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Mr. H. G. Parris
Manager of Power
500 A Chestnut Street, Tower II
Chattanooga, Tennessee 37401

Dear Mr. Parris:

SUBJECT: CONTROL ROOM DESIGN REVIEW/AUDIT REPORT FOR WATTS BAR NUCLEAR PLANT, UNIT 1

Attached is the Human Factors Engineering Control Room Review/Audit Report for Watts Bar Nuclear Plant, Unit 1. As discussed with your staff, we would like to arrange a meeting to discuss the report with them.

The purpose of this meeting will be to discuss TVA's proposal to correct deficiencies identified in the attached report and the schedules for implementing its corrective actions. We further request that, on a one-on-one basis, the actions proposed in TVA's January 13, 1981 report, "Preliminary Control Room Review of Watts Bar Nuclear Plant, Units 1 and 2", be identified with the deficiencies which prompted them, (i.e.: the Essex review at Sequoyah, Unit 1, TVA's own review, or the NRC review at Watts Bar, Unit 1). The present status of these items and the time table for implementation should also be submitted.

Please contact us if you desire any discussion or clarification of the report or request for information.

Sincerely,

Original signed by
Robert L. Tedesco

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

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DATE	5/27/81	5/27/81	5/26/81				

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HUMAN FACTORS ENGINEERING CONTROL ROOM DESIGN REVIEW/AUDIT REPORT

WATTS BAR - UNIT 1

During the week of October 6-10, 1980, a human factors engineering design review/audit of the Watts Bar control room was conducted. The Review/Audit was performed by the Human Factors Engineering Branch, Division of Human Factors Safety. The review team was assisted by human factors consultants G. R. Hatterick and H. E. Price of BioTechnology, Inc., V. Pezoldt of the National Bureau of Standards, and R. Peterson and D. Wentz of Lawrence Livermore National Laborabory.

At the time of the site visit, the control room at Watts Bar was a couple of months from completion. Many of the systems and subsystems were not yet operational or not completely installed, thus limiting the team's capability to assess man-machine interfaces.

The following sections summarize the staff's observations of the control room design and layout, and of the control room operator's interaction with that environment. The contents of the report were organized, whenever practical, according to the draft NUREG-0700 guidelines sections, to be published in the near future. Observed human factors design deficiencies were given a subjective priority rating of one to three, (high, moderate, low) based on the increased potential for that deficiency to contribute to operator error, and the possible consequences of that error.

GUIDELINES SECTION

6.1 CONTROL ROOM WORKSPACE	CATEGORY
A. Emergency Equipment	
Protective Clothing - there are several problems:	
- Donning is difficult.	
- Changing air tanks is a two-man operation.	
- With the five minute warning bell, there is perhaps too little time to change.	
- Mask virtually prohibits the wearer from speaking to anyone.	
- There are too many steps to don gear.	1
B. Communications	
(1) There are no labels on the six area sound powered phone jacks to identify the area to which they are hard wired.	2
(2) No headsets are located on any of the back cabinets.	2
(3) Distance and noise interferes with voice communication between the Unit 2 control room operator at the panels and the operator at the common panels. The problem is particularly acute when a breathing apparatus is worn by both.	1

6.2 WORKSPACE ENVIRONMENT	CATEGORY
A. Lighting	
(1) The control room lighting design appears to be for general illumination purposes and not specifically for effective man-machine interface.	2
(2) The plastic prismatic luminous ceiling diffusers minimize indirect glare through out the control room but they contribute to direct glare on panel meters, recorders, printers and polished surfaces.	2
(3) A number of burned out or extinguished overhead lights were observed indicating poor maintenance practices.	3
(4) Dirt on overhead plastic diffusers reduced lighting levels indicating poor maintenance.	3
(5) The A.C. emergency lighting illuminating level is too low for optimum reading of displays.	1
(6) D.C. emergency lighting incandescent lamps are not located for optimum reading of displays.	1
(7) The ratio of luminosity, (background luminous ceiling and the green painted metal reading surface of panels/consoles) 140 foot lamberts/18 foot lamberts, is 8/1. This is 3 times the recommended standard.	2

6.3 ANNUNCIATORS	CATEGORY
A. There is no auto-clear capability when alarmed parameters are returned within tolerance limits. Each alarmed tile requires operator manual action to clear.	1
B. There is no capabilty for silencing an alarm while preserving the flashing tiles (for diagnostic purposes).	1
C. The auditory alarms that were functional were barely detectable above the ambient background noise.	1
D. Poor organization of annunciator tiles, difficult to locate in the standard operating instruction (SOI). No cross references provided.	1
E. Alarms are not prioritized.	1
F. The contrast between steady state and flashing tiles is poor.	1
G. The contrast between illuminated and non-illuminated tiles is too low.	1
H. The poor relationship between the acknowledge-reset controls and their associated annunciator displays could result in the incorrect acknowledgement of an alarm.	1
I. The location of acknowledge-reset controls are not standardized across panels.	2
J. The replacement of annunciator bulbs frequently subject the operator to a shock	1

