

Docket Nos.: 50-416  
and 50-417

JUL 16 1981

Mr. James P. McGaughy, Jr.  
Assistant Vice President  
Mississippi Power and Light Co.  
P.O. Box 1640  
Jackson, Mississippi 39205

Dear Mr. McGaughy:

SUBJECT: CONTROL ROOM DESIGN REVIEW/AUDIT REPORT, GRAND GULF 1

Enclosed is a copy of the Human Factors Engineering Control Room Design Review/Audit Report for Grand Gulf 1 for your review and comment. Please contact us as soon as possible if you have any questions regarding this report. The concerns identified in this report will be the subject of a meeting to be held with the staff in Bethesda on July 16, 1981.

If you require any clarification on this matter, please contact M. D. Houston, Project Manager, (301)-492-8593).

Sincerely,

Original signed by  
Robert L. Tedesco

Robert L. Tedesco, Assistant Director  
for Licensing  
Division of Licensing

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HUMAN FACTORS ENGINEERING  
CONTROL ROOM DESIGN REVIEW/AUDIT REPORT

GRAND GULF NUCLEAR STATION UNIT 1  
MISSISSIPPI POWER AND LIGHT COMPANY

A human factors engineering preliminary design review of the Grand Gulf Unit 1 control room was performed at the site on June 8 through June 12, 1981. This design review was carried out by a team from the Human Factors Engineering Branch, Division of Human Factors Safety. This report was prepared on the basis of the HFEB's review of the applicant's Preliminary Design Assessment and the human factors engineering design review/audit performed at the site. The review team was assisted by human factors consultants from BioTechnology, Inc. (Falls Church, Virginia) and from Lawrence Livermore National Laboratory (University of California), Livermore, California.

Observed human factor design discrepancies were given a priority rating of one to three (high, moderate, low), based on the increased potential for operator error and the possible consequences of that error. Priority rating 1 and 2 discrepancies should be corrected prior to issuance of an operating license. Priority rating 3 discrepancies should be evaluated and proposed actions reported as part of the long term design review (due one year from the issue date of NUREG-0700). Note that some priority ratings include a superscript one (e.g., 3<sup>1</sup>). Since the resolutions of these discrepancies involve simple corrective actions relative to the potential for improving operator performance, these discrepancies should be corrected prior to loading fuel.

The following sections are numbered to conform to the guidelines of the draft version of NUREG-0700 and summarize the team's observations of the control room design and layout and of the control room operators' interface with the control room environment.

A list of human factors strengths observed in the Grand Gulf Unit 1 control room is given at the end of the ten major sections of this report. This list includes those features that the review team felt enhanced the operator interface with the control room. Finally, a list of those items that could not be evaluated is presented. The condition of construction or installation of these items at the time of the site visit was not sufficiently finalized to permit review.

HUMAN FACTORS ENGINEERING  
CONTROL ROOM DESIGN REVIEW/AUDIT REPORT

GRAND GULF NUCLEAR STATION UNIT 1  
MISSISSIPPI POWER AND LIGHT COMPANY

1. CONTROL ROOM WORKSPACE

<u>PRIORITY RATING</u>	<u>FINDING</u>	
3	1*	<p>The total height of the wing portions of the Panel 680 console is 62 inches above the floor level. This dimension exceeds that recommended for a sit-down console. The recommended maximum heights are:</p> <ul style="list-style-type: none"><li>Not necessary to see over console - 58 inches above floor level.</li><li>Necessary to see over console - 44 inches above floor level.</li></ul> <p>The right wing portion of the Panel 680 console blocks the operator's view of Panel 601. An operator standing at the central position of Panel 680 cannot see the benchboard or the lower part of the vertical board on Panel 601 over the right side of the console. A seated operator cannot see the Panel 601 benchboard, vertical board, or annunciators.</p>
3	2	<p>The triangular metal panels at the left and right ends of Panel 680 unnecessarily obstruct the view past the ends of the console.</p>
3	3	<p>There are several instances of unnecessary panel-mounted instruments on the main control room panels, the back panels, and the Remote Shutdown panels.</p> <p>The square root extractor for the RCIC FLOW CONTROL meter on Panel 601 requires no operator interaction.</p> <p>Two CHLORINE SAMPLE TEMPERATURE switches located on Panel 855 are maintenance switches that require no operator interaction.</p>

\* Discrepancy also noted in Mississippi Power and Light Control Room Design Review Report for Grand Gulf Nuclear Station Unit 1.

1. CONTROL ROOM WORKSPACE

<u>PRIORITY RATING</u>	<u>FINDING</u>	
31	4	There are some non-functioning, spare meters on section 1 and section 2 of Panel 807.
2	5	The controls and displays for the EXHAUST SYSTEMS RADIATION MONITORS and the controls for the same systems for the HVAC system are divided into four divisions that are at four separate locations. Two divisions are located on separate racks in the back panel area and two divisions are located on separate racks in the upper cable spreading room.
1	6	The RHR JKY PUMP controls are located on widely separated panels. These controls are located on the main control room panel (Panel 601) that contains the remainder of the RHR system controls and displays, on a back panel (Panel 872), and on a panel in the upper cable spreading room (Panel 871).
3	7	The desk for the second reactor operator is located behind the shift supervisor's desk and faces away from the main control console and panels. The views of Panel 680 and Panel 601 are poor from this location. The view of Panel 870 is totally blocked by the Panel 680 console.
1	8	No telephones or other communications facilities are provided for the shift supervisor at the shift supervisor's desk.
1	9	There are small openings on the benchboard sections of the Panel 680 console that permit small parts and debris to fall into the panel interior.
3	10	A large switch handle protrudes from the 480V fuse box located near the end of Panel 655 in the back panel area. The protruding handle leaves only a 16 inch wide passageway between the end of the switch and the end of Panel 655. The protruding switch handle is a hinderance to movement and a safety hazard to personnel going past it. This switch is also susceptible to inadvertant operation.

