Appendix B

Human Factors Review Team Guidelines

HUMAN FACTORS REVIEW TEAM GUIDELINES

No.	Description
1	Systems within a functional group should be grouped together.
2	Layout of identical systems within a group should be identical, not mirror images.
3	Associated controls and displays should be in close proximity (within 2 ft of each other).
4	Displays which have to be compared should be adjacent and values easily readable and comparable.
5	Displays and controls which are considered to be the most important or are used extensively should be placed in the optimum viewing use areas.
6	Devices of lesser use or importance should be placed in lower, optional areas.
7	Devices which are used infrequently should be removed to local boards.
8	Alarms, displays and controls for systems should have identical spatial arrangements.
9	Relationships between functional characteristics of systems and components should be the same on all of the control boards.
10	Boundaries between systems should be demarked and the areas so contained should be single (one system should be clearly separated from another system).
11	Systems and subsystems should be clearly identified as systems, not by the identification of each individual component.
12	An annunciator system should draw the distinction between safety and economic functions with plant safety being the highest layout priority.
13	Easiest line up of functional devices used during accident and check out.
14	For process flow type systems, other than the CVCS system, the arrangement of components should follow the process flow (valve suction then pumps, recirculation alongside pumps, discharge valves, etc.).
15	The association of control variable controller snad systems should be unambiguous. It should be clear which system is which.
16	Order of precedence: A safety related system layout should have a higher priority than a non-safety related system. The system (within systems of the same relationship) requiring quicker operator/response should have a higher priority.
17	The operator shall have an immediate useable indication of the primary safety response of a system to his control actions.
18	Status instruments and recorders shall be clearly readable by the operator from his normal working position.
19	All controls, switches, valves and other devices shall be designed so as to be easily operated by the operator but not be subject to inadvertent operation.
20	The design of displays and controls should enhance functional grouping (be distinguishable by color, shape or label, so that confusion is avoided if one type of instrument is used for a number of different operating functions).
21	All labels shall be as brief as possible, but consistent with clarity of purpose and of systematic hierachy based on system, subsystem, and component designation.
22	For a given function the simpler control/device design is to be preferred over a more complex control/device.
23	Alarm systems with audio signals shall be pleasant sounding but readily detectable.
24	Where possible, primary reactor protection system devices shall be color coded for easy identification.
25	Sufficient instrumentation shall be provided for each system/subsystem to optimize that system's/subsystem's safe operational control.

Appendix C

Control Room Operations Questionnaire

Appendix C

CONTROL ROOM OPERATIONS QUESTIONNAIRE

PURPOSE OF QUESTIONNAIRE

The questionnaire, attached, is being sent to each reactor operator, senior reactor operator, shift supervisor, and shift engineer at all TVA nuclear plants. The questionnaire is part of the control room design review (CRDR) required by the Nuclear Regulatory Commission. The questionnaire affords every individual experienced in a TVA nuclear control room the opportunity to make their experience, knowledge, and skills contribute to safe, satisfying, and productive power plant operations. The completed questionnaires will be studied and evaluated by the CRDR team - a multidiscipline team of TVA scientists and engineers who have the responsibility to inquire into all human factors engineering aspects of control room operations. The CRDR team will use respondents' completed questionnaires in assessing TVA nuclear control rooms. With your help, their assessment may lead to necessary and desirable changes and/or redesigns of control rooms. Questionnaire responses will be summarized and incorporated in the CRDR team's written report.

QUESTIONNAIRE PROCEDURE

The questionnaire should be completed and mailed (envelope attached) not later than _____. This will permit the CRDR team to read your completed questionnaire at least two weeks prior to their scheduled arrival onsite for the plant control room survey.

The questionnaire contains anthropometric and biographical items that will be useful to TVA engineers and designers. Your questionnaire responses and comments will be treated as confidential and anonymous. However, if you wish, to amplify or clarify any response or comment, write your name and telephone number on the questionnaire and a CRDR team member will contact you during the onsite survey.

