from the point of view of the control room operator. | UTA | UTA | | | Data not available |
| (3) Procedures should be in hardcopy form as a minimum. | UTA | UTA | | | Data not available |
| (4) Operating procedures should describe: | | | | | |
| (a) The overall computer system. | UTA | UTA | | | Data not available |
| (b) The computer system components with which the operator can interface. | UTA | UTA | | | Data not available |
| (c) The specific procedures necessary to accomplish all of the operator-computer interface functions. | UTA | UTA | | | Data not available |
| (5) Contingency procedures should describe: | | | | | |
| (a) Indications available to the operator which identify failure or malfunctioning of the computer system. | UTA | UTA | | | Data not available |
| (b) Necessary actions to be performed by the operator if the computer fails or malfunctions. | UTA | UTA | | | Data not available |

TABLE 3-7
COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 8 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.7.1.8 (Cont'd) | | | | | |
| b. **DATA POINT INDICES** | | | | | |
| (1) The specific codes, or addresses, by which data displays can be called up by an operator should be cross-indexed by: | | | | | |
| (a) Alphanumeric or numeric code | UTA | UTA | | | Data not available |
| (b) Program name | UTA | UTA | | | Data not available |
| (c) System/subsystem identification | UTA | UTA | | | Data not available |
| (d) Functional group identification. | UTA | UTA | | | Data not available |
| (2) Cross-indices should be available in the control room in hardcopy form as a minimum. | UTA | UTA | | | Data not available |
| **6.7.2.1 CRT DISPLAY CHARACTERISTICS** | | | | | |
| a. **READABILITY** — Alphanumeric and graphic characters should be easily readable by the operator under all control room lighting conditions. | UTA | UTA | | | Data not available |
| b. **REFLECTED GLARE** — CRT screens should be installed to minimize or eliminate reflected glare at normal operator viewing angles. | UTA | UTA | | | Data not available |
| c. **SCREEN LUMINANCE** | | | | | |
| (1) Ambient illumination should contribute no more than 25% to screen luminance through diffuse reflection and phosphor excitation. | UTA | UTA | | | Data not available |
| (2) When ambient illumination in the vicinity of the CRT is in the medium to high range (see Guideline 6.1.5.3), the CRT should use dark characters and symbols on a light background. | UTA | UTA | | | Data not available |

TABLE 3-7
COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 9 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.7.2.1c (Cont'd) | | | | | |
| (3) When the CRT uses dark characters on a light background, the screen background luminance should be 23 foot-Lamberts (ft-L) minimum and 46 ft-L preferred. | UTA | UTA | | | Data not available |
| (4) When the CRT uses light characters on a dark background, the character luminance should be 23 ft-L minimum and 46 ft-L preferred. | UTA | UTA | | | Data not available |
| d. **LUMINANCE CONTRAST** | | | | | |
| (1) Contract between light characters and a dark screen background should be 15:1 minimum and 20:1 preferred. | UTA | UTA | | | Data not available |
| (2) Contrast between dark characters and a light screen background should be 1:15 minimum and 1:20 preferred. | UTA | UTA | | | Data not available |
| e. **GEOMETRIC DISTORTION** — The cumulative effects of all geometric distortion should not displace any point within the viewable area of the screen from its correct position by more than 5% of picture height. | UTA | UTA | | | Data not available |
| f. **RESOLUTION** — Discrimination of fine detail is a function of the number of scan lines or addressable points ("resolution elements") per unit length. | | | | | |
| (1) CRTs for displaying simple alphanumeric text should have a minimum of 20 resolution elements per inch. | UTA | UTA | | | Data not available |
| (2) CRTs for displaying complex symbols and graphic detail should have a minimum of 100 resolution elements per inch. | UTA | UTA | | | Data not available |

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COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 10 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.7.2.1f (Cont'd)** | | | | | |
| (3) Complex symbols which must be distinguished from other complex shapes should have a minimum of 10 resolution elements for the longest dimension of the symbol. | UTA | UTA | | | Data not available |
| (4) Alphanumeric characters should have a minimum of 10 resolution elements per character height. | UTA | UTA | | | Data not available |
| g. **REGENERATION RATE** — The regeneration rate for a particular CRT display should be above the critical frequency at fusion so that the occurrence of disturbing flicker is not perceptible. | UTA | UTA | | | Data not available |
| h. **CRT DISPLAY CONTROLS** | | | | | |
| (1) Parameters such as luminance (brightness), contrast, and color should be adjustable by the control room operator. | UTA | UTA | | | Data not available |
| (2) Adjustment controls should conform to the appropriate guidelines in Section 6.4, Controls, and Section 6.9, Control-Display Integration. | UTA | UTA | | | Data not available |
| **6.7.2.2 SYMBOLS AND CHARACTERS** | | | | | |
| a. **SYMBOL SIZE** — When a displayed symbol of complex shape is to be distinguished from another symbol shape that is also complex, the visual angle of the symbol should subtend not less than 20 minutes of arc at the required viewing distance. | UTA | UTA | | | Data not available |
| b. **ALPHANUMERIC CHARACTER SIZE** | | | | | |
| (1) The height of alphanumeric characters should have a visual angle of not less than 12 minutes of arc at the required viewing distance. | UTA | UTA | | | Data not available |

TABLE 3-7
COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 11 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.7.2.2b (Cont'd) | | | | | |
| (2) Alphanumeric characters should be uppercase letters. | D | YES | | | |
| c. **CHARACTER WIDTH-TO-HEIGHT RATIO** — The width-to-height ratio for alphanumerics should be between 3:5 and 1:1. | UTA | UTA | | | Data not available |
| d. **STROKE-WIDTH-TO-CHARACTER-HEIGHT RATIO** — Stroke-width-to-character-height ratio should be between 1:5 and 1:10. | UTA | UTA | | | Data not available |
| e. **GRAPHICS** — A graphic line will appear continuous if the separation between addressable points, or resolution elements, is less than one minute of arc. To provide the illusion of continuity, graphic lines should contain a minimum of 50 resolution elements per inch. | UTA | UTA | | | Data not available |
| f. **CHARACTER AND SYMBOL SEPARATION** | | | | | |
| (1) Horizontal separation between characters or symbols should be between 10% and 65% of character or symbol height. | UTA | UTA | | | Data not available |
| (2) Separation should be not less than 25% of character or symbol height when any of the following degraded conditions exists: | UTA | UTA | | | Data not available |
| (a) When character or symbol width is less than 85% of height; | UTA | UTA | | | Data not available |
| (b) When character or symbol luminance is less than 12 ft-L; | UTA | UTA | | | Data not available |
| (c) When luminance contrast is less than 88%; | UTA | UTA | | | Data not available |
| (d) When CRT screen location is greater than 35° to the left or right of the operator's straight-ahead line of sight; | UTA | UTA | | | Data not available |

TABLE 3-7
COMPUTER SURVEY FINDINGS & HED GENERATED Page 12 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.7.2.2f(2) (Cont'd)** | | | | | |
| (e) When the visual angle subtended by symbol height is less than 15 minutes of arc; | UTA | UTA | | | Data not available |
| (f) When the visual angle subtended by character height is less than 12 minutes of arc. | UTA | UTA | | | Data not available |
| **g. CHARACTER STYLE (FONT)** | | | | | |
| (1) Simple character fonts should be used, with no serifs, variable stroke widths, slanting, etc. | UTA | UTA | | | Data not available |
| (2) When dot-matrix characters are used, 7x9 dot-matrix should be used in preference to 5x7 dot-matrix. | UTA | UTA | | | Data not available |
| (3) Character styles such as Lincoln/ Mitre or Leroy should be used. | UTA | UTA | | | Data not available |
| **6.7.2.3 OPERATOR-DISPLAY RELATIONSHIPS** | | | | | |
| a. **VIEWING DISTANCE** — Viewing distance should be greater than 18 inches. | M | YES | | | |
| b. **VIEWING ANGLE** — The minimum angle between the operator's actual line-of-sight (LOS) as measured from the operator's normal work station, and the plane of the display screen should be 45° or greater in either the horizontal or vertical direction. See Exhibits 6.7-8 and 6.7-10. | M | NO | 2V**-1406 | 9 | Anthropometrics, TP-1.2 |
| c. **SCREEN LOCATION, SEATED OPERATORS** | | | | | |
| (1) CRT displays which require frequent or continuous monitoring, or which may display important (e.g., alarm) information, should be located within the following limits as measured from the normal operator work station (see Exhibit 6.7-9): | | | | | See next page |

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COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 13 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.7.2.3c (Cont'd)** | | | | | |
| (a) Horizontal limits — Not more than 35° to the left or right of the operator's straight-ahead LOS. | M | YES | | | |
| (b) Vertical limits — Not more than 20° above and 40° below the operator's horizontal LOS. | M | YES | | | |
| (2) CRT displays which do not require frequent or continuous monitoring, and which will not display important (e.g., alarm) information, should be located within the following limits (as measured from normal operator work stations which permit full operator head and eye rotation). See Exhibit 6.7-10): | | | | | |
| (a) Horizontal limits — Not more than 95° to the left or right of the operator's straight-ahead LOS. | M | YES | | | |
| (b) Vertical limits — Not more than 70° above and 90° below the operator's horizontal LOS. | M | YES | | | |
| d. **SCREEN LOCATION, STANDING OPERATORS** | | | | | |
| (1) CRT displays which require frequent or continuous monitoring, or which may display important (e.g., alarm) information, should be located within the following limits as measured from the normal operator work station: | | | | | |
| (a) Horizontal limits — Not more than 35° to the left or right of the operator's straight-ahead LOS. | M | YES | | | |
| (b) Vertical limits — Not more than 35° above and 25° below the operator's horizontal LOS. | M | YES | | | |

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| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.7.2.3d (Cont'd) | | | | | |
| (2) CRT displays which do not require frequent or continuous monitoring, and which will not display important (e.g., alarm) information, should be located within the following limits (as measured from normal operator work stations which permit full operator head and eye rotation): | | | | | |
| (a) Horizontal limits — Not more than 95° to the left or right of the operator's straight-ahead LOS. | M | YES | | | |
| (b) Vertical limits — Not more than 85° above and 90° below the operator's horizontal LOS. | M | YES | | | |
| e. **MOUNTING IN CONSOLES** — When CRTs are permanently mounted in consoles, the console configuration, dimensions, and type of use (such as seated, sit-stand, or standing) affects the CRT/operator interface. Consoles in which CRTs are installed should conform to the guidelines of Section 6.1.2. | M | YES | | | |
| f. **VISIBILITY OF DATA** — All data and messages on the CRT screen should be within the unobstructed view of an operator at the normal work station. | M | YES | | | |
| **6.7.2.4 DATA PRESENTATION FORMAT** | | | | | |
| a. **USABILITY OF DATA** | | | | | |
| (1) Data should be presented to the operator in a readily usable format. | UTA | UTA | | | Data not available |
| (2) There should be no requirement for transposing, computing, interpolating, or mentally translating displayed data into other units or numerical bases. | UTA | UTA | | | Data not available |

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COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 15 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.7.2.4 (Cont'd) | | | | | |
| b. **ILLUSTRATIONS** — Illustrations should be used whenever possible to supplement or explain text. | UTA | UTA | | | Data not available |
| c. **CHARACTER GROUPING** | | | | | |
| (1) When 5 or more digits and/or non-text alphanumerics are displayed, and no natural (i.e., population stereotyped) organization exists, characters should be grouped in blocks of 3 to 4 characters each. | UTA | UTA | | | Data not available |
| (2) Groups should be separated by a minimum of 1 blank character space. | UTA | UTA | | | Data not available |
| d. **MAINTENANCE OF ORDERING** — Elements in a data field should be displayed in logical order (e.g., chronological). | UTA | UTA | | | Data not available |
| e. **PRESENTATION OF IDENTICAL DATA** | | | | | |
| (1) The manner of presentation of identical data should be based on the uses to which the data will be put by the operator. | UTA | UTA | | | Data not available |
| (2) Within the limits of (1) above, identical data in different presentations should be displayed in a consistent, standardized manner. | UTA | UTA | | | Data not available |
| f. **MENU DESIGNATORS** | | | | | |
| (1) Numbers should be used as designators when listing selectable items. | UTA | UTA | | | Data not available |
| (2) Numerical designators should start with the number "1" (not zero). | UTA | UTA | | | Data not available |

TABLE 3-7

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| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 3.7.2.4f (Cont'd) | | | | | |
| (3) If the use of numbers as designators would create confusion because of other numbers which make up the item to be designated, alphabetic characters should be used. | UTA | UTA | | | Data not available |
| (4) When used, alphabetic designators should start with the letter "A." | UTA | UTA | | | Data not available |
| g. **LISTS** | | | | | |
| (1) Lists should be vertically aligned and left-justified. | UTA | UTA | | | Data not available |
| (2) Indentation should be used for subclassifications. | UTA | UTA | | | Data not available |
| h. **TABLES AND GRAPHS** — Quantitative data which must be scanned and compared should be presented in either tabular or graphic form. | UTA | UTA | | | Data not available |
| i. **HYPHENATION** — The use of hyphenation should be minimized. | UTA | UTA | | | Data not available |
| j. **ALIGNMENT** | | | | | |
| (1) When presented in tabular form, alphanumeric data should be left-justified. | UTA | UTA | | | Data not available |
| (2) When presented in tabular form, numeric data should be right-justified with decimal points aligned. | UTA | UTA | | | Data not available |
| k. **PERIODS** — Periods should be placed after item selection designators and at the end of a sentence. | UTA | UTA | | | Data not available |

TABLE 3-7
COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 17 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.7.2.4 (Cont'd) | | | | | |
| l. **STANDARDIZED FIELDS** — The following standardized fields should be used: | | | | | |
| (1) Telephone Number: (914)555-1212 | UTA | UTA | | | Data not available |
| (2) Time: HH:MM:SS, HH:MM, MM:SS:(.S) | UTA | UTA | | | Data not available |
| (3) Date: MM:DD:YY. | UTA | UTA | | | Data not available |
| m. **DATA GROUP LABELING** | | | | | |
| (1) Each individual data group or message should have a descriptive title. | UTA | UTA | | | Data not available |
| (2) Labels should reflect some unique characteristic of the content of the data group or message. | UTA | UTA | | | Data not available |
| n. **LABEL PLACEMENT** — Labels should be located in a consistent manner either above or to the left of the data group or message they describe. | UTA | UTA | | | Data not available |
| o. **LABEL ORIENTATION** — Labels should be oriented horizontally. | UTA | UTA | | | Data not available |
| p. **LABEL HIGHLIGHTING** | | | | | |
| (1) Labels should be highlighted or otherwise accentuated to facilitate operator scanning and recognition. | UTA | UTA | | | Data not available |
| (2) The technique used to highlight labels should be easily distinguished from that used to highlight emergency or critical messages. | UTA | UTA | | | Data not available |
| q. **OPTION LABELS** — When presenting a list of operator options, the label should reflect the question or choices being posed to the operator. | UTA | UTA | | | Data not available |

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| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.7.2.5 SCREEN LAYOUT AND STRUCTURING** | | | | | |
| a. **ORGANIZATION OF DATA** | | | | | |
| (1) Displayed data should be organized in a logical, consistent manner. | UTA | UTA | | | Data not available |
| (2) Displayed data should reflect some obvious and inherent quality of the data groups (e.g., hierarchical, sequential, or mimic relationships). | UTA | UTA | | | Data not available |
| b. **LOCATION OF DATA GROUPS** — Physical location of specific data groups (e.g., alarms, menus) on the screen should be consistent. | UTA | UTA | | | Data not available |
| c. **DEMARCATION OF DATA SUBGROUPS** — Organization and separation of information subgroups should be made apparent to the operator through the use of blank spaces, lines, or some other form of visible demarcation. | UTA | UTA | | | Data not available |
| d. **USE FREQUENCY RANKING** — Lists of options should be organized according to the probability of selection for each item, with high probability items presented first. | UTA | UTA | | | Data not available |
| e. **ALPHANUMERIC RANKING** — Non-option lists of equal-probability options should be presented in alphabetical or numerical order. | UTA | UTA | | | Data not available |
| f. **SEPARATION OF PARAGRAPHS** — Paragraphs in continuous text should be separated by at least one blank line. | UTA | UTA | | | Data not available |
| g. **SELECTION DESIGNATORS** — Selection designators in menus should be separated from text descriptors by at least one blank space. | UTA | UTA | | | Data not available |

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| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.7.2.5 (Cont'd) | | | | | |
| h. **PAGE DESIGNATION** — When data are contained on multiple pages, each page should display both page number and total number of pages. | UTA | UTA | | | Data not available |
| i. **CONTINUOUS NUMBERING** — Items contained in a numbered list and described on "continue" pages should be numbered relative to the first number on the first page of the list. | UTA | UTA | | | Data not available |
| j. **PLACEMENT OF INSTRUCTIONS** — When directions to the operator accompany a list of options, such directions should precede presentation of the list. | UTA | UTA | | | Data not available |
| k. **URGENT MESSAGES** | | | | | |
| (1) Urgent messages requiring immediate operator response should be highlighted to attract the operator's attention. | UTA | UTA | | | Data not available |
| (2) Urgent messages should always be displayed in the same location. | UTA | UTA | | | Data not available |
| l. **USE OF CURSOR** — In systems in which selection is made by use of a cursor, formats should be organized to minimize positioning movements of the cursor. | UTA | UTA | | | Data not available |
| m. **SCREEN LOADING** — The amount of information-bearing activated screen area should not exceed 25% of the total screen area. This does not include demarcation lines used to separate groups of data. | UTA | UTA | | | Data not available |

TABLE 3-7
COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 20 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.7.2.5 (Cont'd) | | | | | |
| n. **TREND PLOT SCALES** — CRT displayed trend plot scales should be consistent with the intended functional use of the data. (For example, the monitoring of neutron flux at reactor trip may have a variable scale of 0% to 1% of the design value and a time scale resolution of seconds. However, post-trip monitoring may have a variable scale of 0% to 10% with a time scale resolution of minutes. Finally, operational log data of neutron flux may have a time scale resolution of hours.) | UTA | UTA | | | Data not available |
| 6.7.2.6 **MESSAGES** | | | | | |
| a. **MESSAGES, GENERAL** | | | | | |
| (1) Messages should be concise. | UTA | UTA | | | Data not available |
| (2) Messages should provide the operator with the information necessary to complete a specific action or decision sequence. | UTA | UTA | | | Data not available |
| b. **MESSAGE CONTENT** — Information contained in messages should be necessary, complete, and readily usable. | UTA | UTA | | | Data not available |
| c. **USE OF PROMPTS** — Prompts should be displayed whenever the operator may need directions or guidance to initiate or complete an action or sequence of actions. | UTA | UTA | | | Data not available |
| d. **CONTENT OF PROMPTS** — Prompts should contain clear and specific cues and instructions which are relevant to the action to be taken. | UTA | UTA | | | Data not available |
| e. **PROMPT INFORMATION SEQUENCE** — Directions should be placed in the sequence to be used by the operator. | UTA | UTA | | | Data not available |