1. CONTROL ROOM WORKSPACE

PRIORITY  
RATING

FINDING

- |   |    |   |
|---|----|---|
| 2 | 11 | The back portion of Panel 680 that is recessed below the front portion of the console benchboard contains controls and displays. These controls and displays are partially hidden from the view of a seated operator. The recessed portion of the benchboard may also become a convenient receptacle for extraneous items that may interfere with viewing the displays and operating the controls that are located there. |
| 2 | 12 | No provisions are made at any of the main control room panels for an operator to lay down procedures manuals and other reference materials to be used while performing task sequences at these locations.   |
| 2 | 13 | No writing surface space is provided for an operator at the Panel 680 console.  |
| 1 | 14 | The top row of meters on each of the Remote Shutdown panels is located higher than the recommended maximum height of 70" for reading by a 5th percentile operator. The high location also causes parallax error when reading the upper portions of the vertical meter scales.   |
| 3 | 15 | The annunciator SILENCE, RESET, and TEST response switches for the SEISMIC annunciators on Panel 856 are mounted too high. These pushbutton switches are located 83 inches above the floor and are beyond the reach of a 5th percentile operator.   |
| 3 | 16 | There are some controls and displays on the back panels that are mounted higher than is recommended above the floor (recommended max heights are 70" for displays and approximately 60" for controls).  |
| 3 | 17 | Some controls and displays on the backpanels are mounted too close to the floor for easy operation or viewing. For example, a 3-position switch on Panel 694 is located only 22 inches above the floor (recommended minimum distance from floor = 34 inches).   |

1. CONTROL ROOM WORKSPACE

<u>PRIORITY RATING</u>	<u>FINDING</u>	
1	18	There is no paging system phone at the Division 2 Remote Shutdown panel. When the fire door between the Division 1 and the Division 2 Remote Shutdown panels is closed, access to the paging system telephone at the Division 1 Remote Shutdown panel is blocked.
2	19	The handset cords of the paging system phones located at the ends of the panels in the main control room area are too short to allow an operator reasonable mobility at the control surfaces while using the phone.
2	20	No provisions have been made for speech transmission and voice communications while wearing emergency breathing apparatus face masks.
1	21	There are no provisions to store procedures at the two Remote Shutdown panels.
3	22	There is no systematic or sequential correlation between the identification number assigned to each panel and the location of that panel in the main control room area, the back panel area, or the upper cable spreading room.
1	23	The temporary emergency telephones are not readily distinguishable from other black telephones in the control room.

2. WORKPLACE ENVIRONMENT

<u>PRIORITY RATING</u>	<u>FINDING</u>	
2	1	The ventilation in the area of the Remote Shutdown panels is very poor. This condition will be made worse if the fire door separating the two panels is closed.
2	2	The curved-face meters located in the middle and top rows of displays on all vertical boards in the main control room area exhibit glare from the ceiling lights. Although this glare generally does not obscure the scales or pointers of the meters, it is distracting and will induce operator fatigue.
1	3	The SSW SYSTEM B FLOW meter on the Division 2 Remote Shutdown panel exhibits glare from the ceiling lights.
2	4	The CRT displays on Panel 680 exhibit extreme glare from the ceiling lights. This problem is especially noticeable from the position of a seated operator because of the upward tilt orientation of the CRTs.
3	5	Some labels on the back panels are shadowed by their associated displays. While these labels are generally still readable, the shadowing will contribute to operator fatigue.
3	6	The curved-face meters on the vertical boards of the main control room panels have luminance ratios (LRs) that are too high. The portions of the meters that exhibited glare had LRs of approximately 11:1, while the portions without glare had LRs of approximately 5:1 (recommended max LR = 3:1).
3	7	The reflectances off of the displays on the main control room panels are below the recommended 80%-100% range, with the exception of a section of Panel 870 (measured reflectance = 95%). The reflectances measured at the other panels ranged from 3% to 72%.



2. WORKPLACE ENVIRONMENT

<u>PRIORITY RATING</u>	<u>FINDING</u>	
1	8	The emergency lighting system provides inadequate levels of illumination to the areas in front of main control room Panels 870, 601, and 864 (recommended min illumination level = 10 footcandles). The measured levels ranged from 0.2 footcandles in front of Panel 601 to 9.1 footcandles in front of Panel 870.
1	9	There is no emergency lighting provided in the back panel area, other than battery-powered lights indicating the exits. The exit lights do not provide sufficient illumination to allow the operator to read displays or labels at the back panels.
1	10	There is no convenient supply of spare bulbs for the indicator lights on the Remote Shutdown panels. The closest supply of spare bulbs is in the control room which is three levels above the Remote Shutdown area. Since there is no lamp test capability for the indicators on these panels, the operator cannot easily determine the actual status of the indication.

