- Program Plan -

HUMAN FACTORS ENGINEERING EVALUATION AND IMPROVEMENT OF THE VIRGIL C. SUMMER NUCLEAR STATION CONTROL ROOM

Docket Number:
50/395

November 10, 1980

1.0 INTRODUCTION

On August 6, 1980, the Essex Corporation submitted to South Carolina Electric & Gas (SCE&G) its report on the preliminary human factors engineering review of the Virgil C. Summer Nuclear Station control room. On October 9, 1980, SCE&G received a draft report of the NRC audit of the Virgil C. Summer Nuclear Station control room, conducted by the NRC August 25 through 29, 1980. Both reports cite a number of human engineering deficiencies and rank these deficiencies on a three point criticality scale. The Essex report is included as Appendix A. The NRC audit report is included as Appendix B.

On October 22, 1980, representatives of SCE&G and their consultants met with NRC Human Factors Engineering Branch personnel to discuss the specific problems identified in the NRC audit. At this meeting SCE&G presented a draft plan for resolving the problems identified in both the NRC audit and the Essex preliminary evaluation and for completing the comprehensive evaluation of the control room as required by NUREG 0660 and NUREG 0694. This document is the final version of the SCE&G program plan for Virgil C. Summer Nuclear Station control room improvement and human factors engineering evaluation.

The effort will be conducted in two phases. Phase I addresses the Near Term Requirements of NUREGS 0660 and 0694 which must be met before fuel loading for NTOL plants. This phase will identify and implement improvements required to correct problem areas identified as Category 1 or 2 in both the NRC Audit and the Essex preliminary evaluation. These improvements will be complete prior to fuel loading or on a schedule approved by the NRC.

The tasks to be conducted in Phase I are depicted in Figure 1 and are described in detail within this plan. These tasks will require approximately three months to complete. The outputs of Phase I will include a report describing activities completed during the effort and a report to the NRC describing the specific method of correcting each discrepancy identified in the NRC Audit and the Essex preliminary evaluation. If, following Phase I of this evaluation, any of the listed discrepancies are determined not to warrant improvement, the report will provide justification. This report is scheduled for issue to the NRC January 15, 1981, for input to the SCE&G SER supplement.

