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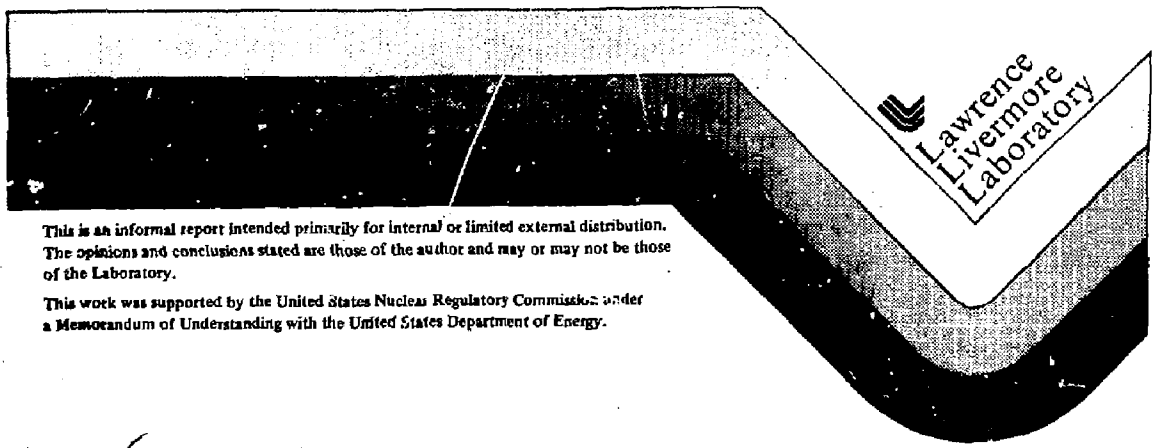
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**HUMAN FACTORS ENGINEERING
CONTROL-ROOM-DESIGN REVIEW/AUDIT REPORT;**

**PALO VERDE NUCLEAR GENERATING STATION,
ARIZONA PUBLIC SERVICE COMPANY**

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This is an informal report intended primarily for internal or limited external distribution. The opinions and conclusions stated are those of the author and may or may not be those of the Laboratory.

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**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 Human Factors Engineering Branch (HFEB) audit of the applicant's Preliminary Design Assessment (PDA) and the human factors engineering design review performed at the site. This design review was carried out by a team from the HFEB, 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., 3¹). Since priority 3¹ 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.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that it will not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

HUMAN FACTORS ENGINEERING
CONTROL ROOM DESIGN REVIEW/AUDIT REPORT
PALO VERDE NUCLEAR GENERATING STATION
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1. CONTROL ROOM WORKSPACE

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
	JD,JS	3	1* The control room bookshelves are inadequate. (056C)
S1,H9	JD,JS	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)
S2	JD,JS	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)
	JD,JS	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)

Note: Throughout the report,

- * Discrepancy also noted in Arizona Public Service (APS) Palo Verde Nuclear Generating Station Control Room Human Factors Study.
- The numbers and letters in parentheses are the IDs from the APS study.
- The numbers in parentheses not followed by letters are the ID numbers of Human Engineering Discrepancies (HEDs) identified by the HFEB audit team.
- Numbers in parentheses preceded by CLD are APS Checklist Discrepancy numbers.

