HFE PRELIMINARY ASSESSMENT OF THE COMANCHE PEAK UNIT 1 CONTROL ROOM

Prepared For:

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INTRODUCTION

Background

The Comanche Peak Control Room Evaluation Task Team supported by Essex Corporation has performed a preliminary assessment of the Comanche Peak Unit 1 control room for the purpose of identifying conspicuous human factors engineering (HFE) design problems.

The evaluation consisted of:

- Operator interviews
- Surveys of the physical characteristics of the control room
- Comparison of Comanche Peak design features with generic nuclear control room HFE discrepancies
- Videotaping and analyzing walk-throughs of Comanche Peak emergency procedures
- Application of human factors engineering design checklists.

The control room was evaluated as is, without regard to planned changes in layout, ventilation, etc. This was the case since: (1) as changes in the control area are implemented, they may introduce different HFE design problems which will not have been evaluated; (2) all changes may not be completed prior to plant operation, and Comanche Peak personnel should otherwise contend with the temporary provisions having HFE design problems; and (3) evaluation of existing conditions can aid Comanche Peak engineers in implementing planned changes without introducing the HFE problems found in the current, temporary provisions.

Data collection and evaluation spanned approximately 24 days and involved ten Essex personnel and numerous Comanche Peak operators and engineering staff members.

Evaluation Plan/Approach

The evaluation was conducted in three phases, as follows:

1 — Documentation Collection and Control Room Survey

2 — Data Collection

3 — Analysis, Verification, and Reporting.

Each phase is discussed more fully below.

Documentation Collection and Control Room Surveys. This phase of the HFE evaluation plan/approach was directed towards: (1) assembling control system documentation to be used as data references during data collection; (2) familiarizing evaluation team members with the Comanche Peak Unit 1 control room; and (3) initiating data collection.

Activities during this initial phase entailed:

- Collection and review of plant documentation. Emergency and normal operating procedures, control room drawings and floor plans, systems descriptions, and piping and instrumentation diagrams were collected or made immediately accessible to the evaluation team for review. Office space was set aside for documentation storage and meetings.
- Conduct of control room surveys. Control room layout and operation were initially reviewed via direct observation and discussions with Comanche Peak Unit 1 operations staff members. Descriptive data regarding:
  - ambient noise (measured at various points using a sound intensity level meter, A and C scales)
  - control and display design conventions, in terms of standard modes of information presentation and control usage conventions
  - presence and design of emergency and safety equipment (e.g., fire extinguishers, etc.)
  - levels of uniformity and design of lighting systems, and
  - control room layout (board profiles and dimensions, etc.)

  were gathered for evaluation and comparison with HFE evaluation criteria.
- Distribution of operator questionnaires. Control room operators were provided with questionnaires to be completed and returned for review and subsequent debriefing.
- Identification of generic problems. Comanche Peak control room design features were compared with a list of generic control room HFE design discrepancies in order to help quickly identify HFE problem areas.

Data Collection. During this phase more detailed data were collected and compared to HFE evaluation criteria. The basis for the evaluation criteria was a preliminary evaluation guidebook developed by Essex for the Nuclear Regulatory Commission. Throughout this phase, Comanche Peak personnel and documentation were required to address specific design areas and issues. Individual activities during this phase included:

- Analysis of procedures. Selected emergency operating procedures were walked-through and videotaped in the control room. The walk-throughs consisted of an operator simulating an emergency condition,

and simulating performance of procedural step sequences. Throughout the walk-throughs, human factors analysts noted potential problem areas and participated by asking specific questions and for more detailed task information, by requesting individual procedural steps and sequences.

- Application of control room checklists. Checklists containing human factors evaluation criteria were applied to the Comanche Peak control room. These checklists addressed the design of:
  - emergency gear/protective equipment
  - procedure documents
  - control room layout
  - panel layout
  - computer systems
  - communications.

  Developing these checklists required asking specific design questions in terms of compliance with evaluation criteria, thereby immediately identifying discrepancies.

- Application of control and display checklists. Another set of checklists containing evaluation criteria applicable to controls and displays design were applied in the control room. These addressed:
  - annunciators
  - pushbuttons
  - levers
  - process controllers
  - CRT's
  - meters
  - simple indicator lights, etc.

  These checklists also immediately identified discrepancies.

Analysis, Verification, and Reporting. This final phase of the evaluation plan/approach entailed: (1) review of data collected; (2) verification of the data; (3) further identification of discrepancies; (4) prioritization of HFE discrepancies; and (5) reporting of results. Specific activities conducted during this final phase include:

- Data reviews. Specific discrepancies were checked for accuracy by further operator interviews, references to documentation, and so forth. Further, descriptive type data were reviewed (e.g., board layout in terms of procedural step sequences, ambient light) and compared to evaluation criteria to further identify discrepancies. Finally, all discrepancies identified were consolidated into groups:
  - control room environment
  - controls
  - displays
  - annunciators
  - communications
  - labels
  - procedures
  - operator/computer interface
  - panel layout.