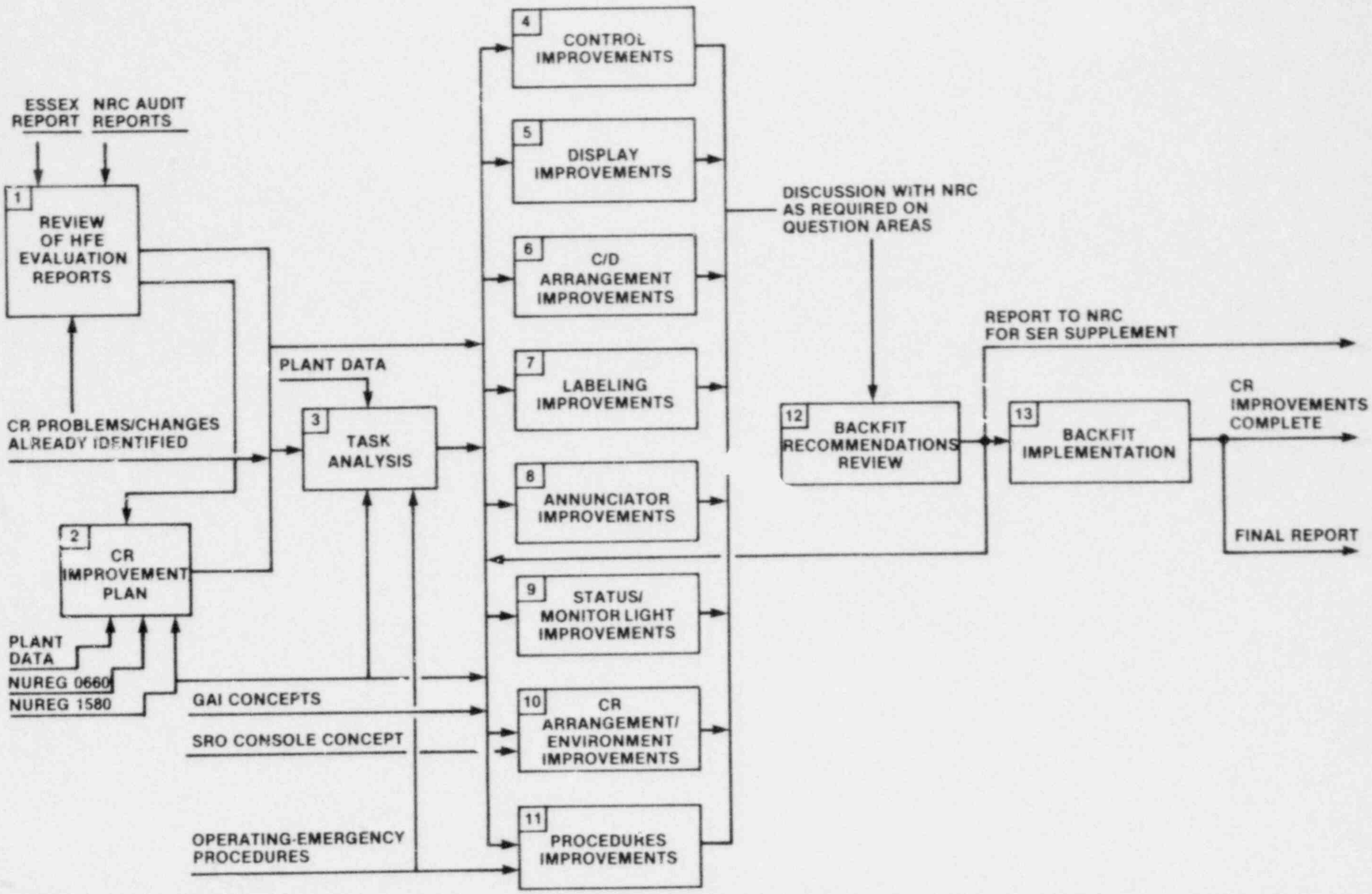


FIGURE 1.
PHASE I TASKS:
VC SUMMER CR IMPROVEMENT

Phase II of this effort addresses the long term requirements of NUREG 0660 for a comprehensive review of the control room using NRC human factors design guidelines and evaluation criteria. This phase of the report will not begin until issuance of this criteria which is now in draft form (NUREG/CR-1580).

These tasks to be conducted in Phase II together with the results of Phase I will constitute this comprehensive control room evaluation. This comprehensive evaluation and any additional improvements will be completed by January 1, 1982, or on a schedule approved by the NRC.

The Phase II tasks depicted in Figure 2 are described within this plan and are expected to require approximately three months to complete. Products of Phase II will include: 1) the comprehensive file describing the evaluation of each control room man/machine interface and the disposition of the discrepancy reports; 2) recommendations for backfits to correct problem areas identified in the full-scale evaluation; and 3) results of any special studies (i.e., post-accident monitoring, integration of design with procedures and training, etc.).

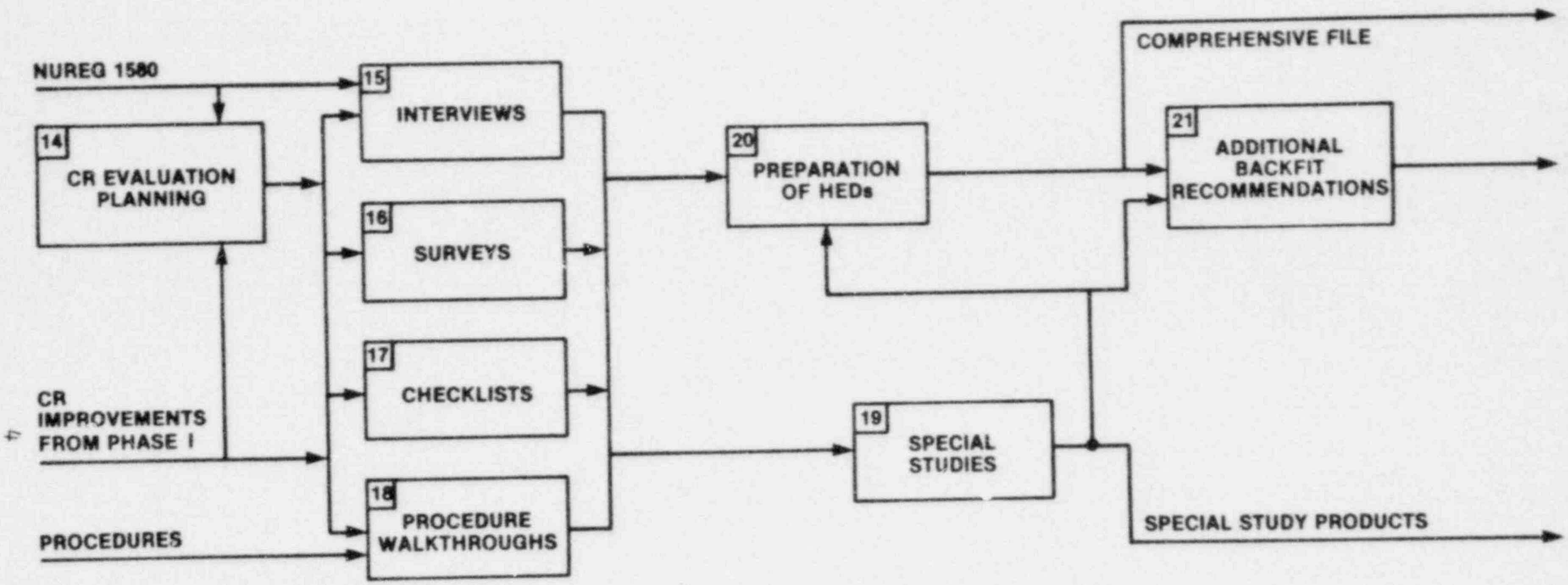


FIGURE 2.
PHASE II FULL SCALE EVALUATION OF
VC SUMMER CONTROL ROOM

2.0 PHASE I CR IMPROVEMENT

The overall objective of this phase is to implement improvements to correct discrepancies identified in the NRC and Essex evaluations of the Virgil C. Summer Nuclear Station control room. Each task of this phase is described in the following subsections in terms of:

- Task objective
- Inputs to the task
- Outputs
- Activities
  - overview of the task
  - subtasks
  - schedule.

