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WATERFORD SES UNIT NO. 3 CONTROL ROOM DESIGN
REVIEW/AUDIT TECHNICAL EVALUATION REPORT

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June 1981

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His work was supported by the United States Nuclear Regulatory Commission under
a Memorandum of Understanding with the United States Department of Energy.

HUMAN FACTORS ENGINEERING BRANCH

CONTROL ROOM DESIGN REVIEW

WATERFORD SES UNIT No. 3

INTRODUCTION

As part of the NRC staff actions following the TMI-2 accident (Item I.D.1, NUREG-0660, Vol. 1, May 1980) (ref. 1), it is required that all licensees and applicants for operating licenses conduct a Detailed Control Room Design Review (DCRDR) to identify and correct human factors design deficiencies. These DCRDRs will be initiated after final issuance of NUREG-0700, Guidelines for Control Room Design Reviews (ref. 3), and will be completed within one year. Those applicants for operating licenses who are unable to complete this DCRDR prior to fuel loading are required to conduct a preliminary design assessment of their control rooms, identify human factors deficiencies, and establish a schedule, approved by NRC, for correcting the deficiencies.

As a result of these requirements, Louisiana Power & Light Co. (LP&L) performed a preliminary assessment of the Waterford SES Unit No. 3 control room and submitted its findings to the NRC in a report dated April 15, 1981 (ref. 4) for review and evaluation.

The Human Factors Engineering Branch (HFEB) performed an interim review of the LP&L preliminary assessment report. The HFEB was assisted in the review by human factors consultants from Lawrence Livermore National Laboratory.

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HUMAN FACTORS DEFICIENCIES IDENTIFIED

The HFEB reviewed the Waterford SES No. 3 preliminary assessment report to identify human factors deficiencies in the control room. Some of these deficiencies were identified by LP&L, and actions for their correction were proposed. Some deficiencies were identified by LP&L, but no corrective actions were proposed in the preliminary assessment report. The HFEB evaluation of the preliminary assessment report systems descriptions also identified deficiencies not reported by LP&L.

This section presents those deficiencies considered by the HFEB to be the most serious and which will require significant corrective action before licensing can occur. If the preliminary assessment report included an LP&L proposed corrective action for a specific deficiency, a description of this action is also provided.

1. MAIN CONTROL BOARD ANTHROPOMETRIC DESIGN The LP&L reviewers used some of the anthropometric criteria given in NUREG-1580 to review the design of the main control boards. Even by using an "average operator" (whose height is approximately 5'8"), none of the control boards are within the recommended anthropometric envelopes for height, depth, or viewing distance. The reviewers stated that some of the convex meters are located high enough to cause parallax error. The standard annunciator panel positions are too high for easy reading, and plans exist for added panels located above these positions. The CRT control keyboards are placed low enough to necessitate bending and reaching for most operators. The 5th percentile female operator (approximately 5' tall) would find it impossible to operate most portions of the boards comfortably, if at all.

Even an "average" operator would find some routine operations uncomfortable. The reviewers concluded that the "average operator" could, in reality, manage to operate the controls and perform maintenance on the displays/recorders of the existing board configuration by leaning over the boards. This conclusion is questionable, and does not address the problem of making the control boards operable by 90% of the possible operator population.

2. OPERATOR CONSOLE DESIGN The operator console is a sit-down console in the center of the main control area. Final configuration of the console is not complete. In the present configuration, access around the console to the control boards is clumsy. A proposed enlarged configuration may create additional obstructions, although it will provide a central access passage. The preliminary assessment reviewers could not evaluate whether the CRT turrets on the console would obstruct the operator's view of the control panels, since these turrets were not yet installed. LP&L plans perform a thorough investigation of the console's use as part of the control room review done to satisfy NUREG-0700.

3. DOCUMENTATION/PROCEDURES STORAGE AND WORKSPACE At present, the only storage facilities for procedures and other documents provided in the control room is a 2-drawer file cabinet in the operator console. This limited space will be inadequate for the substantial documentation needed to support operations.