- Prioritization of HFE discrepancies. Discrepancies were prioritized according to the following:
  Category 1 — Induced error in safety related activity
  Category 2 — Induced errors in potentially safety related activity
  Category 3 — Induced errors in critical activity
  Category 4 — Further analysis required.
  Assessments of safety related activities, potentially safety related activities, and critical activities were performed by engineering and human factors personnel. Determinations of errors and error types induced by design discrepancies were performed by human factors engineering personnel.

- Reporting. The evaluation plan/approach and results were documented and outlined for the present report.

RESULTS

Following are summarized general problem areas identified in the Comanche Peak control room. These briefly state:

- The problem areas dealing with:
  - control room
  - controls
  - displays
  - annunciators
  - communications
  - labels
  - operator/computer interface
  - panel layout
- Examples of the problems
- Operational effects (performance decrement) or anticipated operational errors contributed to or caused by the HFE design problem areas.

Control Room Problem Areas

1. Presence

   a. Control room (CR) does not presently provide personnel protective equipment (e.g., air pack, fire extinguishers, etc.). Firefighting equipment is not provided (e.g., sufficient quantity for extinguishment and reflash). (Category 1)

   b. No storage for essential material. (Category 1)

   Degradec personnel safety; delays in documentation retrieval.

   CPSES Response

   1a. Personnel protective equipment, including firefighting equipment will be provided prior to fuel load. Firefighting equipment has been considered in the plant fire hazards analysis.

   1b. Essential material and documentation will be stored in the file and chart supply rooms as indicated on the CR layout drawing. A movable CART will be provided for storage of emergency and abnormal procedures prior to fuel load.

2. Ambient Noise — Temporary CR ventilation presents white noise, which could degrade communications as well as mask alarms and communication signals. (Category 4)

CPSES Response

2. Temporary CR ventilation will be removed prior to fuel load and a noise assessment will be performed during the long term HFE evaluation.

3. Visual Search Aid — CR panels (system level). Subsystems and components are not demarcated. Performance can be degraded by increasing search time with the probability that control and display substitution errors will increase. (Category 1)

CPSES Response

3. A system/subsystem demarcation study is in process. Completion and implementation will be completed prior to fuel load.

4. Obstructions

   a. CR has several traffic obstructions, notably the PRODAC and drawing layout table, which obstruct traffic flow between portions of the control boards. Performance can be degraded by: increasing time to physically access controls and displays; limiting traffic flow in CR to attain access; and disrupting a task sequence to attain access. (Category 3)

   b. Shift Supervisor's desk has no visual access of main control room. Degrades Shift Supervisor's capability to monitor control room activities. (Category 3)

CPSES Response

4a. The drawing layout table is temporary and will be replaced with permanent operator furniture. The PRODAC is essential for operator information retrieval and presents very minimal time delay to access other controls or displays.

4b. The Shift Supervisor's office is positioned in its location so that he has access to both units.

5. Position of Heating, Ventilation, and Air Conditioning Panels (HVAC)

a. A reactor operator (RO) or senior reactor operator (SRO) must exit the main control area, thereby temporarily reducing manning and rendering positive monitoring and status checking a "catch as catch can" situation. (Category 3)

b. HVAC panels facing each other are close enough that monitoring/operating one panel could cause inadvertent operation of controls (J-handles) on the opposite panel. (Category 1)

CPSES Response

5a. The HVAC panels are infrequently operated, contain equipment common to both units and are positioned in the common area of the control room in order to render convenient access from either Unit 1 or Unit 2 operators. The location is deemed suitable for this purpose.

5b. Protective devices or guard rails will be provided where controls are subject to inadvertant activation.

6. Inadvertent Actuation Protection

a. Main control board should have guard rail (01 and 11 panels at minimum) along bottom edge of bench board. (Category 1)

b. Rod control startup pushbutton should have protection device. (Category 2)

Could cause inadvertant activation of controls.

CPSES Response

6a,b Protective devices or guard rails will be provided where controls are subject to inadvertant activation prior to fuel load.

7. Hazards

a. Unused cable floor penetrations at the end of the PRODAC have protrusions that are tripping hazards. (Category 1)

b. J-handles on 11 panel are close to board edge. (Category 1)

CPSES Response

7a. A CRT for upgrade protection surveillance package will occupy this space. This will be installed prior to fuel load.

7b. Protective devices or guard rails will be provided where controls are subject to inadvertant activation prior to fuel load.

Positive Design Features

1. Control Board Profile — The general control panel profile used enhances: 1) readability of annunciator tiles; 2) display readability and control access (with exceptions — see controls), decreasing probability of reading, and control and display selection errors.

2. Illumination — Ambient illumination levels complement display and control illumination without generally increasing display glare. The diffused lighting thereby does not induce excessive glare (although some glare problems exist).