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COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 21 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.7.2.6 (Cont'd) | | | | | |
| f. **USE OF ERROR MESSAGES** — Whenever an operator error or invalid input is detected, an error message should be displayed. | UTA | UTA | | | Data not available |
| g. **ERROR CORRECTION GUIDANCE** — Error messages should contain instructions to the operator regarding required corrective action. | UTA | UTA | | | Data not available |
| h. **ERROR CORRECTION EASE** — Capability should be provided for operator correction of individual errors without affecting adjacent valid entries. | UTA | UTA | | | Data not available |
| i. **SYSTEM STATUS FEEDBACK MESSAGES** — Feedback messages should be provided to the operator to indicate changes in the status of system functioning. | UTA | UTA | | | Data not available |
| j. **SELECTION FEEDBACK** — When a displayed message or datum is selected as an option or input to the system, the subject item should be highlighted, or otherwise positively identified, to indicate acknowledgement by the system. | UTA | UTA | | | Data not available |
| k. **DELAY FEEDBACK** — When system functioning requires the operator to stand by, such as when the computer is searching for requested data, periodic feedback should be provided to the operator to indicate normal system operation and the reason for the delay. | UTA | UTA | | | Data not available |
| l. **ACTIVITY COMPLETION FEEDBACK** — When a process or sequence is completed by the system, positive indication should be presented to the operator concerning the outcome of the process and requirements for subsequent operator actions. | UTA | UTA | | | Data not available |

TABLE 3-7

COMPUTER SURVEY FINDINGS & HEDs GENERATED 

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.7.2.7 GRAPHIC CODING AND HIGHLIGHTING** | | | | | |
| a. **USE OF HIGHLIGHTING** — Highlighting should be used to attract the operator's attention to any displayed data item or message which is important to decision-making or action requirements. | UTA | UTA | | | Data not available |
| b. **CONSISTENT APPROACH** | | | | | |
| (1) Highlighting methods which have information value beyond their attention-getting quality should have the same meaning in all applications. | UTA | UTA | | | Data not available |
| (2) Highlighting methods associated with emergency conditions should not also be used in association with normal conditions. | UTA | UTA | | | Data not available |
| c. **CONTRAST ENHANCEMENT** — When contrast enhancement (i.e., increased illumination intensity level) is used for highlighting, not more than two (preferable) or three (maximum) brightness levels should be used in a single presentation. | UTA | UTA | | | Data not available |
| d. **FLICKER OR BLINKING** — Blinking of a symbol or message (e.g., ON-OFF or alternating high-low brightness) for purposes of highlighting should be reserved for emergency conditions or similar situations requiring immediate operator action. | UTA | UTA | | | Data not available |
| e. **BLINK RATES** | | | | | |
| (1) When blinking is used for high-lighting, a maximum of 2 blink rates should be used. | UTA | UTA | | | Data not available |
| (2) When a single blank rate is used, the rate should approximate 2 to 3 "blinks" per second with a minimum of 50 msec "on" time between blinks. | UTA | UTA | | | Data not available |

TABLE 3-7

COMPUTER SURVEY FINDINGS & HEDs GENERATED 

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.7.2.7e (Cont'd) | | | | | |
| (3) When 2 blink rates are used, the fast blink should approximate 4 per second and the slow blink should approximate 1 per second. | UTA | UTA | | | Data not available |
| (4) When 2 blink rates are used, the "on-off" ratio should approximate 50%. | UTA | UTA | | | Data not available |
| (5) When 2 blink rates are used, the higher rate should apply to the most critical information. | UTA | UTA | | | Data not available |
| f. **INVERSE VIDEO** — Image reversal (e.g., dark characters on a light background) should be used primarily for highlighting in dense data fields, such as a word or phrase in a paragraph of text, or a set of characters in a table of data. | UTA | UTA | | | Data not available |
| g. **USE OF GRAPHIC CODING** — Graphic coding methods (e.g., symbols, boxes, underlines, colors) should be used to present standard qualitative information to the operator or to draw the operator's attention to a particular portion of the display. | UTA | UTA | | | Data not available |
| h. **GRAPHIC CODE CONSISTENCY** — Graphic codes, used separately or in combination, should have the same meaning in all applications. | UTA | UTA | | | Data not available |
| i. **GEOMETRIC SHAPE CODING** — When geometric shape (symbol) coding is used, the basic symbols should vary widely in shape. | UTA | UTA | | | Data not available |
| j. **NUMBER OF SYMBOLS** | | | | | |
| (1) The number of basic symbols used for coding should be kept small. | UTA | UTA | | | Data not available |
| (2) The upper limit under optimum display conditions should be 20. | UTA | UTA | | | Data not available |

TABLE 3-7

COMPUTER SURVEY FINDINGS & HEDs GENERATED 

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.7.2.7j (Cont'd)** | | | | | |
| (3) The upper limit under adverse display conditions should be 6. | UTA | UTA | | | Data not available |
| (4) When needed, other highlighting and graphic techniques (color, filled versus unfilled, and other "modifiers") should be used to display different states or qualities of a basic symbol. | UTA | UTA | | | Data not available |
| k. **USE OF COLOR** — (Exhibit 6.7-11) | | | | | |
| (1) Colors used on the CRT to convey information should be consistent in use and meaning with all other color codes in the control room. | UTA | UTA | | | Data not available |
| (2) Once colors are assigned a specific use or meaning, no other color should be used for the same purpose. | UTA | UTA | | | Data not available |
| l. **COLOR MEANINGS** — When color is used, the meaning of the colors should, where applicable, equate with the commonly understood meaning of those colors. The following specific meanings for selected colors should apply when these colors are used in CRT displays: | UTA | UTA | | | Data not available |
| (1) Red — Unsafe condition, danger, immediate operator action required, or critical parameter value out of tolerance. | UTA | UTA | | | Data not available |
| (2) Green — Safe condition, no operator action required, or parameter value is within tolerance. | UTA | UTA | | | Data not available |
| (3) Yellow/Amber — Hazard, potentially unsafe, caution, attention required; marginal parameter value exists. | UTA | UTA | | | Data not available |

TABLE 3-7
COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 25 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.7.2.7 (Cont'd) | | | | | |
| m. **RED-GREEN COMBINATIONS** | | | | | |
| (1) Whenever possible, red and green colors should not be used in combination. | UTA | UTA | | | Data not available |
| (2) Use of red symbols/characters on a green background should especially be avoided. | UTA | UTA | | | Data not available |
| **6.7.2.8 MULTIPLE-PAGE CONSIDERATIONS** | | | | | |
| a. **OPERATOR MEMORY** | | | | | |
| (1) Page design and content planning should minimize requirements for operator memory. | UTA | UTA | | | Data not available |
| (2) All data relevant to a specific operator entry should be displayed on a single page. | UTA | UTA | | | Data not available |
| b. **AUDIT TRAIL** — When pages are organized in a hierarchical fashion, containing a number of different paths through the series, a visual audit trail of the choices should be available upon operator request. | UTA | UTA | | | Data not available |
| c. **LOCATION REFERENCES** | | | | | |
| (1) When the operator is required to scroll or pan on a large logical frame, location references should be provided in the viewable portion of the frame. (For example, when scrolling a list, ony part of which is visible at any one time, the present and maximum location should be shown.) | UTA | UTA | | | Data not available |
| (2) Sectional coordinates should be used when large schematics must be panned or magnified. | UTA | UTA | | | Data not available |

TABLE 3-7
COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 26 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.7.2.8 (Cont'd) | | | | | |
| d. **OPERATOR CONTROL** — The operator should have some capability for controlling the amount, format, and complexity of information (e.g., core dumps, program outputs, error messages) being displayed by the system. | UTA | UTA | | | Data not available |
| e. **LOCATION CONSISTENCY** — If the message is a variable option list, common elements should maintain their physical relationship to other recurring elements. | UTA | UTA | | | Data not available |
| **6.7.3.1 PRINTER CHARACTERISTICS** | | | | | |
| a. **PRINTER APPLICATIONS** | | | | | |
| (1) Printers should be part of the process computer system and be located in the primary operating area. | D | YES | | | Data not available |
| (2) Control room printers should provide the capability to record alarm data, trend data, and plant status data. | UTA | UTA | | | Data not available |
| b. **DISPLAY COPIES** | | | | | |
| (1) The system should, if possible, be designed to provide hardcopy of any page appearing on the CRT at the request of the operator. | UTA | UTA | | | Data not available |
| (2) If the copy will be printed remote to the operator, a print confirmation or denial message should be displayed. | UTA | UTA | | | Data not available |
| (3) Printer operation should not alter screen content. | UTA | UTA | | | Data not available |
| c. **FORM OF PRINTED INFORMATION** — Printed information should be presented in a directly usable form with minimal requirements for decoding, transposing, and interpolating. | UTA | UTA | | | Data not available |

TABLE 3-7
COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 27 of 29

| GUIDELINE | METHOD | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.7.3.1 (Cont'd) | | | | | |
| d. **PRINTER SPEED** — Printers used for recording trend data, computer alarms, and critical status information should have a high-speed printing capability of at least 300 lines a minute to permit printer output to keep up with computer output. | UTA | UTA | | | Data not available |
| e. **PRINTER OPERATION** — Paper, ribbons, and ink (if used) should be consistent with the following: | | | | | |
| (1) Hard-finish matte paper should be used to avoid smudged copy and glare. | UTA | UTA | | | Data not available |
| (2) There should be a positive indication of the remaining supply of recording materials. | UTA | UTA | | | Data not available |
| (3) Instructions for reloading paper, ribbon, ink, etc., should appear on an instruction plate attached to the printer. | UTA | UTA | | | Data not available |
| (4) When the printer is down during reloading, data and information which would normally be printed must not be lost. | UTA | UTA | | | Data not available |
| (5) A takeup device for printed materials should be provided which requires little or no operator attention and which has a capacity at lease equal to the feed supply. | UTA | UTA | | | Data not available |
| f. **PRINT COPY ACCESSIBILITY** — The following features should be provided to enhance operator accessibility of printed material: | | | | | |
| (1) Provisions should be made so that the operator can always read the most recently printed line. | UTA | UTA | | | Data not available |

TABLE 3-7

COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 28 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.7.3.1f (Cont'd)** | | | | | |
| (2) Printed material should have an adequate contrast ratio to ensure easy operator reading. | UTA | UTA | | | Data not available |
| (3) It should be possible to annotate the print copy while it is still in the machine. | UTA | UTA | | | Data not available |
| (4) The recorded matter should not be obscured, masked, or otherwise hidden in a manner which prevents direct reading of the material. | UTA | UTA | | | Data not available |
| **6.7.3.2 ALARM MESSAGES** | | | | | |
| a. **ALARM RECORDS** | | | | | |
| (1) A printer should be provided for recording alarm messages. | UTA | UTA | | | Data not available |
| (2) All annunciator alarms should be recorded. | UTA | UTA | | | Data not available |
| b. **ALARM SEQUENCE** — Alarm messages should be recorded in the sequence of their occurrence. | UTA | UTA | | | Data not available |
| c. **OPERATOR-REQUESTED PRINTOUT** — Provisions should be included to provide, upon operator request, printouts by alarm group (e.g., system, subsystem, component). | UTA | UTA | | | Data not available |
| d. **ALARM IDENTIFICATION** — Alarm messages should be readily distinguishable from other messages. | UTA | UTA | | | Data not available |
| e. **ALARM DISCRIMINATION** — Alarm messages should provide rapid identification of the nature of the alarm. | UTA | UTA | | | Data not available |
| f. **CONSISTENT TERMINOLOGY** — Wording in alarm messages should: | | | | | |
| (1) Clearly relate to the specific annunciator tile that is illuminated. | UTA | UTA | | | Data not available |

TABLE 3-7

COMPUTER SURVEY FINDINGS & HEDs GENERATED Page 29 of 29

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.7.3.2f (Cont'd) | | | | | |
| (2) Contain at least that information (i.e., wording) presented in the illuminated annunciator tile. | UTA | UTA | | | Data not available |
| (3) Provide additional specific data. | UTA | UTA | | | Data not available |
| **6.7.3.3 GRAPH AND TABLE REQUIREMENTS** | | | | | |
| a. **SHAPE OF FUNCTION** — If the general shape of the function is important in making decisions, a graph should be used. | UTA | UTA | | | Data not available |
| b. **INTERPOLATION** — If interpolation is necessary, line graphs are preferable to bar graphs and tables. | UTA | UTA | | | Data not available |
| c. **GRIDS** | | | | | |
| (1) Graphs should be constructed so that numbered grids are bolder than unnumbered grids. | UTA | UTA | | | Data not available |
| (2) If 10-grid intervals are used, the fifth intermediate grid should be less bold than the numbered grid, but bolder than the unnumbered grids. | UTA | UTA | | | Data not available |
| d. **TABLES** | | | | | |
| (1) Tables should be simple, concise, and readable. | UTA | UTA | | | Data not available |
| (2) When table columns are long, numbers should be separated into groups by providing a space between groups of five. | UTA | UTA | | | Data not available |
| (3) When columns are not separated by vertical lines, the columns should be separated by at least 2 character widths. | UTA | UTA | | | Data not available |

## 3.8 Conventions Survey

This section documents the results of the conventions survey conducted in the main control room, ESP, and ASP at BVPS-2. This review was conducted in accordance with the requirements of NUREG-0700, as specified in the BVPS-2 DCRDR Program Plan.

### 3.8.1 Objectives

The objectives of the conventions survey were to:

a. Identify the NUREG-0700 defined conventions that are applied in the BVPS control room.

b. Determine if the applications of the identified conventions are consistent across the applicable design features.

c. Document any inconsistent or missing conventions in the control room.

### 3.8.2 Scope

The scope of the effort extends to the assessment of color, shape, and arrangement coding across design features in the main control room, ESP, and ASP at BVPS-2 using the applicable guidelines as stated in NUREG-0700. The topics evaluated include:

- Coding of controls
- Color coding of controls and displays
- Label content consistency
- Enhancements of emergency controls
- Use of Abbreviations and Acronyms

### 3.8.3 Criteria

The criteria applied in this survey, identified by NUREG-0700 paragraph number, are: paragraphs 6.3.3.4d; 6.4.2.2a, b, f(1) and f(2); 6.5.1.6b(2), c(2), and d(1) through d(3); 6.5.3.2a(2); 6.6.3.3a; 6.6.6.4c(1) and c(2); 6.8.1.3c and d.

The detailed definiions for each criterion are presented in Table 3.8.

### 3.8.4 Method

#### 3.8.4.1 Data Collection

a. All required data forms, plant documentation, engineering drawings, equipment, and materials were made available prior to conduct of this task. Permission was obtained for all required access to the control room.

b. Data were collected using methods and procedures consisting of observations and document reviews.

3.8.4.2 Analysis -- Data were analyzed according to the following procedure:

a. All deviations from the criteria were recorded on HED reports. Recorded information included the components involved (e.g., controls, meters, labels, etc.), a description of the problem including the NUREG-0700 paragraph number of the criteria, and a recommended solution.

b. The data collection description was also recorded on the HED form. Where data from two or more sources were contradictory, resolution of the conflict was achieved through data review and discussions with cognizant DLC personnel.

c. Upon completion of all analyses, the criteria of the conventions task plan were annotated to indicate compliance or noncompliance with the criteria.

3.8.5 Findings

The findings of the conventions survey are presented in Table 3-8 "Conventions Survey Findings and HEDs Generated." Overall, 18 criteria were applied to the conventions in the BVPS-2 control room, ESP, and ASP. Of the criteria assessed two (11%) were not applicable, eight (44%) were not violated, and eight (44%) were violated. A total of six HEDs were generated which document all of the eight criteria which were not met. In general, those HEDs describe instances of inconsistent uses of color, no administrative control over the uses of abbreviations, and no enhancement techniques used on emergency controls.

TABLE 3-8

CONVENTIONS SURVEY FINDINGS & HEDs GENERATED Page 1 of 3

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.3.3.4 VISUAL TILE LEGENDS** | | | | | |
| d. **ABBREVIATIONS** — Abbreviations and acronyms should be consistent with those used elsewhere in the control room. | O | NO | 2V**-1111<br>2V**-1112 | 8<br>8 | |
| **6.4.2.2 CODING OF CONTROLS (Exhibit 6.4-3)** | | | | | |
| a. **CONSISTENCY** — The coding system should be uniform throughout the control room. | O | YES | | | |
| b. **LOCATION CODING** — Controls should be located so as to be easily related to functions and functional groupings. Controls with similar functions should be in the same location from panel to panel. (See Guideline 6.8.2.3.) | O | NO | 2ES1-3021 | 5 | |
| f. **COLOR CODING** | | | | | |
| (1) Color coding should follow the recommendations of Guideline 6.5.1.6. | O | NO | 2***-2306 | 7 | |
| (2) When color coding is used to relate a control to its corresponding display, the same color should be used for both the control and the display. | N/A | N/A | | | Not used |
| **6.5.1.6 COLOR CODING** | | | | | |
| b. **NUMBER OF COLORS** | O | YES | | | |
| (2) The number of colors used for coding shuld not exceed 11. | | | | | |

TABLE 3-8

CONVENTIONS SURVEY FINDINGS & HEDs GENERATED Page 2 of 3

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| 6.5.1.6 (Cont'd) | | | | | |
| c. **MEANING OF COLORS** | | | | | |
| (2) Red, green, and 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. | O | YES | | | |
| Green: safe, no operator action required, or an indication that a parameter is within tolerance. | O | NO | 2***-2306 | 7 | |
| Amber (yellow): hazard (potentially unsafe), caution, attention required, or an indication that a marginal value or parameter exists. | O | YES | | | |
| d. **CONSISTENCY OF MEANING** | | | | | |
| (1) The meaning assigned to particular colors should be consistent across all applications within the control room. | O | NO | 2***-2306<br>2BC2-3405 | 7<br>7 | |
| (2) The meaning of a particular color should remain the same whether applied to panel surfaces or projected in signal lights or on CRTs. | O | YES | | | |
| (3) The meaning of a particular color should remain the same both within and among the various systems to which it is applied. | O | NO | 2***-2306<br>2BC2-3405 | 7<br>7 | |
| **6.5.3.2 DESIGN AND USE OF NONLEGEND LIGHT INDICATORS** | | | | | |
| a. **IDENTIFICATION OF MEANING** | | | | | |
| (2) The color of the light indicator when transilluminated should conform to the general code established for the control room. (See Guideline 6.5.1.6.) | O | NO | 2***-2306 | 7 | |

TABLE 3-8

CONVENTIONS SURVEY FINDINGS & HEDs GENERATED 

| GUIDELINE | METHODS | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|---|
| **6.6.3.3 LABEL CONTENT CONSISTENCY** | | | | | |
| a. **ADMINISTRATIVE CONTROL** — A list of standard names, acronyms, abbreviations, and part/system numbers should be in place and administratively controlled. | D | NO | 2***-1111 | 8 | |
| | | | 2V**-1112 | 8 | |
| | | | 2***-1114 | 9 | Valid, TP-9.2 |
| **6.6.6.4 USE OF MIMICS** | | | | | |
| c. **SYMBOLS** | | | | | |
| (1) Graphic symbols should be readily understood and commonly used. | D | YES | | | |
| (2) Symbols should be used consistently. | D | YES | | | |
| **6.8.1.3 ENHANCING RECOGNITION AND IDENTIFICATION** | | | | | |
| c. **COLOR SHADING** — Color shading may be used to enhance recognition of controls, displays, or functional groups. When color shading is used, colors should provide adequate contrast, and should be consistent with other color coding in the control room. | N/A | N/A | | | Color shading not used |
| d. **EMERGENCY CONTROLS** — Distinctive enhancement techniques should be used for emergency controls. | O | YES | | | |

# 4.0 SYSTEM FUNCTION REVIEW AND TASK ANALYSIS AND VERIFICATION AND VALIDATION

## 4.1 System Review and Task Analysis

The system review and task analysis forms the basis for the verification of task performance capabilities and the validation of control room functions tasks.