2.1 TASK 1 — Review of HFE Evaluation Reports for Virgil C. Summer Nuclear Station Control Room

Objective: The objective of this task is to review and integrate the control room human engineering discrepancies identified by Essex in its preliminary evaluation, by the NRC in its audit, by SCE&G operations and engineering personnel, and by GAI engineers.

Inputs:

- The report published by Essex on its preliminary evaluation
- The NRC audit report
- CR problems and changes already identified by SCE&G and GAI.

Outputs:

- Compilation of human engineering discrepancies from all sources with indications of criticality and appropriate task within the CR Improvement Program.

Process:

Overview: In this task a final listing of all human engineering discrepancies will be compiled. Table 1 includes the list of discrepancies noted in the NRC Audit report and in the Essex preliminary evaluation report.

Table 1

Human Engineering Discrepancies

Item	Ident. By	Category	Approp. Task	Comments
2.1 Controls				
a. Not easy to recognize and identify	NRC/Essex	1	4 & 7	
b. No demarcation or coding for clusters	NRC/Essex	2	4 & 6	
c. Interchangeability of legend covers	NRC/Essex	1	4	
d. Confusion of momentary with continuous	NRC/Essex	1	4 & 7	
g. Discrimination of one in a group	NRC/Essex	1	4	
h. Discrimination of controls by equipment	NRC	3	4	Needs investigation
i. Inconsistent legend labels	NRC/Essex	1	7	
j. Label readability on colored lens	NRC	2	5 & 7	
k. Poor contrast on markings	Essex	1	4	
l. Difficult reach to some controls	Essex	1	4	
2.2 J Handle Switches				
a. Inconsistent operation of trip controls	NRC	2	4 & 7	May require a two-step fix
b. Control handle - operator hand obscures label	NRC/Essex	1	7	
c. Discrimination of flags	NRC	2	4	
2.3 Hagan Valve Controllers				
a. Confusing in terms of open/close	NRC/Essex	1	4	May require a two-step fix
b. Setpoint difficult to read	NRC	3	3 & 4	
c. Mislabeling	NRC	1	7	
d. No actual vs demand feedback	NRC/Essex	2	4 - 6	
e. Vernier scales difficult to read	NRC	3	3 & 4	

Item	Ident. By	Cate-gory	Approp. Task	Comments
3.0 Displays				
a. Readability - interpretation problems	NRC/Essex	2	5	
b. Dual scales are confusing	NRC	2	5 & 7	
c. Meters fail at mid-scale	NRC/Essex	1	5	Meters fail either off-scale or at bottom end of scale
d. Use of ESF monitor legends difficult	NRC/Essex	1	9	
e. Numerous handmade scales	NRC	1	5	
f. No normal range or setpoints	NRC	1	5	
g. Some displays obscured	Essex	2	6	
h. Information not displayed	Essex	4	5	Needs investigation
i. Trend recorder ink color	Essex	4	5	Needs investigation
3.1 Moduflash Display System				
a. Percent scale difficult to interpret	NRC	2	5	
b. Cannot easily be related to annunciators	NRC	2	6 & 8	
c. Conversion from percent required	NRC	1	5	
d. Discrimination between setpoint and flow/temp	NRC	2	4	
e. Status indicator orientation	NRC	2	6	
4.0 Control/Display Relationship				
a. No consistent pattern of C/D layout	NRC/Essex	2	6	
b. Display not always in viewing distance	NRC/Essex	2	6	
c. Strings not consistently oriented	NRC	2	6	
4.1 Service Water Panel				
a. SW pumps have confusing instruction plate	NRC	1	7	
b. Location and design of SW Pump C discharge layout	NRC	2	5,6,7	
c. Confusion concerning SW Pump alignment indicators	NRC	1	5 & 6	

