TECH

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

NOV 10 1980

Docket No. 50-395

Mr. T. C. Nichols, Jr.
Vice President and Group Executive
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Dear Mr. Nichols:

SUBJECT: HUMAN FACTORS ENGINEERING CONTROL ROOM DESIGN REVIEW/AUDIT - SUMMER

During the week of August 25-29, 1980, a human factors engineering design review/audit was conducted by the NRC staff at the Virgil C. Summer Nuclear Station, Unit 1. The review was conducted by representatives of the Human Factors Engineering Branch who were assisted by our consultant, Biotechnology, Inc.

Enclosed is our assessment of the control room design for your facility. Included are a number of deficiencies which we have identified in the control room design. We will require that you respond in writing with a program for correcting each of these deficiencies.

Your response should be provided as soon as possible in order to permit us to include our assessment in the forthcoming Safety Evaluation Report. If you require any clarification, please contact the staff's assigned project manager.

Sincerely,

A. Schwencer /for

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Assistant Director for Licensing
Division of Licensing

Enclosure:
As stated

cc w/enclosure:
See next page

NOV 10 1980

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HUMAN FACTORS ENGINEERING CONTROL ROOM
DESIGN REVIEW/AUDIT
V. C. SUMMER

During the week of August 25-29, a human factors engineering design review/audit of the V. C. Summer control room was conducted. The review was performed by the Human Factors Engineering Branch, Division of Human Factors Safety, with assistance from Harold E. Price of BioTechnology, Inc., our human factors' consultant.

At the time of the review the control room at Summer was approximately 3 to 4 months away from completion. Many of the systems and subsystems were either not operational, or not installed thus limiting the teams capability to assess the man-machine interface.

The following sections of this report summarize the staff's observations of the control room design and layout, and of the control room operators interactions with that environment. Where possible, observed deficiencies were given a subjective rating based on the potential for that deficiency to result in an operator error during performance of a critical activity. These ratings are divided into three categories:

1. Major concern for potential operator errors that could affect plant safety.

2. Moderate concern for potential operator errors that could affect plant safety.

3. Minor concern for operator errors that should not affect plant safety.

1.0 GENERAL OVERVIEW

a. Labeling and other aids for recognition and identification such as demarcation and color coding is inadequate at present. Excessive time and error potential exist in searching for and identifying systems, subsystems, groups or components.

b. Most controls and associated displays are in the same general area, but layout orientation is not consistent. Series of controls (or displays) are not arranged in sterotypical patterns and identification of displays associated with controls is not clear.

c. Controls were not easy to recognize and identify (particularly CMCs); and, when a series of controls were grouped the orientation was not consistent (i.e., vertical or horizontal, or alpha-numeric order). Clusters of controls were not separated by spacing, demarcation, color or other recognition aids.

d. Some displays (vertical meter scales) are difficult to read, to interpret values, and require mental conversion. Some meters fail at mid scale.

e. Poor control room layout (from a visual task and perception standpoint). A structural column is located in the middle of the control room.

f. General layout of bench consoles, computer console, and future foreman's desk is good. Traffic patterns are satisfactory and passageway clearences are adequate. Visual access from the principal operators position (near rod

control station) to all bench consoles is good. Visual access from the computer console is good except for the in-core monitoring panel. This system, however, has its own audible alarm to attract operator attention.

g. Overall, the control room lighting design is adequate. The combination of open grid work below luminaries and the 2 ft. X 4 ft. ceiling panels provide a comfortable level of illumination, but does reduce panel illumination on on the upper panels. However, this lighting arrangement does not produce excessive glare.

h. No emergency equipment in the control room. No assessment or conclusion can be made as to the adequacy, accessibility, communication problems, etc., of protective equipment at this time.

i. The acoustic background (noise) level is a comfortable 55 to 57 dbA. Alarm levels were about 15 dbA above this level. A potential problem exists with the plant page system as a source for background noise with a peak of about 76 dbA. Announcements over this sytems tend to reveberate throughout the control room.

2.0 THE MOST SIGNIFICANT HUMAN FACTORS DEFICIENCIES OBSERVED DURING THE CONTROL ROOM DESIGN REVIEW/AUDIT.

2.1 CONTROLS

a. Specific Controls (CMC switches) were not easy to locate and identify (Category

b. Clusters of controls had no demarcation, color coding or other recognition aids. (Category 2).

c. Legend covers on CMC switches can be inadvertantly interchanged. (Category 1).

d. Cannot distinguish momentary contact switches from continuous contact. (Category 1).

g. Difficult to identify a specific control in a large group of controls (Category 1).

h. Cannot readily distinguish between controls for valves, pumps, fans, etc. (Category 3).

i. Legend labels on the controls are inconsistent (Automatic sometimes means closed) (Category 1).

j. Component number (or other information) that is engraved on the red and green lenses are difficult to read, particularly when the green lenses are not illuminated (Category 2).

