ARKANSAS POWER AND LIGHT
ARKANSAS NUCLEAR ONE - UNIT 1
CONTROL ROOM DESIGN REVIEW
FINAL SUMMARY REPORT
PROGRAM IMPLEMENTATION
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1.0 INTRODUCTION

The control room design review (CRDR) is part of a broad program designed to ensure consideration of human factors and to enhance plant operation at Arkansas Nuclear One. The purpose of the Arkansas Nuclear One-Unit 1 (ANO-1) CRDR was to review and evaluate the control room workspace, instrumentation, controls and other equipment from a human factors standpoint considering the guidance of NUREG-0700, taking into account both system demands and operator capabilities. Secondly, the human factors review identified and assessed potential control room design modifications which correct inadequate or unsuitable items. Implementation of any such modifications will be accomplished via the established ANO design change process.

1.1 Objectives

The following were the CRDR objectives identified for ANO-1:

1.1.1

Determine whether the control room provides the system status information, control capabilities, feedback, and analytic aids necessary for control room operators to accomplish their functions effectively.

1.1.2

Identify characteristics of the existing control room instrumentation, controls, other equipment, and physical arrangements that may detract from operator performance (i.e., human engineering discrepancies).

1.1.3

Analyze and evaluate the problems that could arise from the aforementioned human engineering discrepancies, and to analyze means of correcting those discrepancies which could lead to substantial problems.

1.1.4

Incorporate into the design change process a structured method that applies human factors principles to improve control room design and enhance operator effectiveness, with particular emphasis placed on improvements affecting control room design and operator performance under emergency conditions.

1.2 Previous Control Room Design Improvements

Since Arkansas Nuclear One-Unit 1 (ANO-1) went into commercial operation in December 1974, Arkansas Power and Light (AP&L) has made several control room upgrades and improvements to the unit. These improvements were made based on experience gained in unit operation and AP&L's continuing commitment to translate that experience into operating excellence.

These human engineering improvements, completed prior to the CRDR, were important to consider during the CRDR in order to provide a more complete context within which to review the control room design. The following sections describe some of these previous control room improvements.

1.2.1 Labels

Instruments and controls in the control room are presently labeled. These labels (nametags) provide information to the operators regarding the function of an instrument as well as the associated system. Some of these nametags also contain the instrument and/or bus number of the component. In many cases, an abbreviation is used for words contained on the nametags. By using the abbreviated form of a word, more specific and detailed information was added to the label.

Through training and control room experience, the operators are familiar with the instruments as well as the intent of the labels in the control room.

1.2.2 Annunciators

Human factors modifications can act to greatly improve an existing annunciator system. Modifications such as format standardization, reduction of ambiguity, letter-quality upgrades, prioritizing alarms, and use of abbreviations supplement the operator's knowledge of systems and improve the operator's performance in responding to annunciator warnings.

1.2.2.1 Annunciator Upgrades

At ANO-1, three steps toward annunciator upgrades have been initiated. The number of alarms has been reduced by combining similar alarms as well as eliminating unnecessary and redundant alarms. In some cases where an alarm could signal multiple conditions, additional indicator lights have been installed on the panel. For example, in the past, the circulating water pump alarm referred to one of several pumps. Indicator lights

were added to the control boards directly below the annunciator tile, as shown in Figure 1, to indicate which pump was affected.

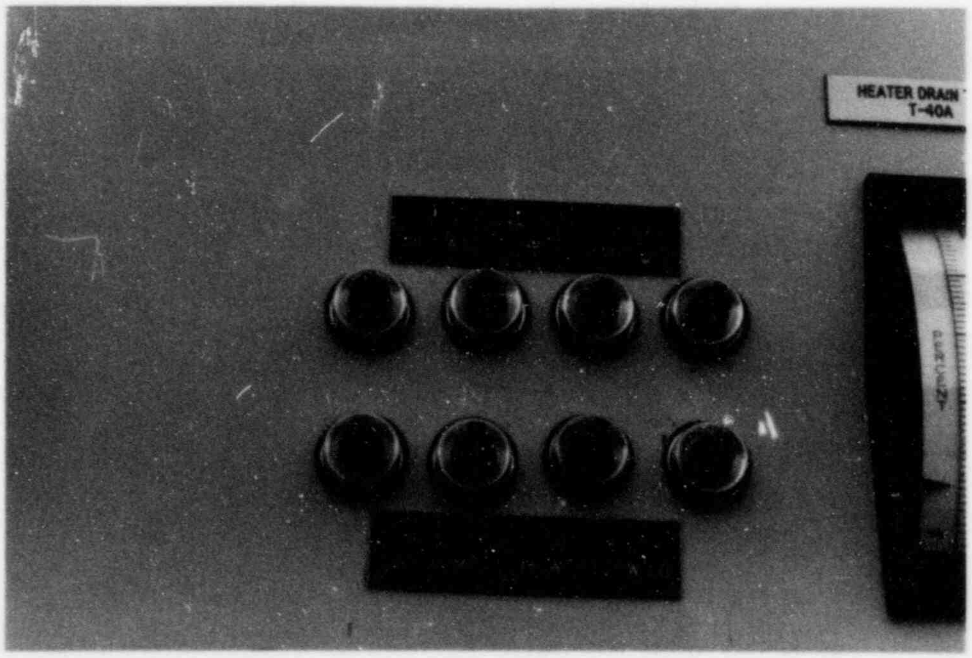


Figure 1. Circ Water Pump Indicator Lights

The second step taken for annunciator upgrades was a regrouping of alarms. This grouping not only functionally clusters alarms from the same system together but also positions alarms in close proximity to related controls and displays to further facilitate ease of operation.

Finally, AP&L plans to prioritize the annunciator windows. This will aid the operators in determining the importance of incoming alarms. For example, where space permits, higher priority alarms will be located in the top half of the annunciator box, while lower priority alarms will be located toward the bottom.

In addition, the annunciator boxes have been labeled with a matrix-type format. This labeling scheme, as shown in Figure 2, aids the operator in searching for and identifying a particular window.

Figure 2. Annunciator Box Labeling

1.2.2.2 Remote Annunciators

Several remote annunciator panels were modified to provide a reflash of the control room annunciator when initiated by subsequent alarms from the same remote panel. Previously, when a remote panel alarm was annunciated and acknowledged in the control room, subsequent alarms from the same remote panel would go undetected.

1.2.2.3 Additional Annunciator

During periods when the reactor coolant system (RCS) is at lower temperatures than during normal operation, the reactor

vessel must be maintained at low pressure due to brittle fracture concerns. This mode of operation requires specific precautions by the operator to protect the reactor vessel. A new system has been provided to alarm when conditions are met in which the RCS can be overpressurized at low temperatures. This feature focuses the operator's attention to this mode of operation so that the chances of operator error are further reduced.

1.2.3 Functional Grouping of Instruments

In order to promote operator efficiency during normal and emergency operating conditions, the operator's movements should be minimized. This can be accomplished by grouping instruments from corresponding systems. Also, when several instruments are used in conjunction with each other during an operating scenario, they should be located within reasonable proximity to each other.

Of course, all instruments cannot be placed next to corresponding ones due to the large numbers involved. The following section details methods of functionally grouping instruments, including demarcation techniques and correction of instrumentation groupings that proved to be difficult to read.

1.2.3.1 Physical Location

Previously, the majority of the components of the Emergency Feedwater system were located on the C16 and C18 vertical panels with some indications on C12 and C03. In a situation where these components are used, one operator must stand at the

vertical panels while another operator stands at the front panel. Verbal communication between operators is the only means of accomplishing this procedure. To facilitate the ease of operation of this system, a design change has been implemented to group emergency feedwater system controls and instrumentation to panel C09 (Figure 3).

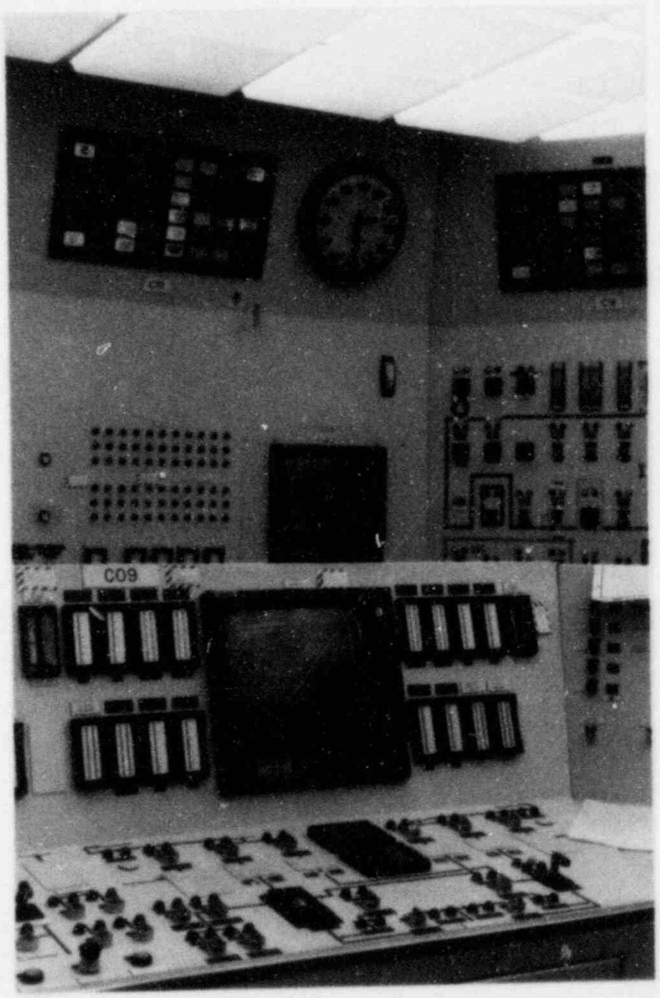


Figure 3. Emergency Feedwater System

All components of the Emergency Feedwater system are involved in the modification. Previously, the alarms were scattered in several places between annunciator boxes; during the annunciator modifications, they were grouped on annunciator box K-12, in close proximity to the C09 panel.

In addition, the old system required manual intervention of the operator to control the following events:

- o Establishing natural circulation to prevent overcooling
- o Establishing reflux boiling by maintaining level at the required 95% on the operate range
- o Isolating the Steam Generator from the Emergency Feedwater system upon identification of the ruptured steam line
- o Establishing steam flow through the atmospheric dump system when there is a steam rupture downstream of the main steam isolation valves

The new system automatically controls the rate of fill and thus relieve the operator from the task of manually throttling the valves for overcooling. Also, the new system has an automatic setpoint for reflux boiling so that the operator does not need to modulate valves to maintain this level.

With the old system, the operator has to identify a ruptured steam line on one of the Steam Generators and manually isolate the Steam Generator from the Emergency Feedwater system. In the new system, these functions are automatic. The other major change is in the atmosphere dump system. Previously, the operator had to manually establish steam flow through the atmosphere dump system when there was a steam rupture downstream of the main steam isolation valves. The new Emergency Feedwater system is fully automatic and does not require operator intervention for pressure control.

Other physical location improvements of instrumentation include: the installation of three digital displays on panel C03 (Figure 4) that can be selected from any point on the plant computer (eliminating the need to move back and forth between the plant computer and the operator workstation); and the addition of a digital display of controlling RCS Tave on panel C03 for operator ease in monitoring RCS average temperature.

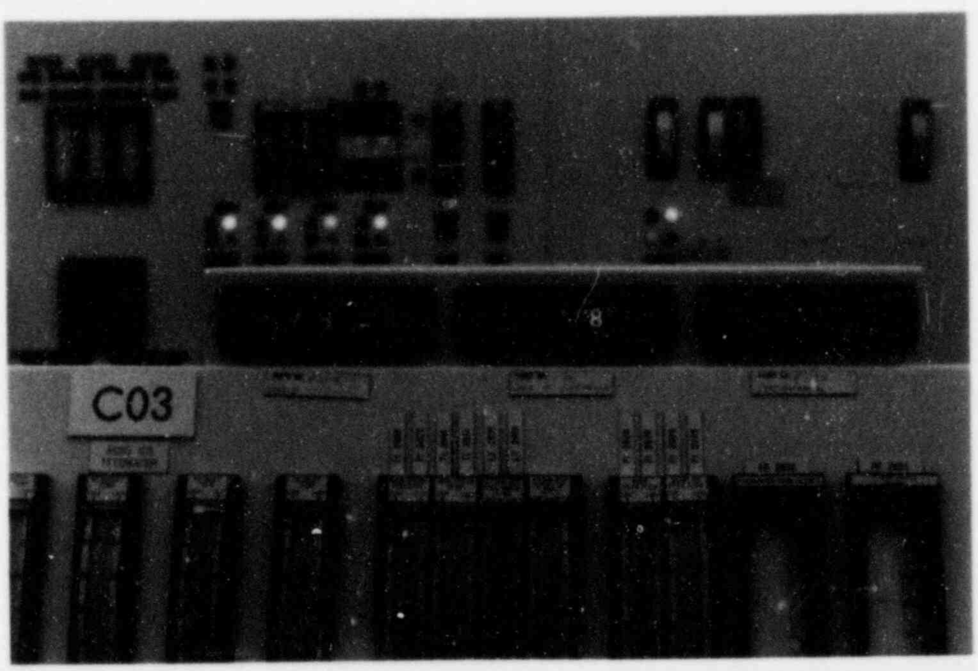


Figure 4. RCS Displays

1.2.3.2 Demarcation

Background shading and demarcation are simple control board enhancements used to achieve functional separation between systems. Currently, ANO-1 relies on a demarcation technique as described below.

Five colors of tape are used for demarcation at ANO-1 on the C16 and C18 control boards to delineate the boundaries of instrument groupings as shown in Figure 5. Red, brown, yellow, and cream are used to separate channels on the engineering safeguards instruments. In addition, green is used to separate

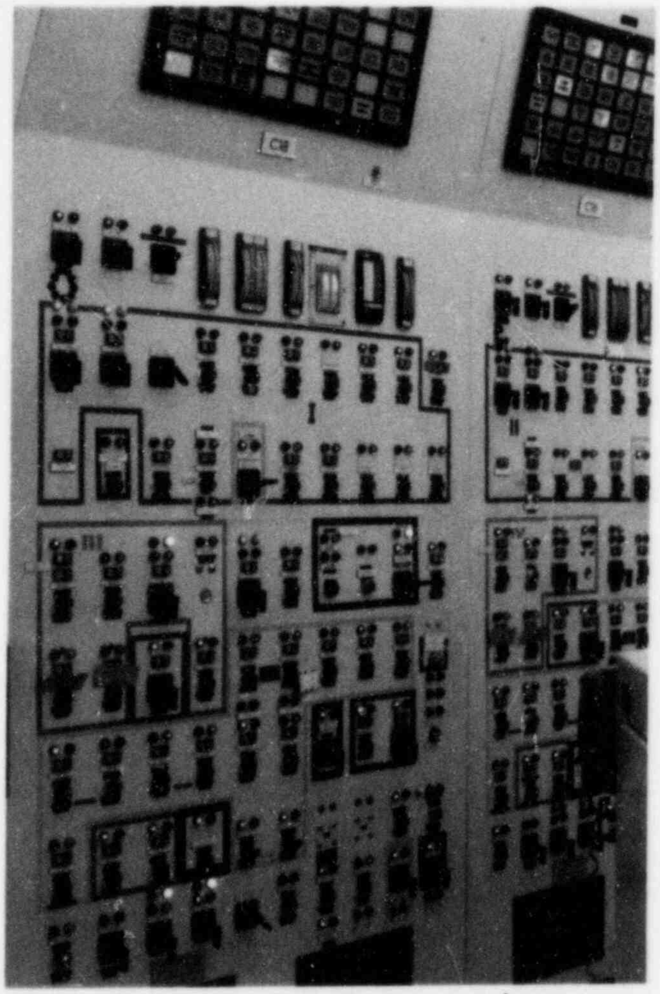


Figure 5. Demarcation

the Emergency Feedwater system instruments and yellow is used for the steam controls on these panels.

1.2.3.3 Excessive Consolidation

The concept of locating instruments close together and consolidating displays can be overdone. The original ANO-1 display for reactor coolant pump seal data was a single, multi-point recorder for all four reactor coolant pumps. Thus, it was difficult to assess seal problems because the display was very cluttered. As a result, the multi-point recorder was replaced by four dual-pen recorders, one for each reactor coolant pump, located on C14 (Figure 6). This design change allows much easier operator monitoring of each reactor coolant pump seal system.

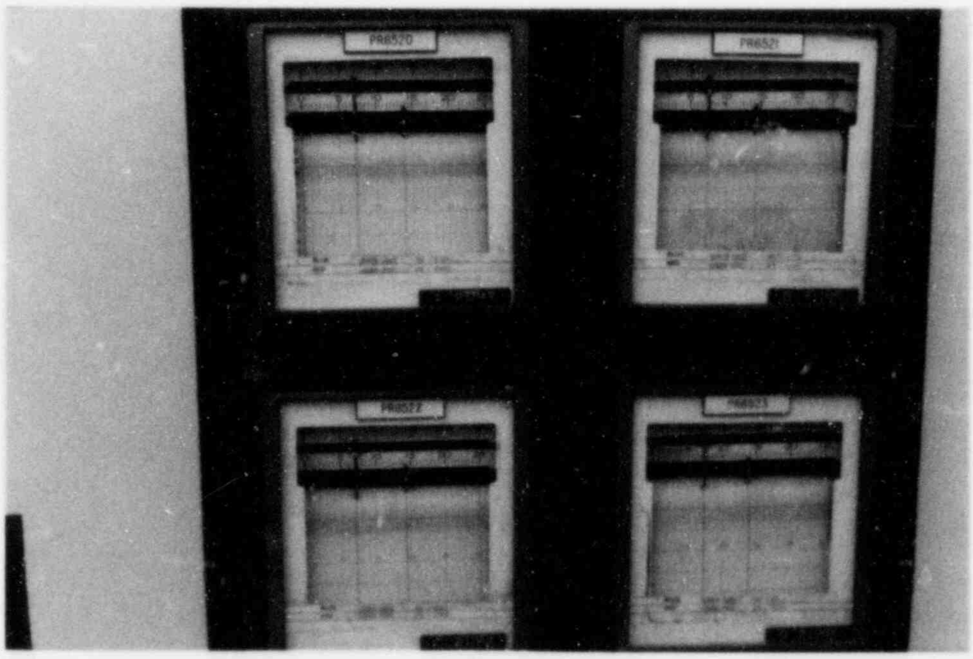


Figure 6. Reactor Coolant Pump Seal Recorders

1.2.4 System Upgrades

In addition to the upgrades previously mentioned in this report, several others have been made that involved the ANO-1 control room. These upgrades improved the operator's ability

to control the plant during normal and emergency situations. Some of the more significant system upgrades are discussed below.

1.2.4.1 Remote CRD Power Supply Trip

This modification involves the Control Rod Drive (CRD) power supply trip buttons. In case of a CRD trip breaker failure, the method of removing power from the CRDs involved going to the local power supply breakers and tripping them (this action involved access through two card reader doors). Trip buttons for each of the CRD power supplies have been installed on panel C03 in the control room as shown in Figure 7 so that the operator can trip the power supply breakers without leaving the control room. This modification allows for a more timely method of removing power from the CRD system.

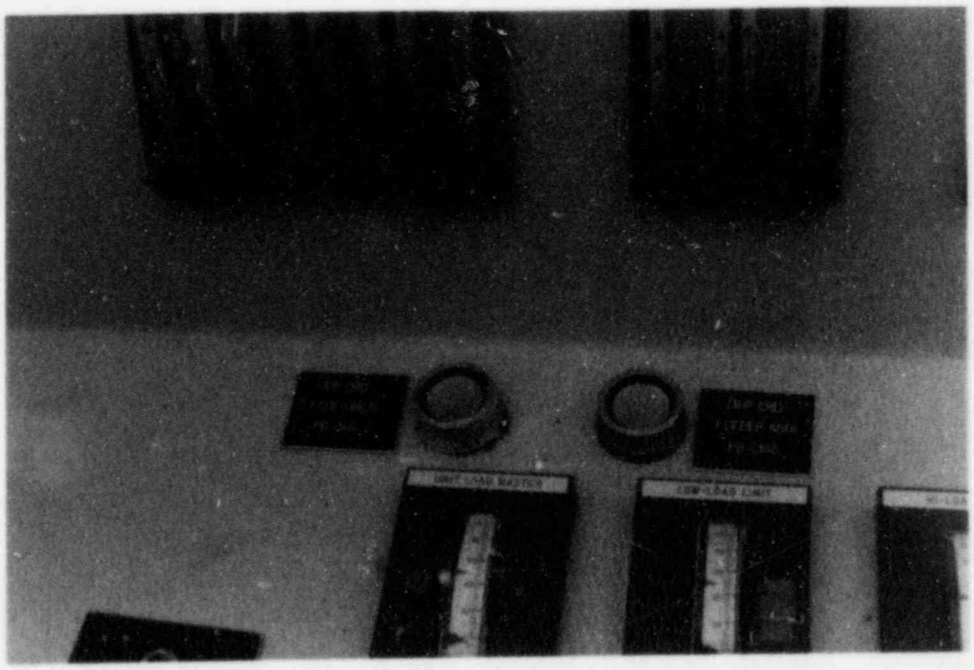


Figure 7. Trip Buttons for Control Rod Drives

1.2.4.2 Atmospheric Dump Valve Controls

Originally, the controls for manually decreasing main steam pressure to control RCS heat removal allowed the operator to use only the turbine bypass valves unless condenser vacuum was lost; this, in turn, caused a switchover to the atmospheric dump valves. In order to provide more operator flexibility, a system upgrade was implemented that included a selector switch in the control room (panel C02) allowing the operator to choose between the atmospheric dump valves and the turbine bypass valves for main steam pressure control. Also, the isolation valves for the atmospheric dump valves were originally manual valves. A system upgrade was made to provide motor operators on the isolation valves that are controlled from the control room. This change provides remote operation of atmospheric dump isolation valves as well as modulating control of the atmospheric dump if instrument air is lost.

1.2.4.3 Trip Reset Controls

Trip reset for the Steam Line Break system (SLBIC), decay heat removal system suction valves, and for low condenser vacuum, previously required operator action outside the control room. Manual trip reset controls have been added to the control room to allow reopening the main steam or main feedwater isolation valves following a SLBIC signal, to allow opening the decay heat removal suction valves following the interlock signal being cleared, and to allow resetting the low condenser vacuum trip to facilitate better control room response for recovery from a trip of these systems. These control room reset features reduce the burden on the control room operator to take action outside the control room.

1.2.4.4 NNI and ICS Power Supply Upgrade

Based on previous operating experience, it was determined that loss of Non-Nuclear Instrumentation (NNI) and Integrated Control System (ICS) power supplies could result in control room instrumentation failures that are not easy to identify and result in incorrect and misleading data from control room instruments. A system upgrade was implemented that provides a backup inverter power supply to the normal NNI and ICS power supplies.

1.2.4.5 ICS Override Control

ICS override switches have been added to the control room on panel C03 to allow the operator the capability to manually position the main feedwater block valves and low load feedwater block valves as desired. This system upgrade, shown in Figure 8, allows better operator control of a steam generator overfill condition caused by ICS failure, without the need to trip the main feedwater pumps.

1.2.4.6 Service Water System Valve Position Indication

The original position indication lights for certain essential service water system valves (return to lake and return to emergency pond) depended on the valves being operable. A system upgrade has been implemented to provide control room indication of the valve position even if the valves are disabled.

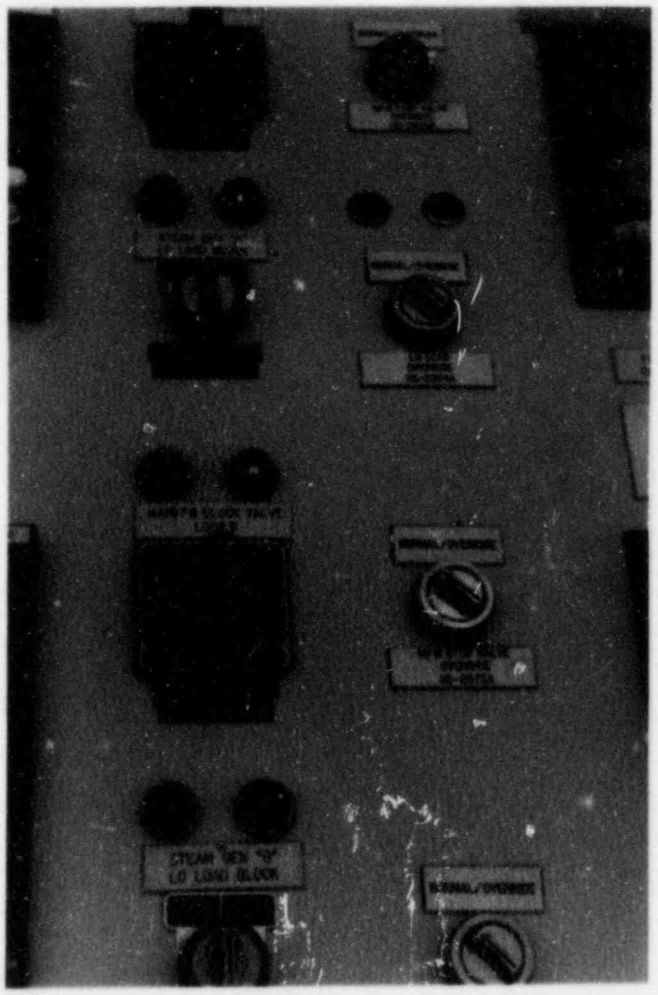


Figure 8. ICS Override Control

1.2.4.7 Control Room Emergency Lighting

A review of the original control room emergency lighting determined that it was marginal. A system upgrade has been implemented to improve the adequacy of the control room emergency lighting. Currently, the new lighting level in the control room exceeds the minimum requirements set by NUREG-0700.

1.2.4.8 Steam Line Break Instrumentation and Control

Manual operator action from the control room was previously required to isolate a ruptured main steam or feedwater line break. Addition of the SLBIC system, provides automatic isolation of a steam line rupture without operator intervention.

1.2.4.9 Reactor Coolant Pump Bleedoff Alternate Path

An alternate path for reactor coolant pump controlled bleedoff to the quench tank has been installed with automatic switchover to the alternate path when the normal path is lost (Figure 9). This frees the operator from the task of tripping the reactor coolant pumps and going to natural circulation or manually re-establishing controlled bleedoff in the event of an engineered safeguards actuation without a loss of subcooling margin.

