UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

OCT 14 1981

MEMORANDUM FOR: Frank J. Miraglia Jr., Chief, Licensing Branch No. 3, Division of Licensing

FROM: Voss A. Moore, Chief, Human Factors Engineering Branch, Division of Human Factors Safety

SUBJECT: CONTROL ROOM DESIGN REVIEW/AUDIT REPORT, PALO VERDE UNIT 1

Please transmit the enclosed Human Factors Engineering Control Room Design Review/Audit Report for Palo Verde Unit 1 to the Arizona Public Service Company for review and comment. Inform the applicant to contact us if it has any questions regarding this report. Also, we request that you arrange for a meeting on October 22, 1981, with the applicant to discuss its proposal to correct deficiencies identified in the enclosed report and the schedules for implementing its corrective actions. We should receive a report of the applicant's proposal (excluding PDA items already addressed) by October 21st at noon.

The enclosed report was prepared on the basis of a review of the applicant's Preliminary Design Assessment (PDA) and the design review information provided by the Human Factors Engineering Branch team and consultants that conducted the Palo Verde Unit 1 control room design review/audit. The team members included D. Tondi, R. Ramirez, and A. Ramey-Smith of the NRC, and our consultants from Lawrence Livermore National Laboratory and BioTechnology, Inc.

Voss A. Moore

Voss A. Moore, Chief
Human Factors Engineering Branch
Division of Human Factors Safety

Enclosure:
Palo Verde Unit 1 Control Room Design Review/Audit Report

cc: S. Hanauer
J. Kramer
DHFS Branch Chiefs
D. Tondi
S. Weiss
J. Kerrigan
J. Savage, LLNL
R. Hatterick, BTI
HFEB Members

HUMAN FACTORS ENGINEERING
CONTROL ROOM DESIGN REVIEW/AUDIT REPORT

PALO VERDE NUCLEAR GENERATING STATION
ARIZONA PUBLIC SERVICE COMPANY

Introduction

A human factors engineering design review of the Palo Verde control room simulator was performed at the site on September 15 through September 17, 1981. The report was prepared on the basis of the HFEB's audit of the applicant's Preliminary Design Assessment and the human factors engineering design review performed at the site. This design review was carried out by a team from the Human Factors Engineering Branch, Division of Human Factors Safety. 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 factors design discrepancies were given a priority rating of 1, 2 or 3 (high, moderate or 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 in accordance with the guidance provided in NUREG-0700. Note that some priority 3 ratings include a superscript 1 (i.e., 3^1). Since priority 3^1 discrepancies involve simple corrective actions relative to the potential for improving operator performance, they should be corrected prior to issuance of an operating license.

The following sections are numbered to conform to the guidelines 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 the human factors strengths observed in the Palo Verde control room simulator is given at the end of the nine major sections of this report. This list includes those features that the review team felt enhanced the operator interface with the control room simulator. 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.

It is expected that the plant control rooms will be made to exactly match the simulator and that the licensee's commitments to correct discrepancies included in this report will apply to both.

HUMAN FACTORS ENGINEERING
CONTROL ROOM DESIGN REVIEW/AUDIT REPORT

PALO VERDE NUCLEAR GENERATING STATION
ARIZONA PUBLIC SERVICE COMPANY

1. CONTROL ROOM WORKSPACE

PRIORITY RATING	FINDING	
3	1*	The control room bookshelves are inadequate. (056C)
2	2*	Glare is a problem for most displays on all of the panels. It is worst on the "C" surfaces, depending on viewing angle. (See Fig. 1 on page 3 for the meaning of "A","B","C, and "D" surfaces.) (049C) (064C) (100B) (101B) (103C)
1	3*	Glare on CMC switch surfaces hinders "light-on" determination. This is more apparent on the "C" surfaces. A matte surface might not be as effective a solution as brighter lights. Example: (Panel B02) a.) ESF SWGRA/EQPT Room switch (098C)
3[1]	4*	The concrete control room floor is not carpeted, which will lead to earlier fatigue during long periods of standing by the operators. (068B)

---

* Discrepancy also noted in Arizona Public Service Palo Verde Nuclear Generating Station Control Room Human Factors Study. The numbers in parentheses at the ends of these discrepencies are the ID's from the APS study.