Item	Ident. By	Cate-gory	Approp. Task	Comments
4.2 HVAC Panel				
a. Mimic color code not consistent	NRC	2	6	
b. Damper controls and mimic confusing	NRC	2	6 & 7	
c. Fan control layout - relation to mimic	NRC	2	6	
d. Mimic glare	NRC/Essex	2	10	
e. Mimic too high	NRC	3	10	
f. CMC component label hard to read	NRC	3	5	
4.3 Reactivity Control System Panel				
a. Bank selector - poor labeling	NRC	1	7	
b. NIS recorder control label	NRC	2	7	
b1. NIS recorder control sequence	NRC	3	4	
c. Part length rod control not used	NRC	2	4	Control to be removed
d. Boric acid pump location	NRC	1	6	
e. Comparison of scales of vertical meters	NRC	2	5	
4.4 Emergency Feedwater System Panel				
a. Poor arrangement of controls strings	NRC	1	6	
b. Min. turbine flow at bottom of scale	NRC	2	5	
c. EF SG press and narrow range pressure different scales	NRC	1	5	Needs investigation
d. Identification of SG components difficult	NRC	2	6 & 7	
4.5 Feedwater Panel				
a. Bypass control handle confusion	NRC	2	4 & 6	Needs investigation
4.6 First Out Panel - Identification	NRC	1	8	
4.7 Condensate Pump Panel Layout	NRC	2	6 & 7	
4.8 Main Steam Panel Isolation Valve Orientation	NRC	1	7 & 9	
4.9 Rad Monitor System Detector - Annunciation Location	NRC	2	6	

Item	Ident. By	Category	Approp. Task	Comments
4.10 Steam Generator Panel				
a. Resets difficult to identify	NRC	2	4 & 6	
b. Bypass flowmeters - poor identification	NRC	2	6	
c. Different scaling on meters	NRC	1	5	
d. Arrangement of master controls	NRC	2	6	
4.11 Power Panel				
a. Engine shutdown reset labeling	NRC	2	7	
b. Miniature meters	NRC	3	5	
5.0 Labeling and Coding				
a. No hierarchical structure	NRC/Essex	1	6 & 7	
b. Little or no use of demarcation lines	NRC	3	6	
c. Minimal use of mimic diagrams	NRC	3	6	
d. Labels are not consistently positioned	NRC	1	7	
e. Labeling techniques not consistent	NRC	1	7	
f. Labels not permanently attached	NRC	1	7	
g. Labels tend to be wordy and inconsistent	NRC/Essex	1	7	
h. Some labels are missing	NRC	1	7	
i. Some labels are obscured by controls	NRC	1	4 & 7	
j. Essentially no color coding	NRC	3	6	
k. Labels under low mounted strip chart recorders cannot be seen	NRC	1	7	
l. Dual function vertical scales are not clearly labeled	NRC	1	7	
m. Symbols on mimics not labeled	Essex	2	7	
n. Labels can be associated with wrong component	Essex	2	7	
6.0 Workspace and Environment				
a. Visual access from Shift Foreman's desk to main control board is restricted by a support column	NRC/Essex	3	10	
b. No storage of essential material	NRC	1	10	

Item	Ident. By	Category	Approp. Task	Comments
c. Inadequate knee space at computer console	NRC/Essex	3	10	
d. No emergency equipment	NRC/Essex	*	10	*Category 1 until reviewed
e. Monitoring HVAC requires exiting CR	Essex	3	10	
6.1 Hazards				
a. Tripping hazards - mats and telephone cords	NRC/Essex	1	10	
b. "J" handles close to the board edge	NRC	1	4	
6.2 Communications				
a. Page phone communications to COC and TSC	NRC	2	10	
b. No phone storage or accountability	NRC	1	10	
c. Incoming calls transferred to the control room at night	NRC	1	10	
d. No procedures for communication control during emergency	NRC	1	10	
e. No direct communication from the main CR area to the HVAC panel	NRC	1	10	
f. 60 dB ambient noise	Essex	1	10	
g. No page phone on panels 5 through 9	Essex	1	10	
h. Radio systems limited	Essex	3	10	
7.0 Annunciators				
a. Annunciators lack prioritization	NRC/Essex	1	8	
b. Most audible alarms are not directional	NRC/Essex	2	8	
c. Windows not located on the same panel with controls	NRC/Essex	3	6 & 8	
d. Up to 3 different styles of print and character size are used on windows	NRC	2	7 & 8	
e. Fire and Security alarm systems could not be reviewed	NRC	*	8	*Category 1 will reviewed
f. Windows hanging open or missing	NRC	1	8	
g. Labels small, wordy	Essex	1	8	
h. Test functions do not coincide	Essex	1	8	

Item	Ident. By	Cate-gory	Approp. Task	Comments
8.0 Process Computer				
a. Typewriter (printing speed) is limiting component in process computer system	NRC/Essex	2	5	
b. Trending capability limited to 4 parameters on 2 process computer controlled - 2 pen strip chart recorders	NRC	2	5	
c. No CRT graphic display capability	NRC	2		
d. No color coding used on CRT displays	NRC	2	5	
e. Not all overhead alarm parameters are monitored by process computer	NRC	2	5	
f. Operators have received 4-hour course in the use of Summer process computer at system level	NRC	1	Training	
g. Data point addresses are not cross-indexed	NRC/Essex	1	5	
h. No labels or other means on panel to identify parameters monitored by strip chart recorders	NRC/Essex	1	7	
i. Incore thermocouples on the process computer are limited to 700° F	NRC	1	5	Subcooling monitors will display 16 incore thermocouples to 2300° F
j. Printer page format - reduced readability	Essex	2	5	
k. Nomenclature is inconsistent	Essex	2	7	
l. Controls have low label contrast	Essex	2	7	
m. Desk not accommodating to 95% of operators	Essex	2	10	
9.0 Other Observations				
a. Arrangement of 3 channels of vertical indicators used to display RCS flow not logical and is confusing	NRC	2	6	
b. There is operator confusion concerning the manual initiation of Safety Injection (SI)	NRC	1	7	