1.2.5 Additional Instrumentation

1.2.5.1 Subcooling Margin Monitors

ANO-1 has installed digital subcooling margin monitors on the C486-3 and C486-4 panels (Figure 10). These monitors replace the need for the operator to use steam tables to determine the

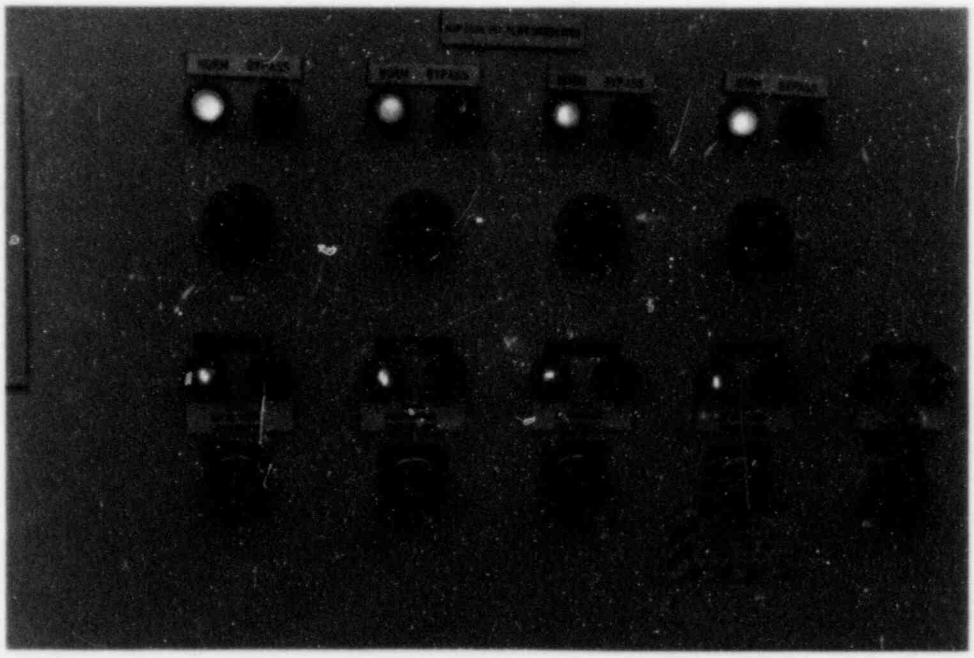


Figure 9. Reactor Coolant Pump Bleedoff Alternate Path

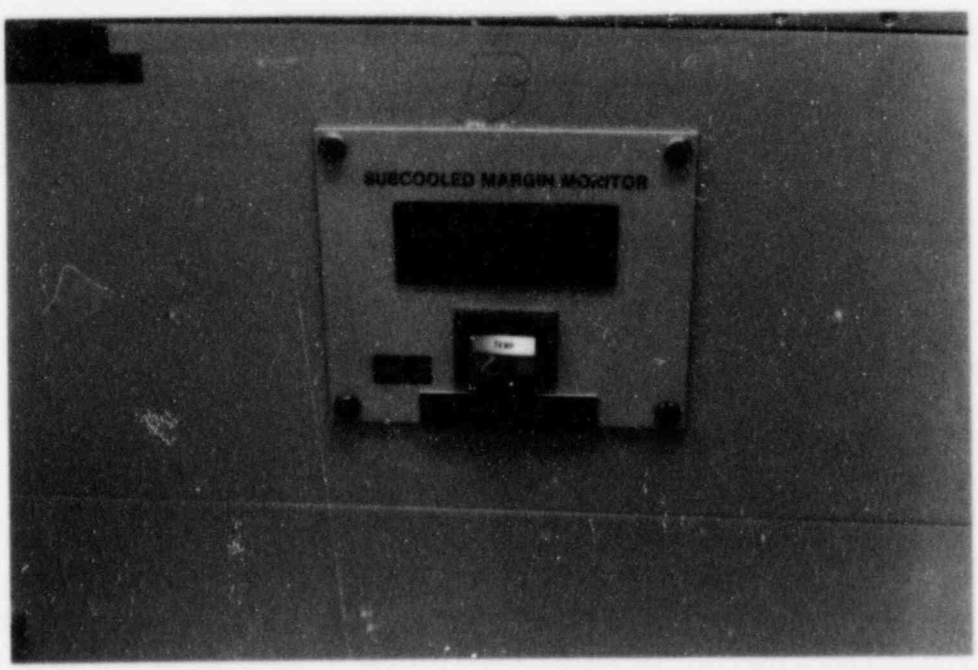


Figure 10. Subcooling Margin Monitors

proximity of RCS to saturation. Instead, the operators are now able to read a value of this condition directly from the recorder located on C04. An annunciator which sounds an alarm on loss of subcooling margin, has also been added.

1.2.5.2 PSV and ERV Position Indicators

Another new system added is an acoustic valve position monitor mounted on the electromatic relief valve and the pressurizer code safety valves. Previously, the operators had only indirect information to determine if these valves were "open" or "closed". The new system monitors for flow through the valves acoustically and provides an annunciator in the control room if a valve opens.

1.2.5.3 NNI Power Supply Monitors

During a transient when NNI power supplies are lost, the operator cannot readily determine which power supply was lost. This information is critical so that the operator will know to which instrument he must switch. To remedy this problem, power supply indicator lights have been installed in the control room, as shown in Figure 11, to indicate which power supplies are operable.

In conjunction with a new section in the emergency operating procedure, these lights serve to improve operator performance during such an incident.

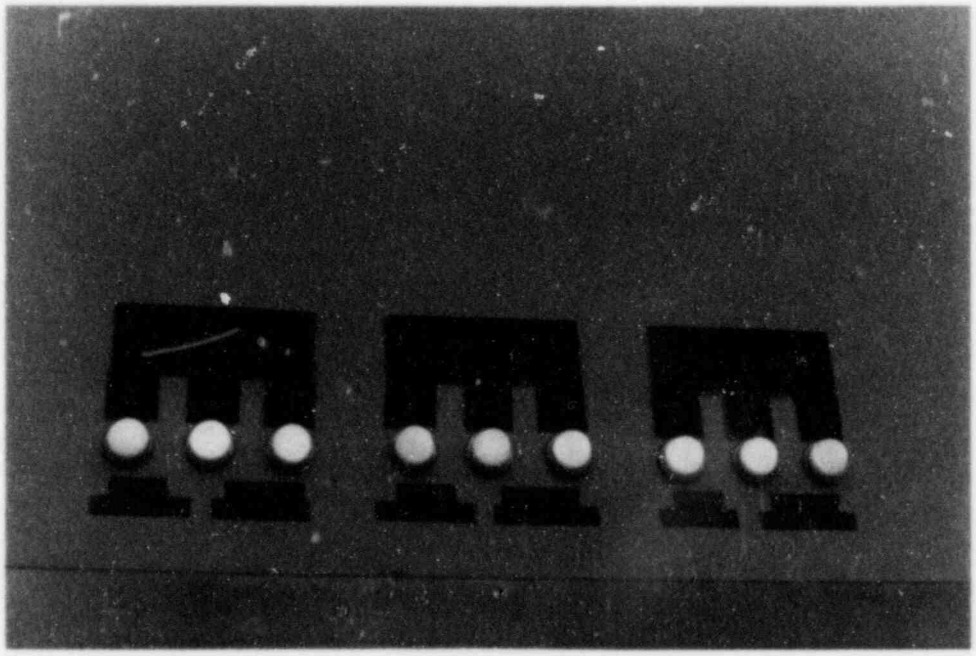


Figure 11. NNI Power Supply Monitors

1.2.5.4 Pressurizer Level Indicator

In the past, the pressurizer level indicators were subject to failure if the NNI "X" power was lost. To prevent this problem, a meter (shown in Figure 12) has been added to supplement the chart recorder on C04.

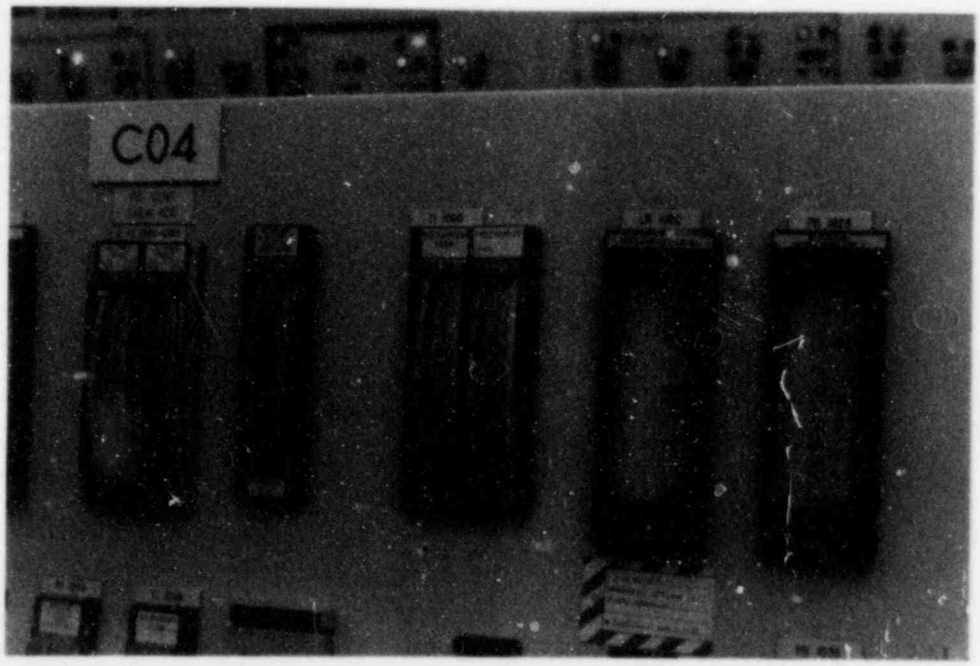


Figure 12. Pressurizer Level Indicator

This pressurizer level indicator is independent from the recorder power supply so that the operator can determine the pressurizer level during a NNI "X" power supply failure.

1.2.5.5 N_{16} Monitors

The original procedure for determining which steam generator was involved in a tube rupture event required sending a team out with local portable survey instruments or by monitoring relatively long-term trending of steam generator levels and pressures. New instrumentation has been added directly on the main steam lines to detect N_{16}; this is a rapid technique for assessing tube rupture. The N_{16} monitor indication, shown in Figure 13, is displayed in the control room on C-24, allowing rapid operator response to a tube rupture event.

Figure 13. N_{16} Monitors

1.2.5.6 Reactor Coolant Pump Vibration Monitors

Based on a review of key parameters for RCP operating status, it was determined that vibration monitoring was needed to supplement existing control room instrumentation. The instrument added to C12 (Figure 14), gives the operator valuable information needed to operate and monitor RCP status and performance.

1.2.5.7 Condensate Storage Tank Level

The condensate storage tank provides the preferred source of demineralized water for normal plant makeup and for emergency feedwater during a transient. Previously, the control room operator had to call an auxiliary operator to get a local reading of condensate storage tank level. A new instrument (shown in Figure 15) has been added to C09 in the control room to give the operator direct indication of this plant variable.

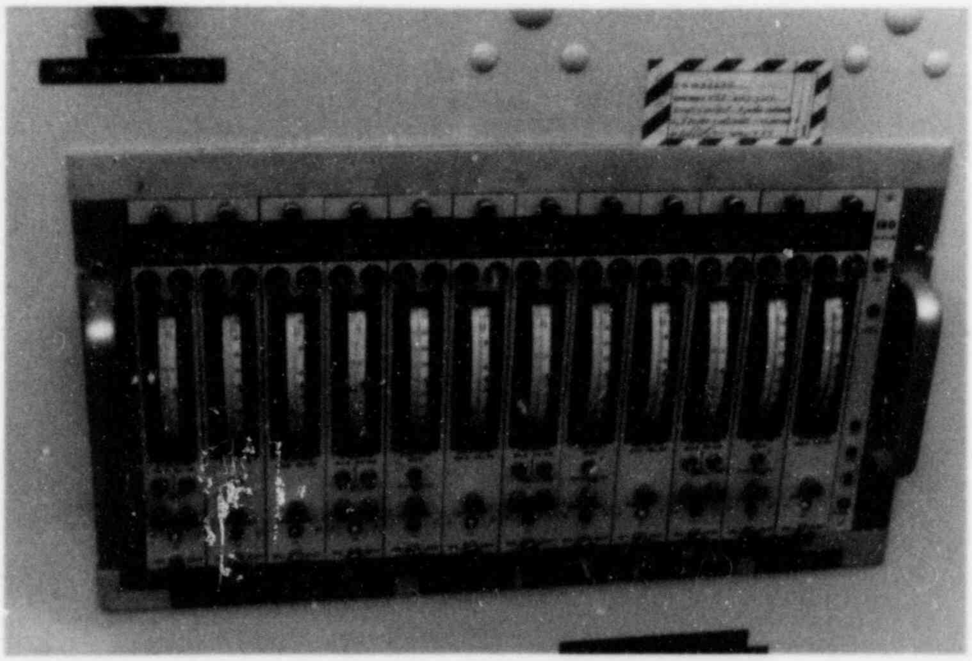


Figure 14. Vibration Monitors

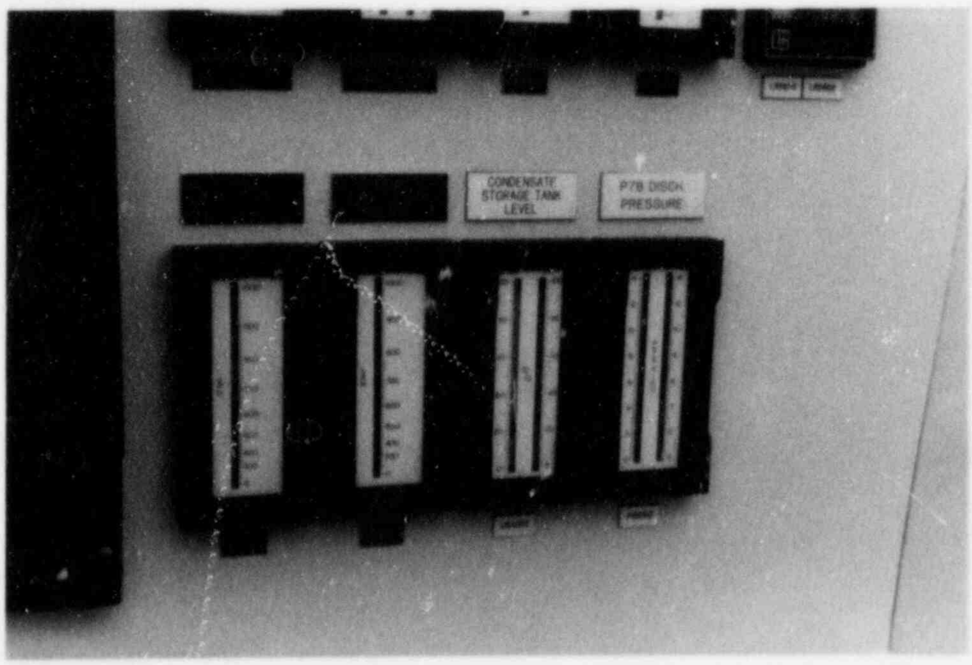


Figure 15. Condensate Storage Tank Level

1.2.5.8 RCS Letdown Monitoring

The RCS letdown system is used for RCS volume control and RCS purification. The original design did not include control room indication of letdown system pressure which is an important parameter for monitoring possible system problems. This feature has been added to the control room instrumentation on C04 (Figure 16).

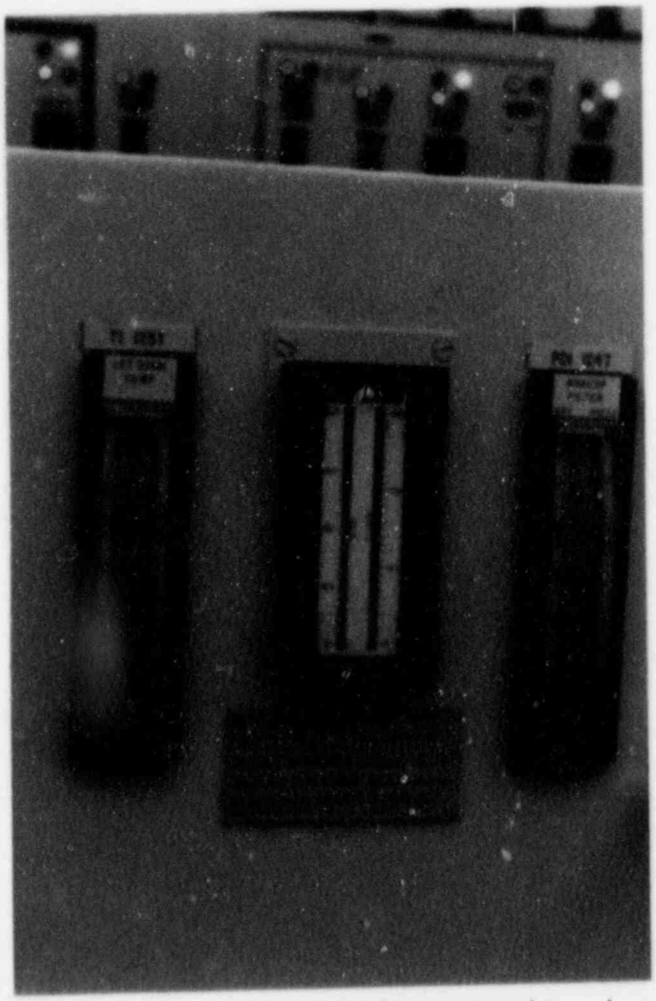


Figure 16. RCS Letdown Monitoring

1.2.5.9 Main Feed Pump Minimum Flow Monitoring

The main feed pump flow instrumentation was provided in the original plant design based on normal full power operational

needs. Based on operating experience, it was determined that an additional lower range flow instrument in the control room would provide better minimum flow recirculation valve control for startup of the unit. This new instrumentation, located on panel C03, adds better operator control during startup.

1.2.5.10 Switchyard Instrumentation

The original design of the control room included only minimum instrumentation related to the switchyard. Based on the fact that the switchyard status can be vital for making plant status decisions in the control room, a new system (Quindar) which provides the operator with status and monitoring information regarding the switchyard, has been added to the control room (Figure 17).

Figure 17. Switchyard Instrumentation

1.2.5.11 Low Range RCS Pressure Monitoring

The original instrumentation for monitoring RCS pressure was based on the full range of operating pressures (0 to 2500 psig). Based on operating experience, it was determined that during startup and shutdown, an additional range of 0 to 500 psig would give the operator more relevant information for this reduced pressure mode of operation. As a result, the new instrument was added to the control room, as shown in Figure 18.

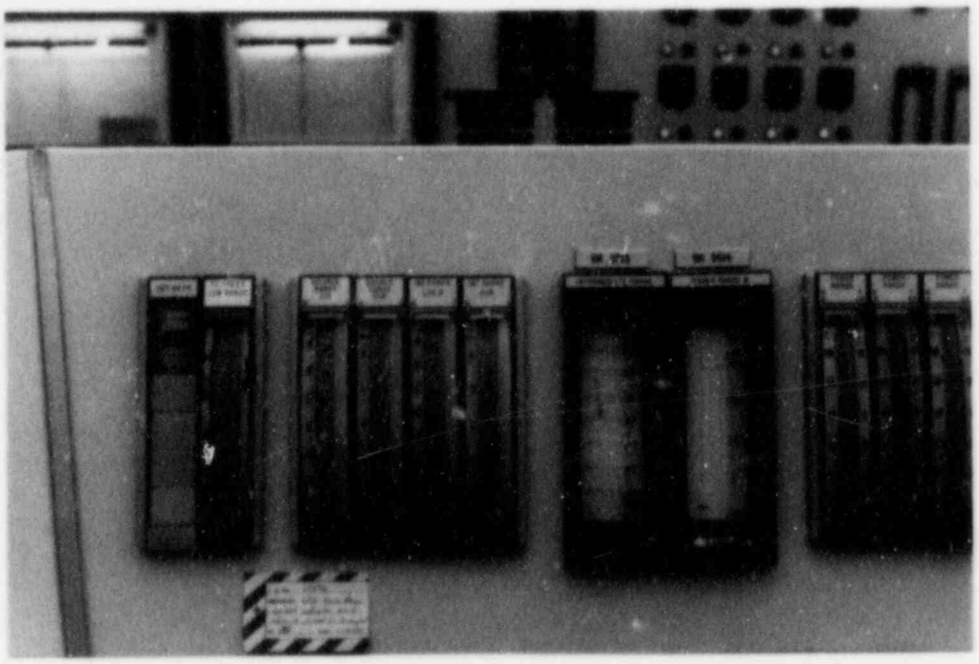


Figure 18. RCS Pressure Monitoring

1.2.6 Process Computers

A Safety Parameter Display System (SPDS) has been provided in the control room to display variables and trends of selected plant parameters for use during an emergency. An SPDS system is currently in use in the ANO-1 control room to monitor the parameters. This Ramtek CRT, shown in Figure 19, is positioned on the C09 panel with a backup CRT display on C19. This system displays RCS pressure and temperature on a graphic pressure/

temperature diagram as well as trend data for other parameters. Other graphic displays on the SPDS include a core map showing core exit thermocouple readings, a trend display depicting primary to secondary heat transfer, heatup and cooldown pressure/temperature diagrams, and selected trends to display parameters for detecting a steam generator tube rupture, a loss of coolant accident and reactivity changes.

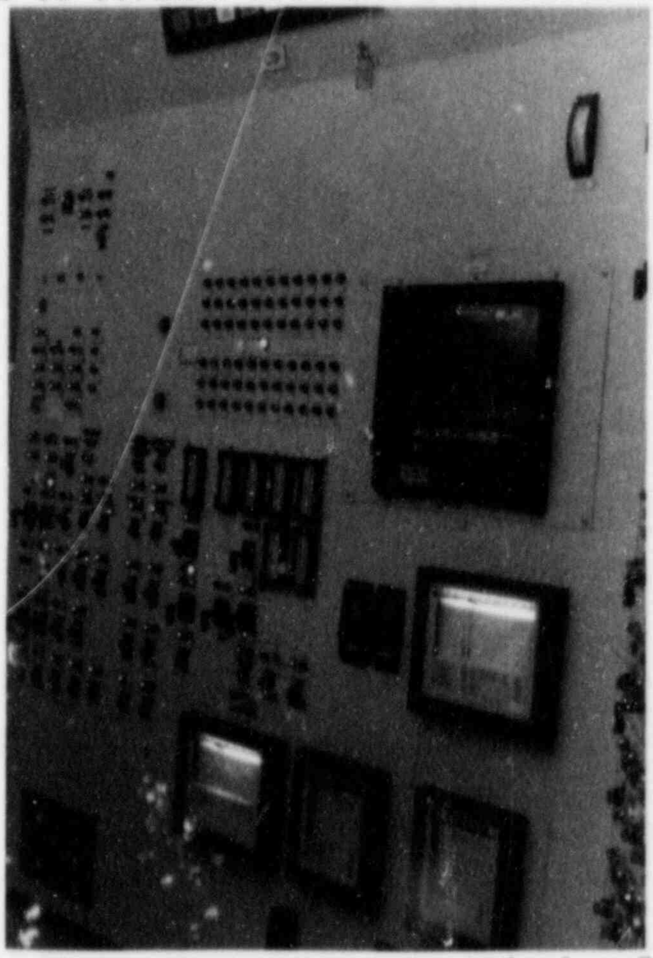


Figure 19. Safety Parameter Display System

1.2.6.1 Incore Temperature Monitoring

The reactor vessel was originally instrumented for readout of incore temperature monitoring during startup testing. As a result of a review of instrumentation needed for inadequate core cooling monitoring, it was determined that incore temperature monitoring was a key variable. As a result, the

incore temperature instrumentation was added to the control room plant computer as well as to the SPDS.

1.2.6.2 Reactor Building Temperature

The reactor building temperature monitoring system has been added to the control room. This new instrumentation has resulted in additional useful information and is available to the operator on the plant computer and the SPDs.

1.2.7 Control Room Function and Arrangement

Because the Unit 1 control room serves as the primary location for control of the plant, any features or arrangement problems that distract from this objective represent a human factors concern. Several human factors-related problems in the control room have been corrected since the plant went into commercial operation. These improvements include:

- o Removal of the plant security system from the control room since it was a major source of distraction to the operators.

- o Removal of plant key control from the shift supervisor since it was a major source of distraction and a drain on the Shift Supervisor's time.

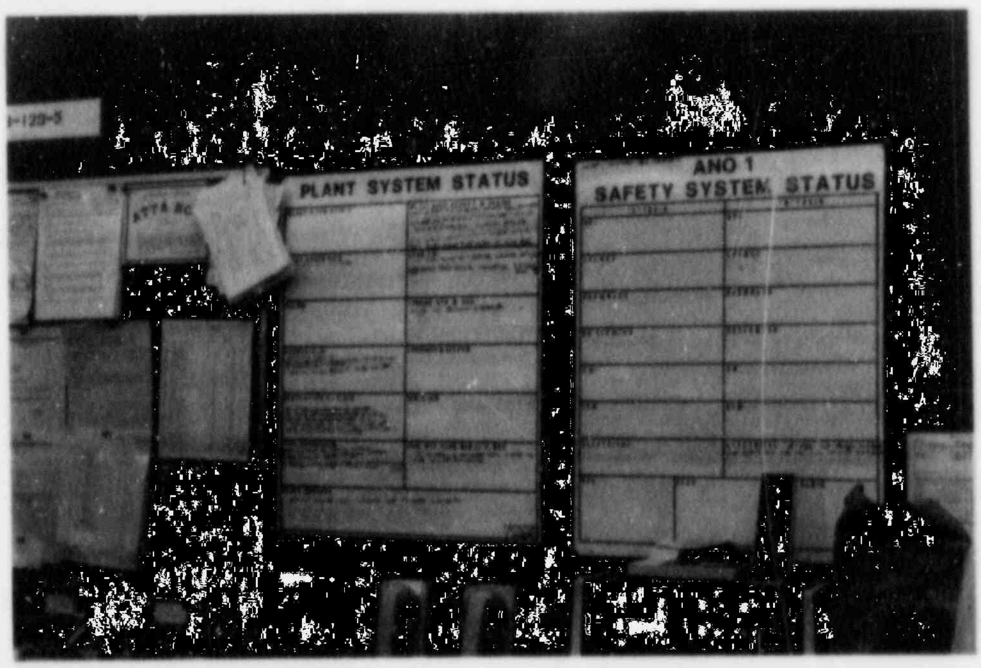
- o Addition of improved communications systems, such as additional phone extensions, a new radio paging system and a dedicated phone line to the NRC.

- o Relocation of the Shift Supervisor's office to a better vantage point for observing control room activities.

- o Addition of a shift Administrative Assistant to alleviate many of the administrative duties that were previously the responsibility of the Shift Supervisor.

- o Addition of control room features and improvements such as status boards (Figure 20), chalkless blackboards, and bookshelves.