### 4.1.1 Introduction

The SRTA program systematically evaluated the needs of the control room operations crew in response to emergency transients. The SRTA process and documentation was based on the methodology (see Reference 1) developed by the WOG and the NRC clarification comments (see Reference 2) on task analysis provided to the WOG at the March 29, 1984, meeting. The SRTA documentation was structured to provide the information required by the CRDR team to perform the Verification of Operator Task Performance Capability review phase of the CRDR.

### 4.1.2 Task Analysis Program

The SRTA program consists of a systematic evaluation of representative plant emergency operations to identify operator actions and associated instrumentation and controls necessary to support operator response to emergency transients. The methodology and documentation for this phase were based on that developed by the WOG (see Reference 1). The following subsections describe the selection of event sequences and EOPs for task analysis and the process used to analyze the EOPs to identify and document operator actions and required instrumentation and controls.

#### 4.1.2.1 Selection of Event Sequences and EOPs for Task Analysis

Task analysis data was developed for event sequences that reflect a spectrum of plant emergency operations. The event sequences selected complied with the recommendations in NUREG-0700 and ensured that the task analysis documentation addressed the important areas of emergency operation (e.g., event diagnosis, critical safety function monitoring, high risk event sequences, etc.). In addition, the event sequences selected representatively exercised the EOPs. The event sequences selected for task analysis are itemized in Table 4.1.

TABLE 4.1

## SELECTED EVENT SEQUENCES FOR TASK ANALYSIS

1. Spurious safety injection
2. Loss of reactor coolant (small break, approx. 1 inch diameter)
*3. Loss of reactor coolant (small break, approx. 4 inch diameter)
4. Loss of reactor coolant (large break)
5. Loss of secondary coolant
6. Combined loss of reactor and secondary coolant
7. Steam generator tube rupture (design basis)
*8. Steam generator tube rupture (multiple ruptures in one steam generator)
*9. Steam generator tube rupture (ruptures in more than one steam generator)
*10. Anticipated transient without scram
*11. Inadequate core cooling (resulting from failures in emergency core cooling system)
12. Inadequate core cooling (resulting from loss of secondary heat sink)
13. Pressurized thermal shock transient
14. High containment pressure transient

* Event sequences recommended in NUREG-0700

Based on the selected event sequences, the EOP set was reviewed to determine which procedures should be used in response to the above event sequences. In the symptom-based EOP set, at least two EOPs (or portions thereof) and the critical safety function status trees were implemented in response to an emergency transient. Figure 4-1 schematically illustrates EOP implementation in response to a small break loss of coolant accident (LOCA). The review of EOP implementation for the selected event sequences identified the selected EOPs to be task analyzed. The selected EOPs task analyzed are itemized in Table 4.2. This table also shows the event sequences for which the EOP is implemented. Note that the Critical Safety Function Status Trees were implemented for all event sequences. Through task analyzing these status trees, documentation was developed for monitoring the plant safety state during emergency operations, independent of the emergency transient.

4.1.2.2 Process for Identification of Operator Actions

Having selected the subset of EOPs to be used, the task analysis process was applied to each EOP to identify the operator actions necessary to implement the EOP in response to emergency transients. Following identification of operator actions, the necessary instrumentation and control requirements to support the operator actions were identified. This detailed information (in addition to general information on the operator function and the purpose of each EOP step) was documented on Element Tables (see Figure 4-2) similar in format to those developed in the WOG SRTA program.

The documents used for task analysis were the generic ERGs, the plant specific EOPs and the plant specific design and operational source documentation (flow diagrams, system descriptions, electrical diagrams, etc). The task analysis activity was a table top evaluation of the plant specific EOPs relative to the generic ERGs and plant specific source documentation and identified the operator actions and associated instrumentation and control requirements necessary to support operator response to emergency transients. The table top evaluation was performed based on the existing plant design and was independent of the existing control room configuration and the specific instruments and controls contained therein. The task analysis process was performed as follows:

1. Each EOP step was evaluated to identify the operator function(s) that the step supported and the purpose for the step. This information was entered at the top of the table.

2. The step was then systematically reviewed to identify the operator actions necessary to implement each EOP step. Since the EOPs frequently utilize concise task statements to trigger operator actions, all actions that are needed for operation of plant systems were not explicitly identified in the EOPs. Where appropriate, the task analysis included identification of the specific actions necessary to perform the tasks identified in the EOPs. The operator actions were then entered on the Element Table.

3. Each operator action was then evaluated to identify the instrumentation and controls necessary for the operator to perform the necessary actions. This evaluation of instrumentation and controls also identified the instrumentation and control criteria requirements necessary for proper performance of operator actions. The instrumentation and controls were entered on the Element Table. Criteria requirements (e.g. decreasing, at zero, etc.) were included in parentheses following the associated instrumentation and controls.

With respect to the task analysis process, any cautions and notes that preceded EOP steps were considered as part of the step and were analyzed on separate Element Tables.

Following preparation of the Element Tables for the selected EOPs, the remaining EOPs were reviewed to identify any operator actions, instrumentation or controls existing in the remaining EOPs but not the selected EOPs. This review ensured that the selected EOPs were representative of emergency operations. Any unique actions, instrumentation, or controls identified in this review were included in the task analysis process and identified on Element Tables. This approach provided representative task analysis documentation in an efficient manner while ensuring complete identification of operator actions, instrumentation, and controls utilized in emergency operations.

EOP USAGE FOR LOSS OF REACTOR COOLANT (SMALL BREAK)

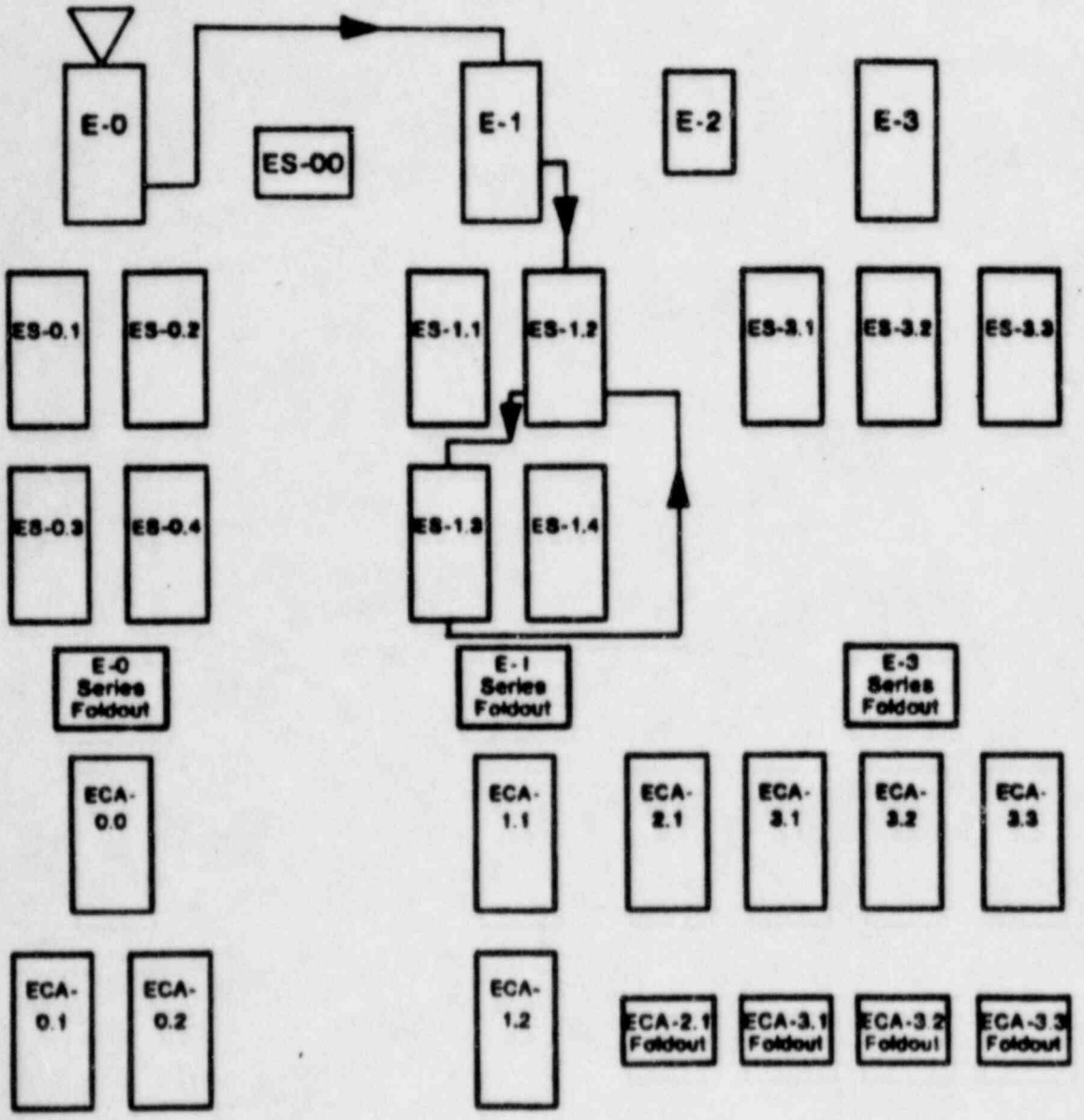



Figure 4-1

TABLE 4.2

## SELECTED EOPs FOR TASK ANALYSIS

| EOPs | Sequences |
|---|---|
| Reactor Trip or Safety Injection | All |
| SI Termination | 1,2,5,12 |
| Loss of Reactor or Secondary Coolant | 2,3,4,5,6 |
| Post-LOCA Cooldown and Depressurization | 2 |
| Transfer to Cold Leg Reciruclation | 4 |
| Transfer to Hot Leg Recirculation | 4 |
| Faulted Steam Generator Isolation | 5,6 |
| Steam Generator Tube Rupture | 7,8,9 |
| Post-SGTR Cooldown Using Steam Dump | 7,8,9 |
| Critical Safety Function Status trees | All |
| Response to Nuclear Power Generation/ATWS | 10 |
| Response to Inadequate Core Cooling | 11 |
| Response to Loss of Secondary Heat Sink | 12 |
| Response to Imminent Pressurized Thermal Shock Conditions | 13 |
| Response to High Containment Pressure | 14 |

## ELEMENT TABLE FOR E-0

STEP 1

FUNCTION: Verify Automatic Actuations
Diagnose Plant Condition

STEP: Verify Reactor Trip

PURPOSE: To Ensure That The Reactor Has Tripped

ACTIONS:

- o Determine if the reactor has tripped
  - Rods are at bottom
  - Reactor trip and bypass breakers open
  - Rod position indication at zero
  - Neutron flux decreasing
- o Trip the reactor

INSTRUMENTATION:

- o Control rod bottom lights indication (rods at bottom)
- o Power range neutron flux indication (decreasing)
- o Intermediate range neutron flux indication (decreasing)
- o Source range neutron flux indication (decreasing)
- o Control rod position indication (at zero)
- o Reactor trip and bypass breaker position indications (open)

CONTROL/EQUIPMENT:

Reactor Trip Switches (trip)

FIGURE 4-2

#### 4.1.2.3 Compilation of Instrumentation and Control Requirements

Following completion of the task analysis process, the resulting information was compiled on summary tables which highlighted specific information. This was especially advantageous for instrumentation and controls since all uses for a specific instrument or control are presented on a single Requirements Table, precluding the need for a user to review all Element Tables to obtain the same data. Consequently, following completion of the Element Tables for the selected EOPs and unique emergency operator actions, the instrumentation and control requirements were compiled on Instrumentation Requirements Tables (see Figure 4-3) and Control/Indication Requirements Tables (see Figure 4-4), respectively, similar in format to those developed in the WOG SRTA program.

#### 4.1.2.4 Compilation of System Sequence Requirements

As part of the task analysis process to identify and evaluate operator actions, plant systems were reviewed to identify equipment (instrumentation and controls) that must be used to accomplish operator actions. Following completion of the task analysis process, the resulting information on operator actions and plant systems were compiled to show the sequence in which the operator uses the plant systems in implementing the EOPs. A System Sequence Matrix was prepared for each selected EOP to show the plant systems that were used to perform each step in the EOP. As with other task analysis documentation, the System Sequence Matrices (see Figure 4-5) are similar in format to those developed in the WOG SRTA program.

### 4.1.3 Summary of Task Analysis Documentation

The documentation resulting from the SRTA program consists of the following:

#### 4.1.3.1 Element Tables

The element tables identify the operator actions necessary for response to emergency transients, including identification of specific instrumentation and control requirements necessary for implementation of operator actions.

## INSTRUMENTATION REQUIREMENTS TABLE

SYSTEM: REACTOR COOLANT

INSTRUMENTATION: Pressurizer Pressure (2RCS-PI444, 445, 455, 456, 457)

| CRITERIA REQUIREMENTS: | PROCEDURE | STEP |
|---|---|---|
| Greater than 1875 PSIG | E-0 | Step 22 |
| Less than 2335 PSIG | E-0 | Step 22 |
| Less than 2335 PSIG | E-1 | Step 5 - Caution |
| Less than 2335 PSIG | FR-P.1 | Step 3 |
| Less than 2335 PSIG | E-1 | Step 5 |
| Less than 2260 PSIG | E-0 | Step 22 |
| Less than PORV Setpoint | FR-P.1 | Step 3 - Caution |
| Stable at or Trending to 2235 PSIG | ES-0.1 | Step 5 |
| Stable | ES-1.1 | Step 28 |

FIGURE 4-3

## CONTROL/INDICATION REQUIREMENTS TABLE

SYSTEM: REACTOR COOLANT SYSTEM

CONTROL/INDICATION: Pressurizer Spray Valves

| CRITERIA REQUIREMENTS: | PROCEDURE | STEP |
|---|---|---|
| Close | E-0 | Step 22 |
| Open/Close/Auto | E-0 | Step 27 |
| Open; Closed | ES-1.1 | Step 20 |
| Open/Close | ES-1.1 | Step 20 |
| Open; Close | ES-1.2 | Step 14 |
| Open/Close | ES-1.2 | Step 14 |
| Open; Closed | ES-1.2 | Step 22 |
| Open/Close | ES-1.2 | Step 22 |
| Open; Closed | E-3 | Step 18 |
| Open; Closed | E-3 | Step 30 |
| Open | E-3 | Step 30 |
| Open; Closed | ES-3.3 | Step 6 |
| Open | ES-3.3 | Step 6 |
| Open; closed | FR-P.1 | Step 16 |
| Open/Close | FR-P.1 | Step 16 |
| Open; Closed | FR-P.1 | Step 17 - Caution |
| Open/Close | FR-P.1 | Step 17 - Caution |
| Open; Closed | FR-P.1 | Step 22 |
| Open/Close | FR-P.1 | Step 22 |
| Open; Closed | FR-P.1 | Step 24 |
| Open/Close | FR-P.1 | Step 24 |

FIGURE 4-4

SYSTEM SEQUENCE MATRIX TABLE

PROCEDURE: ES-3.3, POST-SGTR COOLDOWN USING STEAM DUMP

| STEP | SYSTEMS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BDG | BRS | CCP | CHS | CNM | CVS | DAS | DGS | ESF | FNC | FPW | FWE | FWS | GNS | HVC | HVP | HVR | HVS | HVZ | LMS | MSS | NIS | PGS | QSS | RCS | RDI | RHS | RMS | RPS | RSS | SIS | SSR | SWS | TMS | VRS |
| 1-C1 | | | | | | | | | | | | | ● | | | | | | | | | | | | | | | | | | | | | | |
| 1-C2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | | | | | | | | | | | | | | | | | | | | | ● | | | | ● | | | | | | | | | | |
| 2 | | ● | | | | | | | | | | | | | | | | | | | | | | | ● | | | | | | ● | | | | |
| 3 | | | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4-C | | | | | | | | | | | | ● | ● | | | | | | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5-N1 | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | | | | | | | |
| 5 | | | | | ● | | | | | | | | | | | | | | | | ● | | | | ● | | | | | | | | | | |
| 6-C | | | | | | | | | | | | | | | | | | | | | ● | | | | | | | | | | | | | | |
| 6 | | | | ● | | | | | | | | | | | | | | | | | ● | | | | ● | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | | ● | | | | ● | | | | | | | | | | |
| 8 | | | | | | | | | | | | ● | ● | | | | | | | | ● | | | | | | | | | | | | | | |
| 9-C | | | | | | | | | | | | | | | | | | | | | ● | | | | | | | | | | | | | | |
| 9-C1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | ● | | | | | | | | | | | | | | | | ● | | | | | | | | | | | | | | |
| 10 | | | | ● | | | | | | | | | | | | | | | | | | | | | ● | | | | | | | | | | |
| 11-N | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | | | | | | | |
| 11 | | | | ● | | | | | | | | | | | | | | | | | ● | | | | ● | | | | | | | | | | |
| 12 | | | | ● | | | | | | | | | | | | | | | | | | | | | ● | | | | | | | | | | |
| 13 | | | ● | | | | | | | | | | | | | | | | | | | | | | ● | | ● | | | | ● | | | | |
| 14 | | | | | ● | | | | | | | | | | | | | | | | ● | | | | ● | | ● | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | | | | | | | |
| 16 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Matrix Table 1

Figure 4-5

4.1.3.2 Instrumentation and Control Requirement Tables

The Requirement Tables compile the specific criteria requirements for instrumentation and controls necessary for implementation of operator actions.