Item	Ident. By	Cate-gory	Approp. Task	Comments
c. 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 HVAC panel where a narrow range temperature indication is available.	NRC	2	5 & 6	
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).	NRC	2	6	
e. ESF monitor lights patterns are confusing and difficult to recognize on display panels	NRC/Essex	1	9	
f. Remote shutdown panel not evaluated	NRC	*	10	*Category 1 until reviewed
g. There is temporary ventilation in the back of the main control board	NRC	1	10	
h. The plant page system is too loud, approximately 76 dbA, also the CR has reverberation	NRC	2	10	
i. Emergency DC lighting too low	NRC	2	10	
j. Emergency AC lighting levels not measured	NRC	*	10	*Category 1 until reviewed
k. No system is provided to test indication lamps	NRC/Essex	1	5 & 9	
l. The pressure operated relief valve controls and associated isolation valves controls (445 A, B, C) are inconsistently labeled	NRC	1	6	
m. The rod position recorder scaled from 0 to 100% or 240 steps. Inconsistent with the position indication on the main control board for full out position (100%) which is equal to 228 steps	NRC	1	5	

Item	Ident. By	Cate- gory	Approp. Task	Comments
n. No CRT trending capability or graphic display capability	NRC	3	5	
PROCEDURES				
a. Notes, warnings, and cautionary statements are contained within the immediate operator actions	Essex	1	11	
b. Emergency procedures cross reference information located in other documents	Essex	1	11	
c. Some procedures direct use of alternative procedures as a part of the immediate operator actions	Essex	1	11	
d. Procedures reference labels by names different from the names actually used on labels and annunciator windows	Essex	1	11	
e. CR operators require communications with plant operators	Essex	1	11	

Subtasks:

1.1 Continue to update the list as additional discrepancies are identified.

1.2 Replace the appropriate task with the specific backfit when a backfit is identified for each individual discrepancy.

Schedule:

- Complete the final list by 15 January 1981.

2.2 TASK 2 — Complete the CR Improvement Plan

Objective: Publish a plan for Virgil C. Summer Nuclear Station CR improvement.

Inputs:

- Review of human engineering discrepancy reports
- Plant data
- Appropriate regulatory directives, e.g., NUREGS 0660, 1580, and 0694.

Outputs: CR improvement plan.

Process: The plan contained herein will be updated as required.

Schedule: Completed.

2.3 TASK 3 — Task Analysis

Objectives: The overall objective of the task analysis is to identify, analyze and integrate requirements associated with operator tasks. Ancillary objectives of the task analysis are to provide the data base required for the improvement of CR characteristics already identified as at variance with human engineering criteria.

Inputs:

- Operating, abnormal and emergency procedures
- Technical specifications, charts, graphs and other reference data used by CR operators
- CR staffing requirements and watch station responsibilities
- Video tapes of procedure walk-throughs already completed

- Data already gathered from operator interviews, CR surveys, and checklist applications
- NUREG 1580 Human Engineering Guide to Control Room Evaluation.

Outputs:

- Completed task analyses indicating task requirements for selected sequences.

Process:

Overview: The task analysis w[illegible] data required for the selection of backfits to correct individual discrepancies. [illegible]lysis will be conducted as described in NUREG 1580 Volume I section 2.5.6. [illegible]tially the analysis will identify requirements associated with each task of a selected sequence. Requirements will be identified analytically and verified by operator review and/or procedural walk-throughs in the control room.

Subtasks:

3.1 Identify sequences to be analyzed. Criteria for sequence selection will include coverage of important activities, critical procedures and critical failure modes.

3.2 Assemble data for each sequence.

3.3 Identify tasks and task sequences performed in each sequence.

3.4 Identify who performs each sequence, if applicable.

3.5 Identify requirements associated with each task

- Activity
  - operator actions/objectives
  - state of the plant at the beginning of the task
  - state of the plant at task completion
  - criteria for successful task performance
- Time
  - required to respond and begin the task
  - required to complete the task
- Frequency of task performance
- Information
  - required to begin the task
  - required to complete the task
  - required to verify successful task completion
- Concurrent or shared tasks

- Decision requirements
- Control requirements (accuracy, continuous vs discrete)
- Support requirements
- Controls used
- Displays used
- Procedures used
- Communications required
- Potential errors
- Feedback on error occurrence
- Impact of errors.

3.6 Conduct review of task analyses data.

3.7 Revise and update analyses as required.

Schedule: The task analysis will extend from 10 November through 15 December.

2.4 TASK 4 — Control Improvements

Objective: The objective of this task is to identify backfits for specific control problems identified in the NRC and Essex human engineering evaluation reports.