In addition to the above improvements, many HEDs identified during the CRDR review phase had been corrected or were receiving corrective action by the time that the CRDR assessment phase had begun. These corrective actions were being performed through the normal design change and implementation process as a result of AP&L's on-going commitment to the practical application of human engineering principles. Additional discussion of these HEDs is contained in Section 8.



F gure 20. Status Boards

2.0 OVERVIEW

The AP&L Control Room Design Review (CRDR) Program included evaluation of the control room workspace, instrumentation, controls and other equipment from the human factors engineering perspective. Both system demands and operator capabilities were taken into account. The Human Engineering Discrepancies (HEDs) identified in the review phase were assessed by the Human Engineering Discrepancy Assessment Team (HEDAT). For those HEDs significant enough to warrant a corrective action, this team identified potential control room improvement options which could correct the problems described in the HEDs. A tentative corrective action plan based upon the operational, safety significance and human factors importance was also established. As indicated in the AP&L response to the NUREG-0737 Supplement 1, this plan is dependent upon the results of the integration of all Supplement 1 initiated modifications.

2.1 Review Phases

The review was conducted to determine if the control room provides the operator with the system status information, control capabilities, feedback, and performance aids necessary to accomplish the operator's functions and tasks effectively. Characteristics of the existing control room instrumentation, controls, other equipment and physical arrangements that may

detract from operator performance were also identified during this phase. The following review phases were used to collect pertinent information and/or to identify human engineering discrepancies within the control room:

2.1.1

Operating Experience Review - An operating personnel survey and a review of historical reports was conducted to identify conditions which affect probability for those operator errors which could affect safe operation or reliability of the generating station and to identify positive features of the ANO-1 control room that should not be defeated by subsequent design changes. Industry-wide Licensee Event Reports (LERs) that have generic applicability, were included in this review. Operating personnel were also interviewed to obtain feedback based on previous operating experience.

2.1.2

A review of system functions and an analysis of the tasks involved in control room operator functions using the EOP upgrade program documents as the basis established information requirements and performance criteria for the tasks which operators must accomplish.

2.1.3

An inventory of control room instrumentation and equipment itemized and described the existing control room components for comparison with the information, control, equipment, and material requirements identified in the system functions review and task analysis.

2.1.4

A checklist survey of the human engineering acceptability of control room components and environmental conditions such as lighting, noise/sound control, etc. - This identified whether the control room components and environment were designed to accommodate basic human characteristics such as physical size and perceptual-motor capabilities.

2.1.5

Verification of task performance capabilities - Assessed the adequacy of workstations to support the execution of control room operator tasks. The verification was made by comparing the information and control requirements derived from the task analysis to the inventory of existing instrumentation and controls.

2.1.6

Validation of control room functions - Was conducted to determine whether the functions allocated to the control room operating crew could be accomplished within the structure of the defined Emergency Operating Procedures and the design of the control room as it exists.

2.2 Assessment Phase

Upon completion of the CRDR investigations, a review of the HEDs was conducted by the human engineering discrepancy assessment team (HEDAT). The review served to identify the significance of each of the HEDs, as well as provide the review team the opportunity to evaluate the potential actions

appropriate to correct the HEDs. A plan was then developed to achieve the identification and implementation of appropriate actions in an orderly and integrated fashion considering, among other things, all NUREG-0737 Supplement 1 activities.

2.3 Reporting Phase

This report represents the methodology, findings and conclusions from the ANO-1 Control Room Design Review.

3.0 MANAGEMENT AND STAFFING

The purpose of the Control Room Design Review (CRDR) was to identify and correct those features in the control room environment which were not in concert with the safe and efficient operation of the facility. The CRDR activities were implemented by experienced operations, nuclear systems, human factors and engineering personnel. AP&L organizations were responsible for performing portions of the CRDR that are related to their normal activities. In addition, human factors specialists were utilized throughout the CRDR to develop, review, or otherwise support CRDR activities when necessary. For example, human factors specialists were used to support operator interviews, control room surveys, verification, validation and task analysis. In some activities, the human factors specialists had the lead responsibility. In other activities, the human factors specialist provided support to another lead organization.

3.1 Management Approach

AP&L's organizational approach to managing the CRDR is outlined in Figure 3.1. The primary organizational elements include the Steering Committee, the NUREG-0737 Supplement 1 Program Coordinator, the CRDR Review Team and AP&L support organizations.

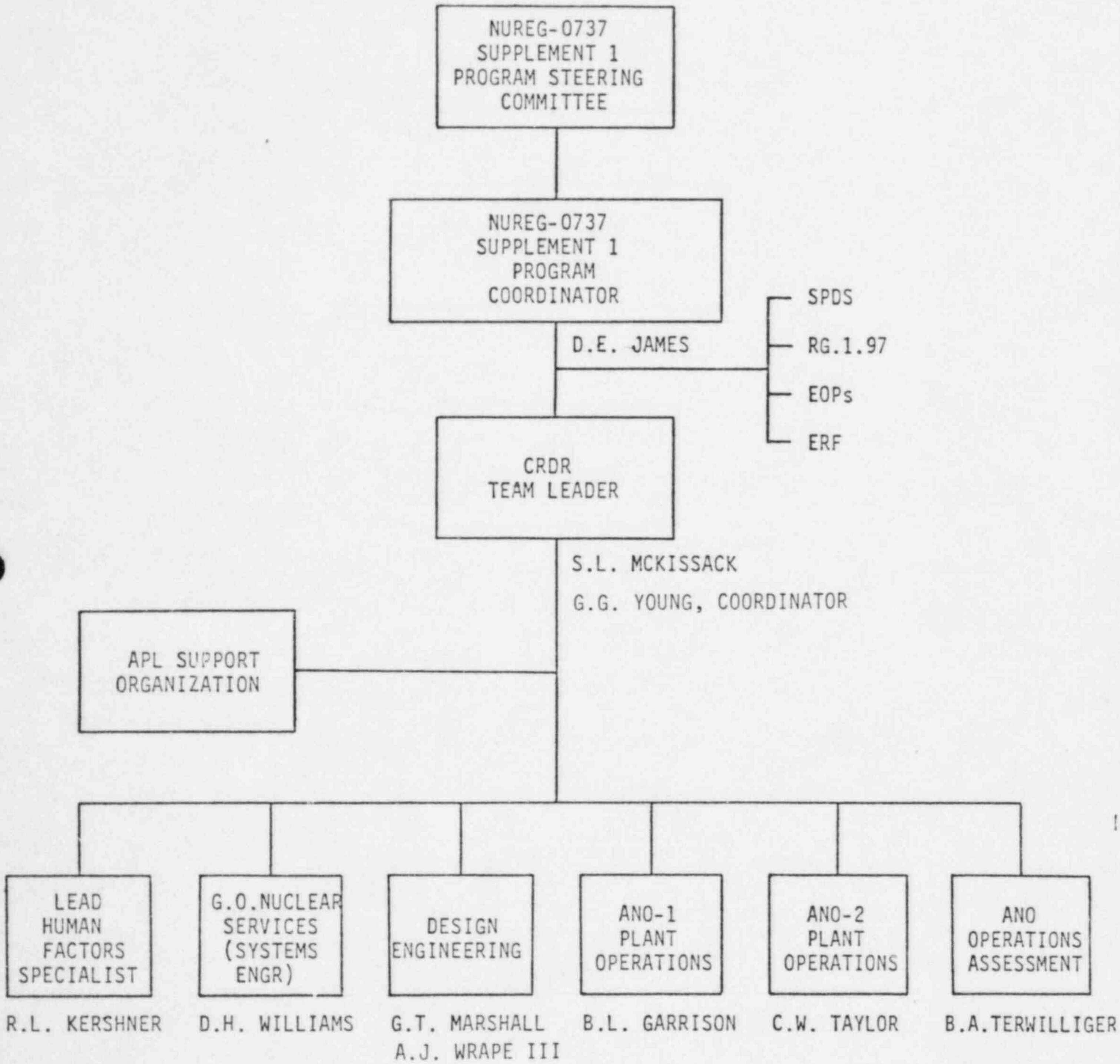


Figure 3.1 Control Room Design Review Team Organization

The primary responsibility of the Steering Committee is to provide a broad management contribution to assure integration of all objectives to meet the intent of NUREG-0737, Supplement 1 - Requirements for Emergency Response Capability.

The CRDR Team Leader reports to the Steering Committee through the NUREG-0737 Supplement 1 Program Coordinator. The CRDR Team Leader is responsible for planning, scheduling, and coordinating the CRDR which includes the assignment of particular activities to AP&L support organizations or obtaining the assistance of consultants, as necessary.

3.2 NUREG-0737 Supplement 1 Steering Committee and Program Coordinator

The Steering Committee provides a critical link between major AP&L organizations, such as nuclear operations, engineering, and licensing. Its primary responsibility is to provide broad management assistance to assure integration of major project objectives in a cost-effective manner. The Steering Committee is responsible for assembling the required expertise to execute emergency response capability activities (NUREG-0737 Supplement 1), the formulation of the overall program and its scope, and assuring coordination to accomplish the job on a timely basis. The Steering Committee will review the Final Summary Report and its recommendations. The Steering Committee is composed of five members representing the following areas:

- Arkansas Nuclear One
  - ANO Operations Manager
  - ANO-1 Operations Superintendent
  - ANO-2 Operations Superintendent

- o Arkansas Power & Light Company General Office
  - General Manager, Engineering Services
  - ANO, Project Manager

The NUREG-0737 Supplement 1 Program Coordinator is responsible for planning and coordinating activities on a continuous basis to assure an integration of all objectives to meet the intent of NUREG-0737 Supplement 1 - Requirements for Emergency Response Capability.

3.3 CRDR Team

The AP&L CRDR team consisted of a group of professionals from various disciplines with the wide range of skills necessary for the performance of the design review and included:

- o I&C engineering
- o Nuclear systems engineering
- o Human factors engineering
- o Operations
- o Electrical engineering
- o Operations assessment

Relevant qualifications of the CRDR Team Members are provided in Appendix C.

The CRDR Team was responsible for planning, scheduling and coordinating the total integrated CRDR. Work activities were carried out by two primary groups: AP&L support organizations, and the CRDR Team.

CRDR Team activities included developing the methods for the review, identification and assessment of discrepancies,

establishing an overall plan and schedule for the CRDR, and serving as a resource for support organizations to integrate all action items. Human factors specialists were used, as part of the CRDR team, to develop, review, and otherwise support CRDR activities. In addition, the CRDR Team developed all reports relating to the CRDR and assured that appropriate reports were submitted for review and approval.

Prior to beginning the review, team members were selected and familiarized with the methods and content of relevant NRC documents, general human factors engineering principles, and methodology. Team members were also provided the opportunity to familiarize themselves with the general design and operation of the plants.

The review team members were encouraged to document dissenting opinions, regarding HEDs, if appropriate. They were also provided access to plant facilities, personnel, necessary documents, and information required to perform their assigned tasks.

3.4 Interfaces

During the course of the CRDR, additional input and support from specific AP&L support organizations was solicited as appropriate. Plant drafting was called on to assist with the control room panel drawing updating process. Members of the Operations staff other than the CRDR team member were used to assist with activities such as validation walkthroughs, validation videotape reviews and task analysis. A member of the technical analysis staff assisted with the assessment of HEDs involving the Gaseous and Effluent Radiation Monitoring System (GERMS) computer. The plant computer support group assisted with the assessment of computer-related HEDs. Input was also solicited from the plant training department during the assessment process.

4.0 DOCUMENTATION AND DOCUMENT CONTROL

This section describes the documentation system (input/output documents) and documentation management/control procedures which AP&L used to support the ANO-1 Control Room Design Review.

From the beginning of the review, the team had at its disposal the following reference documents:

- System Lists
- System Descriptions
- Piping and Instrumentation Drawings
- Control Room Floor Plan
- Panel Layout Drawings
- List of Acronyms, Abbreviations
- Description of Control Room Coding Conventions
- Samples of Computer Printouts
- Procedures (Emergency, Abnormal and Operating)
- Guidelines for Procedural Development

4.1 Output Documentation

In order to facilitate systematizing and recording Control Room Design Reviews, a series of standard forms was developed. The forms used are listed below and appear in their entirety in Appendix A.

- o Control Room Human Engineering Discrepancy Record
- o Historical Report Problem Status Report
- o Historical Review Problem Analysis Report
- o Validation Review Worksheet
- o Sound Survey Record
- o Lighting Survey - Illuminance Record
- o Lighting Survey - Luminance and Reflectance Record
- o Humidity/Temperature Record
- o Air Velocity Survey Record
- o Task Breakdown Form
- o Task Analysis Instrument/Control Requirement Form
- o Control Room Design Review Operator Survey
- o Inventory Form - Controls
- o Inventory Form - Indicators
- o Inventory Form - Controllers

4.2 Document Control

AP&L recognized that a data collection/analysis effort, such as that inherent in a CRDR, can generate volumes of paperwork which, if managed improperly, could result in a great loss of effectiveness, time and money. AP&L, therefore, implemented a database management system (DBMS) to collect, update, analyze and provide the information necessary to fulfill the requirements of the CRDR on a dedicated computer. Implementation of the DBMS minimized the number of manual transformation steps required in the data collection/analysis effort.

4.3 Database Management System

The DBMS was implemented on a VAX 11/730 computer using INFO/INFOTEXT software. It consists of a master program with memory storage devices to hold the data extracted from various source documents. Because manual handling of data is largely eliminated after data is entered into the system, the DBMS

greatly reduced duplication of efforts, document loss and errors resulting from unnecessary handling of data.

After the DBMS was implemented, the series of data files and records was created using information derived from the various source documents. Each source document contained specific forms, charts, schedules, etc., required for the CRDR and each constituted a single data file. Data files, in turn, comprised individual records which represent the specific parameters contained in the file forms, charts, etc. The file then served as a model of the document from which it was created, as well as an area to store data records. The source documents included those reports and forms listed previously in this chapter.

5.0 COORDINATION WITH OTHER SUPPLEMENT 1 NUREG-0737 INITIATIVES

AP&L has a coordinated program to address each of the Supplement 1 to NUREG-0737 initiatives. This program is headed by the previously described Steering Committee which provides the necessary coordination and support to ensure that a systematic approach is adopted for the inclusion of each of the actions resulting from these initiatives. This integrated approach is intended to optimize the interface between the various Supplement 1 areas.

The design of the Safety Parameter Display System (SPDS), the R.G. 1.97 based instrument displays, the development of symptom-oriented emergency operating procedures, the training of the operating staff, and the CRDR have been coordinated in a manner which takes full advantage of the scheduling of each of these initiatives, and is being integrated with respect to the overall improvement of the operator's ability to comprehend plant conditions and cope with emergencies.

Design changes have been coordinated with the CRDR. In addition, the corrective action modifications resulting from the CRDR will be evaluated for their effects on these programs. The coordination of the CRDR and these other programs include provisions for operator retraining and upgrading of operating procedures when necessary to reflect the physical changes made in the control room.

Coordination of these programs is necessary because individual program activities or results may affect the other programs. To ensure overall program synthesis, AP&L developed an integrated implementation in response to NUREG-0737 Supplement 1. This plan (see Figure 5.1) identifies major relationships between the programs and establishes dates for completion of various program milestones.

NUREG 0737 SUPPLEMENT

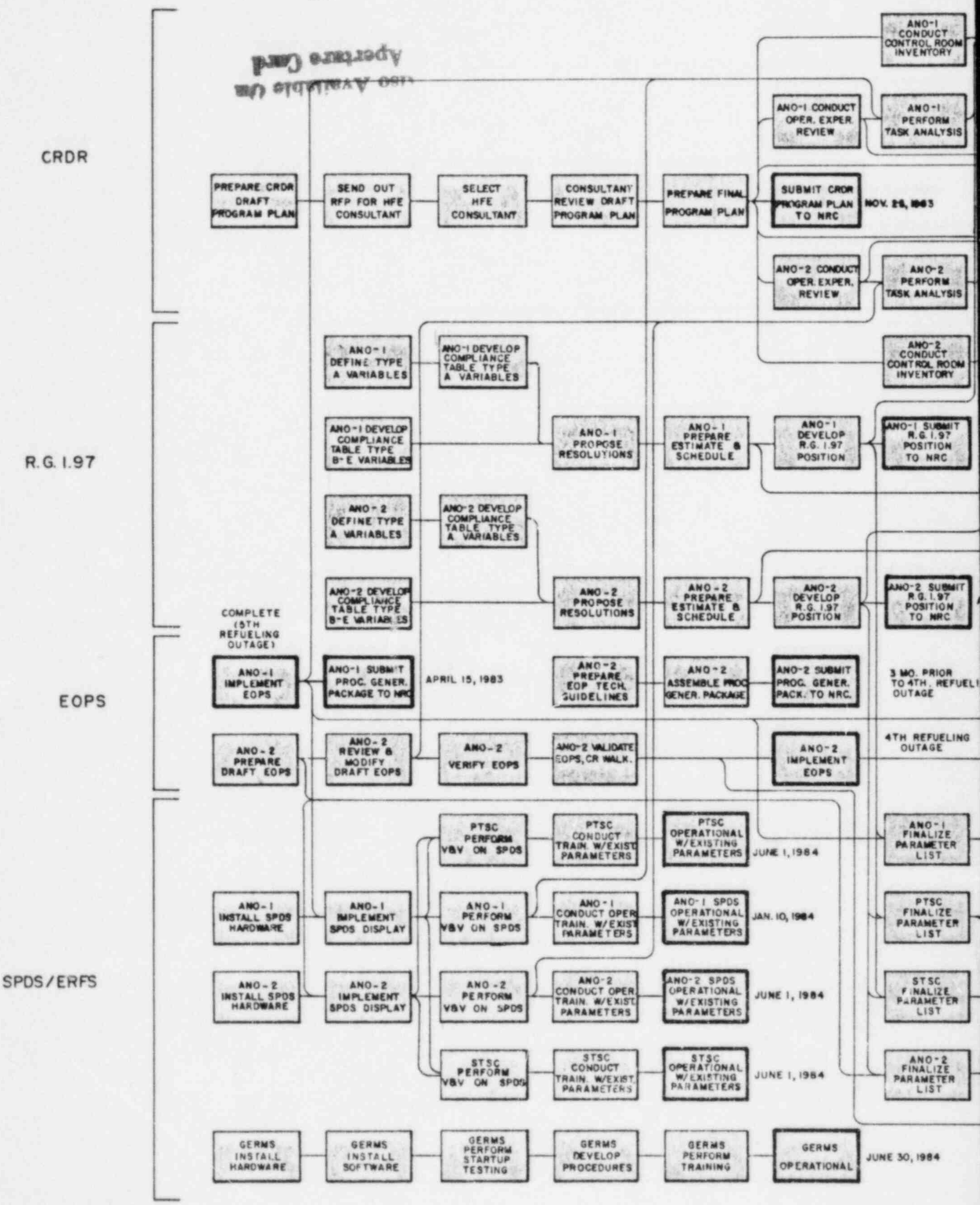
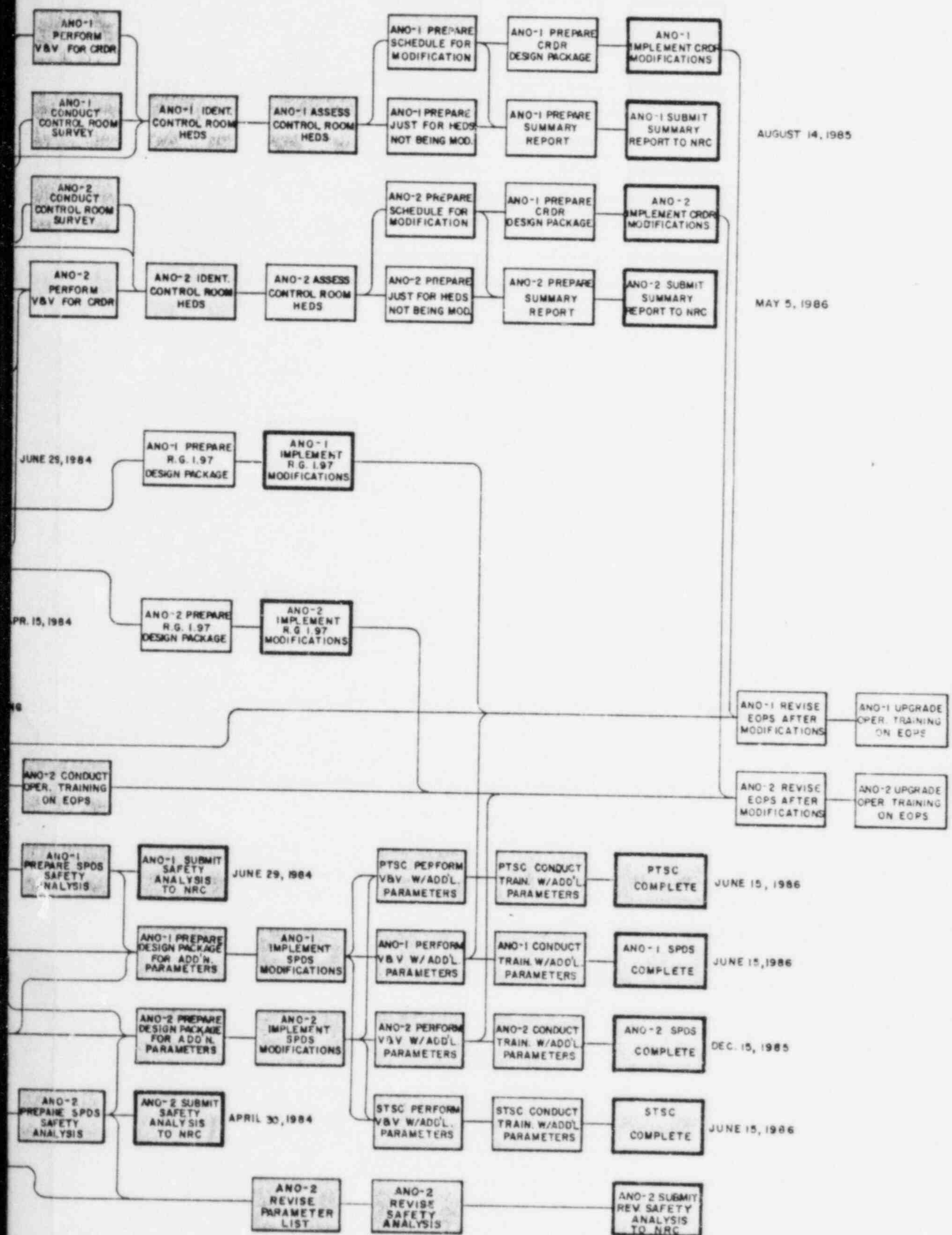


Figure 5.1 NUREG-0737 Supplement 1 Integrated Implementation Plan
Revised 10-15-84

INTEGRATED IMPLEMENTATION PLAN



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6.0 REVIEW PROCESS

The CRDR review process resulted in the identification of a number of Human Engineering Discrepancies (HEDs). These HEDs were evaluated to determine the extent to which they may affect the potential of operating crew errors. Once the HEDs were evaluated and a recommended improvement (if applicable) agreed upon, improvements will be implemented according to a plan based on the relative significance of the HED and the nature of the improvement.

6.1 Historical Event Review

6.1.1 Introduction

The objective of the Historical Event Review was to utilize archival documentation of control room problems to identify areas to investigate to ensure that the man-machine interface perspective was adequately addressed in order to significantly reduce or minimize the potential for subsequent human error.

Human error in performing complicated tasks is a well documented fact and the potential for it is always present. In the nuclear power industry, human error can combine with poor design features and contribute to operational problems. Fortunately, in the nuclear industry, instances of past human performance error and equipment/design arrangement problems are documented in plant and industry records and can be used as a database for recommending design improvements. This section

presents the process used to review several such documents to identify areas of potential human performance problems at Arkansas Power and Light Company's Arkansas Nuclear One-Unit 1.

6.1.2 Methodology

The review and analysis was conducted by a Human Factors Specialist (HFS) and a Subject Matter Expert (SME) from the Control Room Design Review (CRDR) team.

6.1.2.1 Identifying, Collecting and Selecting Historical Reports

AP&L has five convenient sources of historical reports. These sources were used in the historical review process of the CRDR for ANO-1. Three of these reports are industry-wide sources -- the Licensee Event Report (LER), the Significant Event Report (SER), and the Significant Operating Event Report (SOER). The in-house sources included Unit Transient Reports and Transient Assessment Program (TAP) reports. Since ANO-1 events did not include many found in the industry-wide reports, all Babcock and Wilcox (B&W) plants were included in the review. These plants are ANO-1, Bellefonte-1, Crystal River-3, Davis Besse-1, Oconee-1, Oconee-2, Oconee-3, Rancho Seco-1, Three Mile Island (TMI)-1, and TMI-2.

LER information is stored in an NRC computerized database and includes all Reportable Occurrences (ROs) to the NRC. Licensees are required to submit these reports to comply with federal regulations. The database is set up in order to provide ease in obtaining information regarding the incidents.

Since all LERs are submitted to the Institute for Nuclear Power Operations (INPO) in order to conduct this review, an LER sort was obtained from them. The request was limited to reports of those events related to personnel error which occurred in B&W plants over the past five years.

INPO reviews all LERs and identifies those reports (SERs) which are significant; the SERs further analyze LER data. When several SERs concerning similar types of incidents (at different plants) have been collected, a Significant Operating Event Report is generated by INPO. Thus, SOERs analyze significant generic events in great detail. Data is available from the time both the SER and SOER programs began in 1980. In this review, all SERs and SOERs occurring at B&W plants were reviewed.

TAP reports describe reactor trips occurring at operating B&W plants. All TAP reports were analyzed during our review. Each station submits reports detailing their transients so that the other B&W plants can benefit from generic findings based on reported events. Although the program began in 1981, some reports were submitted which discussed events happening prior to that time.

ANO-1 keeps detailed records of all its unit transients. These reports are analyzed and submitted to plant personnel as well as to the TAP program. Each of the reports pertaining to events occurring after 1979 was analyzed during the Historical Review phase of the CRDR.

The HFS, with the assistance of ANO-1 plant personnel, obtained copies of the applicable LERs, SERs, SOERs, TAP, and ANO-1 reports. These reports were then sorted by date and probable applicability. Copies of those events which involve control room operator, procedural and/or control board equipment failure and errors attributed to design arrangement errors were retained in the Historical Review notebook.

All reports were screened to determine if they described and documented a control room problem meeting the following criteria:

1. Equipment referenced (valve/pump controls, displays, indicators, etc.) must be in the physical confines of the control room.

2. Procedure steps referenced must be accomplished within the physical confines of the control room.

3. Personnel error referenced must have occurred in the control room on equipment in the control room, or entailed a deviation from procedures that should be accomplished in the control room.