PALO VERDE

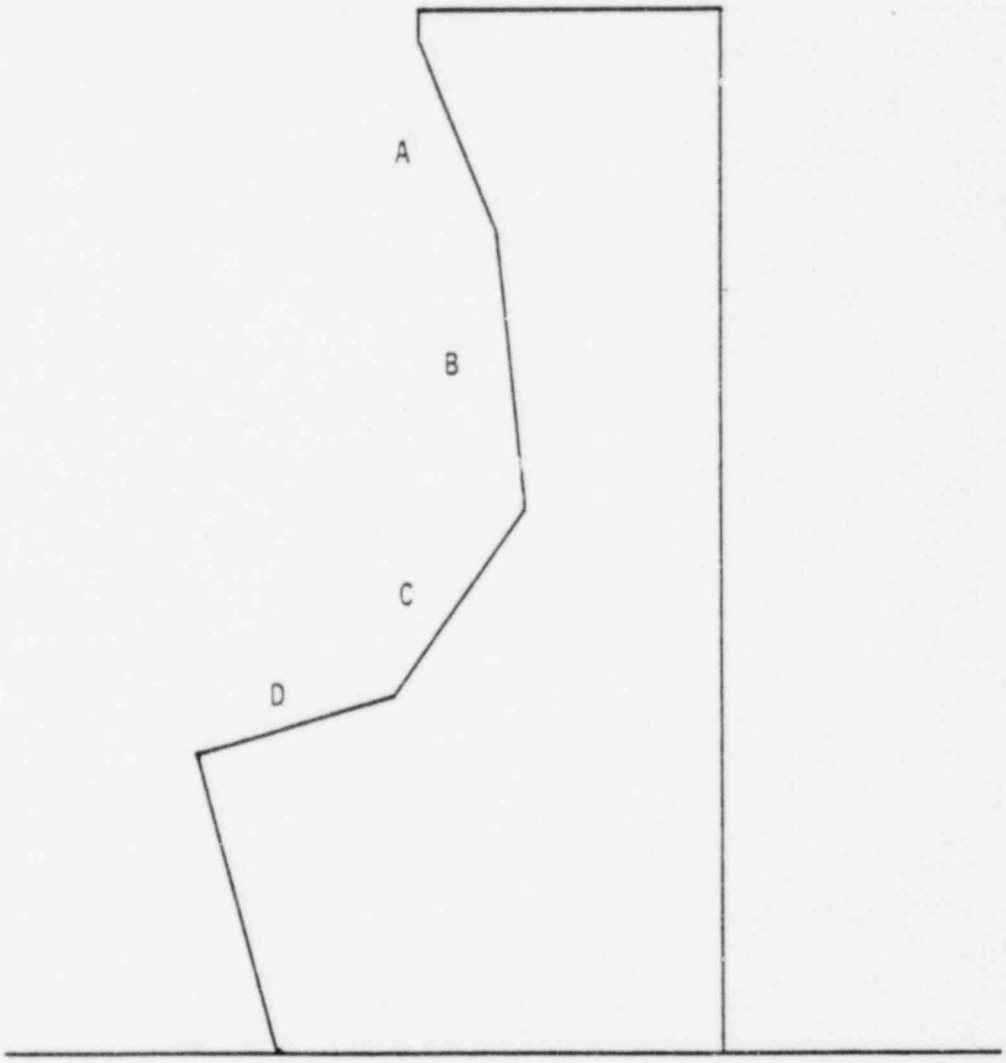

FIG. 1. Identification of control board surfaces.

2. COMMUNICATIONS

PRIORITY RATING	FINDING	
1	1	Instructions are not provided for the use of the communication systems.
1	2	Procedures have not been established for handling incoming communications at night or during emergencies.
1	3	The switching mechanism for the conventionally powered telephone system is not programmed to give the control room automatic priority access to the switching system.
1	4*	The short telephone cords prevent total panel coverage by the operators. The problem is particularly acute on the CVCS and Condensate System panels. (067B)
3[1]	5	No address labels and/or index are supplied for sound-powered phone jacks in the control room.
1	6	EMI noise susceptibility tests have not been conducted to demonstrate that low-level analog or digital equipment is not affected by the frequency bands used by walkie-talkies.
1	7	Procedures have not been developed to provide unambiguous identification of the person speaking on the walkie-talkie when there are two or more parties on a channel operating at separate locations.