PALO VERDE

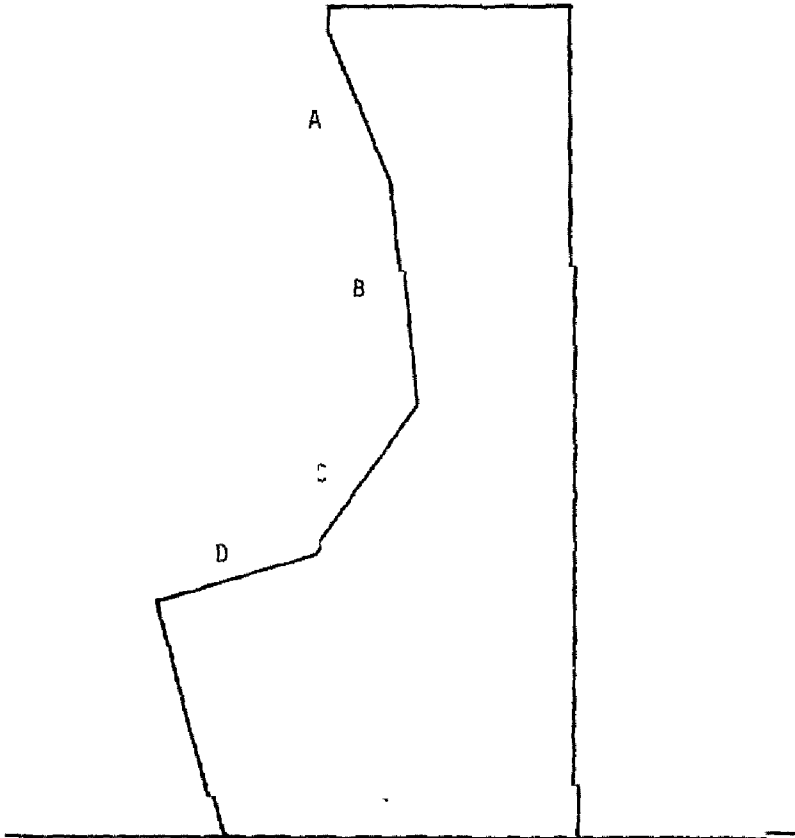


FIG. 1. Identification letters of the four control board surfaces.

2. COMMUNICATIONS

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
	RR,RS	1	1 Instructions are not provided for the use of the communication systems. (001)
	RR,RS	1	2 Procedures have not been established for handling incoming communications at night or during emergencies. (003)
	RR,RS	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. (004)
R15	RR,RS	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)
	RR,RS	3 ¹	5 No address labels and/or index are supplied for sound-powered phone jacks in the control room. (213)
	RR,RS	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. (005)
	RR,RS	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. (006)

3. ANNUNCIATOR WARNING SYSTEMS

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
	RR,RS	1	1* The Annunciator System has several discrepancies. (118A)
	RR,RS	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 (027)
	RR,RS	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. (028)
	RR,RS	3	4 The Turbine Generator System First-Out annunciator panel on Panel B04 should be located with the turbine/generator controls on Panel B06. (032)
R7	RR,RS	3 ¹	5 The Turbine Generator System First-Out annunciators on Panel B04 have tiles with small print font. (033)
	RR,RS	3 ¹	6 The nature of the annunciator auditory signals could, in some cases, cause irritation or a startled reaction. (035)
	RR,RS	1	7 A logical alarm prioritization has not been applied to allow operators to differentiate the most serious alarms from less important ones. (030)
	RR,RS	1	8 Auditory signals do not enable the operator to identify the work station location or system associated with the alarm. (034)
	RR,RS	1	9 More than 5 separate frequencies have been used for audible signal coding. The present use of eleven unique frequencies is excessive.
	RR,RS	2	10* The Condensate Low Vacuum alarm should be located on Panel B07 and not on Panel B05. (095B)

3. ANNUNCIATOR WARNING SYSTEMS

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
	RR,RS	2	11* The Plant Monitoring System Trouble alarm should be located on Panel B04 and not on Panel B01. (094C)
	RR,RS	1	12* There are no Main Generator Trip alarms near the associated controls on Panel B06. (045B)
	RR,RS	3 ¹	13 Annunciator panels are not identified by labels above the panels. (038)
	RR,RS	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. (039)
	RR,RS	1	15* Reaching annunciators to replace lamps poses a safety problem. (004A)
	RR,RS	2	16 Annunciator tiles do not illuminate and burn steadily in case of a flasher failure. (040)
	RR,RS	3 ¹	17 The vertical and horizontal axes of annunciator panels are not labeled with alphanumeric for easy coordinate designation of a particular visual tile. (037)
	RR,RS	3	18 The number of alarm tiles exceeds the suggested limit of 50 tiles per matrix. (043)
	RR,RS	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. (041)
R6	RR,RS	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. (026)
	RR,RS	3 ¹	21* Inconsistent terminology exists between alarms and controls for Generator Seal Oil on Panel B06. (091C)