Inputs:

- Human engineering discrepancies identified for controls
- NUREG 1580
- Task analyses data
- GAI concepts.

Outputs:

- Backfits selected to correct specific problems
- Specifications concerning the backfits.

Process:

Overview: Of the 127 human engineering discrepancies identified by the NRC in its audit of the Virgil C. Summer Nuclear Station control room, a total of 15 or 12 percent were specifically concerned with control design, location operation, or arrangement. This task will address development of concepts for backfits to correct these discrepancies and trade-off of concepts to select the most cost-effective solution.

Subtasks:

4.1 Review specific control problems.

4.2 For each problem area, select feasible candidate backfit concepts. Kinds of backfits to be considered include the following:

- Location change
- Control separation
- Panel demarcation and summary labeling
- Control operation instruction labeling
- Control identification coding
  - control color/shading
  - control shape
  - control texture
  - control place
  - control size
  - background panel color/shading
  - panel demarcation
- Control position coding
  - labeling
  - convention
  - control shape
- Control operation
  - change in direction of motion
  - change in force/torque
  - change in handling qualities
    - . detents
    - . spring forces
    - . number of positions
    - . sensitivity
    - . linearity
  - change in control state
- Control guarding
  - to avoid accidental activation
  - to reduce substitution errors (wrong control)
  - to reduce activation errors (wrong position).

4.3 Develop a set of trade-off criteria to assess the relative cost-effectiveness of candidate concepts. Potential criteria include:

- Expected impact on operator performance
- Potential errors caused by the backfit
- Expected impact on system safety
- Dollar cost to implement
- Time to implement

- Retraining requirements
- Skill requirements
- Workload requirements
- Effects on system reliability
- Effects on system maintainability.

4.4 Trade-off candidate control backfit concepts against criteria for each identified problem area.

4.5 Develop a specification to govern the implementation of each selected backfit.

Schedule: This task will begin 17 November. Fixes for identified problems will be developed by 15 December. All backfits will be identified by 15 January.

2.5 TASK 5 — Display Improvements

Objective: The objective of this task is to identify backfits for specific display problems identified in the NRC and Essex human engineering evaluation reports.

Inputs:

- Human engineering discrepancies identified for displays
- NUREG 1580
- Task analyses
- GAI concepts.

Outputs:

- Backfits selected to correct specific display problems
- Specifications concerning implementation of the backfits.

Process:

Overview: 29 of the 127 discrepancies (23%) were identified as display problems.

Since displays represent the media by which the operators know what is happening in the plant and what they can expect to happen, human engineering of displays to minimize operator errors in processing information should be of paramount importance. Typical operator errors and display design features influencing the occurrence of these errors are listed in Appendix 1-C of NUREG 1580. These errors and design features include:

- Reading errors
  - display location and arrangement
    - display orientation with respect to line of sight
    - display viewing distance
    - display location with respect to 5th percentile operator eye height
    - display location such that operator's view is obscured
  - display design
    - poor brightness contrast
    - glare effects
    - scale increment size
    - scale graduations
    - strip chart readability
    - strip chart scaling
    - pointer conspicuity

- Interpretation errors
  - design
    - indication of in and out-of-tolerance
    - displays to interpret trends
    - process controls displaying demand - not actual
    - required values not displayed on trend displays
    - patterns of status lights confusing

- Display substitution errors
  - location/arrangement
    - display in a string
    - display too close to adjacent displays
    - display not located in a string by sequence
    - displays not functionally grouped
    - display arrangement is illogical or inconsistent
    - display not located next to associated control
  - display design
    - shape not differentiated
    - size not differentiated
    - color not differentiated
    - labeling not readily readable
  - display visibility
    - inadequate illumination
    - line of sight obstructed

- Display activation errors
  - display design
    - no light test capability
    - no indicator lights are provided
    - direction of display motion not conventional or stereotypical
    - it is possible to transpose legend light faces
    - trend recorder speed not controllable
    - a failure to achieve required status is indicated by an extinguished light
    - there is no standard procedure for checking failed lights
    - a meter can fail leaving the pointer at mid-range

        . failure of a meter is not readily detectable
        . valve travel is indicated by extinguishment of open and closed lights

- Display temporal errors
    - location/arrangement
        . display not located within visual access from viewing position
        . display is located in an array of identical displays
        . display located where field of view is obstructed
    - display design
        . displays not functionally grouped
        . displays not arranged by sequence
        . displays not clearly labeled
        . displays not clearly coded.

Subtasks:

5.1 Review specific display problems.

5.2 Select feasible candidate backfit concepts for each problem. Kinds of backfits include:

- Display location change
- Display separation change
- Panel demarcation and summary labeling
- Display interpretation instruction labeling
- Display identification coding
    - color coding
    - shape coding
    - place coding
    - size coding
    - background panel color coding
    - panel demarcation
- Display reading coding
    - in tolerance coding
- Display design for readability
    - scaling
    - pointer contrast
    - scale contrast
    - pointer response
    - use of unambiguous colors
- Display design for visual access
    - reduction of glare
    - provision of sufficient illumination
    - removal of obstacles.

