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EVALUATION
OF ARKANSAS POWER AND LIGHT COMPANY'S
DETAILED CONTROL ROOM DESIGN REVIEW
OF ARKANSAS NUCLEAR ONE - UNIT 1 PLANT

TECHNICAL EVALUATION REPORT

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1. INTRODUCTION

Arkansas Power and Light Company (AP&L) submitted a generic Program Plan to the NRC on November 25, 1983, for performing a Detailed Control Room Design Review (DCRDR) for Arkansas Nuclear One (ANO) Units 1 and 2 (Reference 1). The NRC staff reviewed the Program Plan and forwarded their comments to AP&L on February 2, 1984. Because the AP&L Program Plan had insufficient details addressing the processes to accomplish the DCRDR objectives, the NRC staff met with AP&L on May 2, 1984, to obtain additional information to supplement AP&L's Program Plan. A summary of this meeting, and NRC staff comments, were prepared and transmitted to AP&L on June 7, 1984. AP&L submitted the DCRDR Final Summary Report for ANO Unit 1 on August 14, 1985 (Reference 2). Based on a preliminary review of this Final Summary Report, and on the fact that both ANO Unit 1 and Unit 2 were using the same DCRDR process, the NRC staff decided to conduct an on-site, pre-implementation audit of the DCRDR for ANO Unit 1 and an in-progress audit of ANO Unit 2. The audits were conducted on September 16-20, 1985. The evaluation of ANO Unit 1 was based on the Program Plan and the Final Summary Report submitted by AP&L and the information provided by the licensee during the pre-implementation audit. The NRC audit report, dated November 7, 1985, (Reference 3) was transmitted to AP&L; it requested additional information and documented the request for a supplemental report. The audit report addressed all of the nine elements of the DCRDR process required for conformance with Supplement 1 to NUREG-0737 (Reference 4). Additional guidance is provided by NUREG-0700 (Reference 5) and NUREG-0800 (Reference 6). AP&L responded to the NRC request for supplemental information by submitting its "Response to CRDR Audit Findings," dated April 29, 1986 (Reference 7). Because there were a small number of issues inadequately documented in the supplemental information, the NRC staff requested a meeting with the licensee. (See Appendix B for attendees at the meeting.) The meeting was held in Bethesda, MD, on August 7, 1986.

The objective of the meeting was to resolve as many open items as possible for the DCRDR program. Also, any items which could not be resolved at the meeting were to be identified. Furthermore, a decision was reached at the meeting that the NRC staff would issue an SER on the DCRDR program following receipt of the TER from SAIC. Any open items identified in the TER will be treated as separate action items.

This report is an evaluation of all AP&L submittals, as well as information obtained from the audit and the meeting of August 7, 1986.

2. EVALUATION

Science Applications International Corporation (SAIC), the NRC's contractor, has reviewed all available information on the ANO Unit 1 to date. The purpose of this review was to evaluate whether the DCRDR requirements of Supplement 1 to NUREG-0737 had been satisfied. The evaluation of the AP&L's DCRDR Supplemental Summary Report is provided below on an element-by-element basis followed by other DCRDR Summary Report requirements and audit team observations. Where additional information was obtained from the August 7, 1986 meeting, it is so noted.

2.1 Establishment of a qualified multidisciplinary review team

This element of the DCRDR process was previously evaluated in the audit report and was not reviewed again in this report. The multidisciplinary team, as assembled and utilized by AP&L, was judged to meet the requirements of Supplement 1 to NUREG-0737 satisfactorily.

2.2 Function and task analysis to identify control room operator tasks and information and control requirements during emergency operations

This element of the DCRDR process was also previously evaluated in the audit process and was judged to meet the requirements of Supplement 1 to NUREG-0737 satisfactorily.

2.3 Comparison of display and control requirements with a control room inventory

This element was previously evaluated in the audit process and was not reviewed again as a part of this report because it was judged to meet the requirements of Supplement 1 to NUREG-0737 satisfactorily.

2.4 Control room survey to identify deviations from accepted human factors principles

The survey was conducted in general conformance with the applicable guidelines; however, AP&L had modified six of the NUREG-0700 guidelines to an extent unacceptable to the NRC audit team. Additionally, the audit team found that a number of survey checklist items had not been completed.