Your participation in the questionnaire survey is highly valued and appreciated.

Control Room Operations Questionnaire

A Specify any changes you would recommend in the following areas:

A1 Shift coverage

A2 Shift turnover

A3 Training

A4 Color coding

A5 Control room access

A6 Control panel layout or access

A7 Communication systems

A8 Heating or ventilation

A9 Lighting or noise levels

A10 Special test equipment

A11 Maintenance or surveillance testing

A12 Data recording and log entries

A13 Information flow

A14 Furniture, equipment, or workspace

A15 Computers

A16 Other?

B Are any controls difficult to operate? If so, identify them.

C Are any controls designed, positioned, or labeled in a manner that causes risk of inadvertent operation?

D Are any recorders or indicators difficult or confusing to read?

E Are any important indicators located such that they are difficult to see during normal, abnormal or emergency operation?

F Do you feel any control room displays are unnecessary, provide unimportant information, or needlessly clutter the control panels?

G Based on your operational experience, does your control room lack any controls or displays needed in your response to normal, abnormal or emergency situations?

H Do you consider the annunciator system to be effective in conveying important information to you?

I Do you have any problems locating or using procedures or operational instructions?

J Are individual responsibilities and chain-of-command clearly understood during all operating conditions?

K Is there an adequate number of operators available in the control room (or immediately available) to effectively operate the plant during all conditions?

L Are you required to perform any duties that you consider unreasonable or distracting in your responsibility as an SRO or RO?

M Based on your operational experience, have any errors or incidents occured which could have been averted through improved control room design?

M. Is there a particular panel which you consider more difficult or confusing to operate than the others?

P. General Comments:

Appendix D

Operator Interview

Appendix D

OPERATOR INTERVIEW

PURPOSE OF INTERVIEW

Operator interviews are being made by TVA to tap the vast reservoir of experience, skills, and knowledge possessed by its nuclear power plant operator personnel. The operator interviews are part of the nuclear power plant control room reviews, required by the Nuclear Regulatory Commission. Designers, managers, and operators of electric generating stations, all TVA personnel have vital interests and stakes in safe, satisfying, and productive power plant operations. These vital interests and stakes go far beyond mere compliance with government regulations. This interview will help relay the benefits of your experience, skills, and knowledge to those designers, engineers, and managers who can make desirable changes in present plants, enhance future power plant design, and improve working conditions in present and future plants.

INTERVIEW METHOD

The person conducting the interview is a member of a TVA multidiscipline team conducting the onsite survey. He will ask you questions and will listen to your answers, responses, and suggestions or ideas you may care to volunteer. Your answers, responses, suggestions, and ideas in summary form will be incorporated in a written report. Your identity and extent of participation will remain confidential and anonymous. Your candid participation is highly valued and appreciated.

BIOGRAPHICAL DATA

YOUR POSITION (e.g., Senior Reactor Operator) _____

YEARS OF NAVY NUCLEAR EXPERIENCE: _____

NATURE OF NAVY NUCLEAR EXPERIENCE: _____

YEARS OF FOSSIL FUEL PLANT EXPERIENCE: _____ TYPES OF EXPERIENCE: _____

_____

YEARS OF COMMERCIAL NUCLEAR POWER PLANT EXPERIENCE: _____ TYPES OF EXPERIENCE: _____

OTHER NUCLEAR PLANTS WHERE YOU WORKED: _____

_____

DATE OF FIRST LICENSES: _____ RO _____ SRO

AGE: _____ HEIGHT: _____ WEIGHT: _____

EDUCATION: _____ YRS HIGH SCHOOL _____ YRS COLLEGE OR UNIVERSITY _____

TOTAL CAREER WEEKS OF SIMULATOR TRAINING _____ (WEEKS) WHICH ONES _____

_____

THE CONTROL ROOM

1. Nuclear plant control rooms vary considerably in size. How would you describe your control room size with regard to effective plant operation? Is it too large, too small, or just about right? Please comment on any problems in this area.