5.3 Development of trade-off criteria to assess the relative cost-effectiveness of candidate concepts.

5.4 Conduct trade-offs for each problem area.

5.5 Develop a specification to govern the implementation of each backfit.

Schedule: This task will begin 10 November. Fixes for identified problem will be identified by 15 December. All backfits will be identified by 15 January.

2.6 TASK 6 — Control/Display Arrangement Improvements

Objective: The objective of this task is to identify control/display arrangement improvements.

Inputs:

- Human engineering discrepancies identified for C/D arrangements
- NUREG 1580
- Task analyses
- GAI concepts.

Outputs:

- Backfits selected to correct specific control/display arrangement problems
- Specifications to govern implementation of backfits.

Process:

Overview: Problems for C/D arrangements were identified in the Essex survey and also in the NRC audit. Requirements for arrangements will be developed based on the task analysis. Products of this task will include recommendations for changes in:

- Control/display location with regard to each other
- Control/display coding
- Panel demarcation
- Panel color coding
- Panel mimics.

A total of 29 of the problems identified in the NRC audit were concerned with control/display arrangements (23%).

Subtasks:

6.1 Review control/display arrangement problems.

6.2 Conduct walk-throughs of procedures to assess problems.

6.3 Develop candidate backfit concepts - each problem.

6.4 Develop trade-off criteria to assess the relative cost-effectiveness of each candidate concept for each problem.

6.5 Conduct trade-off - select optimal solutions.

6.6 Develop specifications to govern implementation of backfits.

Types of design requirements to be specified are as follows:

Demarcation Lines:

Size — Demarcation lines should be 1/8" to 1/4" in width, and less than 1/32" depth.

Location — Demarcation lines are to be located closer to the components enscribed than to excluded controls and displays.

Summary labels are to be enscribed within demarcation lines or may serve as terminal points for lines.

Where functionally related components are separated by intervening components, demarcation lines are used in color or pattern coded groups to avoid excess lining.

Demarcation lines are used to identify functional or operational units. Demarcation lines are not used to demonstrate interrelationships between systems and subsystems.

Color Coding — Standard color for demarcation lines is off white or light gray.

Labeling — Each demarcated group having three or more components enscribed is to have a summary label which meets the labeling portion of this specification.

Maintenance — Demarcation lines are to be fixed to the control boards such that they do not separate by bumping, scraping (unintentional) or washing.

Mimic Lines:

Size — Major (primary) lines are to be approximately 3/16" to 1/4" in width. Minor lines are to be approximately 1/8" in width.

Location — Mimic lines must terminate and continue from component labels or system symbols (such as heat exchangers, pumps, etc.).

Ends of mimic lines are to terminate at labels.

No more than four mimic lines are to run in parallel within a 2" space.

Color Coding — The color coding of mimic lines should be consistent throughout the control room. Water lines should be a blue that offers contrast with the board, steam lines should be red. Electric lines are recommended to be a color that cannot be confused with any other coding in the control room. A possible method to use would be to pick a color such as brown and use a different saturation (shade) for each voltage. The highest voltage should be the darkest shade. Each shade should be discriminable from all the other shades.

Labeling — Direction of flow arrows are to be provided.

Lines shall not end abruptly, but at labels or components.

Mimic summary labels are provided.

Maintenance — Mimic lines shall be permanently affixed to the boards.

Lines should not collect dirt, grease, etc., due to elevation above monitoring place.

Schedule: Begin on 1 December. All backfits will be identified by 15 January.

2.7 TASK 7 — Labeling Improvements

Objective: To review and rewrite, if necessary, every label on the Virgil C. Summer Nuclear Station board.

Inputs:

- Human engineering discrepancies concerning labels
- NUREG 1580
- Task analysis
- GAI concepts.

Outputs:

- Backfits selected to correct specific labeling problems
- Specifications to govern backfit implementation.

Process:

Overview: Labeling was identified as the area for backfit for 29 of the deficiencies identified in the NRC audit (23%).

Each and every label on the Virgil Summer panel will be reviewed and rewritten if required in a standardized, consistent and readable format. The format will feature a standard syntax and a constrained vocabulary. The types of problems to be addressed include:

- Readability
  - location/arrangement
    - . labels not located consistently
    - . no labels provided
    - . no panel designators provided
    - . view of labels obscured
  - design
    - . label font makes labels difficult to read
    - . functions mislabeled
    - . safety tags cover labels
    - . labels have poor brightness contrast
    - . labels are cluttered
    - . labels have low contrast to the panel
    - . labels are illegible
    - . color not used consistently
    - . inconsistent use of abbreviations
    - . labels have small fonts
  - use of labels
    - . too many operator added backfits used
    - . backfits not consistent
    - . no demarcation grouping panel elements.