A work surface is needed where material can be reviewed by several persons at once away from the controls on the operator console. LP&L plans to investigate the amount of work space required during a Task Analysis

program and will provide the work space in an appropriate location based on that investigation.

4. GLARE The lighting system was not in final configuration during the preliminary assessment. The LP&L reviewers observed that the lighting levels were excessively high, which contributed to significant glare problems on meter faces, chart recorder faces, and CRTs. It was also observed that the supervisor's office windows will provide a source of reflection and glare which will interfere with CRT viewing. LP&L plans to review the glare problems upon completion of the control room lighting and the supervisor's office.
5. COMMUNICATIONS Communications between the control room and peripheral areas do not appear to be adequate. Specifically mentioned for improvement are communications with the computer room and the kitchen/lavatory facilities. LP&L states that this concern will be addressed through staffing and administrative procedures. LP&L believes that the private page system line and commercial telephone presently installed in the computer room will provide adequate communication with the control room.
6. ANNUNCIATORS The annunciator legends are not engraved with a large enough type face to be read from their associated response controls. The LP&L reviewers estimated that an operator standing at the edge of the benchboard would be able to resolve details on the annunciators at a distance of no more than 5-6 feet laterally. The annunciators on CP-7 are associated with response controls on CP-8 that are more than 14 feet away

laterally. The annunciator legends will not be readable from behind the operator console. This will necessitate the operator moving up to the control board for every alarm.

The annunciator audible alarms are automatically terminated after 3-5 seconds. This may reduce the annoyance factor of the alarms too greatly, especially since an operator must leave the console to read the annunciator legends.

The legends were difficult to read at the "return to normal" flash rate of 1 flash/second.

Maintenance of the annunciators will be impossible without standing on the benchboard or using a special ladder designed to bring the operator to the correct height and in from the edge of the benchboard. The annunciator window assemblies are difficult to remove, and are loose when reinstalled. LP&L plans to investigate the problem of possible accidental interchange of annunciator windows.

7. CONTROLS Toggle switches on a vertical panel (CP-13) in a high traffic area are subject to inadvertent actuation.

The excessive and varied use of safeguards against inadvertent actuation (three different types of key switches, "think buttons", dual actuation, etc.) may cause problems when quick response is required under stress. The basic switch and indicating light assembly used in the control room is a microswitch model CMC device. This device has several problems associated with it:

- a. Excessive force is required to actuate some of the switch knobs. The spring-loaded control knobs were noted as especially difficult to actuate.

- b. There are too many conventions for switch positions, labeling, and color coding. These conventions cause much operator confusion because of the widespread use of the switch in the control room. An operator must examine nearly identical switches to determine the method of operation, the meaning of the integral indicator lights, and the available position choices of each. Since fixed position, momentary contact, and "hold" (throttle) controls are not differentiated, this examination will not always be sufficient to determine the method of operation.
- c. The logic and arrangement for keys on the keylock switches is not understood by the operators.

8. DISPLAYS The displays used in the control room had the following general and specific problems:

- a. Glare and poor visibility were reported by the operators.
- b. The dual scale meters present several problems. Meters should be combined only where an operational advantage is gained and where a scale can be shared. *Some dual meters have scales that are not identical and can confuse the operators. The relation of the dual scale meter labels to the scales is unclear. The scales are sometimes obscured.*
- c. Needed indications are not always provided in the appropriate panel area. For example, the start-up rate is provided on the protection panel only.
- d. "Vertical" orientation scales are sometimes used on horizontally placed meters.

e. The scale graduations on some meters make interpolation difficult.

It is often hard to differentiate between major and minor index marks.

9. PANEL LAYOUT The LP&L reviewers state that the functional systems are in some cases split up to be "event oriented". This may result in some situations where much travel is required between panels or where coordination between operators is needed. LP&L plans to examine the need for relocation of some elements after the completion of the Task Analysis to be performed to satisfy NUREG-0700.