3. ANNUNCIATOR WARNING SYSTEMS

PRIORITY RATING	FINDING	
1	1*	The Annunciator System has several discrepancies. (118A)
3	2	Some alarms require the operator to direct an auxiliary operator to a given plant location to obtain specific information. Example: (Panel B07) a.) Rad Waste System Trouble Tile
2	3	Some annunciators (e.g., some systems on Panel B07) have inputs from more than one plant parameter, but an alarm printout capability is not provided to identify the alarm source.
3	4	The Turbine Generator System First-Out annunciator panel on Panel B04 should be located with the turbine/generator controls on Panel B06.
3[1]	5	The Turbine Generator System First-Out annunciators on Panel B04 have tiles with small print font.
3[1]	6	The nature of the annunciator auditory signals could, in some cases, cause irritation or a startled reaction.
1	7	A logical alarm prioritization has not been applied to allow operators to differentiate the most serious alarms from less important ones.
1	8	Auditory signals do not enable the operator to identify the work station location or system associated with the alarm.
1	9	More than 5 separate frequencies have been used for audible signal coding. The present use of eleven unique frequencies is excessive.
2	10*	The Condensate Low Vacuum alarm should be located on Panel B07 and not on Panel B05. (095B)
2	11*	The Plant Monitoring System Trouble alarm should be located on Panel B04 and not on Panel B01. (094C)
1	12*	There are no Main Generator Trip alarms near the associated controls on Panel B06. (045B)
3[1]	13	Annunciator panels are not identified by labels above the panels.
1	14	No procedure exists to ensure that a legend tile is replaced in the correct location after it has been removed for lamp replacement.

3. ANNUNCIATOR WARNING SYSTEMS

PRIORITY RATING	FINDING	
1	15*	Reaching annunciators to replace lamps poses a safety problem. (004A)
2	16	Annunciator tiles do not illuminate and burn steadily in case of a flasher failure.
3[1]	17	The vertical and horizontal axes of annunciator panels are not labeled with alphanumerics for easy coordinate designation of a particular visual tile.
3	18	The number of alarm tiles exceeds the suggested limit of 50 tiles per matrix.
1	19	Cues for prompt identification of an out of service annunciator are not provided. Rather, periodic testing is required to determine whether an annunciator is out of service.
1	20	The "Seal Oil/H_2 Diff Press Lo" tile on Panel B06 should be reworded to indicate whether the turbine or the generator is being referred to.
3[1]	21*	Inconsistent terminology exists between alarms and controls for Generator Seal Oil on Panel B06. (091C)
3[1]	22*	Inconsistent abbreviations are used on alarm legends. Example: (Panel B06) a.) COND vs. CNDS (090C)
3[1]	23*	Inconsistent alarm legends exist for Linear Power Density on Panel B05. (085C)
1	24*	On Panel B04, the annunciator legend is incorrect for T-AVG and T-REF temperature deviation and for RC SYS TRBL. (081A)
3[1]	25*	Inconsistent terminology exists between H_2 Train alarms and associated control labels on Panel B02. (073C)
3[1]	26*	On Panel B06, inconsistent terminology exists on the alarm window for Header Pressure, (i.e., the word "system" in "Condensate Pump Hdr Press Syst Trouble" should be deleted.) (047C)
3	27	Some alarms on Panel B07 refer the operator to other, more detailed annunciator panels located outside the primary operating area. Example: a.) Rad Waste and Fuel Pool.

3. ANNUNCIATOR WARNING SYSTEMS

PRIORITY RATING	FINDING	
2	28	Some tile legends do not address specific conditions. For example, one alarm is used for Hi-Low and Temperature-Pressure.
1	29	Administrative procedures do not exist which require and control the periodic testing of annunciators.
3[1]	30	Annunicator response controls have not been coded for easy recognition.

4. CONTROLS

PRIORITY RATING	FINDING	
1	1	The manual activation circuitry for the Panel B05 ESFAS system is based on selected two out of four logic which is different from the auto ESFAS which operates on any two out of four logic.
3	2	When GE switch handles are allowed to spring back from "Stop," the position indicator flag may go to "red" instead of staying on "green." Example: (Panel B06) a.) Switch FWPT A Turning Gear R01A
3[1]	3*	There is a problem distinguishing among the five types of Foxboro controllers and displays. (105C)
1	4*	On Panel B05, the Manual Reactor Trip controls lack protection covers. (086A)
1	5*	On Panels B03, B04, B06, and B07, several controls are too close to the panel edge, increasing the likelihood of accidental activation. (025A)
1	6*	The protection covers on some of the setpoint reset controls on Panel B05 can be left open.
3[1]	7	There is an inconsistent use of black and amber bezel color coding on CMC switches. Examples: (Panel B03) a.) Reactor Drain Tank Outlet Isolation Valve b.) Makeup Supply to Reactor Drain Tank Valve
1	8*	The red/green color coding of the Generator Field Excitation pushbuttons is reversed on Panel B06. (035B)
3[1]	9*	It is possible to interchange legend screens on pushbutton legend controls if more than one is removed at a time. Example: (Panel B07) a.) Cooling Tower Fan Control panel (050C)
3[1]	10*	The Panel B03 keyswitch for Letdown Control Valve Bypass (CHN-H5-526) requires keyteeth pointing up, which violates the control room convention. (059B)
3[1]	11*	On Panel B02, there is too strong a resistance for keyswitches requiring activation for long periods. These keys have small key heads, aggravating the situation. (113C)