2. Are there any problems of an environmental nature which detract from effective operations in your control room, e.g., heat, ventilation, humidity, illumination, noise, distractions from visitors or excessive plant personnel? Let's take them one at a time. If yes, please describe.

Ventilation: Yes _____ No _____

Temperature/Humidity: Yes _____ No _____

Illumination: Yes _____ No _____

Noise Levels: Yes _____ No _____

Excessive Traffic through Control Room: Yes _____ No _____

Distractions from Visitors: Yes _____ No _____

General Appearance Factors (Wall colors, decorations, etc.) Yes _____ No _____

Other Environmental Factors, e.g., nature of the floor surface. (Please describe.)

3. Tech Spec Requirements indicate that a minimum of _____ operators must be in the control room at all times. In your opinion, what is the minimum number of operators that are actually needed to effectively operate your control room: during normal operations _____, during start-up _____, during serious accidents _____.

4. Is the control room arranged in such a manner to allow effective operations with the minimum required number of operators during normal and off-normal operations?

5. Can the status of your plant be monitored from one central position or is the operator continually moving about the control room to assess system status? What are your preferences in this regard?

6. Are specific stations established for the operators and watch foreman? _____Yes _____No. Have the operator and supervisor stations within your control room been arranged most effectively so that coordinated actions can be taken in conducting normal and emergency operations? If not, please describe problems.

7. The operator has need to communicate effectively with others in the plant. What improvements, if any, are required with regard to your communication system?

8. Have eating and toilet facilities been located for maximum operator convenience? Yes ___No___ How long does it take an operator using these facilities to return to the control room in the event of a casualty? _____ Minutes. How long can an operator leave the main portion of the control room without calling for a replacement? ____ Minutes.

9. How many generating units do you presently operate? If you operate two or more control stations, are they: _____IDENTICAL, _____NEARLY IDENTICAL, _____ MIRROR IMAGES OF EACH OTHER, _____ DISSIMILAR

If applicable, please describe any problems in shifting from one control station to another.

10. Have the control panels in your control room been placed in an arrangement that is logical for normal and emergency operations? If not, how could the placement of panels be improved?

11. Within each specific panel in your control room, have related controls and displays pertaining to individual subsystems been grouped logically and distinctively?

12. Does your control room include instrumentation, controls, and displays which are unnecessary for you to do an effective job? If "YES", please provide examples.

13. Does your control room lack important instrumentation, controls, and displays which would help you do a more effective job? If yes, please provide examples.

14. Does your control room make use of mimic or graphic/pictorial panel arrangements?
Yes ___ No ___. Do you favor the use of such control panel designs?
Yes ___ No ___.

15. Are important displays generally placed where they can be read easily? Give examples of any problems please.

16. Are important controls generally placed where they can be reached with ease? Give examples of any problems please.

17. Have controls been selected and oriented to minimize accidental disturbance of control settings? Please describe examples of any problems in this area.

18. Have groups of controls which are identical been coded in any way to permit the operator to readily distinguish between them? To what extent do you find yourself reaching for the wrong control or mistaking the identity of an indicator light or meter? Please describe problems, if any.

19. To what extent do operators in your control room find it necessary to add or modify labeling, code meters, add mimic lines, protect certain controls from accidental activation, or otherwise modify the panels to make operation easier?

20. Have major panels, sub-panels and panel elements been labeled clearly and consistently to facilitate identification of control room elements? Please describe problems, if any.

21. In your opinion, are too many or too few functions performed automatically by your system in controlling abnormal events, i.e., should the operator have greater or less control of the system in the initial response to abnormalities? Can you provide examples where direct control by the operator, in place of automatic system response, would be preferable? Are there examples where automatic system response would be preferable to manual control?