4.1.3.3 System Sequence Matrices

The System Sequence Matrices identify the sequence in which the operator uses plant systems in response to emergency transients. Separate matrices are provided for each selected EOP that was task analyzed.

4.1.4 Use of Task Analysis Documentation in Verification of Operator Task Performance Capability

4.1.4.1 The objective of Verification of Operator Task Performance capability is to assure that operator tasks can be performed in the existing control room with minimum potential for human error. Verification evaluates task execution at each work station and consists of:

4.1.4.1.1 Verification of Availability

Verification of the presence (or absence) of instruments and equipment that provide the information and control capabilities necessary to implement operator actions.

4.1.4.1.2 Verification of Suitability

Verification that the man-machine interfaces provided by the displays, controls and other control room features are effectively designed to support operator actions.

4.1.4.2 The task analysis documentation was structured to support a verification process consisting of verification of operator action performance capability. The following subsection describes the use of the task analysis documentation in supporting the verification process.

4.1.4.2.1 Verification of Operator Action Performance Capability

The verification activity consists of evaluating the availability and suitability of control room instrumentation

and controls to support performance of operator actions. The Element Tables were used for this activity.

For each Element Table, the multidisciplinary CRDR review team systematically reviewed the operator actions itemized under the ACTIONS heading. As each action was reviewed, the CRDR team located the instrumentation and controls in the control room necessary to support the operator actions. After locating the instrumentation and controls, the team evaluated the suitability of the instrumentation and controls for performing the operator actions. The suitability evaluation was structured to evaluate the specific operator action criteria (e.g., greater than 1500 psig, less than 700°F, etc.) upon which operator actions are based. The team utilized the information under the INSTRUMENTATION and the CONTROLS headings to identify criteria requirements. In working through each Element Table, the team evaluated all entries under the ACTIONS, INSTRUMENTATIONS, and CONTROLS headings to ensure that the task analysis documentation was complete and self-consistent.

### 4.1.5 Use of Task Analysis Documentation in Validation of Control Room Functions

The objective of Validation of Control Room Functions is to determine whether the functions of the control room operating crew can be accomplished effectively within (1) the structure of defined EOPs, and (2) the design of the control room as it exists. Validation evaluates operator function execution within the integrated control room configuration and consists of walk and talk-throughs of selected event sequences with control room personnel.

The EOPs are the appropriate documents for use by the control room personnel in directing their response to the selected event sequences. Although not specifically developed or needed for Validation, the Element Tables of the SRTA program were used by the multidisciplinary CRDR team as a source document with which to observe the response of the operators to the event sequences. Since the Element Tables

were developed based on the procedures, these tables itemized detailed operator actions and associated instrumentation and control requirements necessary for proper response to emergency transients. Through comparing the actions in the Element Tables with the operator walk-through actions, discrepancies were noted and discussed in the talk-through portion of the validation.

### 4.1.6 References


1. Westinghouse Owners Group, Emergency Response Guidelines System Review and Task Analysis, Volumes 1, 2A, 2B, and 3, April 1, 1983.

2. NRC Memorandum from H. Brent Clayton to Dennis L. Ziemann, Meeting Summary-Task Analysis Requirements of Supplement 1 to NUREG-0737, March 29, 1984. Meeting with Westinghouse Owners Group (WOG) Procedures Subcommittee and Other Interested Persons, April 5, 1984.


## 4.2 Verification of Task Performance Capabilities

The verification of task performance capabilities was accomplished in accordance with the guidelines in NUREG-0700 per DLC NCD Instruction R 405.

### 4.2.1 Methodology

The verification of task performance capabilities was divided into two parts: verification of availability and verification of suitability.

#### 4.2.1.1 Verification of Availability

Each operator need (control, indication, and instrument) identified in the SRTA element tables was listed on a verification of availability checklist (Figure 4-6). The Core Team then compared each operator need with the BVPS-2 CRDR main control board mockup and the inventory data sheets, as required, to verify the availability of the devices necessary to implement each operator task. The main control board section identifier and device mark number was recorded on the checklist for each device found. Any missing device was recorded on a HED and the HED number was recorded on the checklist. In addition, the main control board was compared with the remaining NUREG-0700, Section 6 guidelines pertaining to verification of equipment availability per task plan TP-9.2. Task plan TP-9.2 is contained in the CRDR files.

#### 4.2.1.2 Verification of Suitability

As was done for the verification of availability, each operator need was listed on a verification of suitability checklist (Figure 4-7). The Core Team then compared the operator control, indication, and instrument requirements with the main control board mockup and inventory data sheets, as necessary, to ensure that the devices on the main control board have the characteristics (range, precision, position, etc.) to support each operator task. In addition, the characteristics of the devices were compared against the remaining NUREG-0700, Section 6 guidelines that pertain to verification of equipment suitability.

VERIFICATION OF TASK PERFORMANCE CAPABILITIES

EQUIPMENT AVAILABILITY

| PROCEDURE/ TASK STEP | INFORMATION OR CONTROL REQUIREMENT | MCB SECTION | MARK NO. | REMARKS • OK (✓) • MED NO. |
|---|---|---|---|---|
| E-0 7 | SG Pressure indication (2MSS-PI 474, 484, 494, 475, 485, 495, 476, 486, 496) (Lower than 485 psig) | VCC | 2MSS-PI 474, 484, 494, 475, 485, 495, 476, 486, 496 | ✓ |
| E-0 7 | Tavg indication (2RCS*TI 413, 423) | VBC | 2RCS-TI 413, 423 | ✓ |
| E-0 7 | Switches to actuate SI (actuate) | BA2 | NONE | ✓ |
| | | | | |
| E-0 8 | Position indications for FW Control Valves (2FWS-FCV478, 488, 498) (open, closed) | BC1 | 2FWS-FCV478, 488, 498 | ✓ |
| E-0 8 | Position indication for: FW bypass Valves (2FWS-FCV479, 489, 499) (open, Closed) | BC1 | 2FWS-FCV-479, 489, 499 | ✓ |
| E-0 8 | Position indications for FW isolation Valves (2FWS*HYV157A, B, C) (open, Closed) | BA1 | 2FWS-HYV157A, B, C | ✓ |
| E-0 8 | FW pumps status (2FWS-P21A, B) indication (running, stopped) | BC1 | 2FWS-P21A, B | ✓ |
| E-0 8 | Switches for: FW pumps (2FWS-P21A, B) (trip) | BC1 | 2FWS-P21A, B | ✓ |
| E-0 8 | Switches for: FW Control Valves (2FWS-PK478, 488, 498) (close) | BC1 | 2FWS-FCV478, 488, 498 | ✓ |
| E-0 8 | Switches for: FW bypass valves (2FWS-PK479, 489, 499) (close) | BC1 | 2FWS-PK 479, 489, 499 | ✓ |
| E-0 8 | Switches for: FW Isolation Valves (2FWS*HYV157A, B, C) (close) | BA1 | 2FWS-HYV157A, B, C | ✓ |

Figure 4-6
Sample Completed Verification of Availability Checklist

VERIFICATION OF TASK PERFORMANCE CAPABILITIES

HUMAN ENGINEERING SUITABILITY

| PROCEDURE & TASK STEP | INFORMATION OR CONTROL REQUIREMENT | REQUIRED •RANGE •ACCURACY •POSITIONS •PRECISION | ACTUAL •RANGE •ACCURACY •POSITIONS •PRECISION | MCB SECTION | MARK NO. | REMARKS •OK (✓) •POTENTIAL CONCERNS •HED NO. |
|---|---|---|---|---|---|---|
| E-0 17 | Switches for: Charging/HHSI valves (open/close) | Open/Close | O/C IL | A4/A2 | List of valves | ✓ |
| | | | | | | |
| E-0 18 | AFW flow indication [2FWE*FI100A,B,C] (Total greater than 350 gpm) | Total > 362 gpm | 0-400 10 gpm accuracy (sqrt) | C6 | 2 FWE - FI 100 A,B,C | HED 2*** -22-13 |
| E-0 18 | MD AFW pumps status indication (running; stopped) | Running; Stopped | S/S/PTL IL | C2 | 2FWE*P23 A,B | ✓ |
| E-0 18 | TD AFW pump status indication (running; stopped) | running, stopped | | | | HED 2*** - 2219 |
| E-0 18 | TD AFW pumps Steam Supply valve position indication [2MSS*SOV105A,B,C,D,E,F] (open,close) | Open; closed | O/C IL | C2 | 2MSS*SOV105 A,B,C,D,E,F | ✓ |
| E-0 18 | AFW valves position indication [2FWE*HCV100A,B,C,D,E,F] (open,closed) | Open, Closed | O/C IL | C2 | 2FWE*HCV 100A,B,C,D,E,F | ✓ |
| E-0 18 | Switches for: MD AFW pumps (start) | Start | S/S/PTL IL | C2 | 2FWE*P23 A,B | ✓ |
| E-0 18 | Switches for: TD AFW pump Steam Supply valves [2MSS*SOV105A,B,C,D,E,F] (open) | Open | O/C IL | C2 | 2MSS*SOV 105A,B,C,D,E,F | ✓ |
| E-0 18 | Switches for: AFW Valves [2FWE*HCV100A,B,C,D,E,F] (open) | open | O/C IL | C2 | 2FWE*HCV 100A,B,C,D,E,F | ✓ |
| | | | | | | |
| | | | | | | |

Figure 4-7
Sample Completed Verification of Suitability Checklist

### 4.2.2 Findings

The findings of the verification of task performance capabilities are presented in Table 4.3, "Verification of Availability Findings and HEDs Generated," and Table 4.4, "Verification of Suitability Findings and HEDs Generated."

## 4.3 Validation of Control Room Functions

The validation of control room functions task was accomplished in accordance with the guidelines in NUREG-0700 per DLC NCD Instruction R-406.

### 4.3.1 Methodology

Using the main control board mockup (Figure 4-8), three DLC operator/instructors walked-through the following validation scenarios, under the direction and scrutiny of the Core Team.

Scenario:

| No. | Name |
|---|---|
| A-1 | Reactor Trip |
| A-2 | ATWS from Full Power Following Loss of Off-Site Power |
| A-3 | Loss of All Feedwater |
| A-4 | Secondary Break Outside Containment |
| A-5 | SGTRS in Different Steam Generators Plus Cooldown |
| A-6 | DBA LOCA with Switchover |
| A-7 | Intermediate LOCA-Post LOCA Cooldown |
| A-8 | Steam Generator Tube Leak Plus Spurious SI |
| A-9 | Inadequate Core Cooling |
| A-10 | Secondary Break-All Steam Generator Stop Valves Fail to Close |
| B-4 | Loss of All AC Power Recovery with SGTR |
| C-1 | Plant Startup from Cold Shutdown to Power Operation |
| C-2 | Load Folow from 100% Power to 50% Power |

During the walk-throughs, discrepancies were noted in three ways: by individual Core Team members comparing the walk-through actions with the NUREG-0700, Section 6, guidelines; by operator comment on operational difficulties, discrepancies, or inconsistencies; and by Core Team members observations of operational difficulties.

The entire set of walk-throughs was recorded on video tape using two cameras: one wide-angle view of the entire control room operating area and one close-up camera with a

zoom lens to follow each operator action and permit the recording of main control board device and control position titles.

Following the walk-throughs, at convenient break points, the operators were debriefed by the Core Team while viewing the tapes from the zoom-lens camera. (The debriefings were also video taped so they could be reviewed if questions arose regarding the details of an operational difficulty.) All discrepancies noted during the walk-throughs were discussed. The HFS wrote down all discrepancies and prepared a HED for each.

### 4.3.2 Findings

The findings of the validation of control room functions task are presented in Table 4.5, "Validation of Control Room Functions and HEDs Generated."

## VERIFICATION OF AVAILABILITY FINDINGS & HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.1.1.1 ACCESSIBILITY OF INSTRUMENTATION/EQUIPMENT | | | | |
| A. Present in the Control Room | No | 2ES*-1001 | 6 | High Safety Importance |
| Control room instrumentation and equipment should include all controls and displays needed for (1) detection of abnormal conditions, and (2) bringing the plant to a safe shut-down condition. | | 2AB*-2017 | 6 | ..gh Safety Importance |
| | | 2AB*-0201 | 7 | HED Incorrect |
| | | 2***-2005 | 7 | |
| | | 2***-3002 | 7 | High Safety Importance |
| | | 2***-3003 | 5 | High Safety Importance |
| | | 2***-3004 | 7 | |
| | | 2***-3005 | 7 | |
| | | 2***-3006 | 9 | |
| | | 2BA*-3007 | 9 | |
| | | 2BC*-3008 | 8 | High Safety Importance |

## VERIFICATION OF AVAILABILITY FINDINGS & HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.1.1.1a (continued) | | 2BA*-3009 | 5 | High Safety Importance |
| | | 2***-3010 | 5 | High Safety Importance |
| | | 2***-3012 | 6 | HED Incorrect |
| | | 2VC6-2402 | 5 | High Safety Importance |
| B. Arranged to Facilitate Coverage<br><br>Operators should not have leeway to leave the primary operating area to attend control room instrumentation on back panels during operational sequences in which continuous monitoring or the timing of control actions may be critical. | Yes | | | |

## VERIFICATION OF AVAILABILITY FINDINGS & HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.1.3.1 UNIT INTEGRATION AND INTERFERENCE | | | | |
| D. Sharing of Procedures | Yes | | | |
| Each unit should have its own set of procedures and other reference documents as required to make sure that references are easily available to personnel in each unit, and to avoid conflicting needs for the same reference. | | | | |
| E. Sharing of Equipment | | | | |
| 1. Control of plant equipment from one control room should not affect the ability of operators of other control rooms to maintain control of their respective units. | Yes | | | |
| 2. The status of plant equipment under the control of one control room should be displayed in all control rooms capable of controlling that equipment. | Yes | | | |
| 3. If control of plant equipment from one control room renders that equipment unavailable to other control rooms, availability status indications should be displayed in all control rooms. | Yes | | | |

## VERIFICATION OF AVAILABILITY FINDINGS & HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.1.3.1e - (continued) | | | | |
| 4. A single, centrally located control panel/console may be used for dual-unit control rooms within the same isolation boundary when this design does not conflict with the panel layout and control-display integration guidelines of Sections 6.8 and 6.9. | N/A | | | |
| 5. Administrative procedures should be in place which assign responsibility for allocation of use of controls of shared plant equipment to single control room. | Yes | | | |
| 6.3.4.3 ANNUNCIATOR RESPONSE PROCEDURES | | | | |
| A. Availability<br>Annunciator response procedures should be available in the control room. | | | | Procedures not yet written |
| B. Indexing<br>Annunciator response procedures should be indexed by panel identification and annunciator title coordinates. | | | | Procedures not yet written |

## VERIFICATION OF AVAILABILITY FINDINGS & HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.5.1.1 INFORMATION TO BE DISPLAYED | | | | |
| A. Task Analysis<br>Analysis of operator tasks in relation to system engineering and system functional objectives is recommended as the surest means of establishing operator information requirements. | Yes | | | |
| B. Completeness of Information<br>Visual displays provided in the control room should give operators all the information about system status and parameter values that is needed to meet task requirements in normal, abnormal, and emergenc, situations. | No | 2V**-2006 | 5 | High Safety Importance |
| | | 2VC7-2016 | 9 | |
| | | 2***-2219 | 7 | High Safety Importance |
| C. Unnecessary Information<br>Efficient performance requires not only display of all needed information but also avoiding the display of extraneous information in the prime operating area. | Yes | | | |
| D. Redundancy<br>Redundancy in the presentation of information items should be limited to cases where needed for backup or to avoid excessive operator movement. | Yes | | | |

## VERIFICATION OF AVAILABILITY FINDINGS & HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.5.1.1 - (continued) | | | | |
| E. Demand Information Versus Status Information | No | 2***-3101 | 5 | High Safety Importance |
| Demand information shows that equipment has been commanded (by control settings or otherwise) to a particular state or level. It shows only what is demanded - not what is actually being realized. Status information shows the state or level actually in affect. | | | | |
| 1. To prevent operator confusion, it is essential that displays be identified as to whether they reflect demand or actual status. | No | 2***-3101 | 5 | High Safety Importance |
| 2. Visual display of actual system/equipment status should be displayed for all important parameters. | No | 2***-310 | 5 | High Safety Importance |

## VERIFICATION OF AVAILABILITY FINDINGS & HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.5.1.2 USABILITY OF DISPLAYED VALUES | | | | |
| B. Elimination of Operator Conversion | No | 2V**-2014 | 6 | High Safety Importance |
| All displays should indicate values in a form immediately usable by the operator without requiring mental conversion. | | 2VA5-2216 | 9 | |
| | | 2VC8-2011 | 9 | |
| | | 2VC6-2012 | 9 | |
| | | 2V**-2211 | 5 | High Safety Importance |
| C. Percentage Indication | Yes | | | |
| Percentage indication may be used when the parameter is meaningfully reflected by percentage. | | | | |
| D. Scale Range | | | | |
| Scales should be selected to: | | | | |
| 1. Span the expected range of operational parameters, or | Yes | | | |

## VERIFICATION OF AVAILABILITY FINDINGS & HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.5.1.2d - (continued) | | | | |
| 2. Employ appropriate scale ranging techniques, or | No | 2VA9-2403 | 5 | High Safety Importance |
| | | 2VA5-2009 | 7 | High Safety Importance |
| | | 2VC6-2218 | 5 | High Safety Importance |
| 3. Be supported by auxiliary wide-range instruments. | Yes | | | |

## VERIFICATION OF SUITABILITY FINDINGS & HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.5.1.1 INFORMATION TO BE DISPLAYED | | | | |
| A. Task Analysis<br>Analysis of operator tasks in relation to system engineering and system functional objectives is recommended as the surest means of establishing operator information requirements. | Yes | | | |
| F. Display Failure<br>When panel instruments, such as meters, fail or become inoperable, the failure should be apparent to the operator (e.g., through off-scale indication). | Yes | | | |
| 6.5.1.2 USABILITY OF DISPLAYED VALUES | | | | |
| A. Scale Selection<br>Scale units should be consistent with the degree of precision and accuracy needed by the operator. | No | 2V**-2007 | 5 | High Safety Importance |
| | | 2VC6-2015 | 8 | High Safety Importance |
| | | 2***-2213 | 5 | |
| | | 2VC6-2214 | 5 | |