6.4 CONTROLS	CATEGORY
A. The location of some controls disregards the capabilities of the 5th percentile person.	2
B. Labeling on many valve controllers does not consistently or clearly associate direction of movement with resulting action. A clockwise movement does not always result in opening the valve.	2
C. Controls located near front edge of sloping console create a potential for inadvertent actuation.	1
D. Direction of control movement on "Trip" controllers is not standardized.	2
E. The Reactor Trip-Reset controller on Panel 1-M-6 is incorrectly labeled. It only functions as a trip control.	1
F. Specific control handles were not easily distinguishable when in a bank of controls (i.e., a string of 5 with one different).	1
G. Handles of star switches obscure some of the labels.	1
H. Valve control handles which must be held for many seconds are difficult to hold.	1
I. The function (i.e., use of pull out/in feature) of some J-handle switches is not clearly labeled.	1
J. There are no protection guards over the emergency "start" and "stop" push-buttons on the diesel generator panel.	1
K. The vertical cabinets along the walkway between Units 1 and 2 contain numerous protruding controls which could be inadvertently actuated.	1

6.5 DISPLAY	CATEGORY
A. Meters	
(1) Scale divisions and ranges are not always immediately obvious.	2
(2) Information obtained from some meters is not directly usable. It has to be converted to other units to be meaningful, i.e., "HP Turbine Impulse Chamber" reads in PSIA and must be converted to percent power.	3
(3) Some meters required for post accident monitoring are intermixed with other meters.	1
(4) All of the post accident monitor (PAM) displays are labeled with temporary red tape.	1
(5) Displays indicating sequential information are not always located sequentially or grouped together for ease in visual scanning.	2
(6) Meters indicating parameters which must be compared are not grouped for ease in distinguishing similar or different values.	1
(7) Meters that indicate different parameters look alike, have similar scales, and are similarly labeled. Reading errors could result.	1
(8) Identification of a specific meter is not always obvious among a string of meters.	1
(9) Meters labeled "B" left and "A" right violate stereotypical convention.	2
(10) Meters mounted high on panels are difficult to read by 5th percentile persons and introduce parallax problems.	2

	CATEGORY
(11) The significance of the green scale markings on the frequency meters, Panel 0-M-26, is not clear.	3
(12) The sub-cooling margin monitor is not yet installed or on site; readouts and displays could not be observed.	1
B. Legend Lights and Indicators	
(1) Control position indicator bulbs have single filaments and no lamp test capabilities.	1
(2) The status of the MFPT A Turbine Trip/Reset switch is confusing. It indicates "Red" when in the reset position and "Green" when tripped.	1
(3) The valve position indicator on the EH Fluid operator's subpanel (1-M-2) is not clear. A green lens indicates "Valve Open".	1
(4) Blank windows are intermixed with active windows on the statalarm panels. Windows are not always in the "off" mode during normal operation.	3
(5) The scale on the "boric acid flow to blender" indicator is not graduated to indicate decimal point to "tenths" for last digit.	3
(6) Status Monitoring-Engineered Safety - In the matrix of indicator lights, failure to achieve a proper system status is often given by a light "off". No check is made during EP for failed lights. This could lead the operator to assume that an operating system had failed.	1

		CATEGORY
(7)	Status Monitoring-Engineering Safety - In the matrix of lights, spares are intermixed with operating lights. Since the operator's task is to determine "all on", "spares off" creates a requirement for the operator to review all lights to assure that only the spares are off.	1
C.	Recorders	
(1)	There is no recorder for indicating cold leg temp.	1
(2)	Some recorders do not indicate in real time.	2
(3)	The use of CT Flux Differential meter data requires the use of the Tech. Spec Limit Curve.	2
(4)	Recorder scales and paper scales are not always compatible.	1
(5)	Labels indicating color code of pens are not always compatible with color of pen trace indicating that parameter.	1
(6)	Some recorders do not identify the parameter units indicated on both the scales and paper.	1
(7)	In some instances the test and calibration labels cover meter faces or paper scale indication.	1
(8)	Some dual function recorders do not have name plates indicating the parameters being monitored.	1
(9)	Steam Generator Strip Charts - Labels on chart windows contradict those under chart units. It appears that recorders were reinstalled incorrectly after maintenance.	2

6.6 PANEL LAYOUT	CATEGORY
A. Controls are not arranged in logical order, i.e., by function or sequentially.	2
B. Demarcation between Units 1 and 2 and trains A and B are not clearly indicated.	1
C. Switch Confusion - Large strings/matrices of switches are located at several places on panels:	
(1) Component cooling water	
(2) Water service systems	
(3) Essential raw cooling water	
(4) Ventilation panel	2
D. Violation of Stereotype - Feedwater and condensate system - 480 THOV had a sequence of valves (left to right) CBABA	2
E. Display Confusion - There are several long strings (greater than 4) of vertical meters. Mounting in strings increases the likelihood that the operator will read the wrong display if it is near the middle of the string.	2