Controls Problem Areas

1. Contrast — Low contrast exists on:

a. All J-handle and star-handle control position indicating arrows.

b. Targets (red and green flags) for J-handle controls are hard to distinguish.

Performance decrement can include difficulty in determining control position. (Category 2)

CPSES Response

1a. Control position indicating arrows on J-handle and star-handle will be color contrasted prior to fuel load.

1b. The target flag color differentiation will be upgraded prior to fuel load.

2. Legends, Labels, and Position Indicators

a. Legend plates of discrete controls with transilluminated labels (all CMC type switches) are interchangeable (e.g., SI PMP 1 DISCH TO HL VLV and SI PMPS 1&2 MINIFLOW ISOL VLV). (Category 1)

b. Process controllers have dual labels that are not consistent (e.g., IPK-94C PRESSURIZER SPRAY CONTROL 1 with PRZR SP CNTR 1-PK-455C; 1SK-509B FEEDWATER PMP A CONTROL with FWP1-A TURB SPD CNTR 1-SK-509B). (Category 1)

c. Hagan valve controllers' vernier scales are difficult to read. (Category 3)

d. Brightness of indicator lights varies. (Category 4)

e. Some controls have unlabeled positions (e.g., return to center thumbswitches and safety related actuation J-handles). (Category 1)

f. Controls with split indicators for pump and fan OFF-ON-TRIP are unclear which half of indicator is for which component. (Category 1)

g. Star-handle select switch operation obscures position labeling. (Category 1)

Could cause activating the wrong control; not activating a control; misreadng the display; and/or reading the wrong display.

CPSES Response

2a,e,f,g. A study will be initiated to resolve annunciator and labeling inconsistency of abbreviation, nomenclature, and display. In order to minimize repetitive changes, implementation of label modifications will occur following the long term HFE evaluation. Any labels which have a potential of causing activation of a wrong control will be modified prior to fuel load.

2b. Vendor labeling will be removed prior to fuel load.

2c. The Hagan controllers vernier scales are difficult to read but the actual setting is done by observing the output scale which is readable while adjusting.

2d. Additional investigation of all illuminated indicator brightness will be undertaken during detailed control room study.

3. Control Access

a. All controls on semi-vertical portion of control boards are not easily accessed by 5 percentile of operators.

b. MLB lamp test not accessible by 50 percentile of operators.

Potential performance decrement or operational errors are: (1) increased time to access control; (2) selecting the incorrect control; or (3) actuating another control while reaching for a distant control. (Category 1 for accidentally actuating another control, Category 3 for increased time and control selection)

CPSES Response

3a. A case by case analysis will be made, and switch guards added, where the lower 5 percentile of operators may inadvertently actuate a control while reaching for the controls on the semi-vertical portion. For example, pushbuttons located directly below controller may have guards added.

3b. An evaluation is being made into using lamp test pushbuttons that are on the lower portion of the vertical section. These test pushbuttons would test the upper MLB's.

4. Control Effect Consistency — Process controllers can have opposite system effects: control setting increase can either open or close a valve, increase or decrease pump output, etc. (e.g. SG BLDN CONT, TURB DR AFW SG FLD, and RHR HX FLOW).

Effects on operator performance can include system setting errors (opening a valve instead of closing it, etc.), temporal errors (excessive time to determine appropriate control setting), and failure to determine that a control is inappropriately positioned. (Category 2)

CPSES Response

4. The knobs will incorporate an arrow indicating direction of increasing control movement. In the long term, a study of options available affecting consistency will be made.

5. Control Feedback

a. Process controls present immediate control setting feedback in terms of percent of signal sent to controlled systems and components, rather than actual system response (e.g., FW pump speed controls, PZR level controls).

b. If rod control lever is held down, step counters continue to advance after rods are all the way out at 228 steps.

Other system feedback should be immediately available; where not available, errors include failure to accurately set controls and failure to determine incorrect control setting. (Category 1 or 2 depending on system response rate and availability of alternate system feedback)

CPSES Response

5a. Feedback is from controlled variable, which for the examples chosen are FW pump, RPM and pressurizer level signals, as measured at the process. It is also useful to display the output signal demand, particularly for those controls operated in the manual mode. For the examples cited, FWP speed controllers (SC-2111B, 2112B) are located directly below the indicators (SI-2111F, 2112F); similarly, the pressurizer level controller (LC-459) are directly below both PRZR recorders (LR-459) and indicators (LI-459A & 460A).

5b. CPSES will review with Westinghouse, the supplier of this equipment, the criteria for control board interface as it relates to reactor operation and control rod manipulation.

6. Control Use

a. Knob-type controls with transilluminated legends (e.g., ACCUM TK DISCH ISOL VLV, RHR TO CL ISOL VLV, and SI PMP SUCT FROM RWST) and some thumbswitches (e.g., VI INSTR AIR FROM COMM AIR CMPR VLV 1-HS-3476) not conspicuous as to method of operation, that is, whether control is:

1) Momentary contact closure to fully close or open valve, or

2) Continuous contact to close or open valves.