Reports that meet one or more of the above criteria have been retained in the Historical Review notebook for further analysis.

6.1.2.2 Report Review and Analysis

For every report that cleared the initial screening, a Problem Analysis Report (PAR) was compiled.

The two-page PAR, shown in Appendix A, was used to record the following information:

- o Investigators' names
- o Station and unit
- o Event date
- o Report type and number
- o Operating status of plant
- o Circumstances and events leading to the problem
- o Nature of the problem
- o Steps taken to correct or alleviate the problem
- o Outcome
- o Corrective measures undertaken
- o Human performance problems associated with the event

With the assistance of the SME, the HFS then went through each report to determine whether the event was applicable to ANO-1. In the cases where the systems or equipment were different at ANO-1, the report was not considered applicable. For each event determined applicable to ANO-1, the second page of the PAR was completed. The areas completed at this time were:

- o In which areas is this event applicable to the plant under review?
- o Corrective actions taken at the plant under review?
- o Unresolved discrepancies (if any)
- o HED number (where applicable)

AP&L routinely reviews all SOERs, SERs, TAP reports and Unit Transients. Because of these reviews, corrective actions are often implemented on similar problems at ANO-1 as discussed in the report entitled, "Arkansas Nuclear One - Unit 1 Control Room Improvements Made Prior to the Control Room Design Review." For those problems judged applicable to ANO-1 and uncorrected, an HED was then written.

6.1.2.3 Result Documentation and Reporting

The PAR, discussed and described above, constitutes the primary document for this aspect of the CRDR process and contains pertinent information from the analyzed report. In addition, when the recommendations generated entailed panel alterations, panel enhancements, training revisions or additions, operating procedure modifications and/or administrative procedure modifications, the apparent fundamental problem and its recommended corrective action were recorded by the HFS as a human engineering discrepancy (HED) on an HED form. The event and task relevant to the HED were noted in the description of the discrepancy.

In addition to maintaining the PARs and HEDs, the HFS responsible for this aspect of the CRDR maintained the historical review notebook. This notebook was started at the beginning of the Historical Report Review process; it is a working document and contains:

- o Problem Status Report (PSR) -- an index of all reports reviewed

- o A copy of all completed HEDs identified during the review

- o A copy of all reports applicable to Human Factors which were reviewed and analyzed, with the information collected in the review and used in the analysis (e.g., copies of the pertinent logs, interview notes, drawings, pictures)

- o The final PAR for each document reviewed

The HFS responsible for the review of historical documentation has worked independently from, but parallel to, the rest of the CRDR review team. The PSR was devised as a means of keeping the CRDR team members advised of the progress being made in this review process. The PSR indicates:

- o Report type
- o Report number
- o Event date
- o Current investigative status of each report

The LER sort resulted in a listing of 319 reports. In addition, 41 SERs, 20 SOERs, and 117 TAP reports regarding B&W plant events as well as 30 unit transient reports were collected at the beginning of the review. After the initial

review, a total of 90 human factors related reports were retained. Of these, 59 reports involved problems proved to be control room related as defined by the criteria listed previously.

The systems and equipment involved in 19 of the reviewed incidents are not similar to equipment at ANO-1. In these cases, the incidents were judged not applicable and therefore removed from the review process. Therefore, after this sort, 40 reports remained. Of these reports, 38 of the events noted had been corrected (e.g., see section 1.2.5.3) or did not exist at ANO-1. Two HEDs were identified regarding problems which could potentially occur at ANO-1 derived from the remaining two reports.

6.2 Operating Experience Review

6.2.1 Objectives and Approach

The objective of the operator survey was to obtain special, pertinent knowledge that operating personnel at Arkansas Power and Light Company's ANO-1 plant possess regarding both positive and negative control room system features which they have experienced and/or observed in the course of preparing for operations or during operations themselves. As one of the foundation processes of the CRDR, the operator survey was intended to provide information that would guide the human factors specialists during later, investigative phases of the CRDR (namely the checklist survey, verification, and validation processes). Aside from this primary function, it also provided an avenue for plant management to gather general information about the plant operators' perceptions and opinions of control room design and procedures.

The respondents were encouraged to identify both positive and negative features of the control room. The negative items

were, as appropriate, deferred for further consideration until later stages of the CRDR, presented as general reference information for AP&L's consideration, or written as HEDs. The positive items, also presented for reference, suggest control room features that should not be compromised in the course of correcting other HEDs. These items are used by the review team as guidance for corrective actions, since they illustrate aspects of the control room design that the operators find particularly effective.

An effort was made to present all comments and suggestions made by the operators, even though not all of the negative comments were determined to be valid HEDs. The determination as to which problems qualified as HEDs was based in part on the Human Factors Specialist's understanding of the principles of human factors engineering and in part on information collected from operations personnel during the follow-up interviews. It should be emphasized that many of the operator comments and suggestions proved useful to AP&L management, in addition to those that resulted in HEDs.

Although emphasis was placed on emergency-related design features during the control room review, the operators were encouraged to consider all modes of plant operation in formulating their responses. They followed this charge and identified a number of non-emergency control room features that deserve consideration.

It was expected that, to some extent, the findings would overlap with those resulting from other phases of the CRDR. This redundancy served as one indication of the extent of identified problems. Another indication of problem severity is the number of operators who mentioned a particular problem. Nevertheless, a strength of the Operator Survey is that it gave individual operators the opportunity to apply their unique

backgrounds and experiences to the control room review process. Therefore, the possible importance of concerns that were voiced by only one or two respondents was not overlooked.

Table 6.1 presents the population demographics and statistics for those operators who responded to the survey.

6.2.2 Methods

6.2.2.1 Construction of the Self-Administered Questionnaire

The self-administered questionnaire was structured to address the following nine areas, as suggested in NUREG-0700:

- o Workspace Layout and Environment
- o Panel Design
- o Annunciator Warning System
- o Communications
- o Process Computers
- o Maintenance Procedures
- o Operating Procedures
- o Staffing and Job Design
- o Training

A draft questionnaire was prepared by the HFS. AP&L members of the review team reviewed this draft and provided comments which received concurrence and were incorporated by the HFS. The resulting questionnaires, with accompanying explanatory materials were then distributed to the operators. The distribution packet is shown in Appendix A.

Each question was posed in a multiple-choice format, to encourage the response of operators who might not have been inclined to provide written comments for each item. In addition, open-ended questions for each item encouraged the operators to describe in detail the specifics upon which their

Table 6.1 POPULATION DEMOGRAPHICS AND STATISTICS

NUMBER OF RESPONDENTS			MEAN STATISTICS					
GROUP	SEX		HEIGHT	AGE	NUCLEAR OPERATOR EXPERIENCE	CONTROL BOARD OPERATOR EXPERIENCE	#YRS RO	#YRS SRO
	M	F						
NON-LICENSED OPERATORS	3	0	72.33"	28.33	9.00	2.00	0	0
REACTOR OPERATOR	11	0	72.59"	33.35	9.91	3.11	1.98	0
SENIOR REACTOR OPERATOR	13	0	70.00"	36.00	14.46	6.12	3.26	3.38
OVERALL	27	0	71.31"	34.11	12.00	4.44	2.38	1.63

multiple-choice responses were based. The operators were frequently reminded to consider all modes of plant operation, including possible abnormal or emergency operating conditions in addition to start-up, hot standby, full power and reduced power. Opinions regarding both positive and negative design features of the control room were solicited.

Each respondent was also asked to fill out a separate sheet detailing his background, level of experience, and current status at AP&L (see Table 6.1).

6.2.2.2 Distribution of the Self-Administered Questionnaire

These questionnaires were distributed by the HFS to 48 operators, based on a list supplied by AP&L. The participants included all licensed operating personnel and operators in license class on ANO-1, as well as trainers licensed on Unit One in the training department. The operators were given several weeks to fill out the self-administered questionnaire and to return it by mail to the HFS in a self-addressed, stamped envelope that had been provided. Confidentiality was assured by assigning each outgoing questionnaire a number. The list of potential respondents and corresponding numbers was kept in confidence by the HFS.

6.2.2.3 Analysis of Responses to the Self-Administered Questionnaire

The HFSs logged the 27 questionnaires that were returned and tallied the demographic information and multiple-choice responses. Written comments were compiled for each question and then summarized, collapsing responses which addressed the same issue into a summary statement of the concern with an associated count of the frequency with which that concern had been mentioned. In the few instances in which a concern was addressed by different respondents under different question-

naire items, the responses were pooled under the question which elicited the highest incidence of that response. Ambiguities in the written comments were noted.

The multiple-choice responses and the written comments were examined with an eye towards areas of particular concern to the operators and the extent to which a consensus emerged on each item.

6.2.2.4 Follow-up Interviews

The objectives of the follow-up interviews were as follows:

- o To clarify ambiguities in an individual's written responses to the self-administered questionnaire.
- o To gather additional details (e.g., system or component information) pertaining to that individual's responses
- o To address issues on which the questionnaire responses revealed particular concern or for which no consensus emerged.

Thus there were a few issues that were discussed with all interviewees and some that varied from one individual to the next, depending on each person's written responses on the self-administered questionnaire.

The HFS constructed a set of questions and issues to be addressed during the follow-up interviews, based on the analysis of responses to the self-administered questionnaire. This follow-up form (see Appendix A) was distributed to each of the interviewees prior to the on-site interviews. Some of the issues covered in the follow-up interviews afforded the operators an opportunity to agree or disagree with some of the

suggestions that their colleagues had made. In cases where the previous responses had suggested problems, but offered no solution, opinions about possible corrective actions were solicited.

The HFS supplied AP&L with a list of the operators whom they wished to interview, and AP&L developed a schedule for the interviews to take place on-site. Interviews were conducted with 18 of the operators who responded to the previous questionnaire and two who had not responded previously. Each interview lasted approximately one hour. Confidentiality of operator's responses was maintained both during the interview process and in the notes taken by the HFS during the interviews.

6.2.2.5 Integration of Interview Data with Self-Administered Questionnaire Responses

The information compiled previously from the self-administered questionnaires was enhanced based on notes taken by the interviewer during the follow-up interviews. Ambiguities noted previously were resolved and, where appropriate, specifics such as system or component names were added. The table of issues which had been started previously was then expanded to include possible corrective actions for problems identified. Finally, a recommended action for the review team was determined for each issue of concern, either writing it as an HED, or deferring problems for further investigation during later phases of the CRDR.

6.2.2.6 Findings

6.2.2.6.1 Workspace Layout and Environment

The first four questions under workspace layout and environment involved the availability and usefulness of instrumentation and controls in the control room. Much of the concern expressed by operators regarded local operation of pumps and valves in areas of the plant which may expose operators to high radiation levels. Their responses, therefore, reflect a disposition towards providing the control room with motor-operated controls for this equipment. For example, many respondents noted a preference for motor-operated Decay Heat Removal pump suction valves located in the control room for the Reactor Coolant System recirculation mode. The corrective actions here would, of course, involve plant design changes in addition to control room instrumentation changes.

In addition to the need for selected controls to be located in the control room, the operators identified indicators which they felt would improve control room operations. In some cases, current indicators were available in the control room but inaccessible or inconvenient to use. In other cases, a dedicated display was preferred to information that is presently available only on the computers. Other indications, however, are not available to operators in the control room and were generally recognized as important to operations. A few extraneous controls and displays were identified by respondents.

The last four questions in this section examined communications, lighting, air quality and maneuverability in the control room. Overall, voice communication in the control room was considered good with the only exception being the interference caused by the emergency ventilation system. The air quality was also considered good with the only exception being the occasional discomfort caused by cigarette and cigar smoke.

Lighting received only one negative comment, concerning glare on CRT screens, but overall was considered good.

Finally, operators identified several problems with maneuvering in the workspace. Many respondents felt that the current desk design obstructed the view of the panels and the chairs were outdated and uncomfortable. Though several workspace inpediments were cited by operators, they also noted that these problems were to be expected in a control room of this size.

6.2.2.6.2 Panel Design

Questions posed under panel design included evaluating the following areas: automatic versus manual controls, throttleable controls, functional groupings, control/display accessibility, and usability relating to panel layout, control/display integration, and accidental activation.

Some of the most often noted problems included the two-person operation of High Pressure Injection System, the poor functional grouping of the Service Water System and the Emergency Safeguards Actuation System, and the poor panel locations of Main Steam Isolation Valves, Main Feedwater Isolation Valves, Emergency Safeguards Actuation System Controls, and the Core Flood Tank level and pressure indicators.

Operators also noted problems with interpreting readings on multi-point recorders and comparing readings of indicators monitoring the same parameter but using different scales. Several operators noted a problem with the unit graduations on the Steam Generator level indicator, and reversed scales on the Decay Heat Cooler and Bypass valve position indicator.

There were conflicting responses regarding the operation of the Reactor Building isolation valves and the Integrated Control

System. Some felt operation of these systems was confusing while others did not feel this was a problem. The discrepancy may be attributable to training and experience.

Several controls were identified as prone to accidental activation. Of the controls identified, the Main Steam Isolation Valves were most often cited as prone to accidental activation.

6.2.2.6.3 Annunciator System

Questions regarding the annunciator system examine the appropriateness of alarm setpoints, clarity of alarm messages and methods of determining the cause of the alarms. In general, the annunciator system posed few problems to operators. The most frequently noted problem was the quantity of alarms which accompanied a reactor trip. Many operators found this distracting and misleading when trying to diagnose the cause of the transient.

It was recognized that AP&L has undertaken a review of the Unit 1 annunciator system and that a number of previous problems had already been corrected.

6.2.2.6.4 Communications

The communication section of the questionnaire examined the availability and suitability of communication systems in the control room and other plant locations. Overall, the communication systems were considered good by most operators. Several problems were noted, however, regarding the paging system. First, respondents felt that the paging system was abused by non-operations personnel. Therefore, many respondents

expressed the need for an override capability on the paging system from the control room for emergency situations.

Other problems with the paging system included lack of speakers in important plant locations and personnel lowering the speaker volume during outages, thereby causing a loss of communication in areas where there is high noise when the plant is in operation.

A second area of concern was communication capability during a blackout, and power availability to the in-house and Gaitronics phone systems used to communicate with personnel in remote shutdown.

6.2.2.6.5 Computer-generated Information

Operators were asked several questions regarding the availability and clarity of information presented on control room CRTs and printers. No major problems were identified with the CRTs. Problems were encountered, however, in using the printer and computer procedures.

Many operators noted that SPDS and plant computer programs were presently undergoing upgrade efforts and would provide all needed information at the conclusion of the effort. Some computer programs they found desirable include leak rate determination, and heat-up and cooldown curves.

Some respondents felt that the printer became overloaded with irrelevant data during transients, delaying the availability of important information, and others found the computer procedures unorganized and confusing.

6.2.2.6.6 Maintenance Procedures

Operators were asked to respond to questions regarding the adequacy of maintenance procedures and the maintenance of control room instrumentation. Overall, maintenance procedures and practices were considered good. Some areas in need of improvement were identified. These included maintenance response time to operator's requests and upkeep of an adequate spare parts inventory for control room lights and chart recorders.

6.2.2.6.7 Operating Procedures

Several questions were posed to operators regarding the clarity and usefulness of procedures and other job performance aids.

In general, operators felt the Emergency Operating Procedures were improved but other procedures were in need of better organization.

6.2.2.6.8 Staffing and Job Design

Respondents were asked to evaluate control room staffing and delegation of responsibilities. Many operators commented on the crowding and interference by maintenance personnel during day shift. Some respondents felt that the control room was over-staffed, thereby contributing to the crowding and distraction problems. Respondents acknowledged that the crowding problems had been lessened by recent directives established by plant management to authorize operators to control access to the control room.

Most respondents felt that responsibilities were well delineated with the exception of the chain of command during an emergency when two SROs are present.

6.2.2.6.9 Training

Operators were asked in which areas more training is needed. Many areas were mentioned but the most frequent responses included training on Electrical Bus Failures, Turbine EHC Failures, and SPDS. Most respondents felt that trainers needed more "hands on" experience in the control room and that operators needed training on a plant specific simulator. It was acknowledged, however, that training has improved greatly in recent years and that continuing improvements are being made.

6.3 Task Analysis

A System Function and Operator Task Analysis Identification has been performed at Arkansas Nuclear One Unit-One (ANO-1) in support of the Control Room Design Review. Both activities were designed to comply with the guidance outlined in NUREG-0700, "Guidelines for Control Room Design Reviews."

The first phase, System Function Identification, consisted of analyzing and documenting the functions associated with the systems and subsystems exercised for each emergency operating event. The second phase, Operator Task Identification and Analysis, entailed the identification and documentation of operator functions and tasks for emergency events. Selected normal and abnormal procedure tasks were also analyzed.

6.3.1 Method-System Function Review

The system function review for ANO-1 was performed in conjunction with the AP&L Emergency Operating Procedures (EOP) development program. The information assembled to develop the symptom-oriented emergency procedure was plant-specific and provided the basis for the system equipment operation and operator action necessary to mitigate the consequences of all conceivable transients.

Appendix 6A to the AP&L response to Supplement 1 of NUREG-0737 provided an EOP development program description. Briefly, the program identified operator roles in the accomplishment of plant functions. Major emphasis was placed in the operator's role in assisting the accomplishment of plant safety functions. By studying the means available to accomplish these safety functions, a set of key plant symptoms was identified to guide operator actions regardless of the degree of success in diagnosing the event. Figure 6-1 depicts the process employed in the EOP development program.

The study employed the technique of transient code analyses and the following diagrammatical analyses:

- o Safety Sequence Diagrams (SSDs) developed to identify the specific plant systems and subsystems including necessary operator actions used to accomplish safety functions

- o Event Tree Diagrams constructed to determine the various plant conditions which can evolve following a postulated initiating event

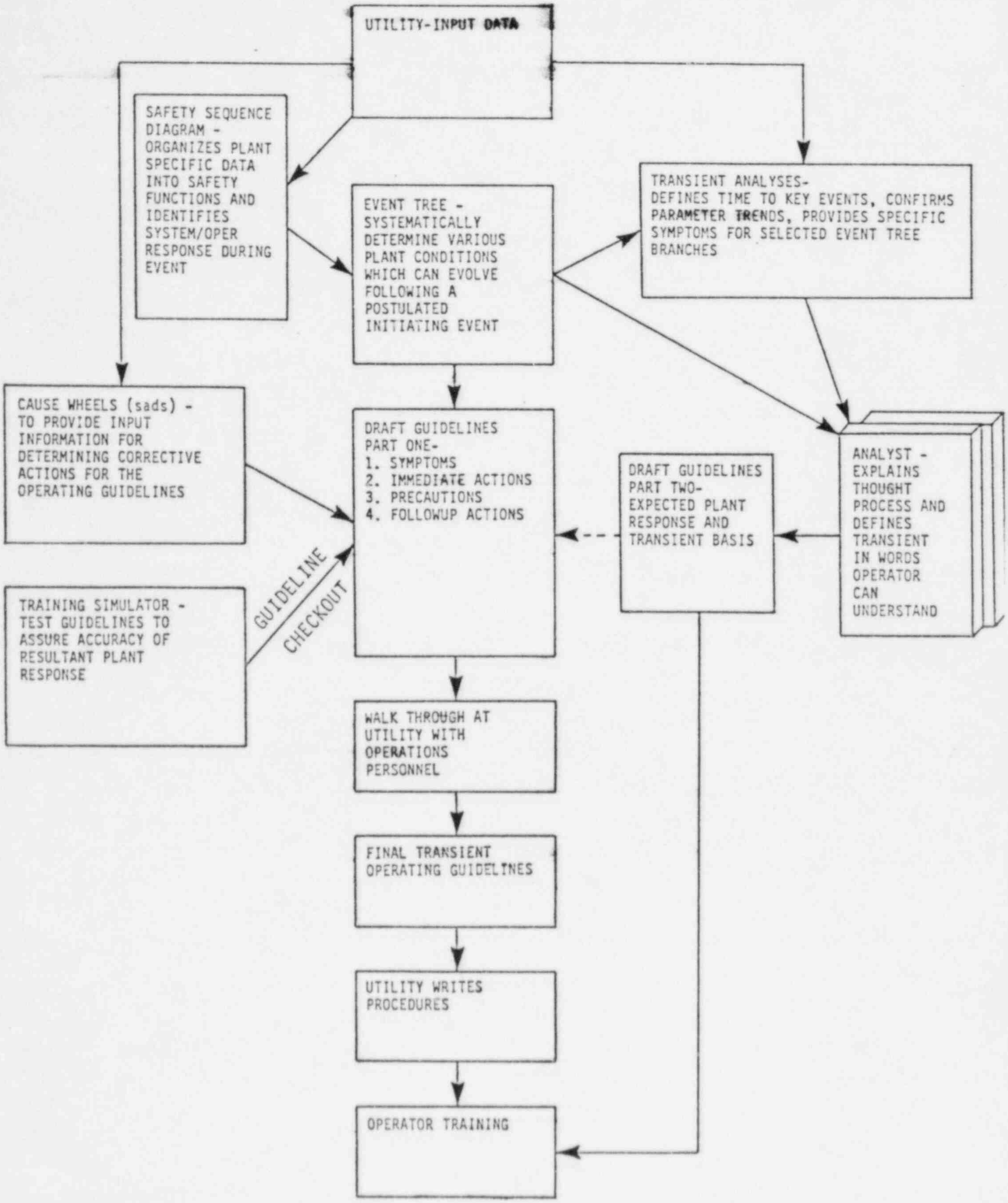


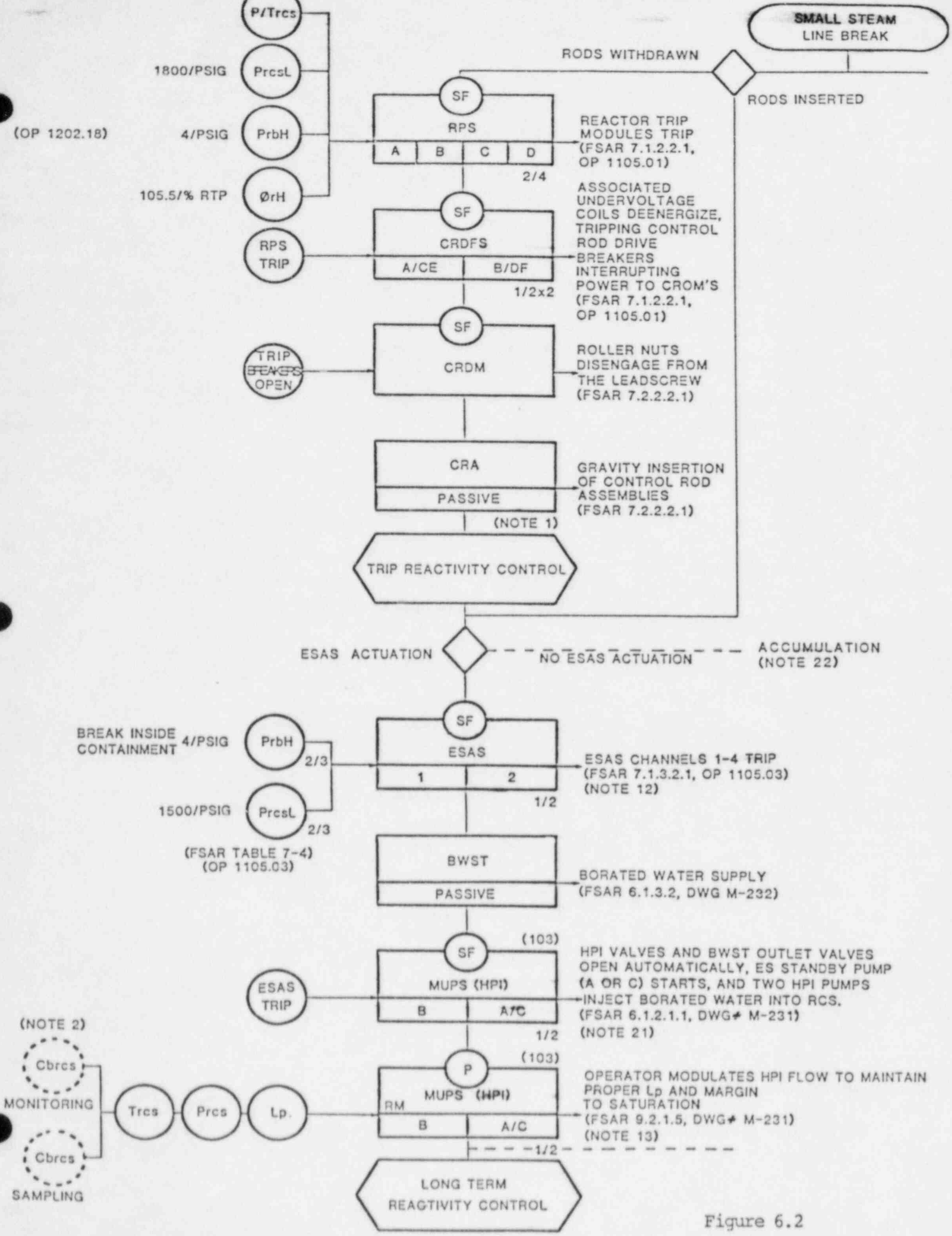
Figure 6-1 Abnormal Transient Operating Guidelines Program

- o System Auxiliary Diagrams (SADs) developed to identify the supporting equipment which must operate in order to support the functions of the front-line systems and subsystems.

Figure 6-2 provides an example of the SSDs which were specifically generated for ANO-1. The event represented in Figure 6-2 is a small steam line break. Each block in the figure represents a specific plant action either in terms of automatic equipment function (SF), equipment availability (passive), or personnel action (P) which may occur in the accomplishment of the safety function. For example, in the first personnel action (P) following ESAS Actuation, the operator observes RCS temperature (Trcs), RCS pressure (Prcs), and pressurizer level (L_p) in modulating HPI flow to the RCS. The action is described in the text to the right of the block along with pertinent references from which the appropriate event sequence and plant operation were based.