The NRC staff requested that the six AP&L checklist items be amended to conform with NUREG-0700 criteria and reapplied in the control room survey process. The NRC staff evaluation of the AP&L response to the items is given below.

1. NUREG-0700 checklist item 6.1.2.2.d.(2), Exhibit 6.1-6, 6.1.2.3.b, 6.1.2.3.d.(2)

These guidelines address the stand-up/sit-down console dimensions for measuring the extended functional reach for the 5th percentile female. The AP&L guidelines deviated from the NUREG-0700 guidelines by several inches. In the Supplement to the Summary Report, AP&L agreed to modify its original checklist dimensions to conform with NUREG 0700. The NRC staff concurs with the current AP&L position for these guidelines. AP&L reported that one HED resulted from this change in dimension.

2. NUREG-0700 checklist item 6.1.2.3.5.(2)

This is another guideline which addresses sit-down console dimensions for sustained control functions. The AP&L guideline was 29 inches while the NUREG-0700 guideline is 25 inches. The NRC staff indicated that 29 inches may be too great a distance to reach, depending on the task difficulty and duration. AP&L has modified the DCRDR review checklist to conform to the

NUREG-0700 guideline. No new HEDs resulted from this change. The NRC staff agrees with this guideline.

3. NUREG-0700 checklist item 6.3.2.1.c

This guideline addresses the auditory alert signal detection specification. The AP&L guideline specified that 90dB(A) should be the maximum signal intensity while the NUREG-0700 guideline was less specific with regard to actual dB(A) level. AP&L has modified the DCRDR review checklist and the AP&L human factors review guideline document to conform to the NUREG-0700 guideline. No new HEDs resulted from this change. The NRC staff concurs with this position for this guideline.

4. NUREG-0700 checklist item 5.1.6.c.(2)

This guideline addresses the color coding of displays. Because the AP&L guidelines for color displays deviate from the NUREG-0700 guidelines, the NRC staff requested that justification be provided for the deviations. The AP&L justification for using red and green to indicate actual position (of valves, breakers, pumps, fans, etc.) instead of the NUREG-0700 meaning describing equipment status (such as danger, safe, and caution) is that the use of color codes to indicate position is an industry and AP&L standard. The AP&L plant operators (nuclear, fossil, and hydro) are accustomed to these meanings, and there are many years of history using this standard. NUREG-0700 does not address the use of color for indicating position. Therefore, the AP&L standard for color coding assigns an explicit meaning based on the behavioral attributes of the AP&L operator population due to years of use and training. The NRC staff accepts this justification.

5. NUREG-0700 checklist item 6.5.1.g

This guideline addresses the use of tag-outs for controls. The AP&L guideline does not require tag-outs to physically prevent actuation of a control since such a guideline is impractical. The NRC commented that plastic cover tag-outs can physically prevent actuation; however, if power is not removed from the breaker, an operator could remove the tag-out and manually operate the control, or automatic control actuation could occur. Therefore, AP&L requires that equipment being taken out of service shall

have the power removed when practical by opening the breaker and locally tagging out the breaker. Thus, this NUREG-0700 guideline is not appropriate for the ANO control room design features. The NRC staff can accept this justification.

6. NUREG-0700 checklist item 6.9.2.2.e

This guideline addresses criteria for modular packaged units of displays and controls. The AP&L guideline deleted this section since modular construction was not used in the ANO control rooms. The NRC audit team defined modular to mean vendor panel inserts. Since the ANO checklist guidelines applied the general principles of display and control to the vendor panel inserts (as defined in NUREG-0700 Section 6.9.2.2.e), there is no deviation from NUREG-0700 guidelines. Therefore, using the NRC staff definition of modular packaged units, no new HEDs were identified.

A review of the above responses to the NRC staff concerns indicates that AP&L has amended the discrepancies and justified the departures from NUREG-0700 noted at the time of the pre-implementation audit. The subject checklist guidelines are now deemed satisfactory.

During the pre-implementation audit, the NRC audit team noted that a number of survey checklist items had not been completed and recommended that the licensee resurvey these items and incorporate any findings into the review process.

In response to the incomplete survey checklist, AP&L stated that it reexamined these items and either resurveyed them or located documentation of the original survey to establish completion of the survey. It did not discover any auditional HEDs. The reviewers conclude that the action taken by AP&L is sufficient to allay any concerns and that the discrepancy has been rectified.