Anticipated operation error is failure to correctly position a valve. (Category 1)

b. AMMETER selector control and annunciator controls on 12 panel do not meet minimal separation requirements. (Category 3)

c. Key-operated controls do not have OFF indicator in vertical position and key teeth do not point up when inserting key. (Category 3)

Could cause activating the wrong control; not activating a control; misreading the display: and/or reading the wrong display.

CPSES Response

6a. All valve switches will be marked to show the method of operation. In addition, the operating procedures will address mometary or continuous operation where applicable.

6b. AMMETER selector control has no safety significance if an inadvertant operator error is made and therefore should be left in present configuration. Annunciator controls will be standardized with the other panels.

6c. All key-operated switches have OFF position consistent with other on/off switches. Additional investigation will be made during the detailed design review to determine which direction teeth should point for insertion.

Positive Design Features

Most controls accessible by 95 percentile of operators.

Displays Problem Areas

1. Display Readability

a. Top row of vertical displays on all main control board vertical panels and HVAC panels create a parallax. (Category 2)

b. Legends on control rod permissive lights on panel 04 are not readable from rod control panel 07. (Category 1)

c. Displays on miniature turbine control panel have excessive glare. (Category 3)

d. No normal range or setpoint markings. (Category 1)

e. Some displays at very bad viewing angle (e.g., circular meters on panel 12 and rod step counters). (Category 1)

f. Hagan 3-channel strip charts, middle channel (green) numerals are obscured by upper (red) scale. (Category 2)

g. CCW TR B SUR TK LVL HX OUT FLOW scale and paper do not agree. (Category 3)

h. Circular and vertical meters' scales are not all linear (e.g., AC AMPERES BKR 1A4-1 A-1A4-1, RC FLOW meters and RCP SEAL WTR INJ FLOW). (Category 4)

i. Display numerals are positioned between graduation marks and pointers (e.g., some process controllers, circular meters, and turbine controls). (Category 3)

Could cause incorrect display reading and interpretation.

CPSES Response

1a. A study will be made on a case by case basis of displays with a parallax problem. Where the effect of errors caused by parallax problems would be significant, a different type of meter or improved positioning of existing meters will be implemented.

1b. A previous study of permissive light locations has indicated the necessity of a permissive panel. A permissive panel is in design and will be installed on 07 panel (reactor control) prior to fuel load.

1c. Modification to minimize glare on the miniature turbine control panel will be implemented prior to fuel load.

1d. Meter coding to readily differentiate between normal, marginal, and out-of-limits will be made after operating bands have been established.

1e. The circular meters on 12 panel are syncroscopes and the viewing angle will not hinder paralleling operation. The criteria for control board interface as it relates to reactor operation and control rod manipulation will be reviewed with Westinghouse, the supplier of this equipment.

1f. Evaluation will be continued with Westinghouse, the supplier of this equipment, to improve the scale readability.

1g. Recorder paper will be exchanged to have consistent scales as their respective recorders prior to fuel load.

1h. All circular ammeters on the main control boards have scales which are nonlinear. There are various flow indicators which utilize square root scales. These scales are very readable for a nonvarying parameter. The scale allows good readability at its 100 percent value. These scales are acceptable at CPSES.

1i. All General Electric circular type electrical control indicators have numerals between graduated scale and pointer; the numerals are overshadowed but never blocked by the tapered pointer. Graduation marks are never obscured.

2. Visual Access —

a. Trend recorders obscured by labels placed over windows (e.g., RWST LVL, CONT VENT SYS TEMPS MAIN, and CONDRS CIRC WTR TEMP). (Category 2)

b. Some MLB legends are obscured by being too close to top edge. (Category 3)

c. Rod counters numerals are not mounted close to surface of indicator. (Category 2)

d. Back row of rod counters cannot be seen by 50 percentile of operators. (Category 2)

Could cause incorrect display reading and interpretation.

CPSES Response

2a,b A study will be initiated to resolve annunciator and labeling inconsistency of abbreviation, nomenclature, and display. In order to minimize repetitive changes, implementation of label modifications will occur following the long term HFE evaluation. Any labels which has potential of causing activation of a wrong control will be modified prior to fuel load.

2c,d CPSES will review with Westinghouse, the supplier of this equipment, the criteria for control board interface as it relates to reactor operation and control rod manipulation.

3. Presence — Information which is not displayed in control room includes:

a. RCP vibration. (Category 1)

b. Turbine stress trending (Category 3)

c. Condensate pump amp meter. (Category 2)

d. Turbine cooling water level. (Category 2)

e. Chill water surge tank level. (Category 2)

f. RCDT level indication (need for RCS leak rate). (Category 2)

g. Need turbine percent of power meter or wide range turbine MW meter. Operator now has to convert all parameters for shifting FWP and rod control to AUTO. (Category 4)

Could cause delay in response or second guessing a system response.