4. CONTROLS

PRIORITY RATING	FINDING	
3[1]	12	Some CMC switch position indicators point between switch positions. Example: (Panel B03) a.) Pre-Holdup Iox Inlet Bypass Selector
3[1]	13*	Control position is not visible during use of the Nuclear Cooling Water HX control on Panel B07. The pointer on the knob will be covered by the operator's hand. Also, position indications are obscured by the knob.
3	14	There is an excessive use of keylock switches in the control room.

5. DISPLAYS

PRIORITY RATING	FINDING	
2	1*	There is no valve position indication for the Demineralizer Differential Pressure Control Bypass Valve on Panel B05. (031C)
2	2	On Panel B05, channels A, B, C and D have Calculator Select controls for CEAC. However, this capability exists only on channels B and C.
3	3	On Panel B05, operators have been given the ability to calibrate the "actual" power level indicator using a helipot control which appears on the benchboard. The "actual" level appears on the same Foxboro display as the "sensed" power level, which varies with time. Inadvertent use of the control can cause false power level readings if the calibration is changed.
1	4*	The loss of one of the two signal trains causes the status of 2 loops to be indeterminant in the High Pressure Safety Injection Flow indication on Panel B02. (077A)
2	5*	On Panel B06, there is inadequate Steam Generator Level indication during manual, auxiliary and main feedwater control. (089A)
3	6*	Foxboro recorders do not provide good resolution over a short time range because of a slow recording speed. (106B)
2	7*	There is no overload indication on the ammeters for large pumps. (075C)
1	8*	On Panel B05, there is inadequate indication of safety system status (i.e., SIAS, MSIS, CIAS, etc.). (029A)
2	9*	There is a need for a wide-range pressure and level indication near the pressurizer controls on Panel B03. (017B)
3	10*	The large size of the Power Factor meters found on Panel B06, is not consistent with their importance. (092C)
3	11	There is an unnecessary, redundant indication for the Refueling Water Tank Level (CHN-LI-700) on Panel B03.
3	12*	There is a lack of intermediate valve position indication for jog-open valves on Panel B06. Valve position is known only when valve is fully open or fully closed. (108A)

5. DISPLAYS

PRIORITY RATING	FINDING	
1	13*	A large number of Foxboro meters and recorders have a 0 - 100 (i.e., %) scale instead of an engineering unit scale. Example: (Panel B05) a.) The SG level indicators are scaled 0 - 100% for both the narrow and wide range. (083B)(111C)
2	14	The plastic faces of the Foxboro displays seem to scratch and become obscured easily. They also produce excessive glare.
1	15	The blue switch position indicator lights, on CMC switches, are not clearly visible in the ambient control room light. Example: (Panel B07) a.) Containment Purge Mode Selector
3[1]	16	Some Foxboro display scales incorporate leading decimals which are difficult to notice, leading to possible misreading of the scale numerals.
1	17*	On all Foxboro displays in the control room, the engineering units of parameters being measured are not given. (007A)
3	18	On many displays, e.g., the small ammeter displays, the graduation size is too small and the scale labeling is hard to read.
3[1]	19	Foxboro meters having major, intermediate, and minor graduations do not differentiate intermediate and minor by using different index lengths. Instead, index mark thickness is used, and is difficult to discriminate.
3	20	There is a poor scale progression on some meters. Examples: a.) LOOP 1A T-HOT / LOOP 2A T-HOT b.) LOOP 1A T-COLD / LOOP 2A T-COLD
3	21	Foxboro display scale units are sometimes inconsistent in their use of decimal points. For example, some have 100, 200, etc. while others use .1K, .2K etc. Example: (Panel B06) a.) AFW PUMP B DISCH PRESS
3	22	Red/green coloring is used to denote open/closed, following the industry convention. However, red/green are also used for other coding besides valve and breaker positions.