3. ANNUNCIATOR WARNING SYSTEMS

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
R5	RR,RS	3 ¹	22* Inconsistent abbreviations are used on alarm legends. Example: (Panel B06) a) COND vs. CNDS (090C)
R4	RR,RS	3 ¹	23* Inconsistent alarm legends exist for Linear Power Density on Panel B05. (085C)
R3	RR,RS	1	24* On Panel B04, the annunciator legend is incorrect for T-AVG and T-REF temperature deviation and for RC SYS TRBL. (081A)
R2	RR,RS	3 ¹	25* Inconsistent terminology exists between H ₂ Train alarms and associated control labels on Panel B02. (073C)
R1	RR,RS	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)
	RR,RS	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. (044)
R9, R10, R11	RR,RS	2	28 Some tile legends do not address specific conditions. For example, one alarm is used for Hi-Low and Temperature-Pressure. (045)
	RR,RS	1	29 Administrative procedures do not exist which require and control the periodic testing of annunciators. (042)
R12	RR,RS	3 ¹	30 Annunciator response controls have not been coded for easy recognition. (046)

4. CONTROLS

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
	DL	1	1 The manual activation circuitry for the Panel B05 ESFAS system is based on <u>selected</u> two out of four logic which is different from the auto ESFAS which operates on <u>any</u> two out of four logic. (150)
S10	JD,JS	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 RO1A (052)
S7	JD,JS	3 ¹	3* There is a problem distinguishing among the five types of Foxboro controllers and displays. (105C)
	JD,JS	1	4* On Panel B05, the Manual Reactor Trip controls lack protection covers. (086A)
S3	JD,JS	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)
L29	DL	1	6* The protection covers on some of the setpoint reset controls on Panel B05 can be left open. (132)
S31	JD,JS	3 ¹	7 There is an inconsistent use of black and amber bezel color coding on CMC switches. Example: (Panel B03) a) Reactor Drain Tank Outlet Isolation Valve b) Makeup Supply to Reactor Drain Tank Valve (072)
S4	JD,JS	1	8* The red/green color coding of the Generator Field Excitation pushbuttons is reversed on Panel B06. (035B)

4. CONTROLS

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
S5	JD,JS	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)
	JD,JS	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)
S8	JD,JS	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)
S30	JD,JS	3 ¹	12 Some CMC switch position indicators point between switch positions. Example: {Panel B03} a) Pre-Holdup Iox Inlet Bypass Selector (071)
S11,H31	JD,JS,RH	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. (CLD-4.024) (053)
	RR	3	14 There is an excessive use of keylock switches in the control room. (074)

5. DISPLAYS

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
L21	DL	2	1* There is no valve position indication for the Demineralizer Differential Pressure Control Bypass Valve on Panel B05. (031C)
H38	RH	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. (111)
H15,L14	RH	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. (101)
H6,H7	RH	1	4* The loss of one of the two signal trains causes the status of 2 loops to be indeterminate in the High Pressure Safety Injection Flow indication on Panel B02. (077A)
L8	DL	2	5* On Panel B06, there is inadequate Steam Generator Level indication during manual, auxiliary and main feedwater control. (089A)
L10	DL,RH	3	6* Foxboro recorders do not provide good resolution over a short time range because of a slow recording speed. (106B)
L5	DL	2	7* There is no overload indication on the ammeters for large pumps. (075C)
H36	RH	1	8* On Panel B05, there is inadequate indication of safety system status (i.e., SIAS, MSIS, CIAS, etc.). (029A)
	RH	2	9* There is a need for a wide-range pressure and level indication near the pressurizer controls on Panel B03. (017B)

5. DISPLAYS

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
L13	RH	3	10* The large size of the Power Factor meters found on Panel B06, is not consistent with their importance. (092C)
S27	JD	3	11 There is an unnecessary, redundant indication for the Refueling Water Tank Level (CHN-LI-700) on Panel B03. (068)
H10	RH	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. (109A)
L6, H11	DL, RH	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) The SG level indicators are scaled 0 - 100% for both the narrow and wide range. (0838)(111C)
L16	DL	2	14 The plastic faces of the Foxboro displays seem to scratch and become obscured easily. They also produce excessive glare. (127)
S12	JS	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 (054)
H42	RH	3 ¹	16 Some Foxboro display scales incorporate leading decimals which are difficult to notice, leading to possible misreading of the scale numerals. (114)
L2	DL	1	17* On all Foxboro displays in the control room, the engineering units of parameters being measured are not given. (007A)
L12	DL	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. (128)