CPSES Response

3a. RCP vibration levels are displayed on panel CV-07, behind the main control boards. Vibration alarms for alert and hi levels are provided on the main control board.

3b. The TSE recorder for trending is provided on panel CV-04 in the control room. The TSE indicator on the main turbine panel is sufficient for normal operation.

3c. Each condensate pump's motor is provided with three stator winding RTD's, which are monitored by the plant computer. These provide sufficient information.

3d,e. Alarm procedures will address the requirement to send an auxiliary operator to the tank to locally monitor level prior to initiating control room action. High-high and low-low level alarms are provided in the control room.

3f. RCDT level is monitored by the plant computer. The operator has access to drain tank level and can also trend this information if desired.

3g. Percent turbine power will be engraved on the turbine stress evaluator (TSE) adjacent to the MW load prior to fuel load.

4. Lamp Test

a. There is no provision for lamp testing individual controls' indicators and vertical system valve status indicators. Bulbs or component status have to be changed to test lamps. In the case of component controls there are two bulbs; however, they are in series. (Category 3)

b. No test function for some LED displays (e.g., M/TURB SPEED 1-SI-6572 and AUX FW PMP TURB SPD 1-SI-2452A). (Category 3)

c. MLB's have provision (most unlabeled) for lamp test, however, some of the pushbuttons designated for lamp test function have a status legend in them (e.g., Phase A Isolation and Containment Isolation). (Category 1)

Could cause incorrect display and interpretation.

CPSES Response

4a. Lamp/switch status verification will be included in the operator's weekly surveillance procedure. The operator can determine the status of safety related components by observation of the monitor light panel in the event the components status indicating lights are out.

4b. A study will be conducted to ensure that the LED analog displays do not have failure modes which would give incorrect readings. Test provisions will be added if necessary.

4c. An evaluation is being made into using lamp test pushbuttons that are on the lower portion of the vertical section. These test pushbuttons would test the upper MLB's.

5. Information Presentation

a. System monitor lights require difficult pattern recognitions for different system lineups. (Category 4)

b. Some dials with negative and positive values do not have zero at the 9:00 or 12:00 position (e.g., 125V BATTERY BT1ED1 A-BT1ED1); some vertical meters' zero position are not at center (e.g., VOLUME CONTR TK PRESS and INTERMD RNG S/U RATE 1-NI-35D). (Category 3)

c. Frequency circular meters not consistent in deenergized position (e.g., INCOMING 1-F-IN on right side of 11 panel is correct). (Category 3)

d. FW PMP DISCH PRESS and MS HEADER PRESSURE meters' scales should be the same. (Category 4)

e. KVAR meters have only + indications when KVARs should have both + and - indications. (Category 4)

Could cause activating the wrong control; not activating a control; misreading the display; and/or reading the wrong display.

CPSES Response

5a. Monitor light recognition patterns during accident conditions will be considered in the long term study. Improved labeling and accident mode identification will be implemented prior to full load.

5b. These dials will be evaluated and necessary corrections made if warranted. The vertical meters with elevated zero's are actually compound instruments, i.e., PSIG/VAC in inches of HG or POSITIVE/NEGATIVE rates with different ranges. These off-centered zero's should not cause the meter to be read incorrectly.

5c. Additional evaluation will be made during detailed control room study and necessary corrections made if warranted.

5d. These scales will be changed to be the same.

5e. Varmeter is in process of being rescaled to indicate lead and lag with "0" at 12:00 position on face.

Positive Design Feature

Display glare generally is low due to placement of units and board profile.

Annunciation System Problem Areas

1. Placements — Several annunciator tiles are located away from relevant system controls and related displays (e.g., Accumulators and RWST).

   Performance decrement includes time loss due to excess traffic, inhibits performance of diagnostic procedures and high probability of failing to respond to annunciation. (Category 1)

CPSES Response

   1. A detailed study of annunciator/control orientation has been completed. Approximately 250 annunciators are in the process of being oriented to their respective controls and indication. The design changes will be completed prior to fuel load.

2. Auditory Signals — Although different auditory signals are provided for primary, secondary, switchyard, and HVAC, they do not localize or prioritize.

   Operational effects anticipated include: increased visual search requirements and increased probability of failing to respond to all annunciators. (Category 1)

CPSES Response

   2. The auditory signals for switchyard and HVAC panel are localized by virtue of different tones used for alarms located on these panels. In the main console area, the localization of left side, right side and center of horseshoe auditor tones will be implemented prior to fuel load.

3. Prioritization

   a. Alarms are not visually prioritized.

   b. No first-out panel. (Category 1)

   Operational effects include: failure to respond to alarms within time constraints, failure to respond to alarms, failure to respond to urgent alarms while attending to low priority alarms.