2.2 "J" HANDLE SWITCHES (SBM)

a. There are two reactor trip switches on the bench panel. One turns right (cw) to trip the reactor and the other turns left to trip the reactor (Category 2).

b. It is difficult to read switch position labels while gripping the control (Category 1).

c. The color flags are difficult to distinguish (Category 2).

2.3 HAGEN VALVE CONTROLLERS

a. Controllers which violate position convention are confusing with respect to open/close positions (Category 1).

b. The setpoint scale is difficult to read on the automatic controllers (Category 3).

c. Some 3 way valves are labeled open and closed when in fact they are always open in the same position (e.g., VCT Level Controller) (Category 1).

d. There is no feedback from actual vs demand signal. This can cause transients when switching to the automatic mode (Category 2).

e. Vernier scales are difficult to read on manual controllers (Category 3).

3.0 DISPLAYS

a. Some displays (vertical meter scales) are difficult to read, interpret values, and require mental conversion (Category 2).

b. Dual scales on one instrument are confusing (Category 2)

c. Many meters fail at mid scale (Category 1).

d. ESF Status Monitor Panel indicators with low and bright intensity lights are not consistent in meaning or intensity, and are difficult to use for pattern recognition (Category 1).

e. There are numerous hand made scales (Category 1).

f. There are no normal operating ranges or setpoints indicated on meters (Category 1).

3.1 MODUFLASH DISPLAY SYSTEM

a. The percent scale is difficult to interpret (Category 2).

b. The system cannot be easily related to specific annunicators on the Main Control Board. (e.g., no indication on annunicator tiles as to whether that parameter is monitored by the Moduflash system). (Category 2)

c. Flow readings must be converted from a precent scale (Category 1).

d. Distinction between setpoint and flow/temp selection is poor (Category 2).

e. The orientation of the status indicators on "A" train and "B" train is not consistent (e.g., CC pump SUCT-loop and DISCH loop) (Category 2).

4.0 CONTROL/DISPLAY RELATIONSHIP

a. Layout of controls and associated displays have no consistent pattern (e.g., display directly above control or to the right or left) Category 2).

b. Display is not always within convenient viewing distance when using a related control (e.g., pressurizer pressure indication is several feet from controller) (Category 2).

c. Strings of controls and displays are not consistently oriented (i.e., vertical, horizontal, matrix, etc.) (Category 2).

4.1 SERVICE WATER PANEL (604 & 605)

a. SW Pumps A, B, C have a confusing instruction plate on the panel (e.g., the bottom line says: "Pull to lock in slow speed pull position." Misinterpretation could cause operator to lock the pump in slow speed position when it should be locked out of service) (Category 1).

b. SW Pump "C" Discharge status light is essentially a caution or warning, yet it is a white legend and is not located adjacent to pump switch (Category 2).

c. SW Pump Alignment indicators do not illuminate either red or green (some had both illuminated). These indicators should be set to illuminate either all red or all green for each train (Category 1).

4.2 H.V.A.C. PANEL

a. Mimic is color coded but the coding is not carried out over the controls and the panels (Category 2).

b. Damper Controls and Mimic for LOOP A, LOOP B, TRAIN A, TRAIN B, do not appear to correspond. Cannot tell on the mimic what is a loop or what is a train. The control labeling is very confusing and not apparent on the mimic (Category 2).

c. There are large numbers of fan controls grouped together and it is not easy to find a particular fan by number. Also, the arrangement of those controls does not correspond to their relative position on the mimic (Category 2).

d. Considerable glare on mimic, particularly at the top of HVAC panel (Category 2).

e. Mimic board is too high for a 5th percentile person to read (Category 3).

f. CMC component identification numbers are hard to read when legend is not illuminated (Category 3).

4.3 REACTIVITY CONTROL SYSTEM PANEL (620 & 621)

a. BANK SELECTOR control position indicator is difficult to determine because of poor labeling (Category 1).

b. NIS RECORDER PEN SELECTORS control position is difficult and awkward to determine because alpha numerics are sideways. Also, selector control must be turned though SOURCE range to go from INTERMEDIATE TO POWER (Category 2).

c. Part Length Rod control is not used. (Category 2)

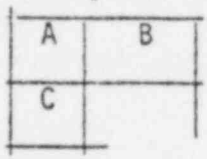
d. Boric Acid Pump controls are 6-8 feet away from BORATE control yet they may have to be used if emergency borate flow is inadequate. (Category 1).

e. There are 8 vertical meters for POWER, INTER & SOURCE range reading % RANGE and % FLUX. These generally must be compared for differences and are not well designed scales for this purpose (Category 2).