5. DISPLAYS

PRIORITY RATING	FINDING	
3[1]	23*	The Core Protection Calculator indicator lights on Panel B05 have incorrect color coding. (116C)
3[1]	24*	The Plant Protection System relay status lights on Panel B05 are incorrectly colored. (087B)
3	25	Foxboro displays have a parallax problem, especially those located on the lower part of the benchboard.
3[1]	26	Zone markings have not been used on meters to show the operational implications of various readings (e.g. "Danger Range").
2	27*	The scales in the Foxboro displays are loosely fitted, allowing incorrect positioning. (102C)
2	28*	There is a lack of lamp redundancy in the CMC switches. (002C)
2	29*	There is a lack of lamp redundancy on the Generex panel on Panel B06. (032C)
2	30*	There is little distinction between lamp failure and status change of CMC switches. There are possible conditions when no light will be on, or when more than one <u>should</u> be on. (001C)
2	31*	There is no lamp test capability on CMC switches. (003C)
2	32*	Lamp removal must be done from the back of the Generex panel on Panel B06. (033C)
2	33*	Green light intensity is used to distinguish faulted from normal status on the Electric Bus Panel on Panel B01. However, the two intensities are not discernible unless one witnesses the change in intensity as it happens. (072C)
2	34*	The Plant Protection System controls on Panel B05 are illuminated when they are in the OFF position, in violation of the convention used throughout the control room. (088B)
3	35	On Panel B04, the control rod full insertion indicator array uses a 'light off' condition to signal failure to fully insert. An unlit indicator could be difficult to find among a field of lit tiles during a reactor scram. However, this approach proves to be satisfactory during a dropped rod situation. In this case, all tiles are unlit, except that for the dropped rod, which is lit.

5. DISPLAYS

PRIORITY RATING	FINDING	
2	36*	There is a general problem which allows legend screens for both indicator lights and backlit switches to be interchanged. Examples: a.) Electric Bus Panel on Panel B01 b.) SESS Panel on Panel B02 c.) CEDM Panel on Panel B04 d.) Reactor Power Cutback System on Panel B04. e.) EHC Control Panel MTN-A-09 (005C);(014C);(021C);(063C)
2	37	The Plant Protection System relay status lights are illuminated to indicate availability. A given light goes out when the related Plant Protection System is not available.
2	38	The low light intensity of some indicators makes them difficult to read.
3[1]	39*	There is a lack of distinction between legend lights and backlit switches. Example: EHC Control Panel MTN-A-09 (063C)
3	40*	Typing-over of data occurs on the multipoint trend recorders on Panel 07. (051C)

6. LABELS AND LOCATION AIDS

PRIORITY RATING	FINDING	
2	1*	The logic for selecting the correct pairs of the manual reactor trip controls on Panel B05 is not clearly indicated on the board. (030A)
3[1]	2*	There are missing labels on the Electric Bus mimic on Panel B01. (011B)
3[1]	3*	There are missing labels on the controls for the CR ESSENTIAL AHU FAN DAMPERS on Panel B02. (015A)
3[1]	4*	Labels are either missing or non-descriptive on the FW & SR Systems Board on Panel B06. (040B)
3[1]	5*	There are missing labels on the Main Steaming Rate switches on Panel B06. (046B)
3[1]	6*	There are missing labels on the RAS ACTIVATION controls on Panel B05. (084A)
3[1]	7	There are no labels on the pushbuttons on Panel B06.
3[1]	8	There are no labels on the indicator lights on Panel B07.
3[1]	9	On Panel B05, the SG Flow indicator is not labeled.
3[1]	10	None of the panels/consoles in the main control room use a heirarchical labeling scheme. All labeling is at individual component level, except for subpanels for some systems (e.g., SESS; Plant Protection System; etc.)
3[1]	11*	The label locations for the four DNBR/LPD calculators on Panel B05 are not consistent. Trains A and B are labeled below while trains C and D are labeled above. (082C)
3[1]	12	Some component labels are not placed above or in the best proximity to the equipment they identify. In general, display labels appear below the displays, while control labels are above.
3[1]	13	A temporary label has been taped to the panel to explain the control positions for the Nuclear Cooling Water HX which appears on Panel B07.
3[1]	14*	On the vertical panels, the Foxboro displays obscure their own labeling. (104A)
1	15*	There is an incorrect label on the Reactor Coolant Pump 1B control. (023C)