CPSES Response

   3a. Annunciator tiles will be visually prioritized. A study will be conducted to determine levels of prioritization. Implementation of this will be by first refueling.

3b. CPSES has a sequence of events recorder (SER) for all reactor and turbine trip inputs. The SER prints out first and all subsequent trips and time of occurrence.

4. Readability — Titles wordy, excess printing:

a. PRESSURIZER
LO PRESSURE
PWR RELIEF VLV
456 A BLOCKED

b. REACTOR COOLANT
PUMP 2 UPPER
OIL RESERVOIR
LEVEL HI-LO

c. ACCUMULATOR 4
ISOLATION VALVE
8808 D STILL
NOT FULLY OPEN

Character height of annunciator legends is approximately .22" (7/32"). At a viewing distance of 10 feet, visual angle subtended by the characters is approximately 6.3 arcminutes, which is well below established limits of 16.4. (Category 1)

Could cause misreading displays.

CPSES Response

4. A study will be initiated to resolve annunciator and labeling inconsistency of abbreviation, nomenclature, and display. In order to minimize repetitive changes, implementation of label modifications will occur following the long term HFE evaluation. Any labels which have potential of causing activation of a wrong control will be modified prior to fuel load.

5. Silence Function — There is no provision for a single master silence. During a transient, incoming alarms must be silenced at the panel from which they originate. This causes unnecessary operator traffic. NOTE: If a master silence is provided, it should not inhibit subsequent incoming alarms. (Category 4)

CPSES Response

5. Existing system has capability for a single master annunciator silencer which will be implemented prior to fuel load. This change will not inhibit incoming alarms.

Positive Design Features

1. Tiles directed down towards operators.

2. Dedicate acknowledge and resets for each panel.

3. Black bezels provide good figure/ground contrast.

4. Annunciators "reflash."

5. Annunciators inform operator of problem conditions being cleared.

Communications Problem Areas

1. Control Room — Inadequate provisions for communications between HVAC and main control room. Presently operators must either: 1) shout over panels; or 2) hook up to phone jacks at both locations.

   Errors anticipated include: failure to accurately communicate between HVAC and CR; temporal errors in accessing phones; errors of omission because operators are restricted to two relatively broad areas. (Category 1)

CPSES Response

1. Design includes provisions for page phone. Installation is in process on CV-01 which will also serve CV-03.

2. Plant — Page phone channels shared, possibly leading to competition for communications. Major potential error is failure to send/receive communicated messages. (Category 1)

CPSES Response

2. CPSES has a 5-channel page system. Administrative procedures will address the priority assigned to page phone system. Sufficient communications will be provided for operations purposes prior to fuel load.

3. Policy — Operators serve as switchboard operators during off-hours. Performance decrement/errors include failure to monitor plant and detect plant anomalies. (Category 1)

CPSES Response

3. Operators will not be required to serve as switchbaord operators following fuel load initiation.

Labels Problem Areas

1. Consistency

   a. Multiple abbreviations for 1 term, for example:

      1) CONT - CNTMNT - CONTAINMENT

      2) PRT - PRZR RLF TK - PRESSURIZER RELIEF TANK

      3) MSIV - MS ISOL VLV

      4) AVG TEMP - TAVG

      5) SIS PMP - SI PMP - SIP

   b. Labels are not positioned consistently. Majority are positioned below display, some are above, and some to the side (e.g., TOTAL MU COUNT 1FY111B, AS SMPL CLR OUT TEMP, and INST AIR AFT FILT PRESS, respectively). (Category 1)

   Could cause confusing one control/display for another.

2. Meaning

   a. Many labels describe engineering maintenance features primarily (e.g., ACCUM FILL VLV is labeled TST LNE HDR ISOL VLV). (Category 2)

   b. Dual scales are not clearly labeled (e.g., HP/TURB V POS MCV4 MCV1 1-ZI-2428B 1-ZI-2429B). (Category 1)

   c. Labels tend to be wordy and inconsistent. (Category 1)

   Could cause confusing one control/display for another.

3. Presence

   a. Summary labels not provided at panel or functional group level increase visual search times. (Category 1)

   b. Labels under low mounted strip charts cannot be seen (e.g., CONT VENT SYS TEMPS and SSW IN & OUT CCW HXS TEMP). (Category 1)

   Delay/failure to identify a needed control or display.

4. Association — Some labels can be associated with incorrect controls and displays, for example:

   a. COND PMP 1 DISCH VLV really means COND PMP 1 & DISCH VLV.

   b. Control labeled SI PMP FANS really means SI PMP 1 & FANS.

   c. Labeled VCT DIV HLD UP TK LVL CNTR really means VCT LVL CNTR.

   Could cause confusing one control/display for another. (Category 1)

CPSES Response

1-4 A study will be initiated to resolve annunciator and labeling inconsistency of abbreviation, nomenclature, and display. In order to minimize repetitive changes, implementation of label modifications will occur following the long term HFE evaluation. Any labels which has potential of causing activation of a wrong control will be modified prior to fuel load.