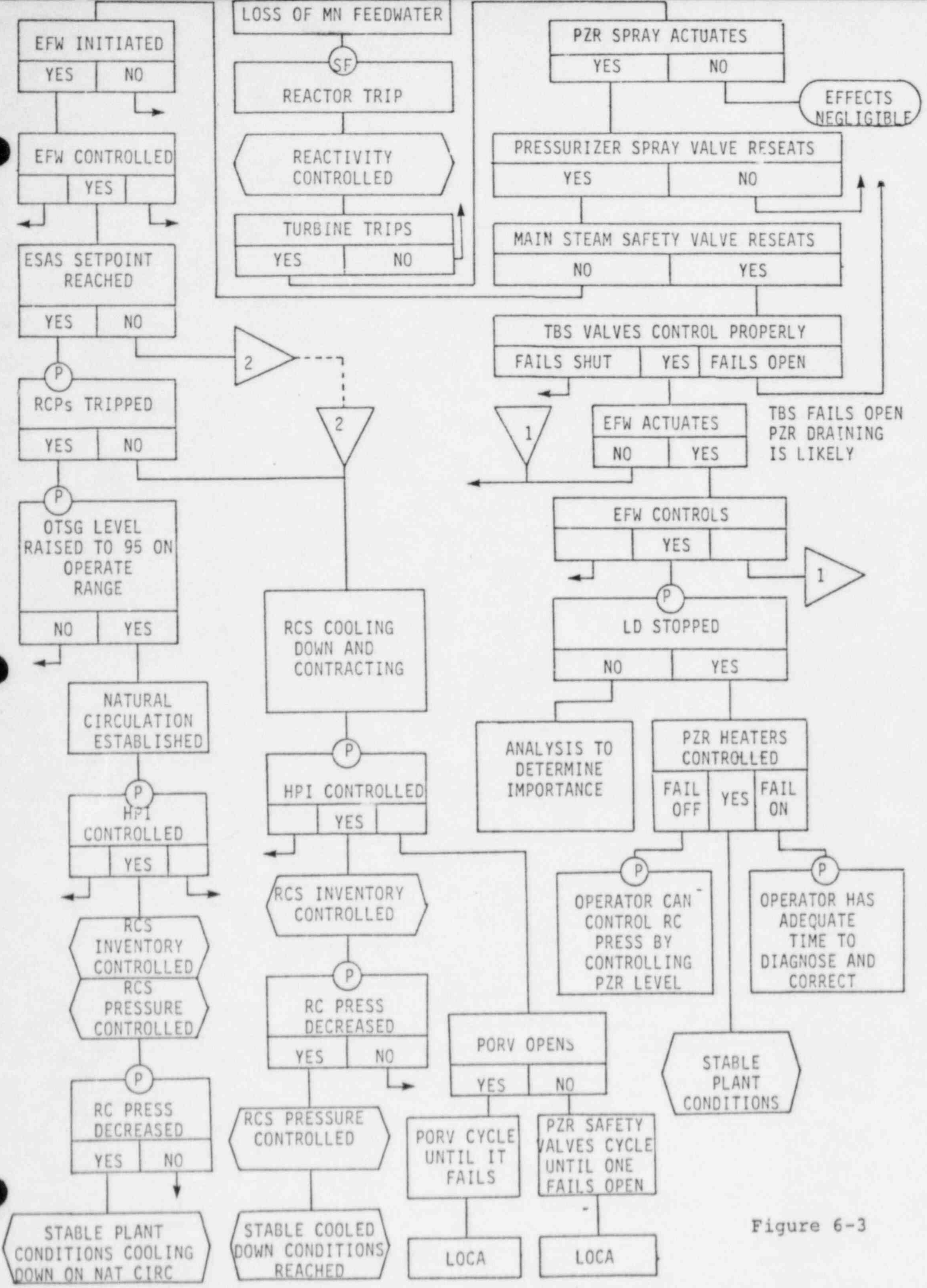
Although the SSDs identify the system and operator responses to initiating events for accomplishing safety functions, they do not identify all of the combinations in which these responses might occur. Event trees were developed for selected basic types of transients for this purpose. A simplified event tree is depicted in Figure 6-3.

The last tool employed in the development of the EOP guidelines is the SAD. This diagram describes the components and supporting systems and subsystems which enable each major system to function properly. Included in this information is trip setpoint information, equipment status following ESAS actuation, main and backup power supply information, system interlocks, verification instrumentation and annunciated information, and other system description information helpful in determining causes of system malfunctions.



SMALL STEAM LINE BREAK
RODS WITHDRAWN
RODS INSERTED
P/Trcs
1800/PSIG
PrcsL
(OP 1202.18)
4/PSIG
PrbH
105.5/% RTP
ØrH
SF
RPS
A
B
C
D
2/4
REACTOR TRIP MODULES TRIP (FSAR 7.1.2.2.1, OP 1105.01)
RPS TRIP
CRDFS
A/CE
B/DF
1/2x2
ASSOCIATED UNDERVOLTAGE COILS DEENERGIZE, TRIPPING CONTROL ROD DRIVE BREAKERS INTERRUPTING POWER TO CROM'S (FSAR 7.1.2.2.1, OP 1105.01)
TRIP BREAKERS OPEN
CRDM
ROLLER NUTS DISENGAGE FROM THE LEADSCREW (FSAR 7.2.2.2.1)
CRA
PASSIVE
(NOTE 1)
GRAVITY INSERTION OF CONTROL ROD ASSEMBLIES (FSAR 7.2.2.2.1)
TRIP REACTIVITY CONTROL
ESAS ACTUATION
NO ESAS ACTUATION
ACCUMULATION (NOTE 22)
BREAK INSIDE CONTAINMENT
4/PSIG
PrbH
2/3
1500/PSIG
PrcsL
2/3
(FSAR TABLE 7-4) (OP 1105.03)
ESAS
1
2
1/2
ESAS CHANNELS 1-4 TRIP (FSAR 7.1.3.2.1, OP 1105.03) (NOTE 12)
BWST
PASSIVE
BORATED WATER SUPPLY (FSAR 6.1.3.2, DWG M-232)
(103)
ESAS TRIP
MUPS (HPI)
B
A/C
1/2
HPI VALVES AND BWST OUTLET VALVES OPEN AUTOMATICALLY, ES STANDBY PUMP (A OR C) STARTS, AND TWO HPI PUMPS INJECT BORATED WATER INTO RCS. (FSAR 6.1.2.1.1, DWG# M-231) (NOTE 21)
(NOTE 2)
Cbrcs
MONITORING
Cbrcs
SAMPLING
Trcs
Prcs
Lp.
P
(103)
RM
MUPS (HPI)
B
A/C
1/2
OPERATOR MODULATES HPI FLOW TO MAINTAIN PROPER Lp AND MARGIN TO SATURATION (FSAR 9.2.1.5, DWG# M-231) (NOTE 13)
LONG TERM REACTIVITY CONTROL

Figure 6.2



LOSS OF MN FEEDWATER
SF
REACTOR TRIP
REACTIVITY CONTROLLED
TURBINE TRIPS
YES
NO
EFW INITIATED
YES
NO
EFW CONTROLLED
YES
ESAS SETPOINT REACHED
YES
NO
2
P
RCPs TRIPPED
YES
NO
OTSG LEVEL RAISED TO 95 ON OPERATE RANGE
NO
YES
NATURAL CIRCULATION ESTABLISHED
HPI CONTROLLED
YES
RCS INVENTORY CONTROLLED
RCS PRESSURE CONTROLLED
RC PRESS DECREASED
YES
NO
STABLE PLANT CONDITIONS COOLING DOWN ON NAT CIRC
RCS COOLING DOWN AND CONTRACTING
HPI CONTROLLED
YES
RCS INVENTORY CONTROLLED
RC PRESS DECREASED
YES
NO
RCS PRESSURE CONTROLLED
STABLE COOLED DOWN CONDITIONS REACHED
PZR SPRAY ACTUATES
YES
NO
EFFECTS NEGLIGIBLE
PRESSURIZER SPRAY VALVE RESEATS
YES
NO
MAIN STEAM SAFETY VALVE RESEATS
NO
YES
TBS VALVES CONTROL PROPERLY
FAILS SHUT
YES
FAILS OPEN
1
EFW ACTUATES
NO
YES
TBS FAILS OPEN PZR DRAINING IS LIKELY
EFW CONTROLS
YES
LD STOPPED
NO
YES
ANALYSIS TO DETERMINE IMPORTANCE
PZR HEATERS CONTROLLED
FAIL OFF
YES
FAIL ON
OPERATOR CAN CONTROL RC PRESS BY CONTROLLING PZR LEVEL
OPERATOR HAS ADEQUATE TIME TO DIAGNOSE AND CORRECT
STABLE PLANT CONDITIONS
PORV OPENS
YES
NO
PORV CYCLE UNTIL IT FAILS
PZR SAFETY VALVES CYCLE UNTIL ONE FAILS OPEN
LOCA
LOCA

Figure 6-3

The information yielded by the SSDs, event trees, and SADS provided the necessary input for the Review of System Functions in the precise formats recommended by the NRC in NUREG-0700. In that document, the NRC suggested an approach which:

- o Identifies major plant operating systems and subsystems to the level of major components [e.g., SADS]

- o Identifies appropriate event sequences for analysis with emphasis on abnormal and emergency conditions [e.g., Event Trees]

- o Identifies and documents, on functional block diagrams, the functions associated with the systems and subsystems involved in each selected event including codes indicating the allocation of functions to man or machine, and where control of the function resides [e.g., automatic, control room manual, local manual, or a combination (e.g., SSDs)]

The results of the transient analyses indicated that operator action in response to a certain set of observable symptoms was sufficient to mitigate the consequences of the transient and maintain the plant in a safe condition regardless of the cause of the transient. These symptoms are:

1. <u>Loss of Subcooling Margin</u> - Upon observing a loss of subcooling margin, the appropriate response is to maintain RCS inventory, restore the subcooling margin, and assure a heat sink for the decay heat.

2. <u>Inadequate Primary-to-Secondary Heat Transfer (Overheating)</u> - An overheating symptom is generally due to a loss of feedwater transient. The appropriate

response is to reduce the heat source and establish an alternate means of core cooling until feedwater can be restored.

3. Excessive Primary-to-Secondary Heat Transfer (Overcooling) - In this case, the symptom is indicative of a secondary side malfunction, e.g., loss of steam pressure control or steam generator overfill.

4. Inadequate Core Cooling - Inadequate core cooling signals failures within the systems designed to maintain RCS inventory resulting in the core becoming uncovered.

It was demonstrated and validated in the EOP development program that if the operator recognized and properly treated these symptoms, then regardless of the event, the consequences of the transient would be mitigated. The mitigation approach developed to effect this proper treatment is organized into the following sections:

I. Entry Conditions or Symptoms - List of reactor trip symptoms and conditions

II. Immediate Actions - Immediate response to reactor trip and attending symptoms

III. Follow-up Actions - Verification of normal post trip functions and identification of key symptoms of the transient

IV. Tabbed Section for Abnormal Conditions - Corrective actions for identified observable symptoms

Thus, EOPs were developed using a program that identified the system and operator functions necessary to mitigate abnormal

operating transients. To accomplish the objective of the CRDR task analysis, a detailed breakdown of the operator functions into tasks being performed at each stage of the symptom-oriented procedure was necessary.

6.3.2 Method

The Task Description Form in Appendix A represents the link between the EOP transient analyses and functional design bases and the CRDR task analysis effort. A task description form was completed for each tabbed section of the ANO-1 EOP identifying:

- o Operator functions to be accomplished
- o Operator tasks associated with operator functions
- o Corresponding procedure step numbers of identified tasks
- o Unique task numbers for future analysis

The Task Description Form depicts the hierarchical relationship between the EOP mitigation approach and the defined operator functions and tasks for reactor trip.

For each task identified in the Task Description Form, a Task Analysis Instrument Requirement Form, depicted in Figure 6-4, was completed by a human factors specialist working with an ANO-1 Subject Matter Expert. It was emphasized to the SME that the task requirements should be considered independently from existing control room features. A single task was generally comprised of several subtasks or action steps. The purpose of the Task Analysis Form was to identify the information and control needs for task performance and provide a template of operator activities in the task for use in verification and validation efforts. The information collected to describe the control needs for operator tasks included:

TASK ANALYSIS INSTRUMENTATION REQUIREMENT FORM

Same as: ______ Task Number

Alt. to: ______ Task Number

Page ____ of ____

Date ______

Analyst ______

______ Procedure Section

______ Step Number

______ Task Number

______ Function/Purpose

______ Task Title

ACTION STEP	OP	VERB	OBJECT																OTHER PERFORMANCE REQUIREMENTS	EXIT OR COMMENTS
			CONTROL								INDICATOR/FEEDBACK									
			PARAMETER	EQUIPMENT	POSITION	STATUS	ID	TYPE	MODE	OTHER	PARAMETER	STATE	TYPE	ID	UNITS	RANGE	DIV	OTHER		

VERB KEY
1.1 OBSERVES
2.1 COMPARES
2.2 CALCULATES
3.1 PUSH
3.2 TURN
3.3 LOCK-OUT
3.4 TOUCH
3.5 ADJUSTS
3.6 TYPES
3.7 PULL
4.1 INFORMS
4.2 REQUESTS
4.3 RECEIVES

CONTROL TYPE KEY
J J HANDLE
JS JOYSTICK
K KEY OPERATOR
LP LEGEND PUSHBUTTON
NP NON-LEGEND PUSHBUTTON
R ROCKER SWITCH
RS ROTARY SWITCH
S SLIDE SWITCH
T T HANDLE
TG TOGGLE SWITCH
TW THUMBWHEEL
TS TOUCHSCREEN
KB KEYBOARD
C CONTROLLER
A AUTO
M MAN
A/M AUTO W/MAN OVERRIDE
M/A MANUAL W/AUTO OVERRIDE

CONTROL MODE
D DISCRETE
C CONTINUOUS

CONTROL OTHER KEY
SR SPRING RETURN
T THROTTLE
B BACKLIT

DISPLAY TYPE KEY
A ANNUNCIATOR
C DRUM COUNTER
EC ELECTRONIC COUNTER
M METER
R RECORDER
D DIGITAL DISPLAY
CSL CONTROL STATUS LIGHT
LL LEGEND LIGHT
NL NON LEGEND LIGHT
CRT CATHODE RAY TUBE
G GRAPHIC

Figure 6.4 Task Analysis Instrumentation Requirement Form

- o Parameter - The system parameter directly affected by the control operation

- o Equipment - The name of the plant equipment involved in the control action, noting the required type of control equipment (e.g. pump, isolation valve, governor valve, etc.)

- o Position - The control position name which corresponds to the escutcheon label (e.g., ON, RUN, CLOSED, AUTO)

- o Status - The actual status of the equipment as a result of the control action (e.g., ON, OFF, OPEN, CLOSED, etc.)

- o Type - The required or desired type of control to suit the nature of the control action. (A key at the bottom of the form provided the most common types.)

- o Mode - The required mode (i.e., continuous or discrete) of control operation for the task

- o Other - Other descriptive features or characteristics necessary or desirable for the control action

- o Type of Feedback - The type of feedback indication provided to assure the operator that the desired control action was initiated or established (e.g., control status lights)

- o Feedback State - The state of the indication for display of control feedback (e.g., color of control status lights)

The information needs for the operator task were described in terms of the following categories of characteristics:

- o Parameter - The system parameter which the display is monitoring
- o State - The state of the parameter which is pertinent to the task accomplishment (e.g., less than 500 psig, At Low Level Limit, Lit, etc.)
- o Type - The required or desired type of display to suit the nature of the information need (e.g., recorder, annunciator, graphic plot, etc.)
- o Units - The units needed for the parameter display in order to accomplish the task without the need for conversion
- o Range - The range of parameter values required for the accomplishment of the particular task under investigation
- o Divisions - The required precision of the parameter value display in terms of the smallest scale division
- o Other - Other descriptive features or characteristics desirable or necessary for display of the information requirement

The Task Analysis Form was specifically designed to support the CRDR verification and validation efforts. The elements of the form are arranged so the description of the task activity represents a declarative statement (i.e., similar to a sentence). The "OP" column (referring to operator) provides the "WHO", or the subject, of the sentence. This is followed

by a column entitled "VERB", describing the action of the task. Finally, the equipment or object of the task action was described. A separate column entitled "OTHER PERFORMANCE REQUIREMENTS" was provided for description of operator activities other than control and display actions. The last column of the form entitled "EXIT OR COMMENTS" was employed to record the number of the next action step or task for the conditions following the completion of the task activity. In many cases, multiple entries were needed in this column to account for both expected task results and unexpected conditions. This element accommodated transfer "IF STATEMENTS" in the procedure and contingency task actions required if the expected response was not obtained. The column also served as a space to record pertinent comments of the analyst or SME relating to information and control needs or task performance.

The Task Analysis data constitute a specification of operator needs to accomplish the operator functions. This specification was then used as a foundation reference point to verify the availability and suitability of control room instrumentation, to provide a context within which to survey the control room, and to provide a base of understanding on which to assess Human Engineering Discrepancies.

6.4 Control Room Inventory

6.4.1 Overview

The objective of the control room inventory for ANO-1 was to establish a reference set of data which identified instrumentation and controls within the control room, for comparison with the equipment requirements identified during the task analysis. All displays, controls, controllers and annunciators in the primary operating area of the control room were included in this inventory. Based on the guidance of NUREG-0700, HFSs

completed the inventory with support as needed from AP&L's Operations staff. In order to ensure that an up-to-date inventory was generated, the approach taken was that of direct observation in the control room.

Each piece of equipment on the control boards was identified by a sequential code which allowed that component to be uniquely referenced during the verification. This code was associated with the information about the physical characteristics of each piece of equipment, as they appeared from the front of the control panels. The characteristics noted were those which would determine, from a human factors standpoint, the usefulness of the equipment to the operators in monitoring and controlling the plant.

The data were stored in the computerized data base management system (DBMS). The data were then sorted in a manner which facilitated the verification process, whereby it was determined the extent to which suitable equipment was available in the control room to allow the plant operators to effectively perform emergency and other operating procedures.

6.4.2 Methods

All equipment on the two rows of control panels in the primary operating area of the ANO-Unit 1 control room, as well as the equipment on selected back panels, was inventoried. The following panels were addressed: C01, C02, C03, C04, C09, C10, C11, C12, C13, C14, C15, C16, C18, C19, C20, C21, C24, C25, C37-1, C37-2, C37-3, C42, C43, C88, C100, C486-1, C486-2, C486-3, C486-4, C493, C498, K-15, K-16.

The following steps summarize the approach taken in performing the inventory:

- o The most recent set of control panel elevation drawings was obtained. An HFS compared these prints, component by component, to their respective control panels and penciled in any discrepancies on the prints. AP&L draftsmen then produced an up-to-date set of as-built prints.

- o A sequential code was developed for uniquely identifying each component. A sequence number was incrementally assigned to equipment components of a given type (indicators, controls, controllers, annunciators), scanning left to right and top to bottom across a given panel, and then continuing on the next panel to be inventoried. Information about indicator lights associated with a control was collected along with information about the control switch itself. Therefore, one sequence number was assigned to the control and its indicator lights. Similarly, one sequence number was assigned to a controller or a multi-pen recorder. Indicator lights that were not associated with a control were individually assigned sequence numbers.

- o The inventory was accomplished panel by panel in the order of these sequence numbers. As each piece of equipment was inventoried, it was checked off on the appropriate print.

- o Separate Inventory Forms, as shown in Appendix A, were used for indicators, controls and controllers. Annunciators were coded on the indicator inventory forms. The inventory forms were completed by an HFS, based on direct observation of the equipment in the control room. AP&L Operations staff were available to answer questions as needed. At the top of each sheet, the following information was entered:

- o Plant
- o Unit
- o Page ___ of ___
- o Date
- o Analyst (initials of the person filling out the form)

For each component, regardless of whether it was an indicator (all displays including annunciators), control, or controller, the following information was entered:

- o ID (Equipment piece number, if it appeared on the control boards)
- o Sys (System name)
- o Label (Engraved component label as it appeared on the control boards)
- o Manufacturer (If engraved on the equipment)
- o Model (If engraved on the equipment)
- o Other label (Secondary component label on the control boards or on the equipment itself)
- o Notes

For indicators (displays), the following additional information was entered:

- o Type of instrument -- for example:
  - RM -- rotary meter
  - VM -- vertical meter
  - SP -- Single-point recorder
  - MP -- Multi-point recorder
- o Range (the low and high points that were labeled on the meter face or chart paper)
- o Div -- Divisions (the incremental value associated with the distance between adjacent tick marks on the scale of the meter face or chart paper)

- o Units (e.g., kiloamperes, volts)
- o Markings -- (e.g., color of pens on multi-pen recorder)
- o Pens -- (parameters recorded by multi-pen recorders)
- o No. Recorded Pts. -- (on multi-pen recorders)

If an indicator light was not associated with a control, it was entered as a line item with its own sequence number. Indicator lights associated with controls were entered in the record with the information about the corresponding control.

Annunciator labels were entered on the Inventory Form for Indicators.

For controls, the following additional information was entered:

- o Type of control switch
  - JS -- Joy stick
  - SCS -- Standard Control Switch
  - TB -- "Thumb-buster" switch
  - PB -- Pushbutton
  - K -- Keylock switch
  - RS -- Rotary Selector Switch
  - TS -- Thumbwheel selector switch
- o Mode -- a check was entered for each of the following features that pertained to each control:
  - DIS -- Discrete control
  - CONT -- Continuous control
  - auto -- automatic control
  - SR -- control switch is spring return
  - TH -- Throttleable control
  - pull to lock -- switch has a pull-to-lock position
- o Pos/range -- switch positions (as they appeared on the escutcheon plate)

- o CSL/DIV -- the color of any control status lights
- o Backlit Units -- engraved labels on backlit indicator lights

Controllers typically consisted of several control and display functions (e.g., manual-auto switch, setpoint adjustment, demand meter, status meter). For controllers, the following additional information was entered:

- o Indicator Type
  - RM -- rotary meter
  - VM -- vertical meter
- o Range (the low and high points that were labeled on the meter face)
- o Div -- Divisions (the incremental value associated with the distance between adjacent tick marks on the scale of the meter face)
- o Units (e.g., kiloamperes, volts)
- o Controls -- a check was entered in the appropriate column for:
  - A/M -- Auto/manual controller
  - setpt -- contains setpoint adjustment and display
  - param -- contains status (response) meter
  - other --
- o Control Types
  - JS -- Joy stick
  - SCS -- Standard Control Switch
  - TB -- "Thumb-buster" switch
  - PB -- Pushbutton
  - K -- Keylock switch
  - RS -- Rotary Selector Switch
  - TS -- Thumbwheel selector switch
- o POS -- switch positions
- o Marking -- other descriptive markings that distinguish among the various controls on the controller

- o The information that had been entered on the Inventory Forms by the HFS in the control room was typed by data entry personnel into the computerized data base management system.

6.4.3 Findings

As detailed in the section of this report on the Verification process of the CRDR, the inventory data were used for comparison with the equipment requirements derived from the task analysis.

6.5 Verification of Equipment Availability and Suitability

6.5.1 Overview

The objective of the CRDR Verification process was to assure that operator tasks can be performed in the existing control room at the ANO-Unit 1 station with minimum potential for human error. The focus was on instruments and equipment, not on operator skills and knowledge. The verification was accomplished by comparing the operators' requirements for information and control capabilities during emergency and other operations, which were derived from the CRDR task analysis, with the equipment that is present in the ANO-1 control room, as identified by the control room inventory.

There were two aspects to this verification process. First, it was determined whether or not appropriate equipment was available in the control room to perform each functional task required by emergency operations. Second, for equipment that had been identified as available, it was determined whether or not the characteristics of each piece of equipment made it

suitable for the task, i.e., whether it offered the operator sufficient control and display capabilities to efficiently accomplish the task. The characteristics addressed were those physical aspects of the equipment that were apparent from the front of the control panels and which, from a human factors perspective, determined the equipment's usability by the plant operators.

As detailed in the summary of the ANO-1 control room inventory, a compilation of relevant equipment characteristics was completed for all displays, controls, controllers, and annunciators on the panels in the primary operating area. The inventory identified each piece of equipment with a unique code, the Sequence Number, so that specific equipment could be referenced during the verification and all pertinent characteristics of each piece of equipment could be retrieved from a computerized data base.

As detailed in the summary of the ANO-1 task analysis of emergency procedures, the operators' need for specific display information or control capabilities was identified at each step throughout sequences of emergency and other operations. The tasks to be performed during emergency operations were derived from the ANO-1 Emergency Operating Procedure and other ANO-1 operating procedures. The equipment requirements implied by these tasks were categorized in terms of the same equipment characteristics that were identified during the control room inventory. Finally, in separate data collection sessions from the initial task analyses, for each task, operators noted the sequence numbers of the equipment that they presently use to perform that task. The sequence numbers had been penciled in on as-built prints of the control panels and were noted by HFSs on the Task Analysis Instrumentation Requirement Form. Cases were noted for which there was no equipment presently available to adequately perform a given task.

The verification process involved two stages. First HFSs, working from the Task Analysis Instrumentation Requirement Forms and computer print-outs of the control room inventory that had been sorted by sequence number, looked up the equipment in the inventory that is presently used to perform each task. The requirements for the equipment that had been identified on the task analysis form was then compared to the features of the present equipment that had been noted during the inventory. Second, the resulting apparent discrepancies between equipment requirements and presently available equipment, were checked in the ANO-Unit 1 control room by HFSs with guidance from AP&L operators. Equipment that was thus confirmed to be unavailable or unsuitable was documented in the form of Human Engineering Discrepancies (HEDs).

6.5.2 Findings

The HEDs that resulted from the ANO-Unit 1 verification process were presented to the Human Engineering Discrepancies Assessment Team (HEDAT) for resolution. The Team determined whether unavailable equipment was, in fact, required and, if so, what features that equipment should possess. Similarly, they determined what equipment changes, if any, should be evaluated further to resolve instances in which the available equipment had been found to be unsuitable.

6.6 Validation

6.6.1 Introduction

The objective of the validation review was to determine whether the functions allocated to the control room operating crew could be accomplished effectively within both the structure of the established emergency procedures and the design of the control room as it exists.

6.6.2 Methodology

The following paragraphs describe the processes used at ANO-1 to select events to be evaluated, the validation procedure, the process used to analyze the data and results.

6.6.2.1 Selection of Events

Six events were selected for validation. In the estimation of plant operations SMEs, these events provided a comprehensive exercise of unit systems and control room workstations:

- Scenario 1 - Automatic reactor trip with no abnormalities

- Scenario 2 - Reactor trip with overcooling event (stuck open main steam safety)

- Scenario 3 - Reactor trip with low subcooling margin (RCS leak within HPI capacity with subsequent failure of the HPI system resulting in inadequate core cooling)

- Scenario 4 - Reactor trip with overheating (loss of all feedwater)

- Scenario 5 - Steam generator tube rupture (within HPI capacity)

- Scenario 6 - Steam line break (downstream of main steam isolation valve)

6.6.2.2 Procedure

The walk-throughs were performed on the ANO-1 simulator according to the following procedural steps:

1. An HFS, with the assistance of the CRDR SME, developed a floor diagram of the unit work space and identified, numerically, workstations for that unit.

2. The audio-visual equipment was set up and tested. A "dry-run" of an event (a sample walk-through) was performed in order to judge the adequacy of the process.

3. After ANO operations representatives had reviewed and judged the tapes to be of adequate quality, adjustments to camera layout, microphone configurations, etc., were made.