5. DISPLAYS

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
	RH	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. (514)
L13,H13	RH,DL	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 (515)
L11	DL	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 (126)
H4,H14	RH	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. (516)
H12	RH	3 ¹	23* The Core Protection Calculator indicator lights on Panel B05 have incorrect color coding. (116C)
H12	RH	3 ¹	24* The Plant Protection System relay status lights on Panel B05 are incorrectly colored. (0878)
H41	RH	3	25 Foxboro displays have a parallax problem, especially those located on the lower part of the benchboard. (113)
L14	DL	3 ¹	26 Zone markings have not been used on meters to show the operational implications of various readings (e.g. "Danger Range"). (523)
	RH	2	27* The scales in the Foxboro displays are loosely fitted, allowing incorrect positioning. (102C)

5. DISPLAYS

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
L1	DL	2	28* There is a lack of lamp redundancy in the CMC switches. (002C)
L3	DL	2	29* There is a lack of lamp redundancy on the Generex panel on Panel B06. (032C)
H1,H2	RH	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. (007C)
	DL	2	31* There is no lamp test capability on CMC switches. (003C)
L3	DL	2	32* Lamp removal must be done from the back of the Generex panel on Panel B06. (033C)
	RH	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)
L7,H8	DL	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)
L38	DL	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. (075)

5. DISPLAYS

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
H3,H4,H5 S6	RH,DL JD,JS	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)
H12	RH	2	37 The Plant Protection System relay status lights are illuminated to indicate availability. A given light goes <u>out</u> when the related Plant Protection System is not available. (120)
L15	DL	2	38 The low light intensity of some indicators makes them difficult to read. (532)
S6	JD,JS	3 ¹	39* There is a lack of distinction between legend lights and backlit switches. Example: EHC Control Panel MTN-A-09 (063C)
L4	DL	3	40* Typing-over of data occurs on the multipoint trend recorders on Panel 07. (051C)

6. LABELS AND LOCATION AIDS

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
H40	RH	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)
L17	DL	3 ¹	2* There are missing labels on the Electric Bus mimic on Panel B01. (011B)
L18	DL	3 ¹	3* There are missing labels on the controls for the CR ESSENTIAL AHU FAN DAMPERS on Panel B02. (015A)
H16	RH	3 ¹	4* Labels are either missing or non-descriptive on the FW & SR Systems Board on Panel B06. (040B)
L22	DL	3 ¹	5* There are missing labels on the Main Steaming Rate switches on Panel B06. (046B)
H22	RH	3 ¹	6* There are missing labels on the RAS ACTIVATION controls on Panel B05. (084A)
S14	JD,JS	3 ¹	7 There are no labels on the pushbuttons on Panel B06. (056)
S24	JD,JS	3 ¹	8 There are no labels on the indicator lights on Panel B07. (064)
L30	DL	3 ¹	9 On Panel B05, the SG Flow indicator is not labeled. (134)
H25,S16	RH,JD,JS	3 ¹	10 None of the panels/consales in the main control room use a hierarchical labeling scheme. All labeling is at individual component level, except for subpanels for some systems (e.g., SESS; Plant Protection System; etc.) (102)
H12,H21	RH	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. (092C)

6. LABELS AND LOCATION AIDS

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
H29,H30	RH	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. (103)
H31	RH	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. (104)
H23	RH	3 ¹	14* On the vertical panels, the Foxboro displays obscure their own labeling. (104A)
L20	DL	1	15* There is an incorrect label on the Reactor Coolant Pump 1B control. (023C)
H13	DL	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.
L9	DL	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)
L24	DL	1	18* There is an incorrect label on the Diesel Generator start-stop switch Panel B01. (071B)
H24	RH	1	19* Incorrect labeling is used for the alarm acknowledge button on the Radiation Monitor Terminal. (109C)
S15	JD,JS	3 ¹	20 On Panel B06, the MSIV control labels are insufficiently descriptive. (057)
H28	RH	3 ¹	21 On Panel B06, trend recorders are not labeled as being designatable. (631)
L31	DL	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. (135)