Operator-Computer Interface Problem Areas

While the computer in the Comanche Peak Unit 1 control room is not a safety related system, it can be used to display information about safety systems over and above those safety instruments in the control room. Category 2 discrepancies are cited here since the computer can display information from safety related systems.

1. Job Aids

   a. Sequence of Events Recorder (SER) prints in code, requiring operator to reference a code book to decipher output. (Category 2)

   b. CRT has no index for GROUP 1 through 20 selections, requiring operator to search for desired information or memorize coverage of GROUP 1 through 20 selections. (Category 2)

   Could cause failure to obtain or apply all relevant decisionmaking information.

CPSES Response

1a. The sequence of events recorder is duplicated by the process computer. The process computer prints out in sentence format. A SER code book will be readily available to the operator when needed.

1b. An index listing the points in each group will be provided for the control board's Group Monitor. When group listings are changed, a new printout can be demanded from the computer.

2. Physical Design

a. If operator fails to acknowledge alarm at printer console, subsequent audio alarms will be inhibited when main CRT flashes alarm. (Category 2)

b. Numeric keypad for alarm printer and CRT is "calculator" type (i.e., 7-8-9 on top row) rather than telephone type (i.e., 1-2-3 on top row). (Category 2)

c. PRODAC has excessive glare and brightness intensity adjustable to below threshold. (Category 2)

d. CRT lacks graphic display capability, requiring operator to reference documentation. (Category 3)

Could cause failure to obtain or apply all relevant decisionmaking information.

CPSES Response

2a. Computer will be reprogrammed so that the computer audio alarm will continue to sound until the operator acknowledges the alarm at the printer console.

2b. Keypad format will be evaluated in detail during the long term evaluation.

2c. Intensity control will be modified so CRT brightness cannot be adjusted below threshold. A study will be made to alleviate glare.

2d. Computer points can be assigned to two analog recorders to provide trending capability.

Panel Layout Problem Areas

1. Organization

a. Systems are layed out consistently from bottom to top except:

1) Containment ventilation controls seem to use left to right flow (e.g., supply, recirc and exhaust). (Category 4)

2) CHRG TO RCS ISOL VLV TRA 1/1-8147 is positioned at bottom of benchboard. Should be moved to top of benchboard to reflect discharge side of system. (Category 2)

Could cause activating the wrong control; not activating a control; misreading the display; and/or reading the wrong display.

b. Positioned in string without regard to operational sequence.

1) Computer trend recorders are in the middle of MU and Charging meters. (Category 2)

2) Rod counters need reorganized to match operational sequence. S/D should be to the left of control and the bank selector switch (Not installed yet) should match layout from left to right. (Category 1)

Could cause incorrect display reading and interpretation.

CPSES Response

1a.1) CPSES will investigate containment ventilation controls layout during long term study. Prior committment to demarcation lines may alleviate this concern.

1a.2) This item is under investigation. Controls layout will be changed prior to fuel load if deemed significant. System demarcation lines or mimics, may alleviate this concern.

1b.1) Computer trend recorders can be labeled or color coded to differentiate them from other recorders.

1b.2) CPSES will review with Westinghouse, the supplier of this equipment, the criteria for control board interface as it relates to reactor operation and control rod manipulation.

2. Visual Search

a. Layout of components of subsystem levels can cause excessive visual search requirements:

1) PRZR & PRT displays need rearranged to give component grouping. (Category 2)

2) FWP 1A & 1B turbine drain pot status indicators are located over SG meters left side of panel and FWP 1A & 1B drain pot isolation valves located over FWP controls on right side of panel. (Category 2)

3) Miniature turbine control board organization induces covering indicators when operating some controls (e.g., LOAD CONTROL, GENERATOR REF VALVE) and confusion in meter ID (e.g., FREQUENCY INFLUENCE with OFF-ON VALVE IND. SELECT CAS, & VALVE TSE TEST CAS). (Category 4)

4) Turbine driven Aux FWP status indicators need grouped by component. (Category 2)

5) Aux FW flow, pressure, and temperature meters need grouped to reflect system. (Category 2)

6) Condensate Storage Tank to Condensate MU/Rej. valves mixed with Aux FW System valves. (Category 2)

Could cause activating the wrong control; not activating a control; misreading the display; and/or reading the wrong display.

b. Functionally related controls and displays are not colocated — charging and letdown flow meters should be side by side with equal scales. (Category 2)

Could cause activating the wrong control; not activating a control; misreading the display; and/or reading the wrong display.

c. Coding methods are not employed to enhance discriminability.

1) Color coding is used for different trains, however, all this becomes very confusing due to some components being on both or some only on one (e.g., STM GEN PRESS meters). (Category. 2)

2) Reactor trip switches should be red to make them stand out from others. (Category 1)

Operational errors will include control/display substitution, display reading errors, and temporal errors.