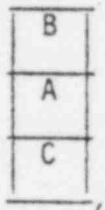
4.4 EMERGENCY FEEDWATER SYSTEM PANEL (622 & 623)

a. Arrangement of control strings is not always optimum

EF Isolation From MDP to SG =



EF Isolation From TDP to SG =



(Category 1)

b. Minimum specified turbine flow of 100 GPM is at very bottom of meter scale (Category 2).

c. EF SG Pressure and SG Pressure (Narrow Range) must be compared but they are two different types of scales, even though they cover the same range of values (Category 1).

d. Identification of A, B, C, steam generator components is difficult (Category 2).

4.5 FEEDWATER SYSTEM PANEL (625)

The switch handles for the bypass controls are the same as the control switch. Search time might lead to confusion (Category 2).

4.6 FIRST OUT PANEL (626)

There is no identification of the first out alarm panel on the control board (Category 1).

4.7 CONDENSATE PUMP PANEL (627)

The control board layout could lead to confusion because the master condensate controller is below pump C (Category 2).

4.8 MAIN STEAM PANEL (629 & 630)

The main steam isolation valves are identified A, B, C horizontally while the status light indicators show channels I. II, III. (Category 1).

4.9 RADIATION MONITORING SYSTEM

Detectors are not associated with their related annunicators, such as, detectors RMA-11 is located in Section No. 4 of the panel while the corresponding annunicator is located in Section No. 5, RMA-6 is located in Section No. 5 of the panel while the corresponding annunicator is located in Section No. 6. (Category 2).

4.10 STEAM GENERATOR PANEL (624)

a. Reset for Feedwater Pump A, B, & C is difficult to identify. It is within a cluster of several CMC switchs. (Category 1).

b. By-Pass Flow Meters are difficult to identify and read when operating flow controllers (Category 2).

c. There are 3 sets of meters which are used for comparison checking and which have similar but different scales. These are Main Steam HDR Press (0-1300 PSIG); FW Pump DISCH HEAD (0-1500 PSIG); FW Pumps A, B, C (0-1800 PSIG) (Category 1).

d. The master controls for a series of valves is located on the left hand side for (Feedwater Pumps,) and on the right for others (e.g., Condensate Master Pump). Also, "Master" displays are located inconsistently (e.g., FW Boost Pump DISCH Press is in the middle) (Category 2).

4.11 POWER PANEL (636 thru 638)

a. On the Diesel Generator A controls, the "Exciter Reset Shutdown" label should be labeled "Engine Shutdow. eset" to be consistent with diesel generator B controls (Category 2).

b. Most wattmeters and voltmeter indicators on the panel are miniature and wide range and do not permit accurate readings which are sometimes required (Category 3).

5.0 LABELING AND CODING

a. There is no hierarchial structure of labeling (e.g., from System, Subsystems to the component label) (Category 1).

b. Little or no use of demarcation lines (Category 3).

c. Use of mimic diagrams on the control panel is minimal (Category 3).

d. Labels are not consistently positioned above, below, to the right or anywhere (Category 1).

e. Labeling techniques are not consistent (e.g., black on white and white on black labels, etc.) (Category 1).

f. Labels are not permanently attached (Category 1).

g. Labels tend to be wordy, inconsistent in the use of abbreviations, and have some misspelled words. (Category 1)

h. Some labels are missing (Category 1).

i. Some labels are obscured by controls (e.g., Barrel Switches) (Category 1).

j. Essentially no color coding for location and identification of systems or functions is used (Category 3).

k. Labels under low mounted strip chart recorders cannot be seen (Category 1).

l. Dual function vertical scales are not clearly labeled to identify the function of each scale (Category 1).

6.0 WORKSPACE AND ENVIRONMENT

a. Visual access from the Shift Foreman's desk to main control board is restricte by a support column (Category 3).

b. Storage of essential material (emergency operating procedures) is undefined (Category 1).

c. There is inadequate knee space at computer console (Category 3).

d. There is no emergency equipment in the control room (Category 1 until reviewed)

6.1 HAZARDS

a. Mats around the bench console and long telephone cords present a potential tripping hazard. (Category 1)

b. "J" Handle controls (e.g., diesel generator panel) are mounted close to the edge of the bench boards. They present a hazard to personnel as well as inadvertent control actuation (Category 1).