**VERIFICATION OF SUITABILITY FINDINGS & HEDs GENERATED**

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.5.1.2a - (continued) | | 2***-2220 | 6 | High Safety Importance |
| | | 2VA5-2009 | 7 | High Safety Importance |
| | | 2VA6-2010 | 8 | |
| | | 2VC8-2011 | 9 | |
| | | 2VC6-2218 | 5 | High Safety Importance |
| E. Scale Size<br><br>Scale ranges may be expanded (or contracted) by multiplying or dividing indicated scale values by powers of ten. All such scales should be clearly marked as to whether the indicated values should be multiplied or divided, and the factor involved (e.g., 10, 100, 1000). | Yes | | | |
| F. Sensitivity<br><br>Display dynamic sensitivity should be selected to minimize the display of normal random variations in equipment performance. | Yes | | | |

**VERIFICATION OF SUITABILITY FINDINGS & HEDs GENERATED**

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.5.1.5 PRINTING ON THE DISPLAY FACE | | | | |
| D. Scale Compatibility | No | 2V**-2212 | 7 | High Safety Importance |
| When two or more displays of the same parameter (e.g., pressure, temperature) must be compared, scales should be compatible in numerical progression and scale organization. | | 2VA9-2406 | 7 | |
| E. Linear vs. Logarithmic Scales | Yes | | | |
| Logarithmic scales should be avoided unless needed to display a range of values. | | | | |
| F. Multiscale Indicators | No | 2*C*-2217 | 9 | |
| Multiscale indicators (i.e., single pointer, multiple scales) should be avoided unless they can be justified as of operational benefit, and precautions are taken to avoid operator confusion. | | | | |
| 6.9.1.2 MULTIPLE CONTROLS AND DISPLAYS | | | | |
| C. 4. Displays should read off-scale, not zero, when not selected, especially if zero is a possible parameter displayed. | Yes | | | |

## VERIFICATION OF SUITABILITY FINDINGS & HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.9.3.2 CONTROL DISPLAY RATIO | | | | |
| A. Controls<br><br>Controls should provide a capability to affect the parameter controlled easily, with the required level of precision. They should be effective in sufficient time, under expected dynamic conditions, and within the limits of manual dexterity, coordination, and reaction time. | Yes | | | |
| B. Displays<br><br>Displays should provide a capability to distinguish significant levels of the system parameter controlled. | Yes | | | |
| C. Excess Precision<br><br>Both displays and controls should have a precision which does not greatly exceed that required. | Yes | | | |
| D. Feedback<br><br>Feedback from the display should be apparent for any deliberate movement of a control. | Yes | | | |

FIGURE 4.8

BVPS - 2 Control Board Mock-up

**VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED**

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.1.1.2 CONSISTENCY OF MANNING WITH EQUIPMENT LAYOUT | | | | |
| A. Coverage<br><br>Control room manning and task assignments should ensure complete and timely coverage of controls, displays, and other equipment required during all modes of operation. | Yes | | | |
| B. Utilization of Additional Personnel<br><br>Additional onsite or offsite personnel may augment the normal crew complement under certain conditions (e.g., refueling). If so, activities and task assignments should be planned to ensure proper coordination. (Note: special training for this situation may be required.) | Yes | | | |
| 6.1.3.1 UNIT INTEGRATION AND INTERFERENCE | | | | |
| A. Equipment Arrangement<br><br>Equipment should be arranged with movement and communication patterns in mind, so that each unit operations do not interfere with each other. | Yes | | | |
| B. Senior Operator Station<br><br>Senior operators who supervise and assist operations of more than one unit need to be stationed so that they can | N/A | | | |

**VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED**

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.1.3.1 (Continued)<br><br>communicate effectively with operators in each unit and have an unobstructed visual path to the control boards of each unit.<br><br>C. Sharing of Personnel<br><br>Where operators may assist those of another unit, potential task loading should be evaluated to assure that each unit can be covered adequately in all situations. | N/A | | | |
| 6.1.3.2 UNIT MIRROR IMAGING<br><br>If a mirror image design has been used:<br><br>A. Dedicated Crews<br><br>Operational crews should be committed to one or the other unit. They should not be allowed to alternate between the two mirrored units. This includes operators manning a single center desk station.<br><br>B. Accentuate Differences<br><br>The distinction between the mirrored units should be heightened as much as possible so that there will be no confusion about where one unit ends and the other begins. | N/A | | | |

VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.1.3.2 (Continued)<br><br>This can be done by using a different color scheme for the elements of each unit, including carpeting, desks, and other work station equipment, as well as the board surface areas. | | | | |
| 6.4.2.2 CODING OF CONTROLS<br><br>F. 2. When color coding is used to relate a control to its correspondind display, the same color should be used for both the control and the display. | N/A | | | |
| 6.4.3.1 PUSHBUTTON DESIGN PRINCIPLES<br><br>A. Position<br><br>Pushbuttons in a row or matrix should be positioned in a logical order, or in an order related to the procedural sequence. | Yes | | | |
| 6.8.1.1 ASSIGNED PANEL CONTENTS<br><br>Controls and displays should be placed within the control room at locations which promote efficient procedures, safe | | | | |

## VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.8.1.1 (Continued)<br><br>operation, and maximum operator awareness of the current system condition. There are three general methods for achieving this condition. They are: (a) grouping by task sequence, (b) grouping by system function, and (c) grouping by importance and frequency of use.<br><br>A. <u>Grouping by Task Sequence</u><br><br>Controls and displays should be assigned to work stations so as to minimize operator movement. To the extent, practical, this assignment should consider both normal and emergency procedures. It should be practical to perform all frequently occurring routine tasks, with a minimum of human movement from panel to panel. | No | 2BA*-3017 | 6 | High Safety Importance |
| B. <u>Grouping by System Function</u><br><br>Within the constraints of grouping by task sequence, controls and displays should be assigned to panels in functional groups related to system structure. This grouping should promote easy understanding of the relationship between controls and system, and should assist graphic or pictorial display or system relationships. | Yes | | | |
| C. <u>Grouping by Importance and Frequency of Use</u><br><br>Within the constraints of grouping by task sequence and | Yes | | | |

## VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.8.1.1 (Continued)<br><br>by system function, controls and displays should be assigned to panels depending on their importance and frequency of use. Controls or displays which are neither important to plant safety nor frequency of use. Controls or displays which are neither important to plant safety not frequently used should be installed in secondary panel locations.<br><br>6.8.1.2 EFFECTIVE PANEL LAYOUT<br><br>The location of controls and displays within a single panel should make the effective use of the viewing and manual manipulative areas. The allocation of panel positions should first ensure the integrity of arrangement or grouping by system function and task sequence. Within those constraints, consideration should be given to the following factors: (a) the frequency with which controls and displays are used; (b) the significance of controls and displays in terms of their possible use during an emergency; (c) the importance of controls and displays to overall system performance; and (d) special requirements in using a control device or display instruments, such as the need for accuracy, speed, application of force, or a particular type of movement. | Yes | | | |

## VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.8.1.3 ENHANCING RECOGNITION AND IDENTIFICATION | | | | |
| A. Spacing<br><br>Spacing consists of physically separating groups of components on a panel with enough space between groups so that the boundaries of each group are obvious. Spacing between groups should be at least the width of a typical control or display in the group. | Yes | | | |
| B. Demarcation<br><br>Demarcation consists of circumscribing functional or selected groups of controls and displays with a contrasting line. The application of demarcation techniques should conform to Guideline 6.6.6.2. | No | | | See Table 3-6 for findings and HEDs from Guideline 6.6.6.2 |
| 6.8.2.1 SEQUENCE, FREQUENCY OF USE, AND FUNCTIONAL CONSIDERATIONS | | | | |
| A. Sequence<br><br>Controls and displays which are used together during a normal task sequence should be grouped together. | | | | |
| 1. Displays which are observed in a specified sequence, as during hot-leg temperature check for all reactor | Yes | | | |

## VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.8.2.1a (Continued) | | | | |
| coolant loops, should be grouped together. It is desirable that they be positioned so that they are normally used in a left-to-right, top-to-bottom, or other natural sequence. | | | | |
| 2. Controls which are operated in sequence, as in energizing a system or aligning a series of valves for a particular function, should be grouped together. It is desirable that they be positioned so that they are normally used in a left-to-right, top-to-bottom, or other natural sequence. | Yes | | | |
| 3. When there is a set of related controls and displays, the layout of displays should be symmetrical with the controls they represent. | Yes | | | |
| B. Frequency of Use | | | | |
| Frequently used controls and displays should be arranged to reduce search time and minimize the potential for error during use. | | | | |
| 1. They should be near the center of the preferred visual and manual areas. | Yes | | | |
| 2. They should be positioned so as to be easily identified. | Yes | | | |

## VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| C. Functional Considerations<br><br>Functionally related controls and displays should be grouped together when they are: | Yes | | | |
| 1. Used together to perform tasks related to a specific function (e.g., operation of the residual heat removal system). | Yes | | | |
| 2. Identical in purpose, (e.g., reactor coolant pumps). | Yes | | | |
| 6.8.2.2 LOGICAL ARRANGEMENT AND LAYOUT | | | | |
| B. Other Expectations<br><br>Where other operator expectations can be identified, components should be arranged to match these expectations. | | 2ES2-3022<br>2***-1201<br>2VC6-2008<br>2BB1-2215<br>2BB1-3011 | 6<br>5<br>8<br>9<br>9 | High Safety Imp.<br>High Safety Imp.<br>High Safety Imp. |
| 6.8.2.4 STANDARDIZATION<br><br>When a precedent has been established in the arrangement and location of controls and displays, that standard practice should be followed unless other crucial considerations necessitate a change. | | | | |

## VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.8.2.4 (Continued) | | | | |
| A. Panel to Panel Standardization<br><br>Standardization should be maintained where similar functions or panels are located at several work stations or units and must be used by the same personnel. | Yes | | | |
| B. Simulator-to-Control Room Standardization<br><br>Standardization should be maintained where simulators or procedure trainers are used that simulate the actual operational equipment. | N/A | | | |
| 6.8.3.2 STRINGS OR CLUSTERS OF SIMILAR COMPONENTS<br><br>On occasions it may be necessary to have a large group of similar components arranged together in strings, matrices, or other clusters. Those human factors principles presented in Section 6.8.2, Layout Arrangement Factors, should not be compromised where large clusters of components are concerned. However, considerations such as search time, discriminability of components, and avoidance of selection errors will often make a strony or matrix the preferred arrangement. The following criteria should apply: | | | | |

## VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.8.3.2 (Continued) | | | | |
| A. Orientation<br>Horizontal rows of displays should be used rather than vertical columns. | Yes | | | |
| B. String Length<br>Strings of small displays should not exceed about 20 inches on the control board. | Yes | | | |
| C. Number of Components | | | | |
| 1. No more than 5 similar components should be laid out in an unbroken row or column. | Yes | | | |
| 2. If more than 5 similar components must be laid out together, the string or cluster should be broken up by techniques such as physical spacing or demarcation | Yes | | | |
| 6.8.3.3 MIRROR IMAGING<br>Mirror-imaging is an arrangement in which two functional groups are laid out symmetrically so that one is a complete, | Yes | | | |

## VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.8.3.3 (Continued)<br><br>or almost complete, reversal of the other. Mirror-imaging should not be used, and any recurring functional groups should be replicated. | | | | |
| 6.9.1.1 SINGLE CONTROL AND DISPLAY PAIRS<br><br>Controls and displays which are normally used together should be located in close proximity to each other, but positioned and separated sufficiently so that the display is not obstructed during operation. | Yes | | | |
| A. <u>Proximity</u><br><br>A visual display that will be monitored during control manipulation should be located sufficiently close that an operator can read it clearly and without parallax from a normal operating posture. | Yes | | | |
| B. <u>Obstruction</u><br><br>Controls and displays should be located so that displays are not obscured during control operation. | Yes | | | |

VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| C. Association | | | | |
| Related controls and displays should be easily identified as being associated. This association can be established (or enhanced) by (1) location, (2) labeling, (3) coding, (4) demarcation, and (5) consistency with operator expectations. The following relationships should be immediately apparent to the operator: | | | | |
| 1. Association of displays with controls. | Yes | | | |
| 2. The direction of movement of control and display. | Yes | | | |
| 3. The rate and limits of movement of the control and display. | Yes | | | |
| 6.9.1.2 MULTIPLE CONTROLS OR DISPLAYS | | | | |
| The control and monitoring of nuclear power plant systems will occcasionally require either multiple controls or multiple displays. Control display relationships in multiple arrays should be apparent to the operator and consistent with human expectations. | | | | |
| A. Multiple Controls, Single Display | | | | |
| 1. Controls should be mounted below the display. | Yes | | | |

**VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED**

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 2. Controls should be centered on the display. | Yes | | | |
| 3. Controls should be grouped in a line or matrix. | Yes | | | |
| 4. If not feasible to mount controls directly below the display, controls should be mounted to the right of the display. | Yes | | | |
| 5. Where there is a normal order of use, controls should be arranged for use in left-to-right, top-to-bottom, or other natural sequence. | Yes | | | |
| 6. Where the above techniques cannot apply, or where for other reasons the relationships are not readily apparent, layout enhancement techniques should be employed - spacing, demarcation, color shading, insert panels, panel relief, and the use of mimics. See Guideline 6.8.1.3 | No | | | See Table 3-8 for Guideline 6.8.1.3 findings See Table 3-6 for related findings and HEDs from Guideline 6.6.6.2 |
| 8. Single Control, Multiple Displays | | | | |
| 1. Displays should be located above the control. | Yes | | | |
| 2. The control should be placed as near as possible to the display, and preferably underneath the center of the display array. | Yes | | | |

**VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED**

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 3. Displays should be arranged horizontally or in a matrix. | Yes | | | |
| 4. If it is not feasible to mount displays above the control, they should be mounted to the left of the control. | Yes | | | |
| 5. Where there is a normal order of use, displays should read from left-to-right, top-to-bottom, or in other natural sequence. | Yes | | | |
| 6. Where the above techniques cannot apply, or where for other reasons the control-display relationship is not clearly apparent, layout enhancement techniques should be employed. See Guideline 6.8.1.3. | Yes | | | |
| 7. Displays should not be obscured during control manipulation. | Yes | | | |
| C. Display Selectors | | | | |
| Where displays are selected for viewing using a rotary selector switch, the following should apply: | | | | |
| 1. The control should move clockwise from OFF (if appropriate) through settings 1, 2, 3...n. | Yes | | | |

## VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 2. The control room position sequence should conform to the display sequence. | Yes | | | |
| 3. Control position indications should correspond with display lables. | Yes | | | |
| 6.9.2.1 LOCATION AND ARRANGEMENT OF CONTROL-DISPLAY GROUPS | Yes | | | |
| A. Functional Integrity | | | | |
| Multiple controls or displays related to the same function (e.g., power, status, test) should be grouped together. | Yes | | | |
| B. Sequence of Use | | | | |
| Sequence of use should be as follows: | | | | |
| 1. Left to right. | Yes | | | |
| 2. Top to bottom. | Yes | | | |
| 3. The above combined (normal reading order). | Yes | | | |

**VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED**

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.9.2.2 SINGLE PANEL ARRANGEMENTS<br><br>Appropriate arrangements for control-display relationship, in order of preference, are (a) display above each control, (b) displays and controls in matched rows, and (c) multi-row displays with a single row of controls. Practice should be consistent, so that operator expectations are not confused. | | | | |
| A. Display Above Each Control<br><br>The preferred configuration is witn the display above each control. If this configuration is used the following should apply: | No | 2 BA4-2307 | 6 | High Safety Imp. |
| 1. Each display should be located directly above its associated control. | | | | |
| 2. The display/control pairs should be arranged in rows. | Yes | | | |
| B. Controls and Displays in Rows<br><br>As an alternative, displays may be arrayed in rows as the upper portion of a panel, matched to controls arrayed in similar rows below. | | | | |
| 1. Each control should occur at the same relative position as the display to which it is associated. | Yes | | | |

**VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED**

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.9.2.2b (Continued) | | | | |
| 2. Controls and displays should have corresponding labels. | Yes | | | |
| C. Multi-Row Displays with Single-Row Controls | | | | |
| A less desired arrangement is one in which two or more rows of displays are arrayed above a single row of controls. | | | | |
| 1. Displays should be ordered left to right and top to bottom (in normal reading order), and matched to controls ordered left to right. | Yes | | | |
| 2. Controls and displays should have corresponding labels. | | | | |
| D. Consisitent Practice | Yes | | | |
| Arrangements of functionally similar controls and displays should conform to the same convention throughout the control room. | | | | |
| E. Control/Display Packages | | | | |
| When controls and related displays are assembled using modular packaged units, the design of the packages will | Yes | | | |

## VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| 6.9.2.2 (Continued)<br><br>Limit the location and arrangement which can be achieved. In this case, modules should be se'ected and arranged to achieve maximum conformity with the principles described above.<br><br>6.9.2.3 CONTROLS AND DISPLAYS IN SEPARATE PLANES<br><br>A. Separate Controls and Displays<br><br>Where displays are on separated panels, they should preferably be on the adjacent upper panel from their associated controls.<br><br>B. Facing Panels<br><br>In no case should related controls and displays be located on separate panels that face each other.<br><br>6.9.3.1 GENERAL MOVEMENT RELATIONSHIPS<br><br>A. Rotary Controls<br><br>Rotary controls should turn clockwise to cause an increase | | | | |

**VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED**

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| in parameter value. The associated display movements should be as follows: | | | | |
| 1. Linear scales, up or to the right. | Yes | | | |
| 2. Digital displays, increasing in value. | Yes | | | |
| 3. Strings of indicator lights, bottom-to-top or left-to-right. | Yes | | | |
| 4. Circular meter pointers, clockwise. | Yes | | | |
| B. Linear Controls | | | | |
| Linear controls should move up or to the right to cause an increase in parameter value. The associated display relationships should be: | | | | |
| 1. Linear scales, up or to the right. | Yes | | | |
| 2. Digital scales, increasing in value. | Yes | | | |
| 3. Strings of indicator lights, bottom-to-top, or left-to right. | Yes | | | |

**VALIDATION OF CONTROL ROOM FUNCTIONS FINDINGS AND HEDs GENERATED**

| GUIDELINE | COMPLIANCE | HED NUMBER | PRIORITY | REMARKS |
|---|---|---|---|---|
| C. Display Respone Time Lag | | | | |
| 1. There should be no time lag between system condition change and display indication. | Yes | | | |
| 2. When there is a time lag between control actuation and ultimate system state, there should be an immediate feedback indication of the process and direction of parameter change. | Yes | | | |

# 5.0 ASSESSMENT AND DISPOSITION OF HEDs

## 5.1 Assessment

Assessment of the HEDs generated by the various CRDR tasks was accomplished in accordance with DLC NCD Instruction R-407.