6. LABELS AND LOCATION AIDS

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
L37,H46	RH,DL	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. (116)
	DL	1	24* On Panel B02, the SESS Panel and related board items have inconsistent labeling. (076A)
L35	DL	3 ¹	25 Poor labeling is used on the LP Heater Train controls, i.e., TRAIN-OUTLET v.s. TRAIN INLET. (145)
H43,H44	RH	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. (115)
H26	RH	3 ¹	27* There are more than 3 lines of text on several switch and indicator legends. (114L)
L36	DL	3 ¹	28 Inconsistent abbreviations are used in some locations. Examples:(on Panel B05) a) <u>COND</u> = <u>Condenser</u> COND = <u>Condensate</u> b) <u>COND POLISHING DEMIN OUTLT VLV</u> <u>CONDENSATE POLISHING DEMIN INLT VLV</u> <u>CONDENSATE POLISHING DEMIN DIFF</u> <u>PRESS CONT</u> (140)
L3	DL	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. (032)

6. LABELS AND LOCATION AIDS

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
S30	RS	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. (071)
L41	DL	3 ¹	31 The Audio Range Selector on Panel B04 has no position labeling to indicate the multiplication factor being chosen. (L41)
H45,S26	RH,JD,JS	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. (067)
H36	RH	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.
H36	RH	3 ¹	34 Manual ESFAS switches have no position indications or direction of movement indicators. (108)
H28	DL	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. (631)
H18	RH	3 ¹	36* There is an illegible label for the CWP/Bypass switch on Panel B04. (066A)
L25	DL	1	37* Label color is incorrect for the "HOT LEG INJECTION B FLOW" on Panel B02. (074A)
H19	RH	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)

6. LABELS AND LOCATION AIDS

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
H25,S25	RH,JD,JS	3 ¹	39* There is a lack of demarcation of all major systems on most of the panels. (112A)
H17	RH	3 ¹	40* Ineffectual multi-colored strips appear on some boards. (052A)
H25,H32 H33,H34 S28	RH,JD,JS	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. (106)
L19	DL	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)
H27	RH	3 ¹	43* There are missing mimic lines on the Electric Bus mimic on Panel B01. (115C)
S20	JD,JS	3 ¹	44 The Electric Bus mimic on Panel B01 does not identify Units 2 & 3 on buses S05 and S06. (060)
H35	RH	3 ¹	45 Directional arrows are missing from some mimics. (The absence of arrows from the Electric Bus mimic is acceptable.) (107)
S23	JD,JS	3 ¹	46 Motor Operated Disconnect (MOD) switch controls on Panel B01 are too far away from the associated MOD on the mimic. (063)
S21	JD,JS	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. (061)
S22	JD,JS	3 ¹	48 There are several breakers on Panel B01 which are not incorporated into a mimic. (062)

7. PROCESS COMPUTERS

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
	RR,RS	3	1 The computer system does not contain a sequential file of operator entries which are available upon operator request. (048)
	RR,RS	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. (049)
R14	RR,RS	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.) (050)
	RR,RS	3	4 The Radiation Monitoring Printer multiple-mode keyboard utilizes the same keys for both alphanumerics and functions by using "shift" keys. (008)
	RR,RS	1	5 Computer system operating procedures and contingency procedures have not been developed. (009)
	RR,RS	2	6 Data point addresses are not cross-indexed by program name, system/subsystem, and functional group. (010)
	RR,RS	2	7* There is glare on the CRT screens. (053C) (065C)
	RR,RS	2	8 Disturbing flicker is evident on the CRT on Panel B01. (011)
R13	RR,RS	3	9 CRT fonts use variable stroke widths such that the vertical strokes of the characters are narrower than the horizontal strokes. (047)
	RR,RS	3	10* There are missing labels in the CRT data displays. (054C)