2.5 Assessment of human engineering discrepancies to determine which HEDs are significant and should be corrected

This element of the DCRDR process was satisfactory as previously evaluated in the audit report. AP&L has met the requirements of Supplement 1 to NUREG-0737.

2.6 Selection of design improvements that will correct the identified discrepancies

During the audit, the NRC staff determined that the process for selection of design improvements was acceptable. However, many HED solutions were still under study, and AP&L had not supplied firm implementation schedules. Additionally, the NRC audit team requested more information to provide assurance that HEDs in categories 2 and 3 which are related to HEDs in category 1 would be considered for possible cumulative and interactive effects. For these reasons, this element of the DCRDR was classified as an open item. AP&L responded to all of the above concerns. The reviewers' evaluation of its response follows.

HEDs for which adequate solutions and implementation schedules were previously acceptable to the NRC staff will not be reevaluated in this report. All other open item HEDs for which proposed corrective actions and implementation dates are now (with this evaluation) considered to be acceptable are listed in Appendix A-1 of this report. The NRC staff still had concerns about another group of HEDs.

Firstly, there is a concern associated with the use of color and background shading for resolving HEDs that address functional grouping of control panel instrumentation. AP&L has presented a color coding matrix that uses six colors. This color matrix is within the NUREG-0700 guidelines (n=11) for color usage. Independent of this color coding matrix, AP&L, in their Comprehensive Surface Enhancements Program (CSEP), introduce an additional 13 colors into the control room to include:

- Six colors to be associated with various systems;

- o Four colors to be associated with different channels or control room displays;

- o Three generic colors to be used as visual/perceptual aides that will not be associated with specific systems or channels.

AP&L's excessive use of color is questionable since it is not in keeping with reasonable human engineering practice. This overuse of color could lead to a reduction in the effectiveness of this technique and possibly introduce operator confusion and error.

At the meeting, the NRC staff review team was presented with color chips of the proposed CSEP. It was noted at the meeting that one of the six system-specific colors was still not selected. Furthermore, the review team expressed the concern that several of the colors to be used may not be easily distinguishable when applied to the control panels.

AP&L presented slides of the Engineered Safety Features Panel. This panel strongly suggested a need for a rigorous verification process to ensure that the proposed use of color would, in fact, resolve the HEDs and not introduce new ones. In general, AP&L needs to reexamine the proposed use of color, particularly in conjunction with the CSEP at ANO 1.

At the meeting held on August 7, 1986, an agreement between the NRC staff and AP&L staff regarding the possible overuse of color was reached. This agreement will require the NRC's Electrical Instrumentation and Control Branch to request that the NRC resident inspectors for ANO-1 and ANO-2 inspect AP&L's use of color in the control rooms overall, and specifically for its use of color for HEDs CK:8-1.058, QS:B3.17-1.071, QS:1-1.097 and QS:1-103 and for the Engineered Safety Features Panels.

The NRC audit team noted that the color-coding scheme differed from those recommended in the NUREG-0700 guidelines. The AP&L response was that the color-coding scheme for ANO Unit 1 was the same as in all its other plants (nuclear, fossil, and hydro). The NRC staff requested that AP&L provide a matrix of color versus meaning. The matrix was provided as part of the supplemental report.

The reviewers found the color-coding scheme, as shown on the matrix, could have been acceptable but for an inconsistency on integral switch plates (pumps). In all cases but this one, the color red indicates equipment activity and black indicates equipment inactivity. Here the meaning of the colors red and black are exactly opposite. This concern should be rectified.

As described above, there are four major problems associated with AP&L's use of colors to solve various HEDs. These concerns are: (1) too many colors (19 instead of the recommended maximum of 11); (2) colors not easily distinguishable; (3) rainbow effect on the ESFP; and (4) an inconsistent color matrix for integral switch plates. SAIC's position is that the issue of color coding is complex and the possibility of operator error is significant should the utility implement their plans to correct HEDs using their current color coding solutions. In principal, SAIC is in agreement that all these concerns need further inspection by the NRC staff.