22. What functions does your computer perform to assist you in operating the control system? How useful and reliable is your computer? What changes or additions in computer usage would you like to see? Are operators adequately trained to use the computer?

23. From all indications, future generation control panels will rely heavily on computer-generated Cathode Ray Tubes or TV screen-type displays for the display of information to operators, thereby minimizing the use of extensive arrays of fixed meters and indicators. Do you favor this trend? What advantages and disadvantages do you foresee from an operational standpoint?

ANNUNCIATOR/WARNING SYSTEM

24. Has the annunciator/warning system in your control room been designed so that you can immediately determine when an abnormal event has occurred and its specific nature? Describe problems, if any, please.

25. When an abnormal occurrence takes place, does your control board provide all the necessary information in the right format to allow you to readily diagnose problems and take corrective action? Describe any problems please.

26. When your system reacts automatically to an abnormal condition, do you have any problems in determining what has happened and/or verifying that automatic system response has been effected properly? Give examples of any problems, please.

27. Have warning/annunciator lights been clearly and consistently color coded so that you can immediately determine whether the system is in a normal or abnormal state? Please give examples of any problems.

28. Are the auditory warning signals differentiated to provide different meanings such as the seriousness of the problem or do they refer you to the specific control panel(s) involved?

29. To what extent does your control room present you with "false alarms" or nuisance alarms that you have to learn to ignore? Please describe problems, if any.

30. Is your alarm system designed so that you are not expending an "unreasonable" amount of effort in silencing or acknowledging alarms?

PROCEDURES/DOCUMENTATION

31. Are your procedures sufficiently detailed and clear to permit effective operation of your control room? If NO , please describe how procedures could be improved.

32. Is the operator required to commit to memory an unreasonable number of procedures of an emergency nature? If so, what measures could be taken to help the operator?

33. In general, is too much or too little emphasis being placed on procedures and "doing things by the book"? Please comment regarding your opinion.

34. Are your emergency operating procedures easily accessible? Is there a need for more efficient means for presenting such emergency procedures to the operator in a more timely manner?

35. Are your emergency procedures designed so that there is a clear definition and division of responsibilities among control room operators in dealing with off-normal events,or is there a duplication of coverage or other problems?

36. Do your record keeping tasks (log entries and reading of parameters) interfere with your operational duties, especially during responses to serious off-normal conditions? If yes, what improvements can you recommend?

SELECTION/TRAINING

37. In your opinion, in what ways could the control room be redesigned to reduce the time it takes to learn to operate the control board?

38. To what extent do you feel that the classroom theoretical training and operational training required to successfully pass the NRC licensing examinations is related to effective operational job performance?

39. What major changes in the training programs for ROs and SROs do you recommend to improve the quality of operator training and reduce training time?

40. What opinions do youhave regarding requalification training for ROs and SROs? Does this required training pose any problem?

41. In your opinion, how useful are control room simulators for training purposes to prepare ROs and SROs for operation of your plant?

42.a What three qualities or characteristics would you personally look for in selecting successful candidates for operator training?

b What three major shortcomings do you feel are representative of the less successful operators in your experience?

SHIFT WORK/OVERTIME

43. Would you prefer a different shift schedule than the one you presently have?

44. Have you observed any problems associated with watch turnover? Please describe any control station turnover problems.

45. Have you noticed any negative effects on operator performance which can be attributed to changing from one shift to another, e.g., going from day shift to the midnight shift?

46. How many hours of overtime do you typically work over a period of one year? Have you noticed any problems associated with operators working extensive periods of overtime?

47. Have you observed any personal problems that operators are experiencing which result from shift work and/or extensive overtime demands?

GENERAL

48a. Based on your operational experience, cite one example of an operator error, accident, or near accident with serious or potentially serious consequences. Describe the specifics of the case and indicate how the situation could have been averted through either improved control room design, improved procedures, or special training provisions.