3. ANNUNCIATORS

<u>PRIORITY RATING</u>	<u>FINDING</u>	
1	1	There is no annunciator to indicate NSSSS DIV 2 TRIP UNIT OOFFILE/PWRLOSS as there is for DIV 1 on Panel 601.
1	2	The annunciator tile for RADWASTE BUILDING EXHAUST FILTER A DIFF PRESS HIGH is missing on Panel 854.
1	3	On Panel 601 and Panel 680, the REACTOR LEVEL LOW annunciators are illuminated for different low water levels within the reactor. However, the specific level associated with each annunciator alarm is not indicated by the annunciator legend.
1	4*	Annunciator windows that have multiple inputs or channels do not have the capability for reflash if the first alarm has not cleared.
1	5	There is no first-out alarm panel. Alarms are stored in the process computer for printout in the order of occurrence.
1	6	The annunciator response procedures have not been properly coded to the panel identification and matrix location systems.
3	7*	Annunciator tiles are not consistently grouped according to priority. Although functional grouping on most panels is generally good, the grouping according to priority is not consistent. The practice of locating the red (trip) tiles on the top row of the annunciator panel is not followed on all panels.
1	8	The FEEDWATER annunciator tiles on Panel 680 are white. These tiles should be amber to conventionally identify second level of consequence alarms.

3. ANNUNCIATORS

PRIORITY  
RATING

FINDING

1	9*	Some annunciators are not located above their associated controls and displays. Two examples of this are the MSR annunciators on Panel 680 and the ADS-B annunciators on Panel 601. The MSR annunciator tiles are on section 8A, while the related controls and displays are on sections 9C and 10C. The ADS-B annunciator tiles are on section 18A, while the related controls are on section 19C. The ADS annunciators are grouped in an unconventional B-left / A-right arrangement while the associated ADS controls and displays are grouped in a conventional A-left / B-right arrangement.
1	10	The CRD ISOLATION VALVE annunciator tile is not located with the other CRD annunciators on Panel 601.
3	11	The bulbs for the small annunciators on Panel 680 are difficult to remove and replace. The small bulbs are hard to grip and are easily dropped.
1	12	The annunciator tile label 480 VCCC 13BD3 on Panel 807 should read 11BD3.
1	13*	The annunciator alarms have no visual or audio signal which indicates a cleared alarm. Presently, a tile for a cleared alarm will remain illuminated until the RESET response control is pressed. This will erroneously indicate to the operator that the alarm condition still exists.
3	14	The annunciators on Panel 855, which are not tilted forward, exhibit significant glare when unlit.

4. CONTROLS

PRIORITY  
RATING

FINDING

- | <u>PRIORITY</u><br><u>RATING</u> | <u>FINDING</u> |   |
|----------------------------------|----------------|---|
| 1                                | 1              | The REACTOR FEED PUMP TURBINE TRIP A and B pushbuttons on Panel 680 are not readily distinguishable from other nearby pushbuttons and are not guarded to prevent inadvertent actuation.   |
| 1                                | 2              | The RCIC MANUAL ISOLATION pushbutton on Panel 601 is not readily distinguishable from the adjacent RCIC RESET and RCIC MANUAL INITIATE pushbuttons. The RCIC MANUAL ISOLATION pushbutton is not guarded to prevent inadvertent actuation.   |
| 3                                | 3              | The pairs of rectangular pushbuttons used on Panel 680 do not have sufficient physical separation or tactile differentiation between the two buttons to prevent inadvertent or incorrect actuation. The pushbuttons of each pair generally have opposite functions (e.g. Close/Open, Start/Stop), but an operator could easily make an error if not looking at the button while actuating it. |
| 2                                | 4              | The four pushbutton IRM RANGE SELECTOR switches on Panel 680 are 3/4 inch square and are separated by 1/4 inch with no barriers between the switches. These switches can be inadvertently or incorrectly actuated.  |
| 1                                | 5              | The INFLUENCE LIMIT control temporarily installed on top of the Panel 680 console is mounted too high and is too near the console edge where it is vulnerable to inadvertent actuation.   |
| 3                                | 6              | Unprotected J-handle switches protrude 2 1/2 inches from the vertical back panels. These handles are vulnerable to inadvertent activation.  |

4. CONTROLS

PRIORITY RATING

FINDING

- |    |    |  |
|----|----|--|
| 1  | 7  | The IRM, APRM, and SRM BYPASS switches for NEUTRON MONITOR BYPASS DIVISION 1 in the left center depressed section of Panel 680 do not lock into the activated position. It is possible to accidentally deactivate these switches while reaching past them for the RPS A, RPS B, and OOSVS switches.  |
| 1  | 8  | An easily accessible internal slide switch in the Bailey flow controller units can reverse the control action of the units. There is no front panel indication of the switch position.   |
| 1  | 9* | Rotary switches on Panel 870 are grouped in large, evenly spaced, rectangular arrays with only labels to identify the function of each control. The largest of these rectangular arrays is a 6x5 matrix of switches. This arrangement impedes rapid and correct selection of a specific control within a group.  |
| 1  | 10 | The white color of the FR 1ST FO43A JOG OPEN backlit legend pushbutton switch in the XOVER PIPE LS TR VLV group on Panel 680 does not conform to the OPEN=Red indicator light color convention used in the control room.   |
| 31 | 11 | The MANUAL SCRAM pushbuttons on Panel 680 have inconsistent color-coding: three are pink and one is red.   |
| 1  | 12 | There is excessive use of keyswitches. Use of large numbers of keyswitches that are operated by identical keys provides little protection from unauthorized operation of the controls.   |
| 1  | 13 | The LOWER (speed decrease) pair of MANUAL SPEED CHANGE pushbuttons for each REACTOR FEED PUMP TURBINE on Panel 680 are in an unconventional left to right arrangement. The pair arrangement is:<br>FAST = left (gray) / SLOW = right (black).<br>The associated RAISE (speed increase) pair of pushbuttons are in the preferred arrangement:<br>SLOW = left (gray) / FAST = right (black). |