CPSES Response

2a.1,2,4,5,6) These items are under investigation. Improved labeling, system/subsystem demarcation, mimics and layout changes will be investigated in the long term study.

2a.3) Turbine control layout will be studied during the long term HFE evaluation.

2b. These displays will be arranged on the same level with equal scales.

2c.1) Color coding on indicator bezels will be deleted or changed as a result of the human factors integration of the Safety Parameters Display System requirements of NUREG 0696.

2c.2) Reactor trip switches will be painted red.

3. Stereotypes

a. On-off, increase-decrease movement stereotypes are not followed.

1) HTNG STM TO MSR 1-A & 1-B B/P VLVS is CLOSE, NEUT, OPEN with HTNG STM TO MSR 1-A & 1-B SPLY LINE ISOL VLVS is NEUT, CLOSE. (Category 2)

2) PR SMPL SYS TR-A, TR-B ISOL MSTR VLV, close position on right side. (Category 2)

Activating control in wrong direction; lack of timely control response.

b. Discriminability is reduced by C/D similarity.

1) J-handles and thumb switches are used for valve controls on 08 and 09 panels. (Category 2)

2) The annunciator pushbutton on the control board are left to right, top to bottom: TEST, ACKNOWLEDGE, SILENCE, and RESET. The HVAC panel is TEST, RESET, and ACKNOWLEDGE. (Category 3)

3) MLBs 61 and 62 are positioned vertically, should be horizontal as all the rest. (Category 4)

4) All frequency meters (except INCOMING 1-F-IN on right side of 11 panel) deenergized positions do not match majority of circular meters' deenergized positions. (Category 3)

Could cause activating the wrong control; not activating a control; misreading the display: and/or reading the wrong display.

CPSES Response

3a.1,2) The labeling program may alleviate these problems. If not, consistency will be achieved during the long term study of all controls.

3b.1) CPSES will replace J-handle valve switch handles with a differnt type of switch handle.

3b.2) The HVAC pushbuttons will be changed to the same arrangement as the control benchboards.

3b.3) MLB's 61 & 62 are not accident monitoring displays. These status boxes display the operational status of various feedwater valves during startup operations. They need to be positioned vertically to depict status sequence.

3b.4) Additional evaluation will be made during detailed control room study and necessary corrections made if warranted.

4. Maintenance

a. Bulbs in annunciators and controls with transilluminated labels require special tools to change. (Category 3)

b. MAIN & AUX CONDRS CIRC WTR TEMP trend recorder door cannot opened without adjacent trend recorder door being opened first. (Category 3)

c. Annunciators windows cannot be opened wide enough to attain full access to bulbs unless adjacent window below them are opened first. (Category 3)

CPSES Response

4a. No special tools required; factory recommended long nose pilers for some bulb changing.

4b. This item is under investigation for correction.

4c. A step ladder and tool to aid in the replacement of annunciator lamps will be provided prior to fuel load.

RECOMMENDATIONS

Based on this preliminary assessment, the following design recommendations can be made.

1. Provide additional safety gear in the control room, including additional fire extinguishers, and emergency breathing apparatus. Placement and design for accessibility and ease of donning (personal protection gear) should be designed into the control room.

2. Provide storage space for documentation within immeidate operating area.

3. Provide aids for visual search. This may extend to removal of bezels, line demarcations of functional control and display groups on the boards, and adding sytem mimics to the boards. The approach selected should be studied in terms of current board layout, any constraints (available space, etc.) and sequential and operational task requirements.

4. Improve communicators betwen HVAC panel and main control area by means of a permanently installed page phone.

5. Provide inadvertent control operation protection where required.

6. Improve control position coding in terms of:
   - Contrast of control pointers and handles
   - Flag (or target) figure/ground contrast on J-handle controls.

7. Design to achieve consistency of process controllers in terms of direction of use. For example, a clockwise rotation always opens valves, increases pump output (or better, increase flows, temps, pressures, etc.). Directional conventions should be consistent with other control conventions.

8. Provide inapproved display readability in terms of:
   - Parallax
   - Positioning for operational tasks
   - Excessive glare
   - Normal range and setpoint markings
   - Viewing angles
   - Consistent linear scaling

- Visual access
- Additional displays required
- Presentation of information.

9. Improve annunciator system in terms of:

   - Positioning to applicable system
   - Audio differentiation
   - Prioritization
   - Readability.

10. Develop and implement a set of plant specific guidelines for labels, which address:

    - Label consistency
    - Patterns of information presentation
    - Accuracy
    - Font size, type, and spacing
    - Board placement relative to labeled components.

11. Improve operator-computer interface in terms of:

    - Job performance aids
    - Physical design.

12. Improve panel layout in terms of:

    - Control/display relationships
    - Operational sequence
    - Functional relationships
    - Coding methods
    - Stereotypes.

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