48b. Are there any other significant examples you wish to share with us?

49a. Based on your operating experience with your control room, cite one example of a particular control, display, panel, warning device, etc., which is not "human engineered" or is poorly designed from the operator's standpoint, and has or could lead to a malfunction or operator error.

49b. Are there any other significant examples you wish to share with us?

50. Now think of an example of a particular display, control, label, panel layout, warning device, or other control room feature which is well "human engineered" and which might have prevented a serious or potentially serious accident or operator error. Please describe this equipment with particular emphasis on the features which make it desirable from an operational standpoint.

51. The reactor operator's job has been described as consisting of "hour after hour of debilitating boredom interspersed with periods of abject terror."

A. Assuming there is some degree of truth to this statement, what can be done to relieve the routine or boring aspects of the operator's job?

B. What can or should be done to relieve periods of intense stress?

Appendix E

Worksheets and Data Forms

Operator Interview/Questionnaire

Biographical/Anthropometric

Data Worksheet

Job Position _____

Age _____ Sex _____ Height _____ Weight _____

Education/Training/Degrees (military and civilian) _____

_____

_____

Power Generating Plant Experience (months in each type plant. Total in years and months)

Commercial Nuclear _____ Navy Nuclear _____

Fossil _____ Hydro _____

Total _____ + _____
(Years) (Months)

Date of First License _____ RO _____ SRO

Additional Current Licenses (Check): Vehicle /_/ Chaffeur /_/

Aviation Pilot /_/ Marine Pilot /_/ Radio Operator /_/

Other /_/ (Specify) _____

HUMAN ENGINEERING CONCERN (HEC) WORKSHEET

Plant:
Unit: 1 - 2 - 3 - Simulator
Date:

HEC ID No.: _____
(Panel) (Checklist) (Sequence #)

HEC Short Title: _____

_____

Location: _____ Checklist Item: _____

How HEC Identified: Checklist Interview Questionnaire Additional Analysis

Plant System/Subsystem: _____

Components Involved (UNID/Name): _____

_____

Human Performance Modality Affected (vision, hearing, decision making, etc.):

_____

Detailed Description: _____

_____

_____

_____

_____

Impact/Significance of Concern (identify how concern relates to events, modes, functions, tasks, any safety consequences, and describe relationship to any other concerns as appropriate):

_____

_____

_____

_____

_____

_____

_____

Photo/Other Reference: Attached /_/ yes /_/ no _____ ID No.

Suggested Correction (optional): _____

_____

_____

_____

_____

HEC Reported By: _____
Name (optional) Position (optional)

HEC Reported To: _____
Team Member Other Person

Comments: _____

_____

_____

_____

_____

_____

_____

_____

TVA HED Report No. _____ Photo ID No. _____
(Panel ID) (Checklist ID) (SEQ No.)
Date _____

HECs Contained Within This HED (HEC Nos.) _____
Plant _____ CRDR Team Reviewer _____
Unit _____ CRDR Team Leader _____

HED Title _____

_____

_____

HED Assessment: _____

_____

_____

_____

_____

Action Proposed to Correct HED: DCR No. _____
ECN No. _____
Other (Specify) _____

_____

_____

_____

Correction Schedule (Specify Type Action): _____
Starting Date _____ Completion Date _____
Assigned Organization: _____

COMMENTS

_____

_____

_____

_____

_____

_____

TVA 488A (EN DES-3-77)

TENNESSEE VALLEY AUTHORITY

Appendix E

SUBJECT LIGHTING SURVEY WORKSHEET

COMPUTED BY DATE CHECKED BY DATE

Plant: _____ Unit: _____

SURVEY PERSONNEL:

INSTRUMENTS:

CALIBRATION: _____
DATE LOCATION

VOLTAGES: START OF SURVEY _____
END OF SURVEY _____

STATION NUMBER	PANEL NUMBER	READING (FOOTCANDLES)	SENSOR PLACEMENT	REMARKS

TVA 466A (EN DES-3-77)