4. CONTROLS

<u>PRIORITY RATING</u>	<u>FINDING</u>	
3	14	The CGCS DIVISION 1 MANUAL INITIATION RESET switch on Panel 870 has unconventional NORMAL/RESET positions compared to similar controls at other locations.
1	15	The DIESEL GENERATOR MANUAL GOVERNOR, MANUAL VOLTAGE SET, and AUTO VOLTAGE SET control switches on Panel 864 which are used for manual control of the diesel generators are not readily distinguishable from adjacent circuit breaker switches. A mistake in switch selection could result in an unintentional trip of an emergency power circuit breaker.
3	16*	The yellow color of the EXECUTE keys on the CRT control keyboards for the computer generated CRT displays on Panel 680 violates the color-code convention of using yellow to denote a potentially hazardous condition.
3	17	The position indication mark on the rotating ARM/DISARM collar of some pushbutton switches is not visible from a location in front of the pushbutton. The operator must lean over and look for the red pointer stripe on the back of the collar to determine the ARM/DISARM status of the pushbutton. An example of this is the HYDRAULIC POWER UNIT SHUTDOWN control on Panel 680.
2	18	The small diameter pushbuttons on the Bailey flow controllers that are mounted flush with the instrument surface or recessed below the instrument surface are difficult to depress.
2	19	The surfaces of some backlit legend pushbuttons are uncomfortably hot to touch when they must be held in the depressed position for more than a few seconds.

4. CONTROLS

PRIORITY  
RATING

FINDING

- |    |     |   |
|----|-----|---|
| 31 | 20  | The white engraved lettering used on the black and gray Cutler-Hammer paired pushbuttons on Panel 680 gives poor contrast between the legend and the dark background. Accumulation of dirt in the white engraved letters has further reduced the contrast and readability of these identification labels. |
| 1  | 21  | The operator cannot readily distinguish between backlit legend pushbuttons and backlit legend indicator lights that are grouped together in the same matrices on Panel 680.   |
| 31 | 22  | The handles of some three-position J-handle switches on Panel 601 obscure the view of the neutral (center) position label.  |
| 3  | 23  | No consistent key teeth orientation convention (e.g., key teeth up or key teeth down) is used for keyswitches.  |
| 31 | 24* | The RECOMBINER SELECT controls on Panel 870 unnecessarily use ten-position rotary switches. Only three of the ten switch positions are used and the remaining seven positions are labeled as unused.  |
| 1  | 25  | The switch positions of some rotary switches are not labeled (e.g., ESF LOGIC DIV 2 switches on Panel 872, STARTUP RANGE PROCESS RADIATION MONITOR switches N11F005A and B on Panel 870).   |
| 1  | 26  | The AUXILIARY BOILER MAXIMUM LOAD controls on Panel 854 do not have control knobs installed and are not labeled to indicate the increase/decrease direction of control rotation.  |
| 2  | 27  | It is fatiguing to the operator to hold some spring-loaded rotary switches in the actuated position for the time required to perform their control function because of the high spring resistance (e.g., LPCS TEST RETURN TO SUPPRESSION POOL switch on Panel 601).                                       |

4. CONTROLS

PRIORITY  
RATING

FINDING

1

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The direction of rotation of the thumbwheel controls on the Bailey flow controllers are not labeled to indicate the direction of rotation to increase or decrease flow.

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The IRM, APRM, and SRM BYPASS four position selector levers have unconventional alphabetical sequences of switch positions (e.g., clockwise position sequences AECG, BFDH, AEC, and BFD).



5. DISPLAYS

PRIORITY  
RATING

FINDING

1	1	The meaning of the two white indicator lights that are associated with the AUX BOILER STANDBY/RUN switch is not clear.
1	2*	The 480V breaker displays on Panel 807, section 2B and section 3A read in volts instead of amps.
3	3	The DROOP indicators on the TURBINE GENERATOR section Panel 680 are not used by the operators.
1	4*	The scale for the PUMP B PRESSURE, on Panel 680, reads 0-3.5 psi. The correct range is 0-1200 psi.
1	5*	The scales for CNPS BOOSTER PUMP FLOW, CNDS PUMP FLOW, and HTR DRN PUMP FLOW on Panel 680 are not consistent with the actual ranges being monitored.
1	6	The CIRCULATING WATER BLOWDOWN VALVE Bailey controllers on Panel 870 and the RFPT-A and RFPT-B Bailey controllers on Panel 680 have different scale indications for the same function (e.g., F513B uses a +/- null scale while F513A uses a % scale).
1	7	The LOAD GRAD and STEAM FLOW DEMAND meters on Panel 680 have no scale indications.
2	8	The TUR MAN/AUTO meters on Panel 680 read in percent full scale rather than in amps for exciter output current and in volts for generator voltage.
2	9	The units on the RTN VLV POS and LVL scales for the LEAK WATER meters on Panel 680 are inconsistent with the parameters being measured.
1	10	The FUEL OIL TANK LEVEL meters for the A and B systems on Panel 865 and the HPCS AUX DG13 LEVEL meters on Panel 870 have scales that use pressure units (e.g., inches of water) rather than level units.