6.2 COMMUNICATIONS

a. Comunications to the Emergency Operations Center and Technical Support Center are via the page phone system (Category 2).

b. There is no storage or accountability for sound powered phones in the control room (Category 1).

c. Incoming telephone calls to the plant are transferred to the control room at night (Category 1).

d. No procedures for communication control during an emergency (Category 1).

e. There is no direct communication from the main control room area to the HVAC panel area (Category 1).

7.0 ANNUNCIATORS

a. Annunciators lack prioritization (Category 1).

b. Audible alarms are not directional - except for Radiation Monitoring System and the HVAC (Cagegory 2).

c. Several annunciator windows are not located on the same panel with their associated controls (Category 3).

d. Up to 3 different styles of print and character size are used on annunciator windows which varies the readability envelope (Category 2).

e. Fire and Security alarms systems could not be reviewed. This system was not turned over to operations at the time of our audit. (Category 1).

f. Numerous annunciator windows are hanging open and others were missing tiles and bulbs (Category 1).

8.0 PROCESS COMPUTER

a. IBM Selectric Typewriter (printing speed) is the limiting component in the process computer system for displaying or printing numerous multiple process alarms (Category 2).

b. Analog trending capability is limited to 4 parameters on 2 process computer controlled - 2 pen strip chart recorders (Category 2).

c. There is no CRT graphic display capability (Category 2).

d. No color coding used on CRT displays (Category 2).

e. Not all overhead alarm parameters are monitored by the process computer (Category 2).

f. Operators have received only a 4 hour training course on the use of the Summer process computer at the system level. (Category 1)

g. Data point addresses are not cross indexed. Present index requires excessive operator search time to locate individual addresses (Category 1).

h. No labels or other means on panel to identify what four parameters are being monitored by the two 2 channel computer controlled strip chart recorders (Category 1).

i. The incore thermocouples on the process computer are limited to 700 F (Category 1).

9.0 OTHER OBSERVATIONS

a. There are 3 channels of vertical indicators used to display RCS flow. The arrangement of these meters and the flow indication is not logical and is confusing to operators reading the display (Category 2).

b. There is operator confusion concerning the manual initiation of Safety Injection (SI) (Category 1).

c. Reactor Building (RB) temperature display on vertical panel is wide range. To detect incremental change in RB Temperature when RB fans are energized requires an operator to go to the HVAC panel where a narrow range temperature indication is available (Category 2).

d. RB cooling units are cooled by industrial coolers. Controls for cooler pumps are on CP 606 (sloping panel) while the industrial cooler temperature alarm windows are on CP 610 (7-8 feet away) (Category 2).

e. Emergency procedures require operators to rely on pattern recognition to identify Train A and Train B initiation on 6 ESF status monitor light panels. Patterns are confusing and difficult to recognize on display panels. Patterns are shown and described in Attachment 1 to EOP-1, and these patterns were even difficult to interpret in the EOP (Category 1).

f. There is construction in the area of the Remote Shutdown Panel, therefore, we did not complete our review of the panels, lighting, and communication syste (Category 1 until reviewed).

g. There is a temporary ventilation fan mounted in the back of the main control board. (Category 1)

h. The plant page system in the control room is too loud, approximately 76 dbA, also the CR has reverberation (Category 2).

i. Emergency DC lighting - Illumination levels were between 2 & 11 footcandles on control and display surfaces (Category 2).

j. Emergency AC lighting levels were not measured or evaluated. Actuation of this system was not accomplished. The applicant should provide us a copy of its survey results for our review and evaluation prior to January 15, 1981. (Category 1)

k. No system is provided to test all the status and position indication lamps (Category 1).

l. The pressure power operated relief valve controls and associated isolation valve controls (445A, B, C) are inconsistently labeled. (Category 1)

m. The strip chart recorder for rod position and insertion is scaled from 0 to 100%, which equals 240 steps. This is not consistent with the position indication on the main control board for full out position (100%) which is equal to 228 steps (Category 1).

n. There is no CRT trending capability or graphic display capability (Category 3).

10.0 SUBCOOLING MONITORS

A Westinghouse system is expected onsite by 10/30/80, installed by 12/1/80 and operational by 1/1/81.

11.0 REACTOR VESSEL LEVEL INDICATION

A Westinghouse system is expected on site by 11/30/80, installed and operational by 1/1/81.

12.0 INCORE THERMOCOUPLE SYSTEM DISPLAYS

A. Limited to 700°F.

B. All 51 thermocouples are monitored by process computer (PC).

C. Thermocouple readings can be displayed on either or both CRTS for a maximum of 30 at a time.

D. PC can provide long and short term thermocouple maps and data on the trend typewriter in the CR and on line printers.