### 5.1.1 Methodology

Following review and signoff by the Westinghous Program Coordinator/I&C Engineer (to ensure accuracy and completeness from a technical standpoint) and by the Essex Human Factors Project Manager/HFS (to ensure accuracy and completeness from a human factors standpoint), each HED was assigned a unique number, recorded in the HED Log and assessed by the review team (the meaning of the HED number is explained in Instruction R-409). Preliminary HEDs that were not legitimate because of the misinterpretation of a NUREG-0700, Section 6, guideline or the misunderstanding of a control room feature were discarded.

The Review Team consisted of the Review Team Leader, the Technical Coordinator, the Instrumentation and Control Engineer, the RO, the HFS, and supporting personnel as determined necessary by the Review Team.

First, the Review Team assessed the priority of each HED based upon a preestablished logic diagram (See Figure 5.1). Each HED was categorized as follows:

- Category I - A HED based upon an error documented as actually occuring at a plant of similar design.
- Category II - A HED based upon a discrepancy having a relatively high potential for degrading performance.
- Category III - A HED based upon a discrepancy having a relatively low potential for degrading performance.

Each HED was then assessed further for safety importance and consequence of error to determine priority, with a scale of 1 through 9 relating relative overall importance from a safety and human factors perspective (for more details on priority rating, see Instruction R-407, Appendix B). Figure 5.1 is a sample of a completed HED Priority Record Form.

The Review Team evaluated each HED and determined what corrective action should be taken. Corrective actions, such as surface enhancement, design change, or procedural, training, or administrative changes, were recommended. The recommendations are recorded on the HED forms.

Following CRDR Core Team agreement on the recommended resolutions, a reassessment was performed to determine whether the correction satisfactorily resolved the existing discrepancy and to ensure that the final recommended resolution would not introduce new discrepancies. Each HED resolution was assessed for the extent of deviation from the guidelines. A rating of zero deviation for the recommended resolution was considered acceptable. A greater-than-zero deviation from the guidelines required a determination of error potential and a determination of consequence of error on a scale of 1 through 6. An error potential or a consequence of error greater than 3 required a modification of the recommended resolution or a documented justification of the original resolution. Figure 5.2 is a sample of a completed Reassessment of Probable Error and Deviation form.

The recommended resolution section of each HED was reviewed and signed by the Westinghouse Program Coordinator, the DLC Review Team Leader, and the Essex Human Factors Project Manager to denote acceptance of the recommended resolution. The HEDs were submitted to DLC management for review and approval. The DLC Management Team consisted of the Engineering Manager, the Regulatory Affairs Manager, and the Operations Manager who approved, disapproved, or modified and justified the recommended resolutions. Dissapproved or modified HEDs were returned to the Review Team for concurrence, reiteration of the original recommendation, or the development of an alternate recommendation.

## HED PRIORITY RECORD

HED # 2BB2-3301

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. DOCUMENTED ERROR? | (NO) | | | | | YES |
| 2. DOCUMENTED UNSAFE CONDITION OR TECH. SPEC. VIOLATION? | (NO) | | | | | YES |
| 3. HIGH SAFETY IMPORTANCE (PAM OR 1E)? | NO | | | | | (YES) |
| 4. ERROR POTENTIAL? | 1 LOW | 2 | 3 | 4 | (5) | 6 HIGH |
| 5. CONSEQUENCE OF ERROR: | 1 LOW | 2 | 3 | 4 | 5 | (6) HIGH |

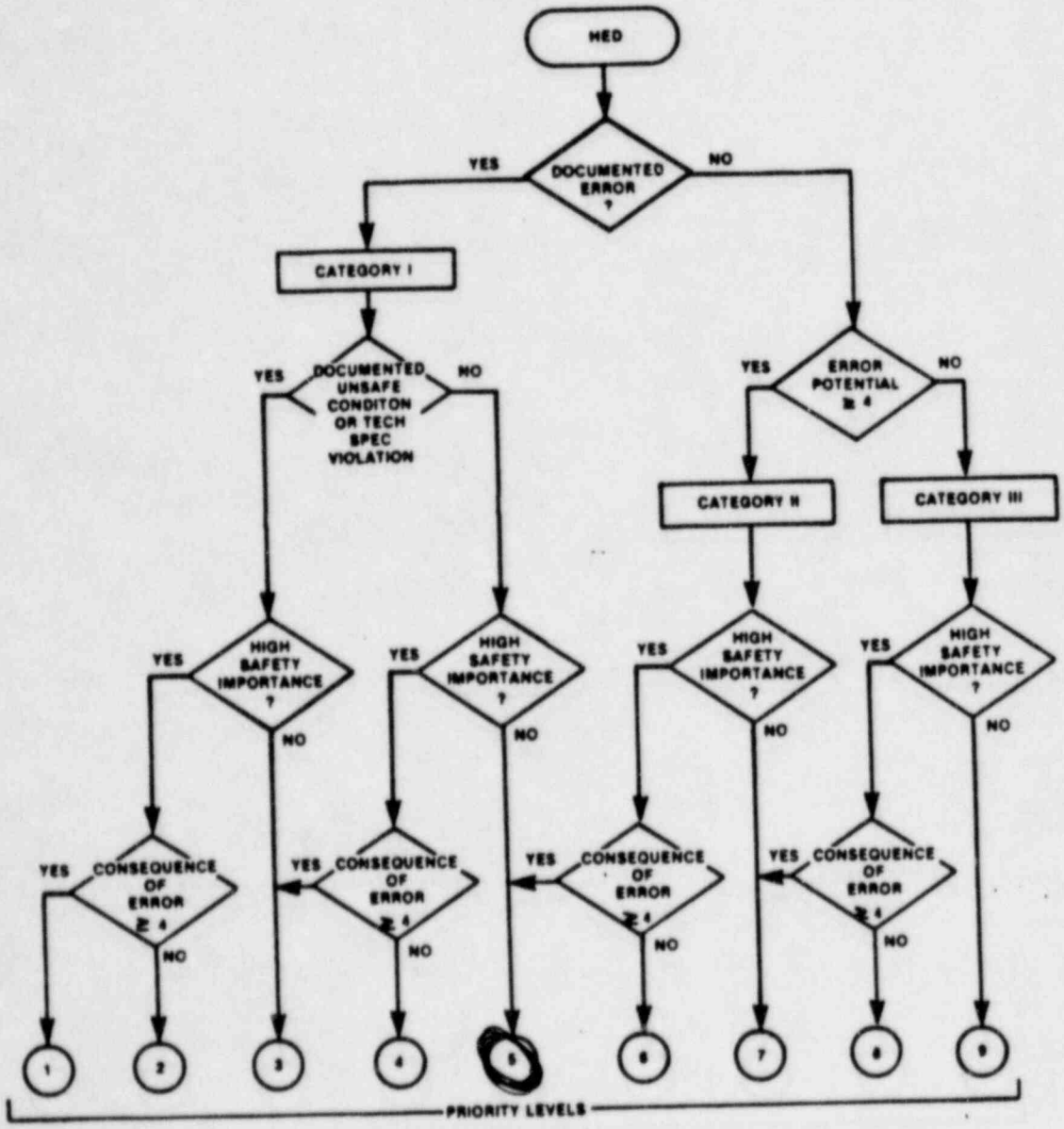
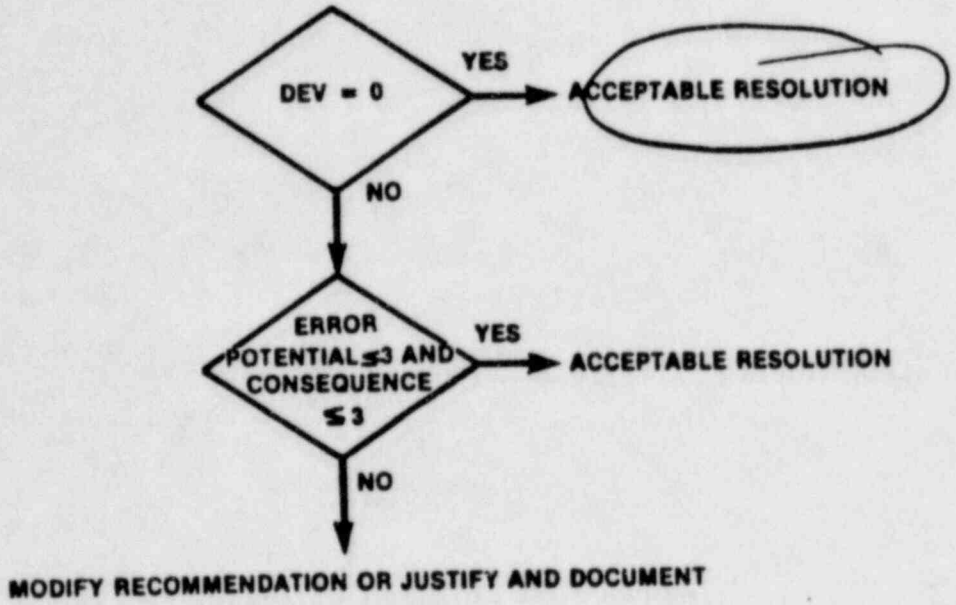



Figure 5.1

## REASSESSMENT OF PROBABLE ERROR AND DEVIATION

HED # 2BB2-3301

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. EXTENT OF DEVIATION FROM GUIDELINES | NONE 0 | SOME 1 | 2 | 3 | 4 | 5 | COMPLETE 6 |
| 2. ERROR POTENTIAL | | LOW 1 | 2 | 3 | 4 | 5 | HIGH 6 |
| 3. CONSEQUENCE OF ERROR | | LOW 1 | 2 | 3 | 4 | 5 | HIGH 6 |




SIGNOFF: DLC-RTL

E. T. Edmonds

DATE: 9/10/85

Figure 5.2

## 5.2 HED Disposition

ATI 160 HEDs identified during the BVPS-2 CRDR have been dispositioned by DLC management and are contained in Volume 3 of this report. Table 5.1, "Summary of Human Engineering Discrepancies," lists all HEDs (except those requiring no change) by type of correction required for resolution. The correction categories and number of HEDs in each category are as follows[3]:

| | |
|---|---|
| C - resolution complete or in progress | 7 HEDs |
| E - equipment change required for resolution | 21 HEDs |
| L - label (surface enhancement) change required for resolution | 26 HEDs |
| P - procedure change required for resolution | 12 HEDs |
| No change required | 98 HEDs |

### 5.2.1 Resolution Complete or in Progress

HEDs in this category either are resolved, or the design effort necessary for resolution is currently underway. Table 5.2, "Corrections in Progress," lists the HEDs in this category and describes the current status.

### 5.2.2 Equipment Change Required

Table 5.3, "Equipment Resolutions," lists all HEDs which require addition, change, or movement of control equipment for resolution.

The HEDs in this category have been assigned a "Change Request" number (as shown in Table 5.1) and placed into the existing change request process in accordance with NCD Procedure 2.12 "Onsite Design Change Control." Inconsistencies in Section L (Disposition) of the HED Report will be resolved through the change request process.

### 5.2.3 Label Change Required

Label (surface enhancement) changes are relatively simple means of improving an operator's ability to control the plant. Included in this category are all HEDs recommending lines of demarcations, flow path mimics, and hierarchical schemes as well as individual device scales and labels. A

[3]When the reviewer adds the HEDs by category, he will arrive at a total of 164. This is because two HEDs fall into categories E and P and two HEDs fall into categories L and P. The actual number of HEDs is 160.

comprehensive program of labeling has begun, which incorporates the following activities to ensure that labeling HEDs are resolved in a consistent fashion.

1. A standard station nomenclature and abbreviations list has been established. This list is contained in Chapter 48 of the Operating Manual and will serve as the standard for both Unit 1 and Unit 2.

2. A standard component nameplate format for both Unit 1 and Unit 2 has been established and will be formatted wherever possible according to the following (see Figure 5.3 for an example):

   Nameplate Line 1:

   1st: Main component or system, related to or serviced by the component controlled or subsystem or parameter displayed, preceded by the appropriate alpha numeric identifier.

   2nd: Equipment or subsystem containing either the component controlled or parameter displayed.

   Nameplate Line 2:

   Component controlled or parameter displayed preceded by the appropriate descriptions.

   Nameplate Line 3:

   Mark number of component controlled centered on this line of the nameplate.

   Power supply identification in the lower right hand corner of the plate.

3. The main control board, building service control panel, emergency shutdown panel and alternate shutdown panel label lists have been revised in accordance with the above standards.

Table 5.4 lists HEDs to be resolved by label change or demarcation.

5.2.4 Procedure Change Required

Table 5.5 lists HEDs which may be resolved by procedure change.

### 5.2.5 No Change Required

This group of HEDs was dispositioned by the Review Team and/or the Management Team as requiring no change. The justifications for no change are documented on the backside of each HED Report (see Volume 3).

### 5.2.6 HED Examples

Photographs of 5 HEDs identified during the BVPS-2 CRDR are shown in Figures 5.4 thru 5.8.

TABLE 5.1
SUMMARY OF HUMAN ENGINEERING DISCREPANCIES

| HED No. | HED Title | Correction Type | Category | Pri | Remarks | Change Request |
|---|---|---|---|---|---|---|
| 2***-1201c | Arrangement not logical | C | CNTRL ARRGT | 5 | E&DCR 2PG-1428 | |
| 2***-1201e | Arrangement not logical | C | CNTRL ARRGT | 5 | Items 1119A and 751 are in correct position | |
| 2AB*-0201 | Locate comm equipment | C | ASP | 7 | | |
| 2BC3-3025 | SAS compressor switches | C | CNTRL TYPE | 7 | | 74 |
| 2ES*-3020 | Controls too close to front | C | ESP | 5 | | |
| 2V**-2007 | Setpoints outside range | C | INDICATORS | 5 | | 68 |
| 2VC6-2214 | Do not use multiplier | C | INDICATORS | 5 | | 65 |
| 2***-1201a | Arrangement not logical | E | CNTRL ARRGT | 5 | | 83 |
| 2***-1201b | Arrangement not logical | E | CNTRL ARRGT | 5 | | 80 |
| 2***-1201d | Arrangement not logical | E | CNTRL ARRGT | 5 | | 81 |
| 2***-1201g | Arrangement not logical | E | CNTRL ARRGT | 5 | | 82 |
| 2***-2005 | Add a control room clock | E | ADD EQUIP | 7 | | N/A |
| 2VC6-2012 | Change scale to feet | E | INDICATORS | 9 | | 67 |
| 2*C*-2217 | Do not use multi-scale | E | INDICATORS | 9 | | 66 |
| 2AB*-2017 | Equip in proc not on panel | E & P | ASP | 6 | 1) and 2) only | ** |
| 2BB*-3015 | Overpress. protection keylocks | E | CNTRL TYPE | 5 | | ** |
| 2B**-3403 | Standby alarm wrong direction | E | CNTRL TYPE | 7 | | 62 |
| 2BB2-3301 | Rod control wrong direction | E | CNTRL TYPE | 5 | | 69 |
| 2ES*-1001 | Equip in proc not on panel | E & P | ESP | 6 | 5) Add clock only | N/A |
| 2ES2-3022 | Arrangement not logical | E | ESP | 6 | | 72 |
| 2ES4-3023 | Different transfer swx used | E | ESP | 5 | | 70 |
| 2V**-2014 | Do not use multiplier | E | INDICATORS | 6 | | 73 |
| 2VA6-2010 | Do not use multiplier | E | INDICATORS | 8 | | 64 |
| 2VA9-2403 | Wrong scale on recorder | E | RECORDERS | 5 | Add linear cards | 63 |
| 2VB2-2404 | Wrong label on recorder | E | RECORDERS | 8 | | N/A |
| 2VC6-2402 | Wrong label on recorder | E | RECORDERS | 5 | | 75 |
| 2VC5-2405 | Recorder scale graduations | E | RECORDERS | 7 | | ** |
| 2BB1-3026 | Block switches; illogical order | E | CTRL ARRGT | 7 | Unit 1 HED Review | ** |
| 2***-1101 | Inadvertent opening of vlv | L | LABEL & DEMARC | 3 | | |
| 2***-1103 | No hierarchical labels | L | LABEL & DEMARC | 5 | | |
| 2***-1105 | No labels for funct groups | L | LABEL & DEMARC | 5 | | |
| 2***-1107 | No demarcation lines | L | LABEL & DEMARC | 6 | | |
| 2***-1108 | No demarcation lines | L | LABEL & DEMARC | 6 | | |
| 2***-1109 | Label coordinates of arrays | L | LABEL & DEMARC | 9 | | |
| 2***-1111 | Non std abbrev used on labels | L | LABEL & DEMARC | 8 | | |
| 2***-1113 | Some labels are incorrect | L | LABEL & DEMARC | 5 | | |
| 2***-1115 | Some labels are incorrect | L | LABEL & DEMARC | 7 | | |
| 2***-1116 | Location aids are needed | L | LABEL & DEMARC | 5 | | |
| 2***-1117 | Label cntrllers for range | L | LABEL & DEMARC | 5 | | |
| 2***-1201f | Group PPDWST indicators | L | LABEL & DEMARC | 5 | | |
| 2***-2213 | Setpoints not match scale | L & P | PROCEDURES | 5 | | |
| 2BB1-2215 | Related indicators not ordered | L | LABEL & DEMARC | 9 | | |
| 2***-2220 | Setpoints not match scale | L & P | PROCEDURES | 6 | | |
| 2***-3002 | Identify SLI switches | L | LABEL & DEMARC | 7 | Wrong HED description | |
| 2AB*-1121 | Add demarcation | L | ASP | 7 | | |
| 2B**-1104 | Labels not always above | L | LABEL & DEMARC | 9 | | |