5. DISPLAYS

<u>PRIORITY RATING</u>	<u>FINDING</u>	
1	11	The CNDSR VAC SHELL PRESSURE meters on Panel 680 indicate that they are measuring "ABS PRESS" without assigning the appropriate units.
1	12	The RHR HXA and HXB Bailey controllers on Panel 601 have no unit designations on the scales.
1	13	The REACTOR VESSEL LEVEL display scale on the Division 1 Remote Shutdown panel ranges from -150 to +60. The values (other than -150) that are less than zero are not labeled with the negative ("-") designation symbol.
31	14	The OFF GAS PRE-HEATER INLET meters and the RECOMBINER INLET meter on Panel 845 each use three colored pointers (red, green, and black) with no explanation of the pointer color-coding.
31	15	The display for a Bailey meter on the Remote Shutdown panel for % OPEN does not have the percent symbol included on the scale.
2	16*	Many of the meters on Panel 680 are too small to be read from a distance (e.g., RX WATER LEVEL, RX PRESSURE, FEEDWATER FLOW, and STEAM FLOW).
1	17	Many of the meters on the Remote Shutdown panels have dirty or damaged face plates that obscure the meter scales.
3	18	The flow meters on the Remote Shutdown panels use a small type face in order to show a range from 0-15,000 GPM. The lettering used on these meters is about half the size of the type face used on all the other meters.
3	19	The circuit breaker and valve position indicator lights do not follow the convention of red = unsafe, green = safe, and amber = hazard (potentially unsafe).
1	20*	The displays on the main control room panels, the back panels, and the Remote Shutdown panels do not have normal operating ranges indicated.

5. DISPLAYS

PRIORITY  
RATING

FINDING

- |   |     |  |
|---|-----|--|
| 1 | 21  | The closely spaced indicator lights on Panel 680 are inductively coupled so that bulbs which should be off sometimes glow when an adjacent bulb is on. The status lights on Panel 601 exhibit the same problem.  |
| 1 | 22  | Control indicator lights, some legend lights, and some legend pushbuttons are not equipped with a lamp test capability or with dual filament bulbs to facilitate detection of burned-out bulbs.  |
| 1 | 23  | Some pushbutton controls use indicator lights that have a clear outer bulb with an inner gas discharge element that emits a pale blue glow when the light is turned on. It is difficult to readily determine whether these lights are on or off. In addition, these indicator lights conventionally should be white instead of blue. |
| 1 | 24  | The CONTAINMENT DRYWELL PRESSURE and TEMPERATURE recorders on Panel 87C have only two pens. These recorders require three pens to record the variables of interest.  |
| 1 | 25* | On most strip chart recorders in the control room, the paper scales are in units of percent (0-100%) rather than in the units and ranges used on the installed recorder scales.  |

6. AUDITORY SIGNAL SYSTEMS

<u>PRIORITY RATING</u>	<u>FINDING</u>	
1	1*	The annunciator audio signals do not adequately localize the incoming alarm by the use of signals of different frequencies or patterns.
1	2	The operator cannot identify the location of alarms originating at some panels by the direction of the audio signal. The annunciator alarm signals for Panel 854, Panel 855, Panel 856, and Panel 862 are emitted from Panel 807. The annunciator alarm signals for Panel 601, Panel 864, and Panel 680 come from a single horn located above Panel 601.

7. LABELS AND LOCATION AIDS

<u>PRIORITY RATING</u>	<u>FINDING</u>	
31	1	Panel 870 and Panel 601 have some alpha-numeric panel section designation labels missing.
31	2	Some annunciator panels do not have an identification label located above each panel.
31	3	Some groups of controls do not have hierarchical system labeling to aid the operator in differentiation between the many functional groups of controls. The functional group of FEEDWATER controls and displays on Panel 680 and the TURBINE TEST group of equipment on Panel 870 do not have hierarchical system labels. The HX SYSTEM mimic on Panel 870 has no hierarchical system label or any other identification label.
1	4	The individual safety device test buttons in the TURBINE TEST group of equipment on Panel 870 are unlabeled.
1	5	Each Remote Shutdown panel has two groups of controls that are unlabeled. There are a total of five unlabeled controls on each panel.
1	6	There are two groups of red and green indicator lights on Panel 855 that are not labeled.
1	7	The bank of PLANT SERVICE WATER/RADIAL WELLS legend pushbutton controls on Panel 854 are not engraved or labeled.
1	8	The sound-powered telephone jacks at the end of Panel 807 are unlabeled.
3	9	The alpha-numeric panel section designation labels do not run in sequential numerical order from left to right on Panel 601.
1	10	The labels for several Unit 1 and Unit 2 indicator light and control/indicator light groups on Panel 862 are located with the incorrect group. The differentiated groups of equipment for each unit presently contain both Unit 1 and Unit 2 labels.

7. LABELS AND LOCATION AIDS

<u>PRIORITY RATING</u>	<u>FINDING</u>	
31	11	The hierarchical system label for the OTBD PROC SMPL functional group is larger than the standard system label size. In addition, this label is located below the functional group it identifies, rather than above, as is the control room convention. This may lead to operator confusion about what the label actually identifies.
31	12	The panel identification labels on the back panels are inconsistently located. Some labels are located below their associated control/display groups, while some are located above.
3	13	The labels on the Bailey panel-mounted instruments (e.g. AUX BOILER A AMPL) on Panel 854 are too low to be read. From a standing position in front of this panel, the labels are totally obscured by their associated instruments.
3	14	The labels for four controls on Panel 680, section 3B are located below the associated units, rather than above. These labels are totally obscured by the associated controls when viewed from a standing position at the panel edge.
3	15	The label for the H2 RECOMB A TC SEL rotary control on Panel 870 is below the control rather than above it, as is the control room convention. There is inadequate separation between this label and the correctly positioned label for an adjacent control.
31	16	The annunciator matrix identification labels on Panel 680 are made of temporary labeling material and are not uniformly positioned.
31	17	The labels for the meters on Panel 694 do not include parameter identification of the information that is being displayed.