6.7 CONTROL/DISPLAY (C/D) ARRANGEMENT	CATEGORY
A. Some displays are not located directly above the controls which relate to them. Some are even located on different panels. Effective control/display relationships do not exist.	1
B. Maintenance and test C/D are located on some panels which contain important operating functions.	2
C. There are many instances where controls and displays are arranged "B" on left and "A" on right. (Not typical stereotype.)	2
D. Some functional groups of valves are not arranged according to operating sequence.	2
E. Some annunciator tiles refer to specific controls or displays which are either not labeled or which have different label information, including inconsistent abbreviations.	1
F. Pattern recognition requirements on statalarm panels are too complex for rapid verification.	2
G. Although most control switches are color-coded by system, associated displays are not color-coded to aid in establishing control/display relationship.	2
H. Some annunciator windows on panel 1A are associated with controls located below panel 1C and visa versa. (No standardization.)	1
I. Some annunciator windows for panel 1-M-9 are located above panels 1-M-3 and 1-M-5. Poor annunciator placement is true for some other systems as well.	1
J. Some annunciator labeling is ambiguous.	1
K. Annunciator tile organization over the radiation monitor cabinet is not consistent for both panels.	3

6.8 LABELING AND CODING	CATEGORY
A. Labels	
(1) Some control panels lack system, subsystem, and functional labels.	1
(2) No hierarchial system of group labeling is used on controls/displays.	1
(3) Many panels have temporary labels.	1
(4) Control labels are placed below the control.	1
(5) Label legibility at normal viewing distances is marginal. Lettering is not sharp and contrast is low, especially for older labels where lettering is smaller and contrast is lower.	1
(6) The control position markings for controls mounted high on panels are difficult to view.	1
(7) Some groups of controls/displays have no function identification labels.	1
(8) Position markings for some J-handle switches are not clear. Some 2-position switches have only 1-position labels.	1
(9) The meaning of "Pull to ---" labels associated with some "J-handles" is not always clear with regard to their rotary position.	1
(10) Annunciator panels are not functionally labeled and individual titles are not matrix number coded to assist in location.	1
(11) Some controls have more than 2 status lights associated with them, with no labeling to indicate the purpose or meaning of the lights.	1

		CATEGORY
L.	A lamp test capability is provided only for the overhead annunciator panels and status panels.	1
M.	Variation of Stereotype - Amps display for feedwater pump B is mounted over a vertical string of pump A related switches.	2

	CATEGORY
(12) Some labels contain erroneous information.	1
(13) Labeling - Font was too small, contrast poor, and information inconsistently placed on specific lines.	1
(14) No Labels - Turbine pump indicators have two red lights but no label for either.	2
B. Demarcation	
No demarcation is used to delineate systems, subsystems, or functional grouping on controls and displays.	2
C. Mimicing	
(1) Most mimics are temporarily affixed to panels and are sometimes confusing.	1
(2) The electrical distribution panel mimic is incomplete.	2
D. Coding	
(1) The number of colors used for switch backplates is excessive and shading differences are sometimes difficult to discriminate.	1
(2) A color coding scheme has not been applied to displays.	2

6.9 PROCESS COMPUTER, KEYBORADS, AND CRTS	CATEGORY
A. To initiate a computer function requires a series of complex operator actions.	2
B. Poor I/O indexing exists; the operator must search through a complete document list to find specific data point address information.	1
C. The process computer and the IBM selectric typewriters are very limited in their ability to present pertinent real time information.	2
D. Filing of process computer documents are not systematic or clearly identified.	1
E. No procedure could be found that covered the necessary actions to take in the event the process computer failed.	1
F. The CRT color coding display required some refinement for clearer status monitoring.	3
G. The status monitoring system was not functional.	1

HUMAN FACTORS STRENGTHS OBSERVED

There are no long strings or large clusters of indicators.

Display legibility is satisfactory.

Control position indicators are generally readily detectable, clearly associated with controls, and consistent with respect to the use of red and green color.

Statalarm panels are readable at normal viewing distances, have built in lamp tests, and are generally logically organized.

C/D relationship is generally adequate.

SG controls/displays are particularily well organized.

In general, most controls and displays are permanently labeled.

Permanent mimics have good flow direction identification.

Control backplates have a consistent and organized scheme of color coding according to system.

Symbols which distinguish between Train A and Train B are clear and easily understood.

Normal ambient lighting level in the control room is generally good.

Overhead plastic prismatic diffusers of luminous ceiling provide uniform distribution of light which minimizes indirect glare.

Lighting controls (5 steps) permit operators to adjust lighting to comfortable levels.

Ambient A.C. and D.C. emergency lighting levels were generally good.