6. LABELS AND LOCATION AIDS

PRIORITY RATING	FINDING	
3[1]	16	There is inadequate labeling on the LOOP 1A T-HOT / LOOP 2A T-HOT indicator on Panel B06. It currently reads: LOOP 1 T-HOT / LOOP 2 T-HOT.
3[1]	17*	Ambiguous labeling appears on all dual-indicator Foxboro displays. Displays have side-by-side vertical scales, while the labels are placed one above the other. Plant convention is, the upper label refers to the left hand scale while the lower label refers to the right hand scale. (104A)
1	18*	There is an incorrect label on the Diesel Generator start-stop switch Panel B01. (071B)
1	19*	Incorrect labeling is used for the alarm acknowledge button on the Radiation Monitor Terminal. (109C)
3[1]	20	On Panel B06, the MSIV control labels are insufficiently descriptive.
3[1]	21	On Panel B06, trend recorders are not labeled as being designatable.
3[1]	22	Redundant but incomplete labeling is used on the Manual Reactor Trip controls on Panel B05. There are two "trip" labels on each, and nowhere is the trip channel specifically stated.
3[1]	23	On Panel B04, labels for Reactor Coolant Pump seal pressure and temperature are inconsistent and do not provide adequate information. They do not indicate "pressure" and "temperature" as applicable, and whether they are inlet or outlet sampling points.
1	24*	On Panel B02, the SESS Panel and related board items have inconsistent labeling. (076A)
3[1]	25	Poor labeling is used on the LP Heater Train controls, i.e., TRAIN-OUTLET v.s. TRAIN INLET.
2	26	Annunciator tiles for SG Differential Pressure do not accurately describe the significant condition. "SG1 > SG2" should read "SG2 < SG1", since the low differential pressure of SG2 is the condition of importance. Additionally, the benchboard label "HI SG-1 Δ P" does not describe the same differential condition as the annunciator tiles.
3[1]	27*	There are more than 3 lines of text on several switch and indicator legends. (114C)

6. LABELS AND LOCATION AIDS

PRIORITY RATING	FINDING	
3[1]	28	Inconsistent abbreviations are used in some locations. Examples: (Panel B05) a.) COND = Condenser COND = Condensate b.) COND POLISHING DEMIN OUTLT VLV CONDENSATE POLISHING DEMIN INLT VLV CONDENSATE POLISHING DEMIN DIFF PRESS CONT
3	29	There is a general problem with the selection and usage of abbreviations in the labeling throughout the control room. Abbreviations are not consistently applied and are sometimes not clear in their meaning. Example: a.) The use of COND for Condenser and CNDS for Condensate. These choices do not uniquely identify the names involved.
3[1]	30	There are inconsistent abbreviations on the component label and the switch legend for the Pre-Holdup Iox Inlet Bypass Selector on Panel B03.
3[1]	31	The Audio Range Selector on Panel B04 has no position labeling to indicate the multiplication factor being chosen.
3[1]	32	The position labeling on some keyswitches is misleading. Examples: a.) The position label "LOCKED NORMAL" refers to the normal position of the key and has no meaning with respect to the equipment being controlled. b.) When key is in "LOCKED" position, operator does not know whether it is locked open or locked closed.
3[1]	33	Most ESFAS rotary controls are jog-type while some (AFAS-1, AFAS-2) have two discrete positions. This distinction is not apparent from the control appearance.
3[1]	34	Manual ESFAS switches have no position indications or direction of movement indicators.
3[1]	35	The procedure for labeling the designatable trend recorder is to handwrite the current designation on an adjoining metal plate with a grease pen. This is not very legible.
3[1]	36*	There is an illegible label for the CWP/Bypass switch on Panel B04. (066A)
1	37*	Label color is incorrect for the "HOT LEG INJECTION B FLOW" on Panel B02. (074A)

6. LABELS AND LOCATION AIDS

PRIORITY RATING	FINDING	
3^1	38*	On Panel B03, the mimic line to the charging pumps used during loss of power is missing from the CVCS mimic. (079A)
3^1	39*	There is a lack of demarcation of all major systems on most of the panels. (112A)
3_1	40*	Ineffectual multi-colored strips appear on some boards. (052A)
3	41	There is a general inconsistency in the use of color coding in the control room. Examples: a.) Mimic colors are not consistently applied, and sometimes use the same colors as in the train/channel color coding on the same panel. b.) The use of both blue and white as an override indication on some valve controls.
2	42*	On Panel B03, there is no clear mimic indication where the flow to and from the reactor occurs. Basically, there is a need for a clear mimic terminator. (020C)
3^1	43*	There are missing mimic lines on the Electric Bus mimic on Panel B01. (115C)
3^1	44	The Electric Bus mimic on Panel B01 does not identify Units 2 & 3 on buses S05 and S06.
3^1	45	Directional arrows are missing from some mimics. (The absence of arrows from the Electric Bus mimic is acceptable.)
3^1	46	Motor Operated Disconnect (MOD) switch controls on Panel B01 are too far away from the associated MOD on the mimic.
3^1	47	On Panel B01, the Circuit Breaker control switch is not labeled to identify the breaker, and is located in the mimic as though it is part of the white-bus when it is not.
3^1	48	There are several breakers on Panel B01 which are not incorporated into a mimic.