7. LABELS AND LOCATION AIDS

<u>PRIORITY RATING</u>	<u>FINDING</u>	
31	18*	The labels on two trend recorders on Panel 855 indicate that these recorders monitor two parameters, when actually each monitors only one (flow).
31	19	The hierarchical labels for the groups of RCIC TURB and RCIC PUMP meters do not clearly apply to all of the three meters in each group. The hierarchical label for the RCIC TURB group is too closely incorporated into the individual label for the SP meter which is centrally located in the group. The RCIC PUMP hierarchical label is too closely incorporated into the individual label for the DISCH DR meter.
1	20	The labels for three recorders on Panel 855 are incorrect. The FRESH AIR UNIT A DIFF PRESS label should read FRESH AIR UNIT B DIFF PRESS. The REFRIGERANT CPRSR A label should read FRESH AIR UNIT A DIFF PRESS. The AIR CONDITIONER UNIT A IN DAMPER should read AIR CONDITIONER UNIT B IN DAMPER.
1	21	The labels for two meters on Panel 807 are incorrect. The label that reads 480V BREAKER should read VOLTS. The label that reads 480V BUS should read SPARE.
31	22	The label that reads RECIRC PUMP for the pump symbol in the RCIC mimic on Panel 601 is incorrect. The pump indicated by this symbol is an RCIC pump.
31	23*	The labeling used in the control room does not use consistent abbreviations, terminology, or syntax. This is especially a problem when the labels for associated controls and displays are not consistent.
31	24	The Bailey meter and square root extractor on the Division 1 Remote Shutdown panel have labels that are a different color and type face from the other labels on the panel.

7. LABELS AND LOCATION AIDS

<u>PRIORITY RATING</u>	<u>FINDING</u>	
31	25	Two terminations on the electrical distribution mimic on Panel 807 are inconsistently labeled. One termination label reads 500 KV SYSTEM, while the other reads SERV XFMR NO. 21. The drawings indicate that the terminations should have been labeled 500 KV SYSTEM at both locations. Two additional labels should have been located adjacent to the terminations that read SERV XFMR NO. 11 and SERV XFMR NO. 21.
1	26	The abbreviations used on the new labels installed in the main area of the control room do not agree with the abbreviations used in the operating procedures.
31	27	A Fischer controller on Panel 680 uses unconventional and inconsistent symbols to indicate "manual" and "automatic" operations.
31	28	The divisional identification labels on Panel 855 use Roman numerals (I, II). Arabic numerals are conventionally used in the control room.
31	29	The labels used to identify individual components on Panel 870 are inconsistently engraved. There is wide variation in the engraved depth of the letters, in the stroke width, and in the spacing between the letters.
31	30	The identification labels for the meters in the D21 RADIATION MONITOR MODULE on Panel 844 are located to the side of each row instead being associated with each meter. Each individual meter has an aluminum label that is used only for maintenance identification.
31	31	The maintenance labels for the meters in the D21 RADIATION MONITOR MODULE on Panel 844 have unpainted lettering that is of low contrast with the shiny aluminum surface.
31	32	The hierarchical label for the TURB GEN AUX system uses a different size lettering and a different type face than is used for the other system labels on Panel 680.



7. LABELS AND LOCATION AIDS

<u>PRIORITY RATING</u>	<u>FINDING</u>	
1	33	The valve controls on the Remote Shutdown panels have temporary tape labels that give the associated valve numbers.
1	34	The temporary maintenance tags on the TRIP UNIT CARD FILE on Panel 855 obscure the switches below this unit.
1	35	The temporary labels used in the control room do not always conform to good human factors engineering principles concerning color, contrast, and letter size.
1	36	The tags that are planned for the tag-out system are large (3"x6"). These tags will be large enough to obscure the label associated with the tagged unit and will also be capable of obscuring the labels and indicators of adjacent units.
31	37	The related controls and displays on Panel 854, Panel 855, Panel 856, and Panel 862 are not sufficiently identified as functional groups. No use of demarcation is made on these panels.
31	38	The tape used for the mimic lines in the main control room area is easily peeled or rubbed off. The RHR A mimic lines on Panel 601 are especially easy to remove.
31	39*	There are several cases of mimic discontinuity. Some mimic lines end with no termination labels. For example, the mimic lines going to and from HX B in the CCW mimic on Panel 870 do not have adequate labeling to indicate the beginning and termination points.
31	40*	There are several different methods used to indicate mimic line intersection. These methods do not always clearly indicate what occurs at the intersection (e.g. overlap, joining, no intersection, etc.).