TABLE 5.1 (CONT.)
SUMMARY OF HUMAN ENGINEERING DISCREPANCIES

| HED No. | HED Title | Correction Type | Category | Pri | Remarks | Change Request |
|---|---|---|---|---|---|---|
| 2B**-2302 | Rework legend light engraving | L | STATUS PANELS | 7 | | |
| 2BA4-2502 | Group digits on counters | L | INDICATORS | 7 | | |
| 2ES*-1118 | Labels not always above | L | ESP | 9 | | |
| 2ES*-1120 | Identical nameplates | L | ESP | 6 | | |
| 2ES1-1119 | No demarcation lines | L | ESP | 6 | | |
| 2V**-1112 | Non-standard abbrev. used | L | ANNUNCIATOR | 8 | | |
| 2VA9-2406 | Distinguish between points | L | RECORDERS | 7 | | |
| 2VC6-2008 | Arrange indicators logically | L | LABEL & DEMARC | 8 | | |
| 2***-2213 | Setpoints not match scale | P & L | PROCEDURES | 5 | | |
| 2***-2220 | Setpoints not match scale | P & L | PROCEDURES | 6 | | |
| 2***-3006 | Equip in proc not on panel | P | PROCEDURES | 9 | | |
| 2AB*-2017 | Equip in proc not on panel | P & E | ASP | 6 | 3) Use 2ES*-1001 resolution | |
| 2AB*-3207 | Switches missing targets | P | ASP | 5 | | |
| 2B**-3206 | Switch pos missing on cntrllrs | P | PROCEDURES | 6 | | |
| 2BA*-3014 | Set controller for pressure | P | PROCEDURES | 8 | | |
| 2BA4-3205 | Pump control without speed sel | P | PROCEDURES | 8 | | |
| 2ES*-1001 | Equip in proc not on panel | P & E | ESP | 6 | 1) TO 4) ONLY | |
| 2ES2-3208 | Pump control without speed sel | P | ESP | 5 | | |
| 2VC6-2218 | Setpoints not match scale | P | PROCEDURES | 5 | | |
| 2***-3018 | Labels not match proc | P | PROCEDURES | 8 | | |

NOTES:

1) CORRECTION TYPE

C - Change to resolve this HED is now in progress

E - Equipment change : add or move

L - Label change : demarcation, grouping, standard nomenclature annunciator engraving, and indicator labels

P - Procedure change only

2) ** - Change request No. not yet assigned

3) PRIORITY - see NCD Instruction R407 (Appendix B)

TABLE 5.2
HEDs WHICH HAVE BEEN RESOLVED

| HED No. | PANEL No. | DRAWING No. | ITEM No. | MARK No. | DESCRIPTION OF RESOLUTION |
|---|---|---|---|---|---|
| 2***-1201c | BB-1,2 | RE-25N | 535,536 537 | 2RCS*PCV455C,D 2RCS*PCV456 | E&DCR 2PQ - 1428 provides acceptable resolution |
| 2***-1201e | BA-4 | RE-25K | 710,711 751,1119A | 2SIS*MOV867A-D | Refer to RE-25K Rev. 5. Items 1119A and 751 are in correct position This HED is resolved when HED 2***-1201 is resolved as indicated |
| 2AB*-0201 | ASP ROOM | | | | Communication equipment part of ASP room design |
| 2BC3-3025 | BC-2,3 | RE-25V,W | 149A,150A | 2SAS-C21A,B | Change of switch handles is completed |
| 2ES*-3020 | ESP | RE-25DE-DG | | All | Admin. control will ensure that plexiglass cover is in place not in use. |
| 2V**-2007 | VA-5 | RE-25A | 995 | 2QSS-LR100 | Current range is 13 - 742 inches |
| | VC-5 | RE-25Q | 290A, B | 2QSS*LI100A, B | Current range is 13 - 742 inches |
| | VC-5 | RE-25Q | 908A, B | 2FNC*LI102A, B | Current range is 0 - 480 inches |
| | VA-5 | RE-25A | 1013 | 2RSS-LR151 | Current range is 0 - 225 inches |
| | VA-6 | RE-25B | 1006A, B | 2RSS*LI151A, B | Current range is 0 - 225 inches |
| 2VC6-2214 | VC-6 | RE-25R | 263 | 2CNM-PI101 | Current range is 0 - 1000 psig |

TABLE 5.3

HEDs TO BE RESOLVED BY EQUIPMENT CHANGE

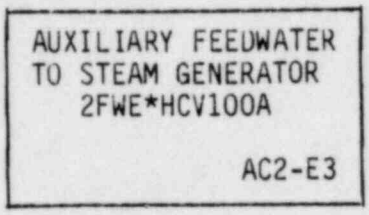
| HED No. | Panel Section | Drawing | Items Involved | Mark No. | Description of Change |
|---|---|---|---|---|---|
| 2***-1201a | BA-2/3 | RE-25H | 644 640 | 2MSS*PK101B,C | Exchange the positions of the controllers |
| 2***-1201b | BA-4 | RE-25J/K | See Description | | Move the following switches:<br>714 - 2CHS*FCVII3B 715 - BA Blend Control 716 - 2CHS*TCV143<br>722 - 2CHS-MOV311 729 - 2CHS-MOV303A 730 - 2CHS-MOV303B<br>731 - 2CHS-MOV303C |
| 2***-1201d | BA-4 | RE-25J/K | See Description | | Move the following switches:<br>709 - 2SIS*MOV869B 710 - 2SIS*MOV867B 711 - 2SIS*MOV867D<br>717 - 2CHS*LCV115D 979 - 2CHS*MOV111 |
| 2***-1201g | BC-2 | RE-25V | HICs | 2FWE*HIC100A-F | Exchange "A" for "E" and "B" for "F" |
| 2***-2005 | N/A | N/A | Clock | N/A | Add digital clock to the control room wall - not on the MCB |
| 2*C*-2217 | BC-3 | RE-25W | 3A | Synch Meter | Delete 0 - 26 kV scale |
| | VC-8 | RE-25S | 3B | Synch Meter | Delete 0 - 26 kV scale |
| 2AB*-2017 | ASP | RE-25GA | Clock | N/A | 1) Add the indicator; circuitry is already in the NME rack<br>2) Add digital clock to the ASP room wall - not on the panel<br>3) Cooldown rate indication not needed |
| 2B**-3403 | BB-2 | RE-25N | 335 | N/A | Reverse contacts on the standby alarm switch |
| | BC-3 | RE-25W | 170 | N/A | |
| 2BB2-3301 | BB-2 | RE-25N | 329B | N/A | Reverse pushbuttons under the rod control station |
| 2ES*-1001 | ESP | N/A | Clock | N/A | Add digital clock to the ESP room wall - not on the panel |
| 2ES2-3022 | ESP-2 | RE-25DF | 207-210 | | Move the following switches:<br>207 - 2CHS*SOV206 208 - 2CHS*LCV115C<br>209 - 2CHS*LCV115E 210 - 2CHS*LCV115D |
| 2ES4-3023 | ESP-4 | RE-25DH | | 2RHS*FK605B<br>2RHS*HIC758B | Replace the current transfer switches with OT-2 switches with small "J" handles |
| 2V**-2014 | VA-6 | RE-25B | 879A-C | 2MSS-PI101A-C | Purchase new scales without the multiplier |
| | VC-5 | RE-25Q | 296,297 | 2CCP*FI117A1,B1 | |
| | VC-5 | RE-25Q | 305A,B | 2CCP-FI117A2,B2 | |
| | VC-6 | RE-25R | 1140 | 2FWS-PI152 | |
| | VC-6 | RE-25R | 913 | 2FWS-PI155 | |
| | VC-6 | RE-25R | 919 | 2MSS-PI104A,B,C | |
| | VC-7 | RE-25S | 260A,B | 2MSS-PI102A,B | |
| | VA-9 | RE-25E | 865 | 2RCS-I121A,B,C | |
| 2VA6-2010 | VA-6 | RE-25B | 879A-C | 2MSS-PI101A-C | See above |
| 2VA9-2403 | VA-9 | RE-25E | 863B | 2CHS-FR154B | 0.2 gpm is required to be displayed, but can not be read on the square root scale. Rework the instrument loops to display the 0.2 gpm reading clearly by changing the recorder scale and:<br>1) adding three square root extractor cards, or<br>2) changing or recalibrating the transmitters |

TABLE 5.3 (CONT.)
HEDs TO BE RESOLVED BY EQUIPMENT CHANGE

| HED No. | Panel Section | Drawing | Items Involved | Mark No. | Description of Change |
|---|---|---|---|---|---|
| 2VB2-2404 | VB-6 | RE-25M | 448 | 2RCS-TR408 | Rework label to call the green pen TRef |
| 2VC6-2402 | VC-6 | RE-25R | 281 | 2FWS-LR477 | Change scale to read 0 - 100 percent |
| 2VC6-2012 | VC-6 | RE-25R | 273A,B | 2FWE-LI104A1,2 | Change scale units from inches to feet (PDWST level) |
| 2BB1-3026 | BB-1 | RE-25N | 344-347 360,361 | DT-2 SWITCHES | Rearrange block switches as follows: SOURCE RANGE INTERMEDIATE RANGE POWER RANGE |
| 2VC5-2405 | VC-6 | RE-25R | 276 | 2CNM-PR103 | Change recorder scale values so they progress by 1, 2, 5, or 10. |
| 2BB*-3015 | BB-2 | RE-25N | 352A 354A | ARM/BLOCK | Install keylock or guard to prevent accidental actuation |

EXAMPLE OF NAMEPLATE USING NEW FORMAT

EXISTING NAMEPLATE:




PROPOSED NAMEPLATE:

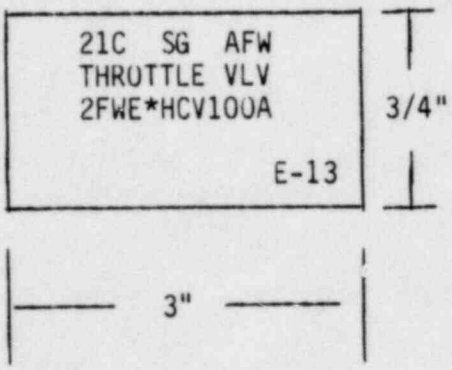



FIGURE 5.3

TABLE 5.4
LABEL CORRECTIONS

| HED No. | PANEL No. | DRAWING No. | ITEMS | MARK No. | DESCRIPTION OF CHANGE |
|---|---|---|---|---|---|
| ----- A CONSISTENT HIERARCHICAL LABELING SCHEME WILL RESOLVE THE FOLLOWING HEDs ----- | | | | | |
| 2***-1101 | BA1-3 | | 571,616,627 | 2SIS*MOV852A-C | Use demarcation to differentiate these |
| 2***-1103 | All panels | | | | Add a hierarchical labeling scheme |
| 2***-1105 | All panels | | | | Add labels for functional groups of controls and displays |
| 2***-1107 | All panels | | | | Add lines of demarcation for functionally related displays |
| 2***-1108 | All panels | | | | Add lines of demarcation for functionally related controls |
| 2***-1116 | All ESF controls | | | | Use color codes to highlight safeguards controls |
| 2***-1201f | VA-5<br>VA-6<br>VA-8<br>BB-1<br>VC-5<br>VC-6 | RE-25A<br>RE-25B<br>RE-25D<br>RE-25N<br>RE-25Q<br>RE-25R | PAM Sets I & II | | Add PAM set demarcation to groups of indicators on these panels |
| 2***-3002 | BC-2 | RE-25V | SLI switches | 789-792 | Provide demarcation and summary labels |
| 2AB*-1121 | ASP | RE-25GA | panel face | | Add hierarchical labeling and demarcation to ASP |
| 2VC6-2008 | VC-6 | RE-25R | 920,921 | 2FWS*LI4*7 | Covered for HED 2***-1201f |
| ----- THE FOLLOWING HEDs WILL BE RESOLVED BY ENHANCING THE INDICATOR FACE OR SWITCH ESCUTCHEON ----- | | | | | |
| 2***-2213 | All indicators | | | | Mark normal zones and setpoints on scale faces where appropriate |
| 2***-2220 | All indicators | | | | Mark normal zones and setpoints on scale faces where appropriate |
| ----- THE FOLLOWING HEDs WILL BE RESOLVED BY CHANGING THE LABEL ----- | | | | | |
| 2***-1109 | BA-3 | RE-25H | 1069 | BISI - A | Add row and column labels to these status light panels |
| | BA-3 | RE-25H | 1070 | BISI - B | |
| | VC-6 | RE-25R | 1020 | MSS DRAINS | |
| | VC-5 | RE-25Q | 1019 | ESS ISOL VLVS | |
| | BC-2 | RE-25V | 18 | MSS BYPASS | |
| | BC-2 | RE-25V | 19 | SG TRIPS | |
| | BC-2 | RE-25V | 47 | SG TRIPS | |
| | BB-1 | RE-25N | 308 | PRI PLANT | |
| | BA-4 | RE-25K | 465 | RCP STATUS | |
| | BA-2 | RE-25G | 464 | ESF Status | |

TABLE 5.4 (CONT.)
LABEL CORRECTIONS

| HED No. | PANEL No. | DRAWING No. | ITEMS | MARK No. | DESCRIPTION OF CHANGE |
|---|---|---|---|---|---|
| 2***-1111 | All labels and annunciator tiles | | | | Use standard nomenclature and abbreviations (Refer to Operating Manual Ch. 4B) |
| 2***-1113 | All labels and annunciator tiles | | | | Same as 2***-1111 Establish standard format ( see HED attachment ) |
| 2***-1115 | BA-2 | RE-25G | 1501,1505 | 2QSS*P24A,B | 1) Change "Chemical Addition Pump" to "Chemical Injection Pump" |
| | BB-4 | RE-25P | 406 | 2QSS-P23 | 2) Change "Chemical Addition Pump" to "Quench Spray Chemical Addition Pump" |
| | BC-3 | RE-25M | 196,198 | QCB 85,94 | 3) See HED writeup |
| | | | 166 | 89-2A | |
| 2***-1117 | All panels | | controllers | | Add "open" and "closed" position indication to controllers |
| 2ES1-1119 | ESP-1 | RE-25DE | 108T,111T | 2MSS*SDV105A-F | Add nameplates for transfer pushbuttons 108T & 111T which state the controls associated w/ each pushbutton |
| 2B**-1104 | BB-3 | RE-25P | 378A | 2NMI-NI35,36 | Place labels above indicators |
| | BB-3 | RE-25P | 378B | 2NMS-NI31,32 | |
| | BB-2 | RE-25N | 313 | 2NMP-NI4*B | |
| | BB-2 | RE-25N | 315 | 2RCS-TI4*2B,C | |
| | BB-2 | RE-25N | 316 | 2RCS-TI408,BB | |
| | BB-2 | RE-25N | 317 | 2RCS-SI408 | |
| | BA-4 | RE-25K | 465 | RCP Status | |
| | BA-1 | RE-25G | 464 | ESF Status | |
| | BB-1 | RE-25N | 307 | Gen MW | |
| 2B**-2302 | Legend lights | | | | Reengrave selected legend lights |
| 2BA4-2502 | BA-4 | RE-25J | 720 | 2CHS-FQIS113 | Add decimal point to drum counters on totalizers |
| | BA-4 | RE-25K | 733 | 2CHS-FQIS168 | Labeling revisions as indicated on HED attachment |
| | BA-4 | RE-25J | 991 | 2CHS-FQ113 | |
| | BA-4 | RE-25K | 992 | 2CHS-FQ168 | |
| 2ES*-1118 | ESP | RE-25DE-DG | | All | Place labels above components |
| 2ES*-1120 | ESP-3 | RE-25DG | 303-304 | 2RHS*MOV702A | Add train designation to labels |
| | ESP-4 | RE-25DH | 406-407 | 2RHS*MOV701B | |
| 2V**-1112 | All annunciators | | | | Use standard nomenclature and abbreviations |
| 2VA9-2406 | VA-9 | RE-25E | 864A,B | 2RCS-TR448A,B | Add label to recorders which identify individual recorder points |
| 2BB1-2215 | BB-1 | RE-25N | 325 | SEL SWTCH | Change label on PZR level channel selector switch |

TABLE 5.5
HEDs RESOLVED BY PROCEDURE CHANGE

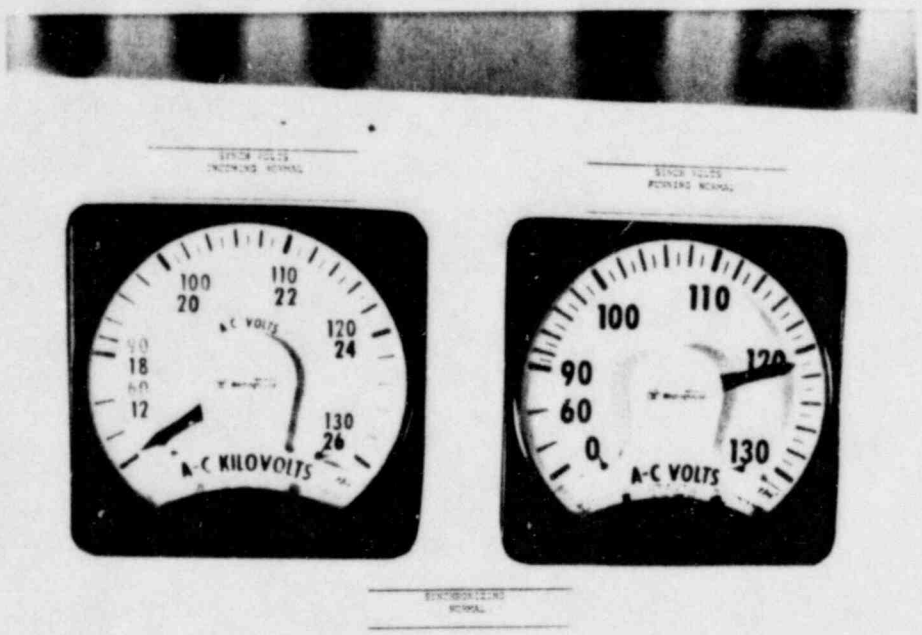
| HED No. | RECOMMENDED PROCEDURE CHANGE |
|---|---|
| 2***-2213 | Revise procedure references to these setpoints to the next most conservative, readable value. Also marking normal operating ranges on the indicator face will help |
| 2***-2220 | Same resolution as HED 2***-2213 |
| 2***-3006 | Change procedure to show local control |
| 2AB*-2017 | 3) See 2ES*-1001 resolution - Require logging of temp and time to determine cooldown rate |
| 2AB*3207 | Change procedure to omit reference to targets on switches |
| 2B**-3206 | Isolation valves are AOVs and do not modulate.<br>Define the need for "pull to lock"<br>Change the procedure to reflect installed equipment |
| 2BA*-3014 | Revise the procedure to show modulation of the controller while monitoring 2MSS-PI101A, B, C. When the desired pressure is attained, and the auto-setpoint corresponds to the desired pressure, the controller should be placed or returned to automatic. The controller will then maintain the set pressure |
| 2BA4-3205 | The procedure should describe the installed single speed pump |
| 2ES*-1001 | Revise the procedures to show the following:<br>1) 2MSS*SOV105A-F (Items 107 - 112) provide the necessary control<br>2) 2FWE-FI100A-C (Items 150 - 152) provide this indication<br>3) The difference between THot (Items 355) and TCold (Items 350) provides this information<br>4) The clock and item 3 above provide this information |
| 2ES2-3208 | The procedure should describe the installed single speed pump |
| 2VC6-2218 | Modify procedure to maintain flow and to maintain steam generator water level |
| 2***-3018 | Ensure procedure matches terminology, abbreviations, and nomenclature used on the nameplates and switch escutcheons |

FIGURE 5-4

HED No. 2*C*-2217

**Description:**

The "SYNCH VOLTS - INCOMING NORMAL" indicator is a multiscale indicator (violates NUREG-0700 criterion 6.5.1.4 f). It is also different than the "SYNCH VOLTS -RUNNING NORMAL" indicator. These two indicators should have identical scales.