4. The HFS briefed the participating control room operating crew on the purpose and specific objectives of the walk-throughs and on how they would be performed. At this time, assumptions (per initial conditions) about the operating situation were specified to the operator. This rehearsal was not an actual walk-through of the action steps to be taken by the operator during the scenario.

5. The video tape was started and the following guidelines were met:

    - The lighting levels were sufficient to record the details of the event being taped.

    - "Non-performing" personnel were instructed to be as quiet as possible during the taping of the event and not to distract the operating crew on camera in any way.

- o The walk-through included two operators since this is the minimum operating crew required by current plant procedures. Each operator was supplied with a microphone (attached to his clothing) to record the verbal communication.

- o HFSs operated the video recording equipment.

- o Two cameras and a recorder were used to document the event simulation run-through. One camera was stationary and had an adjustable angle of view that encompassed the entire control panel work space. The second camera focused on areas of the control boards used by the operators but not visible by the primary camera. This allowed for the monitoring of head movement, verbal response and action response.

6. The event simulation run-through began.

7. The control room crew then walked through what they would do while following the appropriate procedures. During the walk-throughs, the operators (speaking on two separate audio channels) described the following:

   - o Action taken
   - o Information sources used
   - o Conversions or uncertainties involved
   - o Controls used
   - o Expected system response
   - c How those responses would be and/or may be verified
   - o Actions that would be taken if the expected responses did not occur
   - o Additional assistance necessary and/or desirable from personnel outside the control room (as appropriate)

The operators were instructed to simulate actions they would take if the event were real.

8. During the event simulation, a voice-over narration by an SME was performed on the video tape. The narration conveyed what was transpiring, what the operators should be attempting and why.

9. During the event simulation, the HFS observed the event and recorded any discrepancies. A real-time estimate of the time that the operators spent at the workstation was obtained from the video tapes.

10. At a cue from the operating crew performing the event simulation, an SME or the HFS terminated the event and video taping.

11. The HFS, at that point, logged the following data:

- o The event taped
- o The date of taping
- o The time of taping
- o Any unusual circumstances surrounding the taping
- o The names of the operating personnel taped
- o The name of the event narrator
- o The counter reading from the video and audio tape recorders

6.6.2.3 Analysis of Data

After completion of all scenario taping on-site, the HFSs, with assistance from the SME, reviewed the video tapes collected during the Validation. Each scenario was broken down into

procedure steps and recorded on the Validation Review Worksheet (Appendix A). Each procedure step was assessed to see if the step was completed satisfactorily. If an HED was discerned during this step, it was so recorded.

6.6.2.4. Results

The validation process provides for further evaluation of HEDs previously identified in terms of how they may affect operator performance. Also, another object is to determine if new HEDs that may not have been identified by other review methods are apparent during the dynamic review process. This objective was met by the identification of six HEDs during the validation phase of the CRDR. These HEDs cover:

- Pumps located out of sequence
- Meters not functionally grouped on the electrical panel
- Controls used during emergency procedures located too low on the control panel
- Insufficient enhancement techniques
- Displays located too high on the control panel
- Uncomfortable arm spread

6.7 Control Room Survey

This survey considered the extent to which equipment and the environment in the control room are designed to accommodate basic human characteristics such as physical size and perceptual-motor capabilities.

A comparison of instrument and control features to the ANO human factors guidelines was conducted. These guidelines were derived from those given in Section 6 of NUREG-0700 and closely follow them in format and content. The ANO guidelines do

differ from those in NUREG-0700 in that some of the items were quantified, or reworded, so as to make them clearer and more concise for evaluation (see Appendix C).

Human Factors Specialists, in concert with experienced ANO personnel knowledgeable of plant systems and control room instruments and equipment, and operations personnel, observed and measured control room features.

Instrumentation, controls and other equipment items were examined for human engineering acceptability as components without reference to their specific uses in task performance. Discrepancies were based on design incompatibility with human perceptual, motor, psychological or size characteristics. Examples included controls too closely spaced for easy manipulation, meters with markings too small to be distinguishable at a practical distance, and displays too high to be read. Environmental conditions were surveyed independently.

The guidelines included principles or explanatory statements followed by specific categorical or numeric statements. The procedure was to observe or measure, as required, and check compliance with each categorical or numerical statement.

The review team members conducting the checklist survey placed a check in the "Yes" box to indicate compliance and a check in the "No" box to indicate noncompliance. "Yes" was checked only if there is total compliance - i.e., only if every instance of the item is fully consistent with the provisions of the checklist. If there was any instance of noncompliance, the "No" box was checked and a reference made as to where noncompliance occurred. A CR HED form (Appendix A) was filled out for each non-compliant item.

6.7.1 Human Factors Engineering Checklist

The Human Factors Engineering guidelines were examined for the nine topic areas listed below:

1. Control Room Workspace addressed the general layout, availability and accessibility of operating equipment and materials; the anthropometric suitability of work-stations; coordination and separation in multi-unit control rooms; availability and accessibility of emergency equipment; and environmental factors.

   Compliance with most of the workspace guidelines was determined by inspection. Certain sets of guidelines required simple measurements, including measurements of distance, height and span; viewing angles; and reach radius. In addition, assessment of climate control, lighting adequacy and the auditory environment required more specialized measurements or tests of temperature, humidity and air flow; luminance and reflectance; noise and reverberation; and audibility of speech and signals. These measures are explained in section 6.7.2.

2. Communications Section addressed auditory communications equipment used in the control room. Communications is a specialized topic which was treated relatively independently, on a control room-wide basis. Individual workstations were considered only incidentally.

3. Annunciator Warning System Section addressed overall concerns such as alarm parameter selection and set points, first-out alarms and prioritization; and

design features of the auditory alert, visual alarm and operator response subsystem. It was necessary to assess the annunciator system on both a general or control room-wide basis and a panel-by-panel basis. Guidelines concerning such design features as auditory alert signal intensity, automatic reset after silence, labeling of visual alarm tiles, etc., were applied equally throughout the control room.

Compliance with many of the guidelines was determined by inspection, review of annunciator system specifications and questions asked of operating personnel. The annunciator system was tested so that its performance characteristics could be observed. Assessment of auditory signal audibility, discriminability and localizability were based on performance tests with sound measurements where there was any uncertainty (Section 6.7.2).

4. Controls Section addressed principles of selection, protection and designs and specifications for different types of controls. The guidelines were applied on a control room-wide basis and called for measurements of control dimensions, spacing and resistance. Measurement of displacement of key-operated controls was also included. Dimensions and spacing were checked on the panels themselves. Resistance measurements were made with different devices depending on the type of control.

5. Displays Section addressed principles of displays including information to be displayed, usability of displayed values, readability, printing, markings and coding. Guidelines were also given as to design characteristics of particular types of displays

including meters, light indicators, graphic recorders and counters. Each display was checked for conformance to the applicable guidelines. After every display had been checked, they were considered from a system perspective to assure appropriate consistency in labels, markings and coding.

6. Labels and Location Aids Section addressed labeling, location, content and lettering; use of temporary labels; and use of location aids such as demarcation, color and mimics. Labels were checked for accuracy and conformance to guidelines. A system/panel-oriented check was used to examine the labeling hierarchy and consistency of terms and abbreviations used to refer to system components.

7. Process Computer Section addressed software security and characteristics (dialogue/command language, prompting, structuring); procedures and other aids to computer use; keyboard arrangement, function controls and other controls; computer response time; and design characteristics of displays and printers/printer messages. The guidelines addressed generic qualities in a manner that did not require knowledge of specific uses. Compliance with most of the guidelines was determined by inspection in the control room and review of software and hardware specifications. It was necessary to question control room operators or supervisors to make determinations about some of the criteria.

   Measurements were necessary to assess response times, keyboard key dimensions and separation and certain readability factors including character size and separation viewing angle, luminance contrast, geometric distortion and resolution of CRT displays.

8. Panel Design Section addressed allocation of controls and displays to preferred panel areas; grouping of controls and displays; spacing, demarcation and color shading to enhance recognizability of individual components and of groupings; ordering of components within groupings; layout consistency within and between panels; and strings, clusters, or matrices of similar components.

9. Control-Display Integration Section addressed relative positioning of single control and display pairs and multiple controls and displays; function and sequence-of-use relationships; movement relationship and other aspects of compatibility of controls and displays which are used together. The control-display integration survey was conducted panel-by-panel.

6.7.2 Environmental Measurement Procedures

6.7.2.1 Sound Survey Procedures

Using a control room layout drawing, locations were selected and marked where sound measurements were to be taken. Measurements were taken at each operator position that required verbal communication and/or auditor discrimination of a signal.

Measurements were made with the microphone at the center of the head location. The microphone was located 5 ft. above the floor at positions where the operator stands and 4 ft. above the floor at seated positions. Measurement positions include:

- Senior reactor operator's desk
- Reactor operator's desk
- Operator workstation or points near the center of each panel or console

Microphones having an essentially flat response at grazing incidence (90°) were used. The microphone was placed vertically at the measurement location with the sensitive element up.

These measurements were for ambient noise levels (where ambient noise is defined as background control room noise without the contribution of alarms, printers or communications equipment). Integrated "A" weighted db(A) measurements were taken for all of the above positions. Measurements were recorded on the Sound Survey Record (Appendix A) that specifies both location and direction.

A set of tests was performed at each location. First, the control room ambient sound levels were measured. The measurements were taken while each annunciator, corresponding to the unit location, was activated. Finally a measurement was taken while printers and communication equipment were in use.

The following checklist items reference sound level measurements:

- o Ambient Noise (1.5.5)
- o Communications (2.2.3, 2.2.5, 2.2.6)
- o Annunciators (3.2.1)
- o Computers (7.3.2)

6.7.2.2 Lighting Survey Procedures

Using a control room layout drawing, locations were selected and marked where the illumination measurements were to be taken. Readings were taken:

- o In front of each front panel
- o In the center of the control room
- o In front of each back panel

At each position, the following was measured:

- o Full AC ambient
- o Full DC emergency
- o Any typical combination or alternative

Readings were recorded on the Lighting Survey - Illuminance Record Form (Appendix A).

The determination of the luminance and reflectance ratios, followed these procedures:

- o The object was covered with a "perfect reflector" pad, with care taken not to block light.
- o The luminance reading on the pad was taken and recorded
- o The reflector pad was removed
- o The luminance reading of the object was then taken and recorded.

At each panel, measurements were taken of:

- o Reflectance of pad on panel
- o Panel background (where reflectance pad was placed)
- o Meter faces (with and without glare)
- o Other display faces (with and without glare)
- o Lights

Readings were recorded on the Lighting Survey Luminance and Reflectance Record (Appendix A).

6.7.2.3 Humidity/Temperature Procedures

Humidity and temperature were measured by setting up recorders meters in an area where they were not disturbed. The locations(s) of the recorders were marked on a control room layout drawing. Readings were taken at floor level and at 6 ft. above floor level continually for a 24-hour period. The time and the temperature and humidity values for both levels were recorded on the Humidity/Temperature Record (Appendix A).

6.7.2.4 Air Velocity Survey Procedures

Using a control room layout drawing, locations were selected and marked where air velocity readings were taken. Measurements were taken at principal operator workstations. Measurements were taken at an elevation of 6 ft. for standing positions, and at 4 ft. for sitting positions. Measurements were recorded on the Air Velocity Survey Record (Appendix A).

7.0 HED ASSESSMENT

The CRDR review resulted in the identification of a number of Human Engineering Discrepancies (HEDs). Each HED identified represented a potential source of operator error with possible subsequent consequences to plant safety and operations. Moreover, the potential for error varied across HEDs. Therefore, the HEDs were evaluated to determine the extent to which they affected plant safety, plant operability, and personnel safety. The following describes the systematic method for evaluating both the significance of HEDs and the feasibility/viability of any recommended improvements or corrections for the HEDs. Once the HEDs were evaluated, further detailed evaluations of selected HEDs were initiated within the framework of the ANO design change process.

The ANO Assessment Team reviewed and assessed every HED generated based on its impact on plant safety and operability. This review included a formal assessment of each HED and evaluation of the most appropriate action to initiate in order to further pursue correction of the HED. The formal assessment followed the procedure below:

1. The Lead Human Factors Specialist compiled the HEDs into a binder.

2. Each Assessment Team member was given a binder of HEDs to review and evaluated each HED independently, based

on the HED Assessment Rating Form, shown in Appendix A, which addressed the following factors:

a) Impact on physical performance (fatigue, discomfort, injury, control suitability, etc.)

b) Impact on sensory/perceptual performance (distraction, visibility, readability, audibility, noise, display adequacy, inconsistency with stereotypes and conventions, etc.)

c) Impact on cognitive performance (mental overload, confusion, stress, sequential/compound/cumulative/interactive errors, etc.)

d) Interaction with task variables (communication needs, delay or absence of necessary feedback, concurrent task requirements, etc.)

e) Impact or potential impact on operating crew error

f) Impact or potential impact on plant safety (safety of plant equipment, operability of plant equipment, personnel safety and health and safety of the public)

Upon completing the review of the six factors, the Assessment Team member evaluated the significance of the HED based on three categories of significance as follows:

I. HIGHEST SIGNIFICANCE, could affect or has substantially affected a safety system or operator response during an emergency situation.

II. SIGNIFICANT, could substantially affect or has substantially affected a non-safety system or operator response during routine, non-emergency operation.

III. LEAST SIGNIFICANT, could or has affected operator response in a non-substantial way.

Also, an evaluation of the cumulative impact of category III HEDs was addressed in the assessment form to assure that the level of significance was fully considered. All ratings were recorded on the HED Assessment Rating Form. Each Assessment Team member filled in the HED number, their name and check-marked their evaluation of the HED on the form. When an Assessment Team member had finished the evaluation of his binder of HEDs, he submitted the assessment rating forms for compilation of the results. Upon completion of the compilation, the results of the compilation were provided to each Assessment Team member.

3. The Assessment Team then met to discuss the ratings they assigned individually to the HEDs. The objective of the discussions was to reach a team consensus on the HED ratings. It was the CRDR Team Leader's responsibility to facilitate and monitor the team discussions. The following approach was followed:

   a) The discussion began with a summary of the compilation effort results.

   b) Scores which were in agreement by all team members did not require further discussion at this point. Scores that differed were discussed by the team to establish a consensus among the team members.

4. As a consensus was reached, the rating was recorded and a list was maintained indicating the HED numbers and the final rating for each HED.

5. The Assessment Team continued to meet until every HED had been addressed.

8.0 SUMMARY OF FINDINGS AND HED CORRECTIVE ACTION IMPLEMENTATION

8.1 Findings

A total of 462 HEDs was identified. Two things had a significant effect on this total. First, many of the discrepancies were a result of criteria that were either no applicable in the ANO-1 control room or were of little significance for the ANO-1 control room. However, for completeness, these were documented as HEDs anyway. In other words, judgements of applicability and importance were made at the assessment stage, not at the identification stage. This increased the number of HEDs. Second, a single HED was written for all labeling discrepancies. This decreased the number of HEDs.

Table 8.1 illustrates the source of the HEDs and their significance rating by source. Note that 67% of the HEDs came from the checklist survey, but only 21% of the category 1 HEDs came from the checklist survey. The operator survey produced 55% of the category 1 HEDs and 47% of the category 2 HEDs.

As a result of the inclusion of insignificant and inapplicable HEDs, a large percentage (80%) was categorized as least significant. Of these, 75% were produced in the checklist survey. The intrinsic value of the review process was

REVIEW PHASE	SECTION (AS APPLICABLE)	# HEDs BY SIGNIFICANCE RATING 1*	2*	3*	SUBTOTAL OF HEDs**	HED TOTALS BY PHASE***
CHECKLIST SURVEY	1. WORKSPACE DESIGN	1 (8%)	0 (0%)	12 (92%)	13 (4%)	308(66.7%)
	2. COMMUNICATION	0 (0%)	1 (17%)	5 (83%)	6 (2%)	
	3. ANNUNCIATORS	3 (12%)	5 (19%)	18 (69%)	26 (8%)	
	4. CONTROLS	0 (0%)	3 (20%)	12 (80%)	15 (5%)	
	5. VISUAL DISPLAYS	3 (6%)	2 (4%)	43 (90%)	48 (16%)	
	6. LABELS AND LOCATION AIDS	1(100%)	0 (0%)	0 (0%)	1 (0%)	
	7. PROCESS COMPUTERS	0 (0%)	0 (0%)	120(100%)	120 (39%)	
	8. PANEL LAYOUT	1 (2%)	9 (14%)	54 (84%)	64 (21%)	
	9. CONTROL-DISPLAY INTEGRATION	0 (0%)	1 (7%)	14 (93%)	15 (5%)	
OPERATOR SURVEY		23 (22%)	24 (23%)	56 (55%)		103(22.3%)
HISTORICAL REVIEW		1 (50%)	0 (0%)	1 (50%)		2 (0.4%)
VERIFICATION	AVAILABILITY	7 (24%)	3 (10%)	19 (66%)	29 (67%)	43 (9.3%)
	SUITABILITY	1 (7%)	1 (7%)	12 (86%)	14 (33%)	
VALIDATION		1 (17%)	2 (33%)	3 (50%)		6 (1.3%)
	TOTAL HEDs***	42 (9%)	51 (11%)	369 (80%)	462(100%)	

* THESE PERCENTAGES ARE BASED ON THE SUBTOTAL OF HEDs. ** THESE PERCENTAGES ARE BASED ON THE HED TOTALS BY PHASE. *** THESE PERCENTAGES ARE BASED ON THE TOTAL NUMBER OF HEDs.

Table 8.1 HED Summary from Detailed Listings in Volume 2 of this Report

evidenced by the 42 discrepancies categorized as of highest significance and the 51 discrepancies categorized as significant.

One of the findings was that control room human factors design is and has been an important consideration at ANO-1. In addition to improvements made in the control room before the CRDR began (see section 1.2), many of the HEDs identified in the CRDR either had been corrected or were in the process of being corrected for reasons other than their being a CRDR HED by the time the HEDs were assessed. In fact, as noted in Table 8.2, this was true for 43% of all the category 1 HEDs identified and 14% of the category 2 HEDs identified.

Since the category 1 HEDs involve discrepancies that could substantially affect or have substantially affected a safety system or operator response during an emergency situation, these HEDs were evaluated as to the acceptability of continued operation until corrective action could be taken as part of the corrective action implementation plan described in Section 8.2. These evaluations were reviewed by the Plant Safety Committee and the Safety Review Committee. The conclusion of the reviews was that plant safety will not be compromised during the corrective action resolution process and that there was more potential for adverse safety consequences by failing to take adequate time to carefully and deliberately integrate the HED resolutions into a cohesive set of corrective actions that treat the total control room and assure that consideration of operator experience and training will be factored into proposed control room changes. Therefore, the corrective action implementation plan described in Section 8.2 adequately considers the safety significance of the category 1 HED findings.

Volume 2 of this report provides a brief description of each of the 462 HEDs. It is important to note that the category 3 HEDs

do not impact the operators in a substantial way during emergency or during routine plant operation. This does not imply that category 3 HEDs will be ignored. As shown in Table 8.2, 136 or 37% of the 369 category 3 HEDs have been or will be evaluated for correction. These corrective actions address the non-substantial HEDs that warrant corrective action due to the frequency of occurrence and/or due to interaction with other more significant HEDs and those that can be corrected with relative ease. An example is the deletion of spare and/or unused controls and displays on the various control panels. Individually such HEDs do not warrant corrective action since they do not impact the plant operator in a substantial way. However, due to the relatively small size of the ANO-1 control room and the need for additional space to resolve other more significant HEDs, corrective action will be taken to delete certain spare and/or unused controls and displays.

The HED identifying numbers listed in Volume 2 include a reference to the review process step where they were identified. This numbering system is explained in Table 8.3.

8.2 Corrective Action Implementation

A phased approach is planned to resolve the HEDs that still require further action. This phased approach is based on achieving a consistent, coherent and effective interface between the plant operators and the control room through an iterative process of the selection and verification of corrective actions. Also, this phased approach provides an integrated use of utility resources (e.g., engineering, plant operations, etc.) recognizing the commitments already identified regarding design changes associated with Regulatory Guide 1.97, Inadequate Core Cooling, and other regulatory issues. This integration is being coordinated through the AP&L NUREG-0737 Steering Committee which has management representatives involved in oversight of all the NUREG-0737 activities and all other aspects of plant design and operation.

CATEGORY	HEDs ALREADY CORRECTED OR IN THE PROCESS OF CORRECTION PRIOR TO CRDR	HEDs JUSTIFIED AS NOT REQUIRING CORRECTIVE ACTION	HED CORRECTION IS UNDERWAY OR COMPLETED DURING CRDR	HED RESOLUTION IS BEING DEVELOPED		
				INTERIM RESOLUTION COMPLETED	INTERIM RESOLUTION BEING DONE	NO INTERIM RESOLUTION
1	42.9%(18)	0% (0)	4.8% (2)	52.3%(22)		
				16.7%(7)	9.5% (4)	26.2%(11)
2*	13.7% (7)	3.9% (2)	3.9% (2)	72.5%(37)		
				5.9%(3)	33.3%(17)	33.8%(17)
3**	4.1%(15)	62.6%(231)	11.4%(43)	21.1%(78)		
				0.8%(3)	9.2%(34)	11.1%(41)

* NOTE: 3 OF THE CATEGORY 2 HEDs WERE DETERMINED TO BE OUTSIDE THE SCOPE OF THE CRDR.
** NOTE: 2 OF THE CATEGORY 3 HEDs WERE DETERMINED TO BE OUTSIDE THE SCOPE OF THE CRDR.
GENERAL NOTE: PERCENTAGES ARE OF THE TOTAL IN EACH RESPECTIVE CATEGORY.

Table 8.2 HED Status Summary

Table 8.3
HED Numbering Scheme

HED Number	Meaning
CK:2	Checklist Survey: Section 2
HR	Historical Review
QS:C2.4	Operator Survey: Question No. C2.4
VR	Verification of Availability
VS	Verification of Suitability
VL	Validation

Checklist Sections

1. Control Room Workspace
2. Communications
3. Annunciator Warning Systems
4. Controls
5. Visual Displays
6. Labels and Location Aids
7. Process Computers
8. Panel Layout
9. Control Display Integration

This phased approach to resolving all the ANO-1 HEDs can be summarized as follows:

1. First Phase: The corrective actions taken include design changes implemented during 1R6 that correct HEDs identified prior to 1R6. These corrective actions were part of AP&L's continuing commitment to the practical application of human factors principles that was in effect prior to the CRDR program and will continue in effect after completion of the CRDR program through a formal process of human factors review of all control room-related design change packages.

2. Second Phase: These corrective actions include those already committed and planned due to regulatory (e.g., Regulatory Guide 1.97) and non-regulatory issues that correct HEDs. These design changes are being evaluated to assure that new HEDs are not created. Also, all new design changes in the control room are being evaluated to assure that their implementation will not only not create new HEDs but will also correct already identified HEDs to the extent practical. The resources have already been committed to complete these design change activities on an integrated implementation schedule.

3. Third Phase: These proposed corrective actions primarily include control room labeling, demarcation and background shading that will be implemented as part of an integrated overall control room panel relabeling effort on a relatively short schedule. The changes associated with this effort will resolve a significant number of HEDs and provide at least an interim and possibly a permanent solution to many more HEDs that are to be the subject of a more extended and iterative design evaluation process.

Furthermore, additional corrective actions in this phase will include control room changes that will resolve HEDs by design changes that do not require substantial interaction with other proposed design evaluations. These HED resolutions do not involve many HEDs since most HED resolutions require interaction with other proposed design evaluations. Examples of these design evaluations are the control room lighting evaluation of egg-crate covers to reduce glare in the control room, and replacement of the process computer printer with a higher speed printer. These evaluations do not interact substantially with other design evaluations to resolve HEDs.

4. Fourth Phase: The remaining HEDs will involve corrective action evaluations planned as part of an extended, comprehensive design evaluation effort. While these HEDs do not have final corrective actions identified since they are part of an extended evaluation effort based on integrated use of engineering resources, interim solutions have been identified in many cases. The final corrective actions will be evaluated by an iterative process of identifying proposed changes, verifying the proposed changes, integrated review of interacting changes, and re-verification of proposed changes. This process may result in several HED resolution options being evaluated in parallel and/or in series until an acceptable resolution is agreed upon.

   Since the HED resolution schedules in this phase cannot be explicitely identified due to the schedules interative process involved, AP&L plans to provide six-month status reports to the NRC. These status reports will identify the corrective action schedules as they are finalized. This approach will provide the NRC with HED resolution schedules as they evolve from the iterative evaluation process,

rather than waiting for all resolutions to be identified before submitting explicit schedules. This evaluation process will require an extended evaluation period (i.e., months) which cannot be precisely defined due to the iterative nature of the process. Also, the ANO-2 HED assessments may necessitate a reevaluation of engineering priorities to support needed design changes for ANO-2. Therefore, the most practical approach to keep the NRC informed of HED resolution status during this fourth phase is through the six-month status reports.

Three programs that overlap into the area of the CRDR (that extend beyond the scope of the CRDR) will pick up the resolution of about 1/3 of the HEDs in the two right-hand columns of Table 8.2. These are the plant labeling program, the annunciator upgrade program and the GERMS evaluation program.

8.2.1 Plant Labeling Program

A program to improve existing labeling and provide additional labeling to the entire plant has previously been established. With direction from the CRDR, this program is moving into the control room. Within the control room, this program will relabel to correct HEDs; use background shading, demarcation or other association techniques to correct HEDs; provide new labels to correct HEDs and satisfy any other objectives of the labeling program itself. In addition, the labeling program will provide engraving services for the annunciator upgrade program described below.

The labeling program is expected to resolve 17 HEDs and provide at least interim resolution of many other HEDs by improving the current situation without actually relocating or replacing any instruments. The control room portion of the labeling program is now in its early stages and will soon be preparing detailed

control board representations (e.g., photographic layouts) to develop association enhancement techniques for specific problems and to design labeling schemes. Constant interface between the labeling program and the CRDR team is being maintained.

8.2.2 Annunciator Upgrade Program

In 1982, an annunciator upgrade program was initiated. A description of the upgrades involved can be found in section 1.2.2. The final phase of this upgrade program was intended to address CRDR HEDs related to annunciators in concert with planned general annunciator upgrade actions such as prioritization. With input from the CRDR, this program is now moving ahead again with this final phase. Thirteen HEDs are expected to be resolved by this program. Constant interface with the CRDR team will be maintained.

8.2.3 GERMS Evaluation

Because of continuing problems with the Gaseous Effluent Radiation Monitoring System (GERMS) of a nature unrelated to the CRDR, an evaluation of alternatives and options for improving, restructuring or replacement of this system has been initiated. As part of this evaluation, the solution achieved will incorporate consideration of 28 HEDs identified on the current GERMS. The CRDR team expects to be informed of the effect of the final GERMS solution on the applicability of these HEDs.