7. LABELS AND LOCATION AIDS

<u>PRIORITY RATING</u>	<u>FINDING</u>	
31	41	The mimic colors used on the Remote Shutdown panels are not consistently applied. Blue is used for both water and low pressure steam. Green is also used for water.
1	42	All the mimics on the Remote Shutdown panels have some errors and inconsistencies: <ul style="list-style-type: none"><li>. Some lines are incorrectly color-coded.</li><li>. Some equipment labels are included in the mimics for equipment that is no longer included in the system design.</li><li>. Some terminations are not labeled.</li><li>. Some mimic lines are missing.</li></ul>
31	43	The ADS/SRV system mimic on Panel 601 contains a conceptually misleading depiction of the flow path from the safety relief valves to the suppression pool. The mimic indicates flow from only one SRV to the suppression pool. This is an incorrect representation, since all SRVs discharge to the suppression pool.
31	44*	Some of the tape used on the mimics in the main control area has outlined, clear arrows to indicate flow while some has filled-in, dark arrows. The clear arrows are of low contrast to the rest of the tape and cannot be seen easily.
31	45	The mimic tape containing the outlined, clear arrows is very reflective and exhibits significant glare. This glare makes the clear arrows very difficult to follow.
31	46	There is not enough contrast between the light blue mimic tape and the white mimic tape used on a Panel 601 mimic. These different colored mimic lines are positioned near each other in the mimic and may be misinterpreted to be the same color.

8. PROCESS COMPUTER

<u>PRIORITY RATING</u>	<u>FINDING</u>	
3	1	Some keywords for access to the computer exceed the recommended maximum of seven characters.
3	2	Many pages of the computer display do not contain a title or other type of functional designation.
3	3	The keyboards on the Panel 680 console do not have the capacity for correcting an error in a single keystroke. The entire corrected input must be entered.
3	4	The alphabetic keyboards on the Panel 680 console do not have a standard QWERTY arrangement of keys.
31	5	The numeric keypad for the Safety Parameter Display System is non-standard and does not conform with other keypads in the control room.
3	6	The keys on the keyboards of Panel 680 require excessive operator effort due to their high actuation resistance.
3	7	There is a long delay (10-15 sec) in the response of the computer to certain input commands. There is no message to acknowledge to the operator that the command is being processed.
3	8	There is noticeable flicker on the CRT mimics when certain colors are used (e.g., light blue and green).
2	9	The alarm displays on the CRTs are very difficult to read. The displays exhibit poor character legibility and low contrast between the red characters and the black background.
3	10*	The CRT brightness and focus controls are not available to the operator. Adjustment of these controls requires the assistance of a maintenance electrician.
2	11	The CRT prompt and advisory messages at the bottom of the screen are not visible to seated operators.

8. PROCESS COMPUTER

<u>PRIORITY RATING</u>	<u>FINDING</u>	
2	12	The value bar graph display option on the CRT screen shows all bar graphs with a scale in 0-100% rather than in the engineering units of the parameter that is being displayed.
3	13	Many data display formats made available by the process computer require several pages of display. However, there is no indication of how many pages are in each data display until the last page is reached.
2	14	One of the pumps on the CCW CRT display is color-coded white for flow indication instead of red (which is conventionally used in this control room).
2	15	The CRT display color-codes are not always consistent with colors used elsewhere in control room. There are also some color-coding inconsistencies between different CRT displays.
2	16	The Terminet printers have a speed of 50 lines/minute. The recommended speed is 300 lines/minute.

9. PANEL LAYOUT

<u>PRIORITY RATING</u>	<u>FINDING</u>	
2	1*	Some controls and indicators for the HPCS DIESEL GENERATOR are located on Panel 870, while the rest of the HPCS system is located on Panel 601.
3	2	The SERVICE WSTE WTR PRESS meters on Panel 854 for Unit 1 and Unit 2 are not installed with the same orientation as the Unit 1 and Unit 2 sections of the control room. The annunciators associated with these meters are in the same orientation as the control room.
2	3	While increasing or decreasing power using the RECIRC MASTER CONTROLLER on section 3D of Panel 680, the operator must simultaneously watch the IRM and APRM recorders on section 5B and section 7B.
2	4	The CRD HDR WTR meters are located on Panel 601, while the other CRD controls and displays are located on Panel 680. The information provided by these meters is needed during operation of the control rod drive system.
2	5	The RHR-B FLOW TO HD SPR keyswitch and the RHR-B TO HD SPR FLOW recorder are located in the RHR-A area of Panel 601. These should be located in the RHR-B area of Panel 601.
3	6	Three groups of related controls on Panel 870 are arranged in non-sequential numerical order. These groups are: <ul style="list-style-type: none"><li>. the DRYWELL COOLING FAN switches,</li><li>. the DRYWELL COOLING WATER switches, and</li><li>. the DRYWELL COOLING DAMPER switches.</li></ul>
3	7	The AUX BLDG FUEL HANDLING VENT recorder channel selector rotary switches on Panel 600 are arranged in a non-sequential alphabetical order. The left-hand switch positions are labeled MON A and MON D. The right-hand switch positions are labeled MON B and MON C.
2	8	The Main Steam Line Isolation safety relief valves switches on Panel 601 are not arranged in sequential alphabetical order.

9. PANEL LAYOUT

<u>PRIORITY RATING</u>	<u>FINDING</u>	
31	9	The high density placement of HVAC controls and indicators on Panel 842 makes it difficult to identify any related groups. This equipment is not logically grouped by area and/or building.
1	10	The control/indicator light groups for JOCKEY PUMP B - RHR and the RHR JOCKEY PUMP B SUCTION ISOL VALVE are used with other B Loop controls and displays on Panel 601, section 17C. These groups are presently located on Panel 872.
3	11	The FUEL POOL COOLING pump and valve controls on Panel 642 are grouped with leak detection equipment with which they are not functionally associated.
3	12*	The entire 500 KV switchyard mimic on Panel 807, while agreeing with the line drawing of the switchyard, is reversed from the layout of the Unit 1 and Unit 2 areas of the control room. Two terminations on the 500 KV switchyard mimic are reversed in layout from the corresponding terminations on the electrical distribution mimic on the same panel (SVCE XFMR 21 and 11 on the switchyard mimic and SVCE XFMR 11 and 21 on the electrical distribution mimic).
3	13	The layout of associated controls and meters on Panel 807 is poor. Some arrays of horizontally oriented controls are related to arrays of vertically oriented meters. Some controls are in different sequential numerical order than their related meters. There are several groups of horizontally oriented controls that are related to meters that are in a mixed horizontal and vertical layout. Some pairs of meters that must be read simultaneously are located in separated meter strings.
3	14	The layout of Panel 854 is generally overcrowded and poor. Functionally related controls for the AUX BOILER A and B are separated by shared controls for the DEAERATOR. Other groups of related shared controls are intermixed with unrelated controls.