Generally, there is a poor relationship between associated displays and controls. The panel elements are basically grouped by system or plant function, but these groups contain both primary and secondary parameters clustered together. In addition, mixed parameters are grouped, i.e., flows, pressures, temperatures, level, concentrations, etc. presented together without any easily noted distinctions.

Some mirror-imaging of sub-groups was found, and an apparent concern for "balance, symmetry, uniformity, and general good appearance" of elements has enforced a disassociated placement of the elements on some panels.

LP&L plans to address the issue of display and device coordination during an extensive demarcation and labeling effort scheduled to begin in June 1981. However, the preliminary assessment report states that excessive use of graphics and color will be minimized because these cause "clutter and/or confusion" and can be "distracting".

10. LABELING The largest number of operator observations and comments concerned labeling. LP&L plans an extensive demarcation and labeling effort to begin in June 1981.

General There is no hierarchical labeling scheme. There are many conflicting labeling conventions. Many exceptions to these conventions were found. Abbreviations are not standardized.

The operators also reported mislabeling, missing labels, switchable labels, inadequate labels, illegible labels, and confusing label arrangements.

Controls In general, controls are labeled below the control switch, where the legend will be obscured while the control is being operated.

Some control switches have two devices associated with them. These controls are labeled with the primary device label below the switch and the secondary device label engraved in the lower half of the control switch plate. This convention can lead to confusion.

The engraved switch face plate labels are hard to read due to low contrast, glare, small letter size, and the poor grouping of legends.

Displays Dual indication vertical meters are labeled on the bottom for the right scale marking, and on the top for the left scale marking. This convention could easily lead to display misinterpretation.

11. PROCESS COMPUTER INTEGRATION The process computer input/output procedures and format adequacy could not be evaluated due to lack of information. However, the systems descriptions provided indicate a poor integration of the computer with the control room operators. The computer hard copy printout devices are located outside of the main control area, behind

panel CP-30. Access to these printers will be awkward and time consuming. LP&L has established a program to integrate the plant computer and the Safety Parameter Display System into the man-machine system of the control room.

It was also mentioned that the operators may need to "bootstrap-start" the computers when no other staff is available. This procedure may require that an operator must leave the control room when needed for other vital operations.

12. RECORDERS The recorders in the control room exhibit typical maintenance type deficiencies. Incorrect scales and incompatible paper were sometimes installed.

The recorder windows are quite small. This presents problems in reading the trend tracings. LP&L plans to evaluate recorder display requirements during the Task Analysis program performed to satisfy NUREG-0700.

CONCLUSIONS

The applicant must perform a Detailed Control Room Design Review (DCRDR) along the guidelines issued in NUREG-0700 to upgrade the Waterford SES Unit to a control room to an acceptable design according to human factors principles. This DCRDR will include a Task Analysis and Systems Analysis program and a more detailed control room audit than was performed for the preliminary assessment. Louisiana Power and Light, in the preliminary assessment report, has stated its intent to perform this DCRDR. Any deficiencies identified during the DCRDR must be corrected before fuel loading or must have long range studies initiated for determining the means of correction on a schedule

acceptable to the NRC. Final resolution of all deficiencies will be expected on a schedule consistent with NUREG-0737 (ref. 2).

Appropriate correction of the items given in the previous section, and of the deficiencies that may be identified in the DCRDR, will enhance the operators' detection and response capability and will lessen the probability of operator error during stressful operating conditions. Based on the review of the applicant's preliminary assessment submittal, we conclude that the Waterford SES Unit No. 3 control room can be sufficiently upgraded along human factors guidelines to allow safe operation of the plant.

REFERENCES

1. NUREG-0660, Volume 1, May 1980; IIRC Action Plan Developed as a Result of the TMI-2 Accident.
2. NUREG-0737, November 1980; Clarification of TMI Action Plan Requirement.
3. NUREG-0700, Guidelines for Control Room Design Review.
4. Preliminary Control Room Assessment for Louisiana Power & Light Company's Waterford SES Unit No. 3, April 15, 1981.