8.2.4 Implementation Status

Implementation of corrective action has begun as shown in Table 8.2. Only 30% of the HEDs fall into phase four activities and 10% of those are included in the annunciator upgrade program. Half of the phase four HEDs have already been provided with an

interim solution or are in the process of being provided with an interim solution. Of all the HEDs, only 15% have neither been resolved nor had implementation of correction action actually initiated, at least for an interim improvement. These 15% are now entering the design evaluation and scoping process. This process will involve constant interface with the CRDR team, careful consideration of sound human factors principles and integration with corrective action being taken on other HEDs before final designs and implementation schedules can be completed.

Corrective actions being implemented will be reviewed to verify their effectiveness from a human engineering perspective. This verification will utilize sound human engineering methods. Verification will be performed using, as necessary, panel mock-ups incorporating the corrective actions, consultation with operators and systems experts, human factors specialist reviews, and possible use of the control room simulator. If the result of the verification determines that a corrective action will result in a negative effect on control room operations, then the suggested corrective action will be altered or cancelled as appropriate. If a corrective action is verified to be effective and cost-beneficial, it will then be scheduled for implementation in the control room.

Considering the improvements already made (described in sections 1.2 and 8.1) and the progress described in section 8.2, a large portion of corrective action implementation has been completed. The remaining items are primarily those requiring the careful, deliberate and integrated consideration which has been initiated. The NRC will be kept informed regarding the progress on HED resolutions by the previously described six-month status reports.

APPENDIX A

FORMS

ARKANSAS NUCLEAR ONE - 1
CONTROL ROOM HUMAN ENGINEERING DISCREPANCY RECORD

Originator   Date: No.:   Page ___ of ___

Source of HED: ______________________________

Panel ID#	Equipment ID#	Equipment Name

Guideline Ref.: ____________________ Photo Log#: ________________

Description of Discrepancy

____
____
____
____
____
____

Comments/Recommendations

____
____
____
____
____
____

Arkansas Nuclear One-1
Historical Document Review
Problem Status Report (PSR)

Date: ____________
Page: ____________
HFS: ____________

Report Type	Report Number	Plant	Event Date	HFE Applic?	PAR Complete?	HED Written?

Arkansas Nuclear One - 1

Historical Document Review

PROBLEM ANALYSIS REPORT (PAR)

Name of Investigator(s): ______________________

Report Type and Number: ______________________

Station: ______________________ Unit: __________

Event Date: ______________________ Operating Status: ______

Circumstances and Events Leading to the Problem: __________

____

____

Nature of the Problem: ______________________

____

____

Steps Taken to Correct or Alleviate the Problem __________

____

____

Outcome: ______________________

____

____

Corrective Measures Undertaken: ______________________

____

____

Human Performance Problems Associated With Event: __________

____

____

Arkansas Nuclear One - 1
Historical Document Review

PROBLEM ANALYSIS REPORT (PAR) (Continued)

Applicable to Plant Under Review? Yes __________ No __________
(If no, end form here.)

In Which Areas: ____

____

____

Corrective Actions Taken: ____

____

____

Unresolved Discrepancies: ____
(If none, end form here.) ____

____

____

HED Number: __________

VALIDATION REVIEW WORKSHEET

Event: ______________________________ Operator: ______________________________

Procedure(s): ________________________ Human Factors Specialist: ____________________

Procedure Step	Yes	No	Comment	HED Index Number

SOUND SURVEY RECORD

Plant: ______________________ Date: __________ Time: __________ Sheet # ____ of ____

Measurements made by: ____

Equipment/Instrument used: ____

Serial #: ______________________ Calibration date: ______________________

Operator Work Station	db(A)	Octave Band Center Frequency					Remarks
		250	500	1K	2K	4K	

LIGHTING SURVEY ILLUMINANCE RECORD

Plant: ______________________ Date: __________ Time: ________

Measurements made by: ______________________________ Sheet # ___ of ___

Equipment/Instrument used: ______________________________

Serial #: ______________________ Calibration date: ______________

Location Ref. No.	Panel I.D. No.	Full AC Ambient	Full Emergency	Other Conditions (Specify)

LIGHTING SURVEY - LUMINANCE AND REFLECTANCE RECORD

Plant: ______________________ Date: __________ Time: ________

Measurements made by: ______________________________ Sheet # ___ of ___

Equipment/Instrument used: ______________________________

Serial #: ____________________ Calibration date: ______________

Location Ref. No.	Panel # and Surfaces	Record					Calculations				
		Panel		Meter/Display			Luminance Ratio of Display: Panel		Reflectance Ratio		
		Reflect. Pad	Panel Back-ground	Reflect. Pad	Surface w/Glare	Surface w/o Glare	w/Glare	w/o Glare	Panel: Pad	Meter/Display: Pad	
										w/Glare	w/o Glare

HUMIDITY/TEMPERATURE RECORD

Plant: ______________________ Date: __________ Time: ________

Measurements made by: ______________________ Sheet # ____ of ____

Equipment/Instrument used: ______________________

Serial #: ______________________ Calibration date: ______________

Time	Height	Temperature	Humidity	Remarks
	Floor		X	
	6 ft.			
	Floor		X	
	6 ft.			
	Floor		X	
	6 ft.			
	Floor		X	
	6 ft.			
	Floor		X	
	6 ft.			
	Floor		X	
	6 ft.			
	Floor		X	
	6 ft.			
	Floor		X	
	6 ft.			
	Floor		X	
	6 ft.			
	Floor		X	
	6 ft.			

AIR VELOCITY SURVEY RECORD

Plant: ______________________________ Date: ______________ Time: __________

Measurements made by: ____ Sheet # ____ of ____

Equipment/Instrument used: ____

Serial #: ______________________________ Calibration date: ____________________

Location	6 ft.	4 ft.

TASK BREAKDOWN FORM

Page _____ of _____
Date ____________
Analyst ____________

Procedure Section: ____________________

STEP	OPERATOR FUNCTION	OPERATOR TASK

TASK ANALYSIS INSTRUMENTATION REQUIREMENT FORM

Page ____ of ____

Date __________

Analyst __________

____________ Procedure Section

____________ Step Number

____________ Task Number

____________ Function/Purpose

____________ Task Title

Same as: ____________ Task Number

Alt. to: ____________ Task Number

ACTION STEP	OP	VERB	OBJECT: CONTROL: PARAMETER	EQUIPMENT	POSITION	STATUS	ID	TYPE	MODE	OTHER	INDICATOR/FEEDBACK: PARAMETER	STATE	TYPE	ID	UNITS	RANGE	DIV	OTHER	OTHER PERFORMANCE REQUIREMENTS	EXIT OR COMMENTS

VERB KEY
- 1.1 OBSERVES
- 2.1 COMPARES
- 2.2 CALCULATES
- 3.1 PUSH
- 3.2 TURN
- 3.3 LOCK-OUT
- 3.4 TOUCH
- 3.5 ADJUSTS
- 3.6 TYPES
- 3.7 PULL
- 4.1 INFORMS
- 4.2 REQUESTS
- 4.3 RECEIVES

CONTROL TYPE KEY
- J J HANDLE
- JS JOYSTICK
- K KEY OPERATOR
- LP LEGEND PUSHBUTTON
- NP NON-LEGEND PUSHBUTTON
- R ROCKER SWITCH
- RS ROTARY SWITCH
- S SLIDE SWITCH
- T T HANDLE
- TG TOGGLE SWITCH
- TW THUMBWHEEL
- TS TOUCHSCREEN
- KB KEYBOARD
- C CONTROLLER
- A AUTO
- M MAN
- A/M AUTO W/MAN OVERRIDE
- M/A MANUAL W/AUTO OVERRIDE

CONTROL MODE
- D DISCRETE
- C CONTINUOUS

CONTROL OTHER KEY
- SR SPRING RETURN
- T TIHOTTLE
- B BACKLIT

DISPLAY TYPE KEY
- A ANNUNCIATOR
- C DRUM COUNTER
- EC ELECMONIC COUNTER
- M METER
- R RECORDER
- D DIGITAL DISPLAY
- CSL CONTROL STATUS LIGHT
- LL LEGEND LIGHT
- NL NON LEGEND LIGHT
- CRT CATHODE RAY TUBE
- G GRAPHIC

Control Room Design Review Operator Survey

The Nuclear Regulatory Commission is requiring that a detailed human factors review of every nuclear power plant control room be performed. Part of the guidance document published to support these reviews, NUREG-0700, suggests the use of your operating experience to help the review team identify operator/control board interface problems.

Arkansas Power and Light Company and the management of this station support the spirit of the NRC's directives. As a result, we are asking for you to support and assist in the program by completing the attached questionnaire. For this program, the Company's goal is to improve the operating crew's capability to recognize, control and manage plant abnormal and emergency conditions.

The questionnaire contains 44 questions that cover nine general topic areas dealing with different aspects of control room design as well as the job duties and tasks performed by the operating crew. The questions deal with "problem" areas as well as good or beneficial features associated with the control room. Each question involves a multiple choice response based on your judgements and opinions. In addition, you will be asked to provide specific examples of the positive or negative aspects of the control room on which you based your multiple choice responses.

In completing the questionnaire please read each question carefully, circle the item in the multiple choice that best reflects your view, and provide additional information as appropriate. In preparing your answers, consider the questions from the perspective of all the various modes of plant operation, e.g., startup, hot stand-by, full power, and reduced power, in addition to possible abnormal or emergency operating conditions. Give detailed answers so that someone not as familiar with the area as you are will be able to understand exactly what you mean.

Please answer all the questions. Your responses are important to the success of this review. Use additional paper if necessary and attach it to this questionnaire. If you do use additional paper, please be sure to match your answer to the appropriate question. If you feel that we have left anything out or failed to cover an area in which you have a concern, please tell us by attaching comments to the questionnaire. If you are unable to answer a particular question, please indicate this in the space provided for your response.

In asking for your support in this program we feel it is important for you to know what we will do with your answers. As the questionnaires are returned, ARD Corporation personnel will summarize your answers on a question-by-question basis and compile results for each question. The team conducting the control room design review will then be informed of each problem area identified, so that they can pay special attention to it during the remainder of the review process. As problems are verified, they will be documented more formally. Positive aspects of the control

room will also be noted, so that in correcting any problems that arise, these positive features will not be compromised.

Although the NRC may eventually be told of the problems you help identify, we want to assure you that your answers and comments on this questionnaire will be kept strictly confidential. You should mail your completed questionnaire directly to ARD using the self-addressed stamped envelope that is attached. Your answers will be summarized so that your exact words do not appear and your name will be dissociated from your answers. You may be contacted for a follow-up interview by ARD personnel, to clarify any ambiguities in your written responses or to gather additional information. However, the information you provide at that time will likewise be summarized and treated confidential. Your answers will in no way affect your career, standing, or promotions within AP&L. Therefore, in answering the questionnaire, be as open, honest and straightforward as you can.

In addition to completing the questionnaire, we would like you to supply us with additional background information requested on the following page. It will help us to integrate your responses with other information we must collect as part of this project. However, this background information will not be associated with your responses when they are reported to AP&L or to the NRC.

When you have completed the questionnaire, place it in the envelope provided, seal the envelope, and drop it in the mail. Thank you very much for your cooperation and assistance.

Please Return To: ARD Corporation
5457 Twin Knolls Road
Columbia, MD 21045
Attn.: Richard L. Horst

- Name: ______________________________
- Present Position: ____
- Nuclear Operating Experience: _________________________years
- Control Board Operating Experience: ___________________years
- Held a Reactor Operator (RO) License: _________________years
- Held a Senior Reactor Operator (SRO) License: __________years
- Age: _________________
- Sex: _________________
- Height: _______________

A. Workspace Layout and Environment

A.1. Are additional controls needed in the control room? Your response should consider the controls needed to respond to potential emergency or abnormal situations in addition to the various modes of normal operations.

a. None
b. 1 or 2
c. Several
d. Many

Please identify any needed controls and your reasons for wanting them. Also identify any systems in which the controls are particularly well designed, i.e. you would not like to see them changed.

A.2 Are any of the controls that are presently in the control room unnecessary? That is, are there controls that are not used in any mode of plant operation?

a. None
b. 1 or 2
c. Several
d. Many

Please identify any extraneous controls.

A.3. Are additional indicators (i.e. meters, status lights, chart recorders) needed in the control room? Your response should consider the indicators needed to respond to potential emergency or abnormal situations in addition to the various modes of normal operations.

a. None
b. 1 or 2
c. Several
d. Many

Please identify the needed displays and your reasons for wanting them. Also identify any systems in which the indicators are particularly well designed, i.e. you would not like to see them changed.

A.4. Are any of the indicators that are presently in the control room unnecessary? That is, are there indicators that are not used in any mode of plant operation?

a. None
b. 1 or 2
c. Several
d. Many

Please identify any extraneous indicators.

A.5. How would you characterize the capability for direct voice communication between personnel in the main control room? Conditions that might impede direct voice communications could include high background noise, physical barriers, or distance between workstations. Remember to consider all modes of operation, including potential abnormal or emergency conditions.

a. Excellent
b. Adequate
c. Some problem areas
d. Many problem areas

Please identify any problem areas.

A.6. Air quality (temperature, humidity, ventilation) in the control room is:

a. Excellent
b. Adequate
c. Some problem areas
d. Many problem areas

Please identify any problem areas.

A.7. Lighting in the control room (illumination, glare, reflections) is:

a. Excellent
b. Adequate
c. Some problem areas
d. Many problem areas

Please identify any problem areas.

A.8. Operator's ability to move around the control room in an unobstructed manner is:

a. Excellent
b. Adequate
c. Some obstructions
d. Many obstructions

Please identify any obstacle(s) in the main control room which interfere with movement.

B. Panel Design

B.1. Automatic control operations allow the operator to attend to other instrumentation and intervene only when the automated system malfunctions. Manual control operations typically demand more attention but allow more flexibility, as the operator can tailor his response to the situation at hand. Are there any control device(s) which should be operated manually instead of automatically or vice versa?

a. None
b. 1 or 2
c. Several
d. Many

Please identify any such inappropriate controls and reasons why they should be reconfigured.

B.2. Throttleable valves typically require the operator to remain at a given workstation for a period of time, operating a particular control. Are there any throttleable valve(s) that would unnecessarily restrict your time to respond should an emergency situation occur?

a. None
b. 1 or 2
c. Several
d. Many

Please identify any throttleable valves that could pose a problem in emergency conditions. Also, identify any throttleable valves that pose problems under other modes of operation, e.g. start-up or shut-down.

B.3. Are there any system(s) in which controls or indicators are not placed in functional groups?

a. None
b. 1 or 2
c. Several
d. Many

Please identify any systems in which instrumentation is not functionally grouped. Also, identify systems in which functional grouping is particularly effective (i.e. that you would not like to see changed).

B.4. The layout of the control equipment on the panels is:

a. Excellent
b. Adequate
c. Some problem areas
d. Many problem areas

Describe any aspects of the layout of control board equipment that should be improved to allow operators to perform more effectively. Also, describe any areas of the control board where the layout of equipment is particularly conducive to effective operations.

B.5. Are there areas on the main control boards where your use of a control is hindered because of other, nearby equipment?

a. None
b. 1 or 2
c. Several
d. Many

Please identify any such problem areas.

B.6. Are there any controls that are hard to reach or indicators that are difficult to read? Remember to consider all modes of plant operation, including possible abnormal or emergency operations.

a. None
b. 1 or 2
c. Several
d. Many

Please identify any such inaccessible instrumentation.

B.7. Are there any control(s) or indicators on back panels that should be on front panels, or vice-versa? In formulating your response, please consider the accessibility of instrumentation that you need under all modes of plant operations.

a. None
b. 1 or 2
c. Several
d. Many

Please identify any controls or indicators that should be moved to a front or back panel, and explain your reasoning.

B.8. Are there any system(s) in the control room which you feel are difficult or confusing to operate?

a. None
b. 1 or 2
c. Several
d. Many

Describe any systems that are difficult to operate. Also, describe any systems that are particulary well-designed for ease of operation (i.e. that you would not like to see changed).

B.9. Are there any controls located in the control room that you feel are prone to be accidently activated? Accidental activation could occur due to the position of the control, its shape, or its labeling.

a. None
b. 1 or 2
c. Several
d. Many

Describe any controls that could be accidentally activated.

C. Annunciator System

C.1. Are there any areas in the control room where background noise levels interfere with annunciator auditory signals? Remember to consider all possible plant conditions and modes of operation.

a. None
b. 1 or 2
c. Several
d. Many

Please identify any areas in which it is difficult to distinguish auditory alarms, and the plant conditions in which the problem occurs.

C.2. Have you experienced or can you conceive of situations in which the annunciator warning system was ineffective in helping, or might have actually hindered, operators response to a system problem?

a. None
b. 1 or 2
c. Several
d. Many

Please describe any such incidents or potential situations.

C.3. Are there any alarm windows that have an inappropriate setpoint; that is, those that give the operator either too much or too little time in which to respond to a plant problem? Please consider all modes of plant operation.

a. None
b. 1 or 2
c. Several
d. Many

Please identify any such windows and the setpoint(s) that would be more appropriate.

C.4. Are there alarms with multiple inputs for which there are no devices (e.g. printers) from which the operator can determine the cause of the alarm?

a. None
b. 1 or 2
c. Several
d. Many

Please identify any multiple input alarms that should be split into single inputs.

C.5. Are there any single input alarms (e.g. "nuisance alarms") that could be eliminated or combined into multiple input alarms?

a. None
b. 1 or 2
c. Several
d. Many

Please identify any single input alarms that could be eliminated or integrated into multiple input alarms.

C.6. Are there any alarm windows in the main control room with engravings that are confusing or difficult to understand?

a. None
b. 1 or 2
c. Several
d. Many

Please identify any confusing alarm engravings and explain why they are difficult to understand.

D. Communications

D.1. Are there any auditory signal(s) presented in the control room, other than annunciator alarms, which are confusing?

a. None
b. 1 or 2
c. Several
d. Many

Please identify any such auditory signals and the reason for the confusion.

D.2. Are there area(s) in the control room where messages presented over the paging system can not be heard clearly?

a. None
b. 1 or 2
c. Several
d. Many

Please identify any such problem areas.

D.3. Given present plant communication systems and procedures for their use, is it likely that the use of communication systems by non-operating personnel could interfere with control room use of the system?

a. No problems
b. 1 or 2 systems vulnerable
c. Several systems vulnerable
d. Major problems with system design or procedures

Please describe any such potential problems.

D.4. Are there any equipment problems with the communications systems that could prevent or interfere with an operators' ability to communicate with individuals in other areas?

a. None
b. 1 or 2
c. Several
d. Many

Please describe any such incidents. Also describe aspects of the communications systems that are particularly effective from the standpoint of control room personnel.

E. Computer-Generated Information (i.e. process computer, SPDS)

E.1. Is there any information or calculations not presently provided on a computer-generated display that would be more useful if it were available in that form? Please consider both information that should be made available on one or the other CRT, as well as information that is presently available on one CRT but which should be available on another. Consider all modes of plant operation, including possible abnormal or emergency conditions.

a. None
b. 1 or 2 kinds of information
c. Several kinds of information
d. Many kinds of information

Please describe any additional computer information that should be made available. Also, describe aspects of the computer-generated information that you find particularly useful.

E.2. Is there any information presently available on CRTs that would be more useful if it was presented in another form? Consider information that could be deleted from all computer-generated displays as well as information that should still be presented by the computers but in a more effective format.

a. None
b. 1 or 2
c. Several
d. Many

Please explain and suggest a better way for presenting such information.

E.3. Do you know of any words or symbols used on the computer displays that are difficult to understand or interpret?

a. None
b. 1 or 2
c. Several
d. Many

What words or symbols would be more accurate or easier to use?

E.4. Are there any CRTs located in the control room which are difficult to use because of their placement in the room? Please consider all modes of plant operations, including possible abnormal or emergency conditions.

a. None
b. 1 or 2
c. Several
d. Many

Please explain and suggest alternative placements.

E.5. Is any of the information presented on the computer printer not useful to control room operations? Particularly consider the information demands of emergency and abnormal operations.

a. None
b. 1 or 2
c. Several
d. Many

Please identify any extraneous information. Also identify any aspect of the hardcopy printouts that you find particularly useful and would not want to see changed.

E.6. Are there any computer system procedures which are difficult to understand?
a. None
b. 1 or 2
c. Several
d. Many
Please identify any such procedures.

F. <u>Maintenance Procedures</u>

F.1. Are there any maintenance procedures that could contribute to an operational problem? That is, assuming that preventive and corrective maintenance is performed "by the book," are there problem areas that could adversely affect operations, particularly during emergency conditions?
a. None
b. 1 or 2
c. Several
d. Many
Please describe any such problems. Also, describe aspects of maintenance activities that are particularly effective from the standpoint of control room personnel.

F.2. How would you characterize current procedures and availability of supplies for replacing equipment such as fuses, bulbs, ink, chart paper, etc.?

a. Excellent
b. Adequate
c. Some problems
d. Major problems

Please describe aspects of these procedures that are particularly effective or ineffective.

G. Procedures

G.1. Are there any procedure(s) which are unclear or difficult to use? Please consider all modes of plant operation including possible abnormal or emergency conditions.

a. None
b. 1 or 2
c. Several
d. Many

Please identify any particular effective or ineffective procedures.

G.2. Are there any operator aids, such as tables/checklists/ status boards etc. which could be redesigned to improve their usefulness?

a. None
b. 1 or 2
c. Several
d. Many

Please identify any such materials and suggest how they should be redesigned. Also, describe operator aids that you find particularly useful.

G.3. Are there any manual log(s) that you feel are difficult to update or maintain?

a. None
b. 1 or 2
c. Several
d. Many

Please identify the troublesome logs and suggest how they could be improved.

G.4. Are there any mathematical calculation(s) that are time consuming and/or difficult to perform?

a. None
b. 1 or 2
c. Several
d. Many

Please describe the calculations that are troublesome.

H. Staffing and Job Design

H.1. Are there any job duties which are presently performed by others in which you feel control room personnel should be more directly involved, or vice versa? Please consider all modes of plant operation including abnormal or emergency conditions.

a. None
b. 1 or 2
c. Several
d. Many

Please describe any such duties that should be reallocated and specify who should perform them.

H.2. Are there any recurring distractions, in the form of unnecessary personnel, traffic, etc., that could interfere with your duties?

a. None
b. 1 or 2
c. Several
d. Many

Please describe any such sources of distraction and how they can be avoided.

H.3. Does the shift turnover process work effectively?

a. Excellent
b. Adequate
c. Some problems
d. Significant problems

If there are problems, suggest how they can be improved.

H.4. Have you experienced or can you conceive of situations in which the operating crew staffing structure could adversely affect control room operations? Consider all modes of plant operation, including potential abnormal and emergency conditions.

a. None
b. 1 or 2
c. Several
d. Many

Please describe any such incidents or potential situations and suggest how they could be improved. Also, describe plant conditions or potential conditions for which the present staffing seem particularly appropriate.

I. Training

I.1. Are there any potential emergency situation(s) for which you feel you have not received enough training?

a. None
b. 1 or 2
c. Several
d. Many

Please describe any emergency situations that you think should receive more emphasis. Also, describe aspects of your emergency training that you think has been particularly effective.

Questions for Follow-up Interviews of Arkansas Nuclear One Personnel

NOTE -- THESE QUESTIONS ARE FOR YOUR REVIEW ONLY. THERE IS NO NEED TO RESPOND IN WRITING. YOUR VERBAL RESPONSES DURING THE INTERVIEW WILL BE NOTED BY AN ARD CORP. INTERVIEWER.

1. In what plant locations is it difficult to communicate with personnel using the paging system? How can the paging system be improved to allow control room operators first priority?

2. Are paging systems adequate to reach high noise areas? Could you identify high noise areas? Are the Gai-tronics phones reliable? Can you recommend a solution for communicating with personnel in high noise areas?

3. Where are supplies such as fuses, bulbs, ink and chart paper stored? Who is responsible for maintaining the inventory?

4. How can non-plant personnel (such as visitors, tour groups and contractors) presence in the control room be controlled to minimize interference? How can interference of maintainence personnel be minimized during the day shift? What can be done to eliminate on-lookers from hindering operations activities during transients?

5. Do you feel training is adequate on the following topics:

   a. Ventilation for battery rooms

   b. Generator

   c. ATOG

   d. SPDS

   e. Turbine EHC failures

   f. Start-up valve failure

   g. Electric bus failures

Other than a plant-specific simulator and increased trainer experience, are there other improvements which could be made to the training program (e.g. improvements in walk-through techniques, etc.)?

6. Are the controls/indicators listed below needed to help operators respond to emergency conditions?

Control/Display	Frequency of Use	Circumstance	CR Location	Preferred Switch
(1) Decay heat pump suction valve				
(2) Motor-operated crossover valves for HPI/LPI line-up				
(3) Steam generator drain system				
(4) Start-up feedwater boiler control				
(5) Auxiliary pressurizer spray valves				
(6) Motor-operated DHR BWST/ RCS suction valves				
(7) Modulating valves on SW to decay heat cooler				
(8) Motor-operated condensate pump discharge valves				
(9) MSIV closure alarm				
(10) Incore detectors which read in %				
(11) Indicator for SW flow through decay heat coolers				
(12) Indicator of RCS level during shutdown				
(13) Feedwater pump suction pressure indication				

Control/Display	Frequency of Use	Circumstance	CR Location	Preferred Switch
(14) Heater drain pump flow indication				
(15) Diagnostic instrumentation for safety systems				
(16) Chart recorder for RB sump leakage				
(17) Main steam safety valve status indication				
(18) Core exit thermocouples (other than CRT)				
(19) Rx core level indicator				
(20) Condenser vacuum display				
(21) Indicating lights for RCP start interlock circuit status				
(22) RCS Pressure (near ESAS?)				
(23) Status lights for instrument air, service air and breathing air cross connects				
(24) Margin of saturation indicators for C16 and C18				
(25) Condensate transfer pump status lights				
(26) Isophase bus cooler status lights				

Control/Display	Frequency of Use	Circumstance	CR Location	Preferred Switch
(27) Exciter air cooler outlet indicator				
(28) Seal oil pressure at generator indicator				
(29) Sealing steam MSR indicator				
(30) P across feedwater pump high efficiency filter indication (other than alarm				
(31) Indicators for P across EH pump discharge filter				

7. How could noise be reduced to enhance face-to-face communications?

8. How could the following obstructions (to movement of personnel in the control room) be relocated?

   a. C09 panel

   b. Bookcases

   c. Phones

   d. Doors to Shift Supervisor office

   e. Neutron noise monitor

   f. SPDS

   g. Disks

   h. Prints disk

   i. Chairs

9. Identify potential solutions to the functional grouping problems below:

   a. H_2 cooler temperature controller and recorder

   b. Main lube oil cooler temperature controller and main lube temperature recorder

   c. Emergency diesel generator cooling water and vent fans

   d. Decay heat system control

e. Emergency feedwater system

f. Emergency Safeguards Actuation System

h. Fire control panel

i. Service water

j. RCS letdown

k. HPI controls, pressurizer level, RCS pressure, and margin-to-saturation indicators

10. How could the following displays be made more easily readable?

    a. Core Flood Tank Pressure

    b. Core Flood Tank Level

    c. RCP Seal Pressure

    d. EFIC OTSG Levels

    e. Reactor Power Chart Recorder

    f. Reactor Building Pressure

    g. MSIV positions

    h. Emergency Feedwater Discharge Pressure

11. Which of the systems/components listed below should be moved from their present location to a front or back panel? Which moves would enhance emergency operations?