Secondly, AP&L has provided assurance that HEDs in categories 2 and 3 which are related to HEDs in category 1 are considered for cumulative and interactive effects. It has argued that its corrective actions are part of a comprehensive program which cuts across HED categories. For example, the annunciator upgrade program involves 13 HEDs, of which 3 are category 1. The surface enhancement program addresses 50 HEDs, of which 4 are category 1. The NRC staff concludes that cumulative and interactive effects of HEDs in all categories are being given due consideration by AP&L.

In conclusion, the NRC staff finds that the process proposed by AP&L should satisfy the requirement of Supplement 1 to NUREG-0737 for the selection of HED solutions. An action item that remains to be completed as a part of this step is the resolution of the possible overuse of color as described above.

2.7 Verification that selected design improvements will provide the necessary corrections and will not introduce new HEDs

Based on verbal description at the audit and on an inspection of previously corrected HEDs, the NRC audit team judged that the AP&L verification processes were satisfactory. However, the staff requested written

documentation of the formal AP&L process which would include details of the use of personnel, equipment, procedures, and techniques that AP&L intends to use to ensure satisfactory completion of this requirement of Supplement 1 of NUREG-0737.

The AP&L response indicated that the processes for verification of HED corrections has been formalized as a part of an engineering department procedure on human factors review of design changes. According to AP&L, the procedure addresses the use of personnel, equipment, etc., as discussed with the NRC staff at the audit. Although AP&L did not submit a copy of this document, they brought documentation, and examples of their verification procedure to the meeting on August 7, 1986. The NRC staff concurred at that meeting that the verification process will satisfy the requirement of Supplement 1 to NUREG-0737.

2.8 Coordination of DCRDR improvements with other NUREG-0737 Supplement 1 improvement programs including Safety Parameter Display System, operator training, Reg. Guide 1.97 instrumentation, and upgraded emergency operating procedures

This element was considered satisfactory at the time of the review of the Summary Report and the audit at ANO-1. AP&L has met the requirement for this element to Supplement 1 to NUREG-0737.

2.9 Other DCRDR activities identified during the audit

2.9.1 Implementation schedule for HED resolutions

The NRC staff position regarding implementation schedules for HED resolutions is that all corrections should be completed within two refueling outages following submission of the Summary Report. This applies especially to category 1 HEDs. AP&L submitted its Final Summary Report for ANO-1 on August 14, 1985. The next fueling outage 1R7, is scheduled for August of 1986. Thus, according to the NRC staff position, AP&L should have completed all HED corrections by the end of 1R8.

AP&L has provided an adequate schedule and/or justification for not scheduling their corrections within this time frame for all but five HEDs.

Five Category 1 HEDs have scheduling concerns. Four are scheduled for 1R9 implementation: QS:A1.7-1.018, QS:A1.8-1.019, QS:A1.9-1.031 and VR:1-1.031. One HED is scheduled for 1R10 implementation, CK:3-1.008.

2.9.2 Reexamination of high location of meters

During an inspection of the ANO Unit 1 control room, the NRC audit team noted that approximately every 10 minutes a member of the control room operating staff, using a movable ladder, took decay heat readings from instruments located on panel C-14. As a result of this observation, the NRC requested that AP&L reexamine the high location of the meters on panels C-14, C-16, and C-18 and consider relocation in order to permit convenient reading from the control room floor level.

The AP&L responded that while the locations of some instruments did not conform with NUREG-0700 guidelines, these locations were justified. The specific instruments on panels C-14, -16, and -18 were discussed, including parameters displayed, accuracy requirements, ease of observation, and noninterference characteristics. AP&L pointed out that several instruments have been changed to a type of indicator that reduces parallax error. AP&L stated that quantitative readings of these meters were not required by emergency operating procedures.

Based on the justifications provided by AP&L, the NRC staff concludes that the present location of the instruments on panels C-14, -16, and -18 is acceptable.

2.9.3 Procedures for testing status lights

At the audit, the NRC staff requested that AP&L provide a procedure for testing status lights in cases involving single bulb lights. The Supplemental Summary Report response was that status lights for safety-related systems for valve positions, pumps, and motors are checked once per shift. The actual check is merely an observation of either "off" or "on" status, i.e., a verification that status light illumination and equipment control positions correspond. AP&L maintains that its operators are trained in the detection of malfunctioning status lights. It also provided a list of conditions which would enable the operators to determine bulb failure in 31

different status lights. Although AP&L did not provide a status light checking procedure as such, the NRC finds their response acceptable.