7. PROCESS COMPUTERS

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
	RR,RS	3	11* Label highlighting is lacking in the CRT data displays. (055C)
	RR,RS	2	12 Error messages on the CRT displays do not contain instructions to the operator regarding required corrective action. (013)
	RR,RS	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. (014)
	RR,RS	3	14 Color use on the CRT is not consistent with other color coding in the control room. (015)
	RR,RS	3	15 Color coding used on CRT displays does not conform to guidelines. (016)
	RR,RS	2	16 Printers do not have a printing capability of at least 300 lines per minute. (018)
	RR,RS	1	17 Printed material does not have an adequate contrast ratio due to the ribbon condition. (019)
	RR,RS	2	18 The operator has no capability to request printouts by alarm group (e.g., system, subsystem, component). (020)
		3	19 Computer printouts of alarms print slowly and contain too much extraneous information. (CLD 11-032) ⁺

+ This APS Checklist Discrepancy (CLD) was not included in the Audit Report sent to APS, but was cited in the HFEB input to the SER.

8. PANEL LAYOUT

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
L33	DL,JD,JS	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)
H37	RH	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 (109)
	JD,JS	2	3* There is an inconsistent mode select sequence for the MSR switches on Panel B06. (093C)
L8	DL	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. (L08)
L28	DL	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. (131)
L39	DL	3	6 On Panel B04, the Reactor Coolant Pump 2A (2B) DP displays are separated by the Core 2A DP display. (L39)
L34	DL	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. (144)
513	JD,JS	3	8 Panel B06 has a hybrid component layout with mixed mirror image and replicated controls and displays. (055)
	RR,RS	1	9* The layout of the SESS Panel does not conform with the layout of Panel B02. (078C)

8. PANEL LAYOUT

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
	DT	2	10 Some differences exist between the designs of the simulator and the Unit 1 control room. (See page 26, item 1) (123)
H39	RH	3 ¹	11 Key tags for keyswitches obscure nearby labels and other controls/displays. (112)
S19	JD,JS	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)
L42	DL	3	13 On Panel B04 there is inadequate functional grouping of the Rod Motion Control indicator lights. (L42)

9. CONTROL-DISPLAY INTEGRATION

<u>PHOTO ID</u>	<u>REVIEWER</u>	<u>PRIORITY RATING</u>	<u>FINDING</u>
S17	JD,JS	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 (059)
H47	RH	3	2 On Panel B04, the five <u>automatic</u> reactor regulation control rod motion demand indicators can be lit in conflict with a <u>manual</u> mode of operation that the operator has selected. (119)
H37	RH	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. (110)
P46	RH	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. (118)
S18	JD,JS	3	5* On Panel B01, the Diesel Generator Synchrosopes are more than nine feet from the circuit breaker controls. (0708)
S18	JD,JS	3	6 On Panel B01, the Incoming Voltmeters associated with the Diesel Generators are located too far from the circuit breaker controls. (070)

HUMAN FACTORS STRENGTHS OBSERVED

1. The mobile procedure cart with procedures attached is a good way to make procedures conveniently available. (Photo S9).
2. The "diamond" orientation of the control switches in the CVCS mimic enhances the operator's understanding of the functions being executed. (Photo S29).
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 "E" enhances the usability 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
 - Document organization and storage
 - Spare parts, operating expendables and tools
 - Supervisor access
 - Non-essential personnel access
3. Emergency Equipment
 - Operator protective equipment
 - Fire, radiation and rescue equipment
 - Emergency equipment storage
4. Environment
 - Temperature and humidity
 - Ventilation
 - Emergency lighting
 - Auditory environment
 - Personal storage
 - 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.

<u>HED NO.</u>	<u>DISCREPANCY</u>
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. (133)