	Front	Back	Emergency
a. HPI			
b. RCP seal staging pressure and temperature recorders			
c. Turbine drains			
d. ESAS controls			
e. Margin saturation monitor			
f. Main Steam Isolation Valves			
g. Decay heat controls			
h. MFIV			
i. Letdown			
j. ICW			
k. Quindar Panel			

12. How could the following components/systems be made less confusing?

a. ICS

b. EHC

c. ESAS

d. Heater drain pump start system

e. Decay heat cooler and bypass valves

HUMAN ENGINEERING DISCREPANCY (HED) ASSESSMENT
RATING FORM

HED NO. ____________________

CRDR TEAM MEMBER ________________________________

1. To what extent do you agree or disagree with the following statements about the attached HED:

A. IMPACT ON PHYSICAL PERFORMANCE

This HED may cause undue operator fatigue or discomfort.

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

This HED may present a risk of injury to control room personnel.

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

This HED may degrade the operator's ability to manipulate controls correctly.

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

B. IMPACT ON SENSORY/PERCEPTUAL PERFORMANCE

This HED may affect the operator's ability to see or read accurately.

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

This HED may affect the operator's ability to hear correctly.

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

This HED violates control room conventions or practices, nuclear industry conventions or population stereotypes.

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

HED NO. ________________________

C. IMPACT ON COGNITIVE PERFORMANCE

This HED may cause operator confusion.

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

This HED may increase the operator's mental workload (e.g., by requiring interpolation of values, remembering inconsistent or unconventional control positions, etc.).

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

This HED may increase the operator's level of stress (i.e., highly time constrained, of serious consequence, etc.).

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

This HED may lead to inadvertent activation or deactivation of controls.

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

D. INTERACTION WITH TASK VARIABLES

This HED may degrade the operator's ability to communicate with others (either inside or outside the control room).

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

This HED may cause a delay of necessary feedback to the operator.

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

Because of this HED the operator may not be provided with positive feedback about control tasks.

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

This HED is involved in a task which is usually performed concurrently with another task (e.g., watching water level meter while manipulating a throttle valve control).

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

E. IMPACT OR POTENTIAL IMPACT ON OPERATING CREW ERROR

Operators have attempted to correct this HED themselves (by self-training, temporary labels, "cheaters," "helper" controls, compensator body movements, etc.).

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

This HED may cause an operating crew error.

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

F. IMPACT OR POTENTIAL IMPACT ON PLANT SAFETY

This HED involves controls or displays that are used by operators while executing emergency procedures.

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

Assuming that this HED caused an operating crew error, it is likely that this error may result in:

i. A violation of a technical specification, safety limit, or a limiting condition for operation.

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

ii. The unavailability of a safety-related system needed to mitigate transients or system needed to safely shut down the plant.

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

This HED involves controls or displays that are part of an engineered safety function or are associated with a reactor trip function.

( )	( )	( )	( )	( )
STRONGLY AGREE	MILDLY AGREE	NEUTRAL	MILDLY DISAGREE	STRONGLY DISAGREE

2. Based on your review and evaluation of this HED, what category of significance do you believe it belongs in?

I. ( ) HIGHEST SIGNIFICANCE, could affect or has substantially affected a safety system or operator response during an emergency situation.

II. ( ) SIGNIFICANT, could affect or has substantially affected a non-safety system or operator response during routine, non-emergency operation.

III. ( ) LEAST SIGNIFICANCE, could or has affected operator response in a non-substantial way.

If this HED is Category III. above, could it be considered substantially more significant when considered in conjunction with other HED's?

( ) YES ( ) NO

If YES, explain ____

____

____

____

Assessment Team Member ____

Plant ____________
Unit ____________
Page ___ of ___
Date ___/___/___
Analyst ____________

INVENTORY FORM - CONTROL

Panel:

ID ____________
Loc ____________
Sys ____________
Param ____________
Label ____________
Type ____________
Manuf. ____________
Model ____________
Mode __ DIS __ CONT __ auto
__ SR __ TH __ pull to lock
Pos/Range ____________
CSL/DIV ____________
Backlit/Units ____________
Other Label ____________
Notes ____________

ID ____________
Loc ____________
Sys ____________
Param ____________
Label ____________
Type ____________
Manuf. ____________
Model ____________
Mode __ DIS __ CONT __ auto
__ SR __ TH __ pull to lock
Pos/Range ____________
CSL/DIV ____________
Backlit/Units ____________
Other Label ____________
Notes ____________

ID ____________
Loc ____________
Sys ____________
Param ____________
Label ____________
Type ____________
Manuf. ____________
Model ____________
Mode __ DIS __ CONT __ auto
__ SR __ TH __ pull to lock
Pos/Range ____________
CSL/DIV ____________
Backlit/Units ____________
Other Label ____________
Notes ____________

ID ____________
Loc ____________
Sys ____________
Param ____________
Label ____________
Type ____________
Manuf. ____________
Model ____________
Mode __ DIS __ CONT __ auto
__ SR __ TH __ pull to lock
Pos/Range ____________
CSL/DIV ____________
Backlit/Units ____________
Other Label ____________
Notes ____________

ID ____________
Loc ____________
Sys ____________
Param ____________
Label ____________
Type ____________
Manuf. ____________
Model ____________
Mode __ DIS __ CONT __ auto
__ SR __ TH __ pull to lock
Pos/Range ____________
CSL/DIV ____________
Backlit/Units ____________
Other Label ____________
Notes ____________

ID ____________
Loc ____________
Sys ____________
Param ____________
Label ____________
Type ____________
Manuf. ____________
Model ____________
Mode __ DIS __ CONT __ auto
__ SR __ TH __ pull to lock
Pos/Range ____________
CSL/DIV ____________
Backlit/Units ____________
Other Label ____________
Notes ____________

INVENTORY FORM - INDICATORS

Plant ____________
Unit ____________
Page ____ of ____
Date ___/___/___
Analyst ____________

Panel:

ID
Loc
Sys
Param
Label
Type
Manuf.
Model
Range
Div
Units
Markings
Pens
No. Recorded Pts.
Other Label
Notes

ID
Loc
Sys
Param
Label
Type
Manuf.
Model
Range
Div
Units
Markings
Pens
No. Recorded Pts.
Other Label
Notes

ID
Loc
Sys
Param
Label
Type
Manuf.
Model
Range
Div
Units
Markings
Pens
No. Recorded Pts.
Other Label
Notes

ID
Loc
Sys
Param
Label
Type
Manuf.
Model
Range
Div
Units
Markings
Pens
No. Recorded Pts.
Other Label
Notes

ID
Loc
Sys
Param
Label
Type
Manuf.
Model
Range
Div
Units
Markings
Pens
No. Recorded Pts.
Other Label
Notes

ID
Loc
Sys
Param
Label
Type
Manuf.
Model
Range
Div
Units
Markings
Pens
No. Recorded Pts.
Other Label
Notes

Plant ________
Unit ________
Page ___ of ___
Date ___/___/___
Analyst ________

INVENTORY FORM - CONTROLLER

Panel:

ID ______________________
Loc ______________________
Sys ______________________
Param ______________________
Label ______________________
Manuf. ______________________
Model ______________________
Ind. Type ____ ____ ____ ____
Range ____ ____ ____ ____
Div ____ ____ ____ ____
Units ____ ____ ____ ____
Controls __a/m __setpt __param __other
Control Types ____ ____ ____ ____
POS ____ ____ ____ ____
Marking ______________________
Other Label ______________________
Notes ______________________

ID ______________________
Loc ______________________
Sys ______________________
Param ______________________
Label ______________________
Manuf. ______________________
Model ______________________
Ind. Type ____ ____ ____ ____
Range ____ ____ ____ ____
Div ____ ____ ____ ____
Units ____ ____ ____ ____
Controls __a/m __setpt __param __other
Control Types ____ ____ ____ ____
POS ____ ____ ____ ____
Marking ______________________
Other Label ______________________
Notes ______________________

ID ______________________
Loc ______________________
Sys ______________________
Param ______________________
Label ______________________
Manuf. ______________________
Model ______________________
Ind. Type ____ ____ ____ ____
Range ____ ____ ____ ____
Div ____ ____ ____ ____
Units ____ ____ ____ ____
Controls __a/m __setpt __param __other
Control Types ____ ____ ____ ____
POS ____ ____ ____ ____
Marking ______________________
Other Label ______________________
Notes ______________________

ID ______________________
Loc ______________________
Sys ______________________
Param ______________________
Label ______________________
Manuf. ______________________
Model ______________________
Ind. Type ____ ____ ____ ____
Range ____ ____ ____ ____
Div ____ ____ ____ ____
Units ____ ____ ____ ____
Controls __a/m __setpt __param __other
Control Types ____ ____ ____ ____
POS ____ ____ ____ ____
Marking ______________________
Other Label ______________________
Notes ______________________

ID ______________________
Loc ______________________
Sys ______________________
Param ______________________
Label ______________________
Manuf. ______________________
Model ______________________
Ind. Type ____ ____ ____ ____
Range ____ ____ ____ ____
Div ____ ____ ____ ____
Units ____ ____ ____ ____
Controls __a/m __setpt __param __other
Control Types ____ ____ ____ ____
POS ____ ____ ____ ____
Marking ______________________
Other Label ______________________
Notes ______________________

ID ______________________
Loc ______________________
Sys ______________________
Param ______________________
Label ______________________
Manuf. ______________________
Model ______________________
Ind. Type ____ ____ ____ ____
Range ____ ____ ____ ____
Div ____ ____ ____ ____
Units ____ ____ ____ ____
Controls __a/m __setpt __param __other
Control Types ____ ____ ____ ____
POS ____ ____ ____ ____
Marking ______________________
Other Label ______________________
Notes ______________________

APPENDIX B

RESOLUTION OF DIFFERENCES BETWEEN NUREG-0700 SECTION 6 AND AP&L CHECKLIST

Resolution of Differences Between
NUREG-0700 Section 6 and AP&L Checklist

Checklist Item Different From NUREG-0700	Resolution
1.2.2.d(2)	Change value to 29" which is accepted extended functional reach for 5th percentile female.
1.2.2.e(2)	NUREG-0700 suggests that the measurement for eye reference be taken from the leading edge of the benchboard. ARD takes the stand that the operator has some maneuverability when reading displays and his eye is closer to 4 inches farther back from the benchboard. Similarly, ARD suggests that the operators reference point for annunciators is 16 inches in lieu of the 12 inch nominal distance provided as guidance in NUREG-0700.
1.2.3.c	The reach criteria has already been established in 1.2.3.b. The 0700 criteria does not provide guidance for an acceptable slope angle. The optimum angle of the benchboard surface would depend upon its use. If the surface contained a keyboard the angle should be within 0-15% (Van Cott) whereas for viewing the optimum angle is 45° (Van Cott). McCormick provides desirable ranges for the angle of the benchboard as 15°-30° for writing and typing surface and 30°-50° for benchboard containing primary controls and some related displays. Since the criteria refers to a benchboard and infers a slope of some kind, a reasonable range is 15°-45° (as shown in Exhibits 6.1-6). The optimum would depend upon the activity performed at the benchboard.

1.2.3.e(2)	Delete "The upper limit is 56 inches". Include Exhibit 6.1-10 and the words (see Exhibit ____________).
1.2.3.f(2)	See 1.2.2.d(2). Change value to 29".
1.5.3.b	Greatly is too subjective a term. Our experience is that 15fc is a good value for this quantification.
1.5.5.a(2)	This value is again selected based upon our experience with noise measurements. This is to quantify a subjective requirement.
2.1.1.b	"Effective" cannot be measured during periodic testing.
2.1.1.c(2)	"and are known to operators" is a redundant statement. It is assumed that if procedures are in place, they are covered in training.
2.1.2.b(6)	"by passing traffic" or by anyone, the concern is with knocking the phone out of the cradle.
3.1.2.c(1)	Instead of using the word "avoided" you can use the multiple annunciator alarms if you have some backup information. See 3.1.2.c(2).
3.1.4.b(1)	90 dB(A) is the accepted threshold of pain for auditory signals. This is provided to quantify checklist item.
3.2.1.d	Incremented steps in loudness are slightly noticeable at 2 dB steps and fully discernable at 5 dB. However, since different frequencies are being produced by the different alarms, the NRC did not specify a value. In order to evaluate the item RD selected $\pm$2.5 which will result in approximately equal sounding detection levels.
4.1.1.d	Easily is a subjective, not quantifiable term.
4.2.1.e .f	MIL STD 1472, the reference for the guideline, makes no distinction between increase and raise and similarly between decrease and lower.

4.2.2.c(4)	Typo on thickness. Original source (McCormick) states that 3/8" in thickness can be identified very accurately by touch. These values were converted to decimals in MIL STD 1472 and it was more convenient and conservative for them to use .4. The experimental evidence actually suggests 3/8" as a limit.
4.3.2.a(1)	Van Cott suggested a lower limit on pushbutton controls as 0.5. However, MIL STD 1472 suggested 3/8" or 0.375". 0.385 has no significance and it is believed that it is a misprint in NUREG-0700.
4.4.1.b	There are other types of coding other than shape which could serve the same purpose.
4.4.3.g(1)	80^{o} for the minimum was a typo in 0700. MIL STD 1472C states 30^{o} for this value.
4.4.4(c)	Thumb and finger encircled is omitted because it is practically never used in nuclear power applications and the term is very confusing without a diagram demonstrating what it is. The fingertip actually refers to the generally accepted continuous rotary control used in the nuclear industry which is grasped between the thumb and the forefingers. The thumb and finger encircled is larger because it is grasped using the thumb with the forefinger wrapping around the circumference of the knob similar to grasping a door knob.
4.5.1.d(2)	Change the values to reflect the updated values from MIL STD 1472 C. Affects minimum diameter and maximum trough distance only.
4.5.4.a	Statement for 4.5.4.a(1) was changed from 0700 to provide guidance for vertical orientation. The statement in 4.5.4.a(2) provides additional guidance based on MIL HDBK 759 A when horizontal orientation is used.

4.5.4.b(1)	An integral light is best but should not be the only acceptable light feedback for a rocker type switch. A separate light located adjacent to the switch would also suffice.
4.5.4.e(1)	These values are the updated values from MIL STD 1472 C.
5.1.1	The numbering scheme has been changed from 0700 to provide more logical grouping of items.
5.1.3.a	Delete preferred visual angle reference. Not a checklist consideration.
5.1.6.c.2(b)	Added to provide industry standard not acknowledged by 0700. Delete "Amber (yellow): Auto trip". This is not an industry standard.
5.3.2.b	The intent of the criteria is to ensure the light intensity is sufficient to accurately determine if the indicator is lit. A spot photometer will give a very accurate reading of the intensity, however a simple photometer provides an accurate enough measure to meet the intent of the guideline.
5.3.3.a(1)	See 5.3.2.b.
5.4.1	Typo.
5.4.1.i	Format (numbering scheme) change.
5.5.1.a(5)	A matte finish is one good way to minimize glare and it is a good design criteria to have in MIL STD 1472, etc. However, the intent should be to evaluate whether the surface is free from glare regardless of the type of finish.
5.5.2.a	Typo.
6.1.1	This guideline refers to the physical presence of a label for every control, display, or other equipment.
6.2.3.a(1)	"and read from left to right" is redundant to oriented horizontally.

Exhibit 6.3	Grass green is not very descriptive. Dark green is a more familiar statement to describe the intended color.
6.5.1.g	Tag outs cannot physically prevent actuation of a control. The best it can do is indicate which controls should not be actuated.
6.6	The "Need for Location Aids" section is tutorial and does not contain guideline checklist material.
6.6.3.b	The fact that differential line widths may be used to code flow is tuitorial. There is nothing to say other methods cannot be used or that this is the preferred method.
7.1.2.a(4) (5)	Operators speak in terms of acronyms not syntax as do computer operators.
7.1.4.g	Cakir, et al. in the VDT Manual recommends a 5^{o}-15^{o} keyboard slope based on experimental evidence. Galitz in Human Factors in Office Automation recommends 10^{o}-15^{o} and MIL STD 1472 C, 15^{o}-25^{o}. The 10^{o}-25^{o} range is a good compromise range between the conflicting documents.
8.1.1.b	The last part of the 0700 guideline is tutorial.
8.1.2	"Effective Panel Layout" section is tutorial and does not contain guideline checklist material.
8.2.1.a(3)	Symmetrical is too limited for this guideline. They are appropriate, logical patterns that are not necessarily symmetrial which could relate a set of controls to displays.
8.3.2.b	Less than two inches wide is a reasonable definition of small displays. Added for quantification.
8.3.2.d	Add "Large matrices are subdivided by appropriate demarcation".

9.1.2.e(1)	Typo.
9.2.2	Control/Display packages is deleted since modular construction not used in typical CRs.
9.3.1.b(4)	Added to give sufficient guidance for display types.
9.3.1.c(1)	"Apparent" added because there must be a time lag, but it should not be significant for operator feedback purposes.

APPENDIX C

CRDR TEAM MEMBERS' RESUMES

Stephen L. McKissack

Instrumentation and Control Engineering Supervisor

- Experience
  - Arkansas Power & Light Company, 10 years
    - Project Engineering Supervisor, White Bluff Steam Electric Station, Construction of two 750MW Coal Fired Generating Units, 3 years
    - Instrumentation and Control Engineering Supervisor since May, 1983
- Education
  - B.S. in Electrical Engineering from the University of Arkansas at Fayetteville
  - B.S. in Accounting from the University of Arkansas at Little Rock
  - Masters in Business Administration from the University of Arkansas at Little Rock
  - General Physics, Applied Human Factors in Power Plant Design and Operations Course
  - Human Factors in Process Control, ARD Corporation

Gary G. Young

Lead Engineer, United Energy Services Corporation

- Experience

  - United Energy Services Corporation, 4 years

    - Lead Engineer, Control Room Design Review Team Coordinator and NUREG-0737 Supplement 1 Assistant Program Coordinator for Arkansas Power & Light Co., 1-1/2 years
    - Supervising Engineer, Licensing Projects for Alabama Power Co., 2-1/2 years

  - Advisory Committee on Reactor Safeguards, USMBC, 2 years

    - Reactor Engineer, various generic issues and plant license reviews including post-TMI implementation issues
    - ACRS Fellow, various systems and operating experience reviews for the ACRS members

  - Arkansas Power & Light Co., 4-1/2 years

    - ANO-2 Lead Mechanical Engineer, mechanical engineering support during construction and startup of ANO-2
    - Production Engineer, ANO-1 and ANO-2 safety systems mechanical engineering support

- Education

  - B.S. and M.S. in Mechanical Engineering, University of Arkansas, Fayettsvilla, Arkansas, 1974 and 1975
  - Human Factors in Process Control, ARD Corporation

Bobby Allen Terwilliger

Operations Assessment Superintendent

- Experience

  - Arkansas Power & Light Company, 15 years

    - Operations Assessment Superintendent since April, 1980 (ANO-1 and ANO-2)
    - Assigned to INPO to develop initial inspection criteria - January, 1980 for 3 months
    - Operations and Maintenance Manager and Chairman of the Plant Safety Committee - December, 1978 - January, 1980 (ANO-1 and ANO-2)
    - Operations Supervisor/Superintendent - December, 1971 - December, 1978 (ANO-1 and ANO-2)
    - Shift Supervisor Initial Operating Group January, 1971 - December, 1971 (ANO-1)
    - Licensed Senior Reactor Operator for ANO-1 since April, 1974
    - Licensed Senior Reactor Operator for ANO-2 since March, 1978
    - Human Factors in Process Control, ARD Corporation

  - U.S. Navy, 20 years

    - U.S. Nuclear Navy Program, 10 years

      - Qualified EOOW/PPWO at three locations A1W, A2W, and D2G

Daniel H. Williams, P.E.

Nuclear Services Project Coordinator

- Experience

  - Arkansas Power & Light Company, 10 years with heavy involvement in system engineering at ANO

    - Instrumental in Initiating B&W Owners Group Efforts on Abnormal Transient Operating Guidelines
    - Involved in Early Human Factors Related Aspects of the CE Owners Group Emergency Operating Procedures Development
    - Served on Technical Advisory Group for the EPRI and DOE Scoping and Feasibility Studies for the Disturbance Analysis and Surveillance Systems
    - Spoke at the International Conference on Computerized Operator Support Systems in Tampa, Florida on "Integration with Plant Training and Procedures"
    - Charter Member and Former Chairman of the B&W Owners Group Operator Support Committee whose Charter Includes Control Room Procedures, Displays, and Operator Training and Their Integration
    - Participant in a Panel Assembled by EG&G Idaho, Inc., under a Task Assigned by the Nuclear Regulatory Commission to Develop a Forecast of Concepts for Future Reactor Control Rooms
    - Presented Paper Entitled "Abnormal Transient Operating Procedures" in Jackson, Wyoming at the ANS Topical Meeting on Anticipated and Abnormal Plant Transient in Light Water Reactors

- o Session Chairman at 1980 Conference on Simulation and Training Technology for Nuclear Power Plant Safety in Arlington, Virginia
- o Member SPDS Validation and Verification Task Force

o <u>Education</u>

- o B.S. in Metallurgical Engineering - Nuclear Option from the University of Missouri, Rolla
- o Received Training on B&W and CE Generic Simulators
- o Human Factors in Process Control, ARD Corporation

o <u>Affiliations</u>

- o Member of Human Factors Division of the American Nuclear Society
- o Member NSPE

Curtis Wright Taylor

Operations Technical Support Engineer, ANO-2

- Experience
  - Arkansas Power & Light Company, 10 years
    - Licensed Senior Reactor Operator for ANO-2 since 1979
    - Licensed Reactor Operator for ANO-2 since 1978
    - Licensed Reactor Operator for ANO-1 1976-1978
  - U.S. Nuclear Navy Program
    - Nuclear Reactor Electrical Operator, 11 years
    - Staff Duty, Basic Nuclear Power School, Bainbridge, MD, 3 years
- Education
  - AP&L Senior Reactor Operator and Reactor Operator training courses for ANO-2
  - AP&L Reactor Operator Training Course for ANO-1
  - Combustion Engineering Pressurized Water Reactor Simulator Course
  - Babcox and Wilcox Pressurized Water Reactor Simulator Course
  - U.S. Nuclear Navy Power School
  - 2 Years Rhoades College (Formerly Southwestern at Memphis) Memphis, TN (Psychology Major)

Bill Leroy Garrison

Senior Reactor Operator, ANO-1

- Experience
    - Arkansas Power & Light Company, 12 years
        - Licensed Senior Reactor Operator, October 1976
        - Licensed Reactor Operator, June 1975
        - ANO-1 Shift Supervisor, 4 years
        - Operations Technical Support, 4 years
    - General Electric, 6 years
        - Licensed Senior Reactor Operator, 1968 (SEFOR, 20MW Experimental Reactor)
    - U.S. Navy Nuclear Power Program
        - Nuclear Submarine Electrician, 6 years
- Education
    - Human Factors in Process Control, ARD Corporation
    - AP&L Reactor Operator and Senior Reactor Operator Training
    - U.S. Navy Nuclear Power School

Gary T. Marshall

Electrical Engineer - Engineering Services

- Experience

  - Arkansas Power & Light Company, 3-1/2 years

    - Nuclear Power Plant Design - Major Projects

      - IE Bulletin 79-01B - Lead Engineer, 3 years

  - United States Air Force, 4 years

    - Titan II ICBM Combat Crew Member (Strategic Air Command)
    - Top Secret Clearance

  - Architect - Engineering Firm (Commercial)

    - Summer Student - Energy Study - Little Rock AFB & AP&L District Offices; Lighting design for new pharmacy at Memorial Hospital - N. Little Rock

- Education

  - B.S.E.E. Memphis State University - Memphis, Tennessee
  - M.S. Op Mgmt - University of Arkansas Fayetteville - currently in progress
  - Environmental Qualification of Class 1E Safety-Related Electrical Equipment training:

    - Wyle Laboratories Seminar (Huntsville, Alabama)
    - EBASCO EQ Training (in-house)

- o Wyle Laboratories Seminar (in-house)
- o NRC/Utilities Seminar (Washington, DC)
- o EQ Utilities Advisory Group Workshops
- o NUS EQ Workshop (Rockville, Maryland)

o Human Factors in Process Control, ARD Corporation

Aloysisus John Wrape III, P.E.

Electrical Engineering Supervisor

- Experience
  - Arkansas Power & Light Company, 4 1/2
    - Fossil Power Plant Field Engineer
    - Nuclear Power Plant Design Engineer

      Major Projects - ANO-1 Emergency Feedwater System Upgrade
      - ANO-2 Emergency Feedwater System 79-028 Replacements

    - Electrical Engeneering Supervisor

      Major Projects - Environmental Qualification Replacement and Maintenance Program

      - R.G. 1.97 Electrical Engineering Liasion and Coordination

      - ANO Cable and Raceway Database Management System

  - Wrape Forest Industries Inc., 8 years
    - Manager of Maintenance and Power Plant Operations
    - Responsiable for all plant engineering and construction

  - Registered Professional Engineer - Arkansas

- Education

  - B.S. in Electrical Engineering - University of Notre Dame, Notre Dame, Indiana

  - B&W Generic Simulator Training

Robert L. Kershner

Lead Human Factors Engineer, ANO-1, ARD Corporation

- Experience
  - ARD Corporation, 4 years
    - Vice President, Human Factors Technology Division
    - Human Factors Specialist, DCRDRs, SPDS, ERF, EOPs, RG 1.97, 4 years nuclear power support, 10 years human factors experience
    - DCRDR, LHFS - Dresden, Quad Cities, LaSalle, Byron, Braidwood, Marble Hill, Waterford III
- Education
  - M.A., Human Factors, Catholic University, Washington, D.C., 1976
  - B.A., Applied Psychology, University of Baltimore, Baltimore, Maryland, 1974