TENNESSEE VALLEY AUTHORITY

Appendix E

SUBJECT LUMINANCE SURVEY WORKSHEET

COMPUTED BY _____ DATE _____ CHECKED BY _____ DATE _____

Plant: _____ Unit: _____

SURVEY PERSONNEL:

INSTRUMENTS:

CALIBRATION: _____
DATE LOCATION

VOLTAGES: START OF SURVEY _____
END OF SURVEY _____

STATION NUMBER	PANEL NUMBER	READING (ftL)	PROBE			REMARKS
			ACCEPTANCE ANGLE	DISTANCE FROM PANEL	HEIGHT ABOVE FLOOR	

ACOUSTICAL TEST DATA WORKSHEET PROJECT _____ TEST CONDUCTED BY: _____

SOUND LEVEL METER/OCTAVE ANALYZER: _____ CALIBRATION: DATE _____ MAKE _____ MODEL _____

MICROPHONE: _____ CALIBRATION: DATE _____ MAKE _____ PERSON _____

DATE OF TEST _____ TIME: START OF TEST _____ END OF TEST _____ METER RESPONSE RATE (CHECK ONE): SLOW [ ] FAST [ ]

TEST CONDITIONS

WRITE DETAILS RE NOISE/SOUND SOURCES

- DOORS; ENTRANCES; EXITS; AISLES (OPEN/CLOSED) _____
- HVAC (ON/OFF/RATE/DUTY CYCLES) _____
- LIGHTING (NORMAL, STANDBY; EMERGENCY) _____
- PANELS/BENCHBOARDS (IDENTIFY ON/OFF STATUS) _____
- PRINTERS/RECORDERS/METERS (IDENTIFY: ON/OFF/DUTY CYCLES) _____
- COMPUTER TERMINALS/COMM. EQP. (IDENTIFY: ON/OFF/DUTY CYCLES) _____
- PERSONNEL DENSITY (IDENTIFY NUMBER & TYPE, EG; 1 SRO; 2 RO, 1 ARO) _____

MICROPHONE POSITION/HEIGHT (HEARING LEVEL CONSIDERATIONS)	SOUND PRESSURE LEVELS (dB)					CENTER FREQUENCY (Hz)											REMARKS
	dB(A)	dB(B)	dB(C)	NIC CATS		16	31.5	63	125	250	500	1000	2000	4000	8000	16000	

[illegible]

Filed: _____ Date: _____ Time: _____

Measurement [illegible]: _____ Depth: _____

Equipment / Instruments used: _____

Serial #: _____ Calibration [illegible]: _____

Location	8 ft.	4 ft.

HUMIDITY/TEMPERATURE RECORD

Plant: _____ Date: _____ Time: _____

Measurements made by _____ Sheet ___ of ___

Equipment / Instrument used: _____

Serial #: _____ Calibration date: _____

Time	Height	Temperature	Humidity	Remarks
	Floor			
	6 ft			
	Floor			
	6 ft.			
	Floor			
	6 ft.			
	Floor			
	6 ft			
	Floor			
	6 ft			
	Floor			
	6 ft			
	Floor			
	6 ft			
	Floor			
	6 ft			
	Floor			
	6 ft			
	Floor			
	6 ft			
	Floor			
	6 ft			
	Floor			
	6 ft			

CONTROL ROOM SURVEY

PHOTO LOG

Plant/Unit _____

Photo Number	Panel Number	Checklist Item	Notes

TASK ANALYSIS WORKSHEET

PRESENTATION GIVEN FOR THIS EVENT SEQUENCE: ☐ YES ☐ NO

TASK	DEVICE LOCATION	ASSOCIATED DEVICES LOCATION	ASSISTANCE COMMUNICATION	NOTES

DATE _____ SIGNATURE _____