PALO VERDE PHOTO LOG

<u>#</u>	<u>ID</u>	<u>PHOTOGRAPH SUMMARY</u>
1-1	H1	"Auto" not lit when "Start" is lit
1-2	H2	"Auto" not lit when "Start" is lit
1-3	H3	Screen interchange possibility
1-4	H3	Lamp interchange possibility
1-5	H4	Controls/displays mixed
1-6	H5	Controls/displays mixed
1-7	H6	High Pressure Safety Injection Flow indicators
1-8	H6	High Pressure Safety Injection Flow indicators
1-9	H7	High Pressure Safety Injection Flow indicators
1-10	H8	Incorrect color coding
1-11	H9	No glare
1-12	H9	Glare
1-13	H10	Lack of position indication (undetented positions)
1-14	H11	Lack of parameter engineering units on recorders
1-15	H12	Improper color usage
1-16	H12	Improper color usage
1-17	H13	Poor scale progression
1-18	H14	Violation of color coding convention
1-19	H15	Calibration helipot
1-20	H15	Display associated with helipot control
1-21	H16	Missing or non-descriptive labeling
1-22	H17	Color striping
1-23	H18	Obscured type
1-24	H19	Mimic missing
1-25	H20	Mimic missing
1-26	H20	Mimic missing
1-27	H21	Inconsistent label positioning
1-28	H21	Inconsistent label positioning
1-29	H22	No label
1-30	H23	Obscured labeling
1-31	H23	Obscured labeling
1-32	H24	Incorrect labeling
1-33	H25	No hierarchical labeling
1-34	H25	No hierarchical labeling
1-35	H26	More than 3 lines of text
1-36	H27	Missing mimic
1-37	H28	Incorrect label
1-38	H29	Label locations
1-39	H29	Label locations

#	ID	PHOTOGRAPH SUMMARY
1-40	H30	Poor label locations
1-41	H31	Control position labeling obscured by hand and handle
1-42	H31	Control position labeling obscured by hand and handle
1-43	H31	Control position labeling obscured by hand and handle
1-44	H32	Inconsistency in color coding
1-45	H32	Inconsistency in color coding
1-46	H33	Inconsistency in color coding
1-47	H33	Inconsistency in color coding
1-48	H34	Inconsistency in color coding
1-49	H35	No directional arrows
1-50	H35	No directional arrows
1-51	H36	No position indicators
1-52	H37	Lack of grouping
1-53	H38	Useless controls
1-54	H38	Useless controls
1-55	H39	Key obscures label/controls
1-56	H40	Inconsistent logic on RPS
1-57	H41	Parallax on Foxboro displays
1-58	H41	Parallax on Foxboro displays
1-59	H41	Parallax on Foxboro displays
1-60	H41	Parallax on Foxboro displays
1-61	H42	Poor scale labeling (use of leading decimal points)
1-62	H42	Poor scale labeling (use of leading decimal points)
1-63	H43	Poor labeling
1-64	H44	Poor labeling
1-65	H45	Misleading labeling
1-66	H46	Displays used in common
1-67	H46	Displays used in common
1-68	H47	Display can be improperly illuminated (not shown lit)
1-69	H47	Display can be improperly illuminated (not shown lit)
1-70	L1	Lack of bulb redundancy
1-71	L2	No parameter engineering units displayed
1-72	L3	No lamp redundancy
1-73	L4	Overprinting on trend recorders
1-74	L4	Overprinting on trend recorders
1-75	L5	No overload amperes indication
1-76	L5	No overload amperes indication
1-77	L6	No scale units. Percent is used
1-78	L7	Controls illuminated when in 'OFF' position (not shown lit)
1-79	L8	Need wide range indicator
1-80	L8	Need wide range indicator
1-81	L9	Ambiguous labeling
1-82	L10	Too little detail on trend recorder (only 1 in./hr)
1-83	L11	Scales not consistent
1-84	L11	Scales not consistent
1-85	L11	Scales not consistent