7. PROCESS COMPUTERS

PRIORITY RATING	FINDING	
3	1	The computer system does not contain a sequential file of operator entries which are available upon operator request.
3	2	On Panel B05, the numeric-only key configuration is not the same in all cases. For example, the Core Protection Calculator keyboard is calculator style and the Core Monitoring Computer keyboard is telephone style.
3	3	Communication Console (I-J-SQN-RR75) control room keyboards contain keys which are not used by operators. (It may be that the keyboard is not used at all.)
3	4	The Radiation Monitoring Printer multiple-mode keyboard utilizes the same keys for both alphanumerics and functions by using "shift" keys.
1	5	Computer system operating procedures and contingency procedures have not been developed.
2	6	Data point addresses are not cross-indexed by program name, system/subsystem, and functional group.
2	7*	There is glare on the CRT screens. (053C) (065C)
2	8	Disturbing flicker is evident on the CRT on Panel B01.
3	9	CRT fonts use variable stroke widths such that the vertical strokes of the characters are narrower than the horizontal strokes.
3	10*	There are missing labels in the CRT data displays. (054C)
3	11*	Label highlighting is lacking in the CRT data displays. (055C)
2	12	Error messages on the CRT displays do not contain instructions to the operator regarding required corrective action.
2	13	When the process computer system requires the operator to standby, periodic feedback is not provided to the operator to indicate normal system operation and the reason for the delay.
3	14	Color use on the CRT is not consistent with other color coding in the control room.
3	15	Color coding used on CRT displays does not conform to guidelines.

7. PROCESS COMPUTERS

PRIORITY RATING	FINDING	
2	16	Printers do not have a printing capability of at least 300 lines per minute.
1	17	Printed material does not have an adequate contrast ratio due to the ribbon condition.
2	18	The operator has no capability to request printouts by alarm group (e.g., system, subsystem, component).

8. PANEL LAYOUT

PRIORITY RATING	FINDING	
1	1*	On Panel B04, the Reactor Coolant Pump 1A control is in close proximity to the Backup Heater Bank A31 - A36. Handles are similar in shape, leading to a potential operator error and reactor trip. (096B)
3	2	On Panel B05, the layout sequence of the Reactor Protection Pretrip/Trip indicators is poor. Related indicators are not grouped together. Examples: a.) Reactor Power b.) Pressurizer Pressure c.) Steam Generator Level
2	3*	There is an inconsistent mode select sequence for the MSR switches on Panel B06. (093C)
2	4	On Panel B06 the SG1 and SG2 wide range steam generator level indicators are not consistently located with respect to the narrow range indicators.
3	5	There is a lack of symmetry between the RPS control switches and the corresponding status lights on the lower benchboard on Panel B05.
3	6	On Panel B04, the Reactor Coolant Pump 2A (2B) DP displays are separated by the Core 2A DP display.
3	7	Mirror imaging is used in the layout of related controls for Condensate Pumps A,B & C as well as for the Condenser controls/displays on Panel B05.
3	8	Panel B06 has a hybrid component layout with mixed mirror image and replicated controls and displays.
1	9*	The layout of the SESS Panel does not conform with the layout of Panel B02. (078C)
2	10	Some differences exist between the designs of the simulator and the Unit 1 control room. (See page 27, item 1)
3[1]	11	Key tags for keyswitches obscure nearby labels and other controls/displays.
2	12*	There is possible interference among the controls on the benchboard of Panel B07 due to their closeness at the intersection of surfaces "C" and "D." (097C)
3	13	The Panel B04 there is inadequate functional grouping of the Rod Motion Control indicator lights.

9. CONTROL-DISPLAY INTEGRATION

PRIORITY RATING	FINDING	
2	1	About 16 annunciator tiles located on Panel B01, belong on the Panel B06 board section where they will be used to signal corrective action to be controlled from Panel B06. Example: a.) Main Generator V/Hz b.) Main Generator Excitation, c.) Under Frequency Negative Sequence Pretrip
3	2	On Panel B04, the five automatic reactor regulation control rod motion demand indicators can be lit in conflict with a manual mode of operation that the operator has selected.
3	3	Trip indicators for High Log-Power and Low Pzr Press should be located in closer proximity to the High Log-Power Bypass and Low Pzr Press Bypass controls.
3	4	In most instances on B04, each of 4 pumps has a separate set of Foxboro meters. However, on the RCP inlet and outlet, common temperature meters are used, wherein, the left bar of the meter is for pump 1A and the right bar of the same meter is for pump 1B. The same is true for 2A and 2B.
3	5*	On Panel B01, the Diesel Generator Synchroscopes are more than nine feet from the circuit breaker controls. (070B)
3	6	On Panel B01, the Incoming Voltmeters associated with the Diesel Generators are located too far from the circuit breaker controls.