9. PANEL LAYOUT

PRIORITY  
RATING

FINDING

3

15

There is one string of seven meters and one string of eight meters in the HPCS system on Panel 870. The RCIC TURBINE and RCIC PUMP meters on Panel 601 are grouped together in a string seven meters long. The recommended maximum number of meters in a string is five.

3

16

The displays for LOOP A and LOOP B on Panel 680, section 2D are layed out in a partially mirror-imaged arrangement.

10. CONTROL-DISPLAY INTEGRATION

<u>PRIORITY RATING</u>	<u>FINDING</u>	
3	1	Groups of related controls and displays are separated by unrelated controls/displays. For example, related SERVICE AIR controls and displays on Panel 854 are separated by a group of unrelated backlit pushbuttons. In addition, the controls and displays for the PLANT SERVICE WATER/RADIAL WELLS on this panel are separated by the SERVICE AIR PRESSURE display.
3	2	Some controls and system status displays on Panel 601 are unnecessarily grouped close together. The NSSSS INBOARD controls and system status displays and the STANDBY LIQUID CONTROL system controls and status displays are in a single group with large areas of blank panel immediately adjacent.
2	3	The range selector switches for the pens and displays of two pen strip chart recorders on Panel 680 and Panel 870 have inconsistent left/right relationships. The left switch selects the range of the right display (front pen) and the right switch selects the range of the left display (rear pen).
1	4	Some Bailey flow controllers have display response that is reversed from the associated control action. When the right-hand pushbutton (OPEN) is depressed, the display pointer moves to the left (0%). When the left-hand pushbutton (CLOSE) is depressed, the display pointer moves to the right.
3	5	Pressure indicator displays are needed in addition to indicator light displays to monitor and verify the operation of the MSIVs. Pressure indicator displays are not included with the indicator light displays on the MSIV relay panels, Panel 654 and Panel 655.
2	6	The REACTOR WATER LEVEL SIGNAL FAILURE indicator light on Panel 680 is not located near the related REACTOR WATER LEVEL SIGNAL selector switches. Instead it is located in the RFPT-A group of controls and indicator lights.



#### HUMAN FACTORS STRENGTHS OBSERVED

The concentration of plant operating information and interactive CRT displays on Panel 680 is good.

The steep sloping benchboards of Panel 870, Panel 864, and Panel 601 provide large benchboard areas while facilitating acceptable reach distances to the vertical panels.

The emergency lighting system activates automatically with no interval of complete darkness following failure of normal power. This should minimize eye adaptation problems for the operator.

In general, the annunciator tiles are well positioned above the controls and displays to which they relate.

Legends on annunciator tiles on the stand-up consoles are generally very legible and contain concise, descriptive messages.

Annunciator response controls are centrally located for most work stations and are generally easily identified.

Legends and scale markings on most displays are easily readable.

Most displays are mounted in the primary viewing area of the control panels.

The new labeling and demarcation system works very well to functionally group and hierarchically identify the related control and display elements.

The new labels (black lettering on white background) are generally very readable, and the standard abbreviation list is consistently applied.

The computer system is designed to provide reasonably effective operator interaction, and data presentation formats are effective and reasonably consistent.

The CRT's and keyboards at the 680 console are well located to support operator activities.

The layout of the HPCS, RCIC, LPCS, and RHR A & B systems' controls and displays on Panel 601 are generally very good.

### SYSTEMS THAT COULD NOT BE EVALUATED

Temperature, humidity, ambient noise level, and alarm levels above ambient could not be evaluated because the permanent HVAC system was not in its final configuration.

The temporary installation of the NSSS Operator's CRT Keyboard, NSSS CRT, and NSSS Peripheral Table prevented a complete evaluation of this system and its final installation configuration.

There are no sound-powered telephone headsets in the control room or at the Remote Shutdown panels. The performance of the sound-powered telephone system could not be evaluated.

The temporary installation and location of the NRC Hotline and Local Offsite Emergency telephones in the control room precluded evaluation of the final emergency telephone installation.

The use of hand-held walkie-talkie radios could not be fully evaluated. Areas of poor walkie-talkie radio transmission/reception are not identified or documented.

Provision and marking of storage locations of emergency equipment for use by control room personnel and by operators at the Remote Shutdown panels could not be evaluated. Adequacy and availability of emergency equipment, operator training in the use of emergency equipment under emergency operating conditions, and procedures for maintenance and inventory of emergency equipment could not be evaluated.

Operational storage and availability of procedures and reference material could not be evaluated.

Many strip chart recorders do not have chart paper. The suitability of the final installation of chart paper and the legibility of the recorder displays could not be evaluated.

Labels on Panels 807, 854, 855, 856, 862, most back panels, and the Remote Shutdown panels are being changed. Labels and location aids on these panels could not be evaluated.