2.9.4 Missing labels

The NRC audit team directed AP&L to ensure immediately that there are no missing labels even if that required using dymo-tape as an interim solution until the labeling study is implemented in refueling outage 1R7. AP&L responded that permanent labels have been installed and no other missing labels were identified. The NRC staff accepts this action.

3. CONCLUSION

The Supplement to the DCRDR Final Summary Report has addressed all the NRC staff concerns identified in its November 7, 1985, audit report. Most of the concerns were resolved by AP&L. However, a small number of open items remained in that submittal which were addressed at the meeting on August 7, 1986. AP&L did not submit any written documentation on the procedures that it intends to use to verify that selected design improvements will provide necessary corrections for HEDs and will not introduce new HEDs. However, at the meeting, the NRC staff determined that based on documents (not formally submitted), discussion, and examples of how the verification process was used for specific HEDs, the utility had adequate procedures for verifying HED solutions. With regard to the numerous concerns about the use of color in the control room, it was decided at the August 7, 1986 meeting, that the NRC resident inspectors would follow up on this concern as previously noted. The SAIC position regarding AP&L's intended use of color is that it will not result in satisfactory HED solutions. With the above exceptions, AP&L has complied with all the requirements for Supplement 1 to NUREG-0737 with respect to its Detailed Control Room Design Review.

REFERENCES

1. Arkansas Power and Light Company, Arkansas Nuclear One, Units 1 and 2, Control Room Design Review Program Plan, dated November 25, 1983.

2. Arkansas Power and Light, Arkansas Nuclear One-Unit 1 Control Room Design Review Final Summary Report, Volumes 1 and 2 dated August 14, 1985.

3. Audit Report of the Detailed Control Room Design Review for Nuclear One, Unit 1 USNRC dated November 7, 1985.

4. Supplement 1 to NUREG-0737 - Requirements for Emergency Response Capability (Generic Letter No. 82-33), USNRC dated December 17, 1982.

5. NUREG-0700 - Guidelines for Control Room Design Reviews, USNRC, Office of Nuclear Reactor Regulation, dated August 1981.

6. NUREG-0800 - Standard Review Plan for Review of Safety Analysis Reports for Nuclear Power Plants, USNRC, Office of Nuclear Reactor Regulation, September, 1984.

7. Arkansas Power and Light Company, Arkansas Nuclear One Unit 1, "Response to CRDR Audit Findings," April 29, 1986.

APPENDIX A

EVALUATION OF HEDS LISTED IN ATTACHMENTS 2 AND 3 OF THE SUPPLEMENTAL SUMMARY REPORT

HEDs for which proposed corrective actions and implementation dates are satisfactory.

AP&L has identified satisfactory corrective actions as well as implementation schedules for the following Category 1 HEDs. The HEDs are listed according to implementation schedule.

Already Corrected	Implementation 1R7	Implementation 1R8
CK:1-1.014	HR:1-1.002	CK:3-1.003
QS:E2.1-1.083	QS:A3.2-1.020	CK:3-1.004
QS:A3.20-1.051	QS:A1.14-1.036	QS:A1.17-1.001
QS:1-1.100	VR:1-1.028	VR:1-1.013
	QS:A3.5-1.042	VR:1-1.006
	CK:6-1.001	QS:E2.2-1.084
	VR:1-1.027	
	QS:A5.2-1.065	

Implementation 1R8 to 1R9

QS:A3.19-1.050
VR:1-1.007

The NRC staff is in agreement with AP&L regarding the solution as well as implementation schedule on the above HEDs. No further discussion is required.

APPENDIX B

ATTENDANCE AT DCRDR MEETINGS ON AUGUST 7, 1986

Name	Organization
Joe Moyer	SAIC
John Stokley	SAIC
Charles Morris	PWR-B
Guy S. Vissing	PWR-B
Dan Williams	AP&L
Dale E. James	AP&L
Garry G. Young	Young Engr. Serv./AP&L
J. Calvo (Jose)	NRC
L. Beltracchi (Leo)	NRC
Jack Ramsay	NRC
Robert Lee	NRC