**Resolution:**

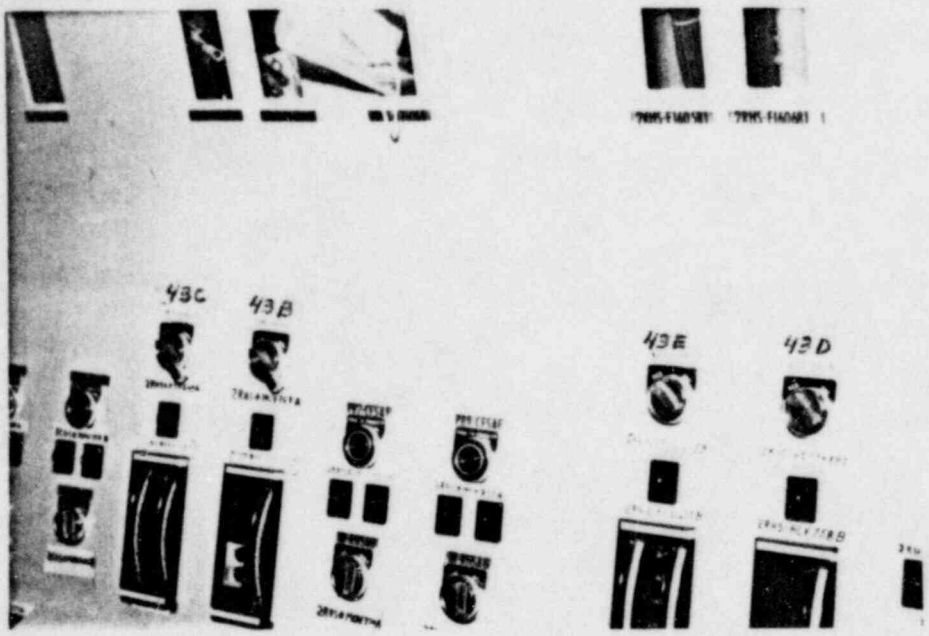
Replace the existing "SYNCH VOLTS - INCOMING NORMAL" indicator with one that matches the "SYNCH VOLTS - RUNNING NORMAL" indicator.

FIGURE 5-5

HED No. 2ES4 - 3023

**Description:**

The emergency shutdown panel uses two different types of switches for transferring control from the main control board (MCB) to the shutdown panel (SDP). (Violates NUREG-0700 criterion 6.4.1.1). The two controls on the left (43C and 4B-CESNL) are preferred (external handle). The two on the right (43E and 43D -CESNL) are of the type normally anticipated when controlling valves.




**Resolution:**

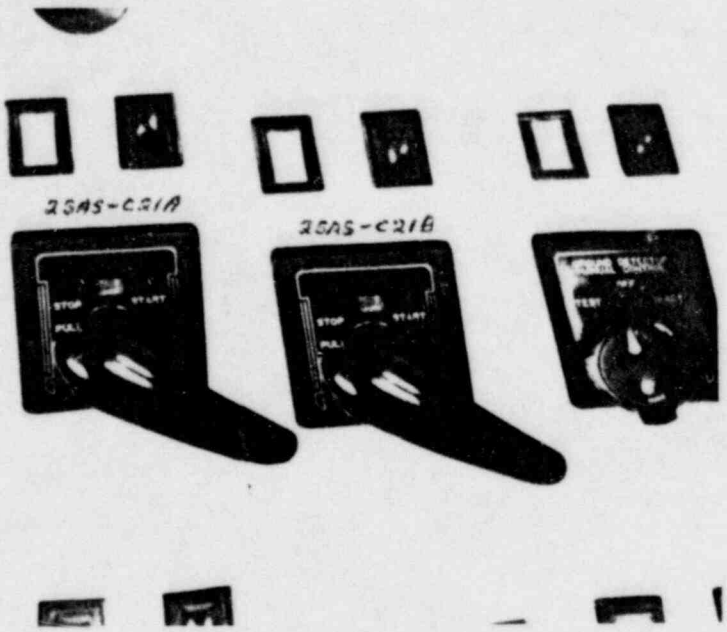
Ensure that all transfer switches are of the preferred type.

FIGURE 5-6

HED No. 2BC3 - 3025

**Description:**

When the control for 2SAS - C21A (Station Air Compressor) is in "PULL-TO-LOCK", 2SAS - C21B cannot be placed in "START" because the control handles interfere with each other (violates NUREG-0700 criterion 6.4.1.1).




**Resolution:**

Install oval-shaped control handles that will not interfere with each other, as shown below.

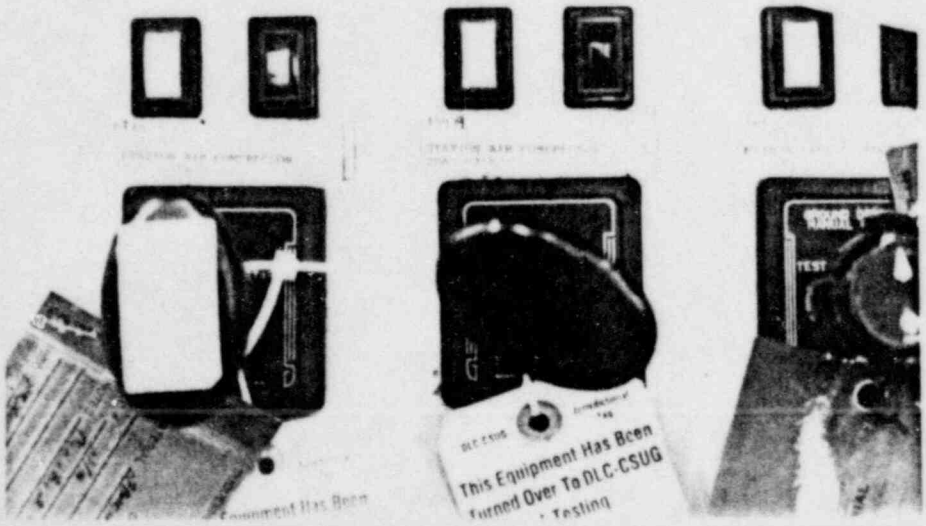
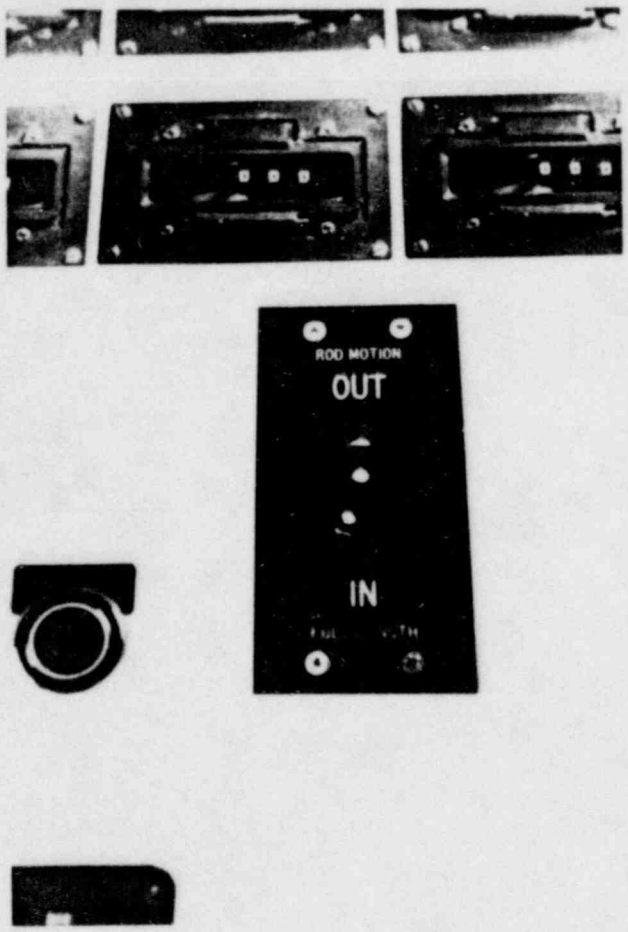


FIGURE 5-7

HED No. 2BB2 - 3301

**Description:**

The existing rod position controller is inconsistent with operator's expectations (violates NUREG-0700 criterion 6.4.2.1). Also, the positions are reverse to that of Unit 1.




**Resolution:**

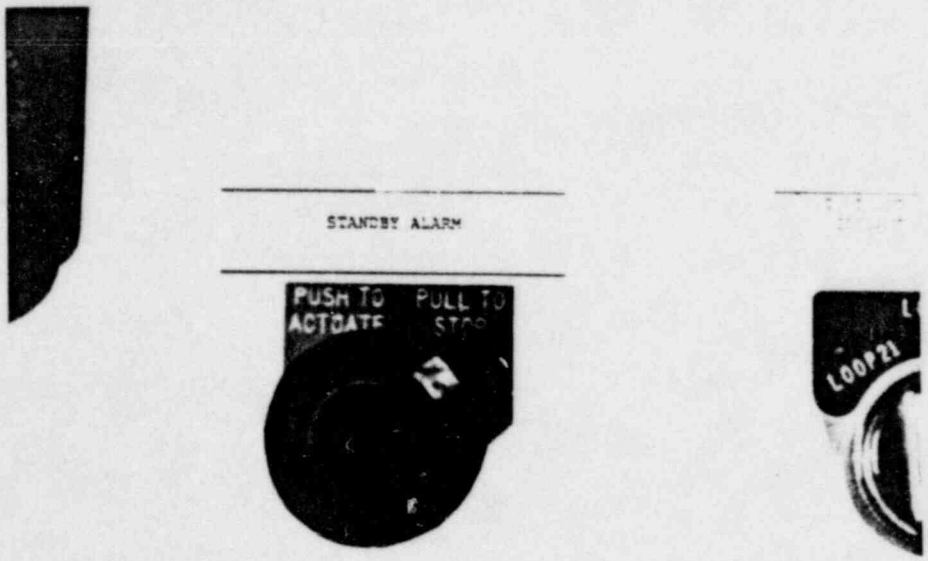
The switch contacts and control labelling will be reversed so that pushing lever foward will push rods IN and pulling lever will pull rods OUT.

FIGURE 5-8

HED No. 2B** - 3403

**Description:**

The standby alarm switch does not conform to convention of pull to start and push to stop (violates NUREG-0700 criterion 6.4.2.1). Also, the positions are reverse to that of Unit 1.




**Resolution:**

The switch contacts and labelling will be reversed so that pulling the switch will actuate the standby alarm and pushing will stop the alarm.

# 6.0 IMPLEMENTATION AND SCHEDULING OF CORRECTIVE ACTIONS

It is anticipated that all HED corrective actions will be implemented prior to the scheduled fuel load date of April 30, 1987. However, there is one exception: HED 2VA9-2403 may involve considerable rework in the instrument loops and/or a change out of the transmitters. The scope for resolving this HED is under investigation. If circumstances should arise which would prevent DLC from implementing an HED identified in this report prior to fuel load, the NRC will be notified.

The NUREG-0700 criteria listed in Section 3.1 of this report which involve dual unit control room characterstics, and those listed as unable to be assessed, will be evaluated using the original set of CRDR instructions, ensuring a consistent approach for the Assessment and Disposition of HEDs which may result. The post-CRDR evaluation will commence after removal of the temporary wall and when the dual unit control room is in a state which will allow for a complete and final review. It is anticipated that any HEDs resulting from the post-CRDR evaluation will be implemented prior to or during the first refueling cycle following completion of the post-CRDR evaluation.

# 7.0 COORDINATION WITH OTHER ACTIVITIES

## 7.1 Emergency Operating Procedures (EOPs)

The usability of the EOPs and their correlation to the control room hardware are important aspects of the EOP development program. With this in mind, BVPS-2 integrated the EOP validation program with the CRDR validation program. This approach ensured a coordinated effort between the two programs while eliminating the duplication of work that would have otherwise occured. In addition, the SRTA portion of the CRDR used the EOPs as its basis. This examination of the EOPs enabled the Review Team to recommend changes to the EOPs which would enhance their usability in the control room. HEDs generated against the EOPs are listed in Table 5.5.

## 7.2 Regulatory Guide 1.97 -- Post-Accident Monitoring

The Regulatory Guide 1.97 instrumentation was already installed at the time of the CRDR and therefore was reviewed as an integral part of the CRDR. The Regulatory Guide 1.97 instrumentation, like all of the operator information and control needs, was reviewed in the Control Room Survey, SRTA, Verification of Task Performance Capabilities, and Validation of Control Room Functions.

## 7.3 Unit 1 Control Room Design Review

The Unit 1 and Unit 2 CRDRs were conducted by separate Review Teams due to the scheduling constraints of the Unit 2 construction project. The Unit 2 CRDR Summary Report was originally scheduled for a June, 1985, submittal while the Unit 1 submittal was scheduled for December, 1985. However, with the announcement in January, 1985, of the 14-month delay in the project completion date, the Unit 2 Summary Report submittal date was changed to December, 1985. The revised submittal date ensured a more comprehensive review and increased coordination with Unit 1 (since both review tasks would now be conducted in parallel), yet allowed for sufficient time to implement the HED fixes prior to the scheduled fuel load date of April 30, 1987.

### 7.3.1 Unit 1/Unit 2 Coordination

The primary means of coordinating the two efforts was through the exchange of HEDs. All BVPS-2 HEDs were forwarded to the BVPS-1 Team Leader and vice-versa. The HEDs were then reviewed to ensure that similar problems would receive similar fixes. The Unit 1 HEDs were then screened by the Unit 2 Operations Startup Group to identify HEDs which:

1. Apply to Unit 2,

2. Have some type of action recommended by Unit 1 Review Team, and

3. Were not identified as an HED by the Unit 2 Review Team.

There are ten Unit 1 HEDs which meet the above criteria (see Table 7.1). Nine of these have resolutions recommended by the Unit 1 team, but at the writing of this report, had not yet received final Unit 1 disposition. Unit 2 will await Unit 1 disposition prior to acting on these HEDs.

TABLE 7.1

UNIT 1 HEDs APPLICABLE TO UNIT 2

| Unit 1 HED No. | Description | Task | Unit 2 Action |
|---|---|---|---|
| 45 | Page phone cords are long and could trip operators | Control Room Survey | Awaiting Unit 1 Disposition |
| 51 | Claxons on fire alarm and radiation alarm are same | Control Room Survey | Awaiting Unit 1 Disposition |
| 52 | Radiation monitor alarm is intense and causes operator discomfort | Operator Interview | Awaiting Unit 1 Disposition |
| 100 | Rod control start-up - control should be protected from inadvertent actuation | Control Room Survey | Awaiting Unit 1 Disposition |
| 116 | OT-2 Emergency Generator ground switch indicator lights violate red/green convention | Operator Questionnaire & Interview | Awaiting Unit 1 Disposition |
| 157 | Volt Meters - most are on the 0-130V or 0-150V scale. Operator must convert when bus has higher voltage | Questionnaire Survey | Awaiting Unit 1 Disposition |
| 183 | Governor valves, throttle position meters and tracking meters - voltage limiter status light in wrong position | Control Room Survey | Awaiting Unit 1 Disposition |
| 337 | Station air and containment Instrument Air indicators are arranged among turbine indicators. Controls are arranged similarly but demarcated differently. | Control Room Survey | Awaiting Unit 1 Disposition |
| 362 | Exciter circuit breaker switch can be confused with containment instrument air compressor switch (side-by-side, same type handle) | Control Room Survey | Awaiting Unit 1 Disposition |
| 386 | Block switches should be ordered 1) source, 2) intermediate, 3) power | Control Room Survey | Unit 2 HED No. 2BB1-3026 |

# 8.0 CONCLUSIONS

The BVPS-2 CRDR program was conducted to ensure compliance with accepted human engineering standards. The standards used are contained in NUREG-0700. Appendix D provides a NUREG-0700 Section 6 Guidelines/BVPS-2 CRDR findings cross-reference.

With the completion of the CRDR, DLC feels confident that the control room, ESP, and ASP will support operation during normal and emergency conditions. The success of the CRDR program can be attributed to three factors:

- o management commitment to the review effort
- o expertise of the multidisciplinary Review Team, and
- o detailed planning and scheduling in the early stages of the review.

## 8.1 Continuing Human Factors Program

The success of the CRDR program also required a good working relationship between the Operations, Engineering, and Licensing departments. This established relationship will be helpful as the HED resolutions are implemented. The equipment change resolutions are being implemented through the Change Request process discussed in Section 5.2.2. The procedure changes will be incorporated into the next revision of the EOPs. The HEDs involving labeling improvements have been addressed through the revised Nameplate Engraving List which incorporates the standard station nomenclature, abbreviations list, and the new nameplate format.

The demarcation and hierarchical labeling scheme was not attempted during the course of the CRDR due to the ongoing construction in the control room (see Figure 8.1). This effort will begin in the near future at which time the design of the control boards will be, for the most part, finalized. DLC plans to use the Electric Power and Research Institute (EPRI) Report NP-2411, "Human Engineering Guide for Enhancing Nuclear Control Rooms," and the existing guidance of the BVPS-1 control board to guide this effort.

Any control board changes made after the CRDR and before operation of Unit 2 will be reviewed by engineers at Stone & Webster Corp. (Architect/Engineer for BVPS-2), who are trained in Human Factors, to ensure that no new HEDs are created. Also, all changes must be reviewed by the Design Change Control Group (DCCG) at DLC. The chairman of the DCCG was a member of the Unit 1 CRDR and had input to the Unit 2 CRDR. The operations representative on the DCCG was an active participant on the BVPS-2 CRDR Team and had extensive input during the Assessment and Disposition phase.

## 8.2 Post-Operational Human Factors Program

At BVPS-1 (an operational plant) any design changes which involve the control room are required to receive a human factors review in the Design Concept stage. When BVPS-2 becomes operational, it will also be subject to this requirement. The existing (BVPS-1) guideline for conducting a Human Factors Review is Nuclear Engineering Department Internal Instruction No. 39, "Human Factors Engineering Guidelines." This instruction recommends operator interviews and use of consultants in reviewing the proposed change and requires compliance with NUREG-0700 guidelines. The full-scale photo mock-up is also available to ensure that the proposed change does not create any new HEDs.

FIGURE 8.1

BVPS - 2 Control Room (under construction)