HUMAN FACTORS STRENGTHS OBSERVED

1. The mobile procedure cart with procedures attached is a good wav to make procedures conveniently available.

2. The "diamond" orientation of the control switches in the CVCS mimic enhances the operator's understanding of the functions being executed.

3. The angled CRT mounting enhances display visibility for the operators.

4. The low height of the CRT cabinets on the sit down console provides easy viewing of other control board sections.

5. The 5 degree slope on control board surface "B" enhances the useability of the controls and displays.

6. The turn-to-start / push-to-stop feature of some valve motion controls frees the operator to perform other functions as compared to controls that require turn-and-hold-to-activate.

7. Generally, the layout and grouping of systems, subsystems and components is clean and uncluttered.

8. There are few instances of long, unbroken rows of similar displays.

9. The number of alarm windows is not excessive.

10. A zero reading is clearly differentiated from a failed-meter status on Foxboro displays.

11. Mimics have been used to enhance the operators' understanding of systems.

12. Equipment labels are generally legible.

13. First-out annunciator panels for reactor trip and turbine trip will identify the initiating events for the operators.

14. Safety systems status is indicated by the SESS Panel.

SYSTEMS WHICH COULD NOT BE EVALUATED

The following items were unavailable for review in whole or in part:

1. A detailed comparison of the simulator with the Unit 1 control room could not be performed to identify all differences that might exist.

2. General Layout

   - o Document organization and storage
   - o Spare parts, operating expendables and tools
   - o Supervisor access
   - o Non-essential personnel access

3. Emergency Equipment

   - o Operator protective equipment
   - o Fire, radiation and rescue equipment
   - o Emergency equipment storage

4. Environment

   - o Temperature and humidity
   - o Ventilation
   - o Emergency lighting
   - o Auditory environment
   - o Personal storage
   - o Ambience and comfort

5. The absence of documents made it impossible to evaluate consistency of procedure terminology with labels, displays, abbreviations, or document indexing and cross-referencing.

6. Due to the existing state of the system, it was not possible to adequately evaluate the CRT displays for content and data presentation format.

7. Lack of actual emergency gear prevented the evaluation of the operation of controls while wearing or using the emergency gear, or the availability of face masks with diaphragms capable of transmitting speech.

8. The actual discernability and reliability of audio signals above ambient noise could not be measured.

9. The capability of complete internal and external communications during emergencies (i.e., paging at the remote shutdown panel and/or direct communication with back panels, shift supervisor's office, etc.) could not be evaluated.

10. Since only Panel B06 had color-shaded background panel sections, it was not possible to evaluate the effectiveness of the use of shading colors to identify groups of functionally related controls and displays throughout the control room.

11. The proposed Plant Protection System logic alarm box on Panel B05 could not be evaluated because it is not yet installed.

12. It was not possible to evaluate the out-of-service and temporary labeling systems because they had not been developed.

13. It was not possible to evaluate the following instrumentation systems because they were not available:
    a.) In-core thermocouple instrumentation displays
    b.) Sub-Cooling monitor instrumentation displays

DELETIONS MADE BY HFEB AUDIT TEAM FROM THE APS PRELIMINARY DESIGN ASSESSMENT

Listed below are the deleted discrepancies, followed by the reason for deletion.

HED NO.	DISCREPANCY
080A	Labels on CVCS charging pumps on Panel B03 imply incorrect operation.
Reason for deletion:	The labels are correct for the present configuration.
122A	The CMC switches used for jog-valve control have uncomfortable knobs.
Reason for deletion:	There is no need to hold knobs longer than 20 seconds.
060B	NORMAL position labels are missing on all jog keyswitches.
Reason for deletion:	The NORMAL label has no meaning for the center position for the jog keyswitches and is misleading.
013C	There are sharp edges on bookstops on Panels B02 and B07.
Reason for deletion:	No discrepancy found.
058C	There is a lack of operator understanding of the control board design.
Reason for deletion:	Training considerations are outside the scope of the HFEB review.
069C	On Panel B02, there is glare on the SESS Panel which hinders a light-on determination.
Reason for deletion:	The lights are easily apparent when lit.
117C	The Generator Ground Voltmeter is poorly located.
Reason for deletion:	This voltmeter has been moved.

The following HFEB audit team finding relates to procedures and operator training. It will be referred to the Procedures and Test Review Branch for further consideration:

> On Panel B05, operator fatigue/error, leading to inadvertent reactor trip, may result from the procedure for reducing the LO PZR PRESS and LO SG PRESS setpoints during shutdown. The procedure must be repeated several times and for each of the 4 channels on the Reactor Protection System.