#	ID	PHOTOGRAPH SUMMARY
1-86	L12	Graduation (whole meter actually) size is too small
1-87	L12	Graduation (whole meter actually) size is too small
1-88	L13	Poor scale progression
1-89	L14	Lack of zone markings
1-90	L15	Light intensity too low
1-91	L15	Light intensity too low
1-92	L16	Plastic covers obscured by scratches, etc.
1-93	L17	No labels on mimic lines
1-94	L18	Missing labels
1-95	L18	Missing labels
1-96	L19	Lack of mimic terminators
1-97	L20	Incorrect label
1-98	L20	Incorrect label
1-99	L21	No value position indication
1-100	L21	No value position indication
1-101	L22	Missing labels (on/off)
1-102	L23	Missing NORMAL label
1-103	L24	Wrong label
1-104	L25	Wrong color label
1-105	L25	Wrong color label
1-106	L26	Inconsistent coloring/labeling of controls
1-107	L26	Inconsistent coloring/labeling of controls
1-108	L26	Inconsistent coloring/labeling of controls
1-109	L27	No labeling and bad orientation
1-110	L27	No labeling and bad orientation
1-111	L27	No labeling and bad orientation
1-112	L28	Lack of C/D symmetry
1-113	L28	Lack of C/D symmetry
1-114	L29	Cover sticks open
1-115	L30	Missing label
1-116	L30	Missing label
1-117	L31	Poor labeling
1-118	L32	ESFAS control arrangement
1-119	L32	ESFAS control arrangement
1-120	L32	ESFAS control arrangement
1-121	L33	Controls poorly located: Too near and similar
1-122	L33	Controls poorly located: Too near and similar
1-123	L33	Controls poorly located: Too near and similar
1-124	L34	Mirror imaging of controls/displays
1-125	L34	Mirror imaging of controls/displays
1-126	L35	Poor labeling
1-127	L36	Inconsistent abbreviations
1-128	L36	Inconsistent abbreviations
1-129	L36	Inconsistent abbreviations
1-130	L36	Inconsistent abbreviations

#	ID	PHOTOGRAPH SUMMARY
1-131	L37	Insufficient label information
1-132	L37	Insufficient label information
1-133	L38	Control rod full insertion indicator panel
1-134	L39	Separation of identical displays
1-135	L40	Confusing trend recorder/display labeling
1-136	L40	Confusing trend recorder/display labeling
1-137	L40	Confusing trend recorder/display labeling
1-138	L41	Lack of position labeling
1-139	L42	Lack of indicator grouping
1-140	L42	Lack of indicator grouping
2-1	R1	Inconsistent terminology
2-2	R2	Inconsistent terminology
2-3	R3	Incorrect T-AVE and T-REF legend
2-4	R4	Inconsistent alarm legend
2-5	R5	Inconsistent alarm legend
2-6	R6	Incorrect legend label
2-7	R7	Print font too small
2-8	R8	No matrix
2-9	R9	Legend does not address specific conditions
2-10	R10	Legend does not address specific conditions
2-11	R11	Legend does not address specific conditions
2-12	R12	No labeling of annunciator controls
2-13	R13	Variable stroke widths on CRT
2-14	R14	Non-functional keyboard
2-15	R15	Phone cord too short
2-16	R15	Phone cord too short
2-17	R16	Keyboard obstructs view of CRT screen
2-18	S1	Meter glare
2-19	S2	Glare on green lighted section
2-20	S3	Controls too close to edge
2-21	S4	Color coding reversed for ON/OFF on Generex panel
2-22	S5	Cooling Tower Fan display light legends interchangeable
2-23	S6	Controls/displays not distinct enough
2-24	S7	Foxboro controllers too similar
2-25	S7	Foxboro controllers too similar
2-26	S7	Foxboro controllers too similar
2-27	S8	Key size too small for jog valves
2-28	S9	Procedure cart
2-29	S10	Control flag can be in opposite position of switch
2-30	S11	Switch position indication is not clear
2-31	S12	Low energized/de-energized contrast
2-32	S13	Mirror image
2-33	S13	Mirror image
2-34	S13	Mirror image
2-35	S14	Lack of labels
2-36	S15	MSIV labels are not properly descriptive

<u>#</u>	<u>ID</u>	<u>PHOTOGRAPH SUMMARY</u>
2-37	S17	Tiles should be on Panel B06
2-38	S18	Synchroscope is too far from control
2-39	S19	Control knob too close to breaker handle
2-40	S20	Mimic should have label
2-41	S21	Mimic is confusing
2-42	S22	Circuit breakers not connected to mimic
2-43	S23	Switch too far from mimic
2-44	S24	No labels
2-45	S25	Color coding
2-46	S26	Label should read "locked"
2-47	S27	Unnecessary redundant meter
2-48	S28	Inconsistent mimic coding
2-49	S29	Good diamond setting for mimic flow paths
2-50	S29	Good diamond setting for mimic flow paths
2-51	S30	Switch position needle does not point to specific positions
2-52	S31	Inconsistent use of color coding