Subtasks:

7.1 Review problem areas associated with labels.

7.2 Develop design requirements for labels based on criteria from NUREG 1580. Requirements will include:

- Font — The font remains consistent throughout the entire control room. Labels should be in all capital letters without flourishes, embellishments, or serifs. Diagonal parts of letters and numerals should be as close to 45^{o} as possible; characteristic features such as breaks or openings should be readily apparent, and critical details should be simple but prominent. Examples of recommended and acceptable fonts are MIL-M-18021B and MIL-STD-MS-33558(ASG), also known as AND (Air Force and Navy Drawing).

  All alpha characters in component and summary labels are capitals.

- Size — Label size graduations are as follows:
  - Summary Labels — Label plates 1" in height, with varying length based on number of characters required. At least 1/2" of space is required from the edge to the first and last characters is required. Character height for summary labels is 1/2".

- Component Labels — Consistent with the current component labeling convention in the control room, switch labels are to enscribe: 1) the switch; and 2) associated feedback lights (where provided). In addition, label nomenclature is not to extend to within 1/4" of any label plate boarder or indicator lights or control mantle. Display labels (for those not totally enscribing the display) one to be dimensioned 2" x 1" maximum and 1 1/2" x 1" minimum. At least 1/4" of space between characters and borders is required at the right and left boarders of the legend plate, and 1/8" of space between any nomenclature and top and bottom boarders of the legend plate.
- All Labels — The width of the character shall be determined by the height of the character, and is usually expressed in terms of a width-to-height ratio. The width-to-height ratio for capital letters should be about 1:1 but can be reduced to 3:5 without significant loss in legibility except for the letters M and W whose width-to-height ratio should not dip below 4:5, and the letter "I" which should be one stroke width wide. In the case of numerals, the width-to-height ratio should be about 3:5 except for 4 which should be one stroke width wider, and "1" which should be one stroke width wide. Stroke width-to-height ratio is about 1:7.

- Character Spacing — Although spacing need not be uniform throughout the control room, there are minimum requirements. The minimum acceptable space between characters is one stroke width; between words, one character width; and between lines, one half of the character height.

- Maintenance — Engraved labels on off vertical panels should be filled with a paint pigment or covered with a clear plastic cover to prevent the etching from filling with dirt or grease causing a reduction in legibility.

  Labels are permanently affixed to the control boards.

- Color
  - Summary Labels — Summary labels are to be white with black characters.
  - Component labels — Component labels are to be high contrast black characters on a white background.

- Content and Syntax — Labels should primarily describe the function of the control, and secondarily describe any engineering characteristics or nomenclature. Labels should be clear and concise minimizing redundancy and avoiding lengthy or complex sentences. Only critical information should appear on labels, controls or displays and such information should be written in language familiar to all operators; unusual technical terms should be used only when absolutely necessary and only when they are familiar to all operators. Every control should have a label indicating direction of activation and the functional result of control movement. The information on the label should be limited to that which is necessary to perform specific actions or make decisions.

When controls and displays are used together, appropriate labels should indicate their functional relationship. Instruments should be labeled in terms of what is being measured or controlled with user purpose taken into account, and the information should be displayed only to the degree of accuracy necessary for operator actions or decisions.

Standard sentence structure is "Component to Component." For example:

- HX VLV TO RHR PUMP
- RHR PUMP VLV TO SPRAY HDRS.

The nomenclature used on the labels should be consistent with that in the procedures or technical specs (e.g., if a procedure mentions flow in gallons per minute, the display should not be in cubic feet per second), where this is not the case, either label or procedure nomenclature should be changed.

Engineering designators (e.g., valve numbers) shall be placed in the lower left corner of the label message.

Function group and system labels should be utilized throughout the control room. Highly similar names for different controls or displays should be avoided. Abbreviations should be standardized and should concur with commonly used abbreviations. The same abbreviation should be used for all tenses of the word, and for both singular and plural forms; no periods should appear after abbreviations except to preclude misinterpretation. Only commonly recognized abstract symbols should be used (e.g., %, Δ, etc.).

Accesses should be labeled with any applicable warning signs that advise of hazards, or state precautions to be taken. Warning notices should be clear, direct, attention getting, and 25 percent larger than any detailed instruction.

- Location
  - Summary Labels — Where possible, summary labels are located above the system or functional group they identify. Locating labels below control display groups is to be avoided. Exceptions include where physical space cannot accommodate summary labels or where label visibility is reduced by intervening components (control handles for example).

    Summary labels are located within associated demarcation lines. In no case should summary labels be located outside associated demarcations of control and display groups.
  - Component Labels — Control and display labels should be located on the flattest most uncluttered surface available, preferably on the chassis of the equipment itself, so that they may be read to the degree of accuracy required by personnel in the normal operating positions. Labels should be located in a consistent manner throughout the equipment, system, and the control room.

    Labels should be located above controls. Labels and information should be oriented horizontally, left to right; vertical orientation may be used, only when controls are not critical

for personal safety or performance, and where space is limited. Curved labeling patterns should also be avoided. In all cases, labels should appear upright at all times even though assembly changes from horizontal to vertical position. Control position labels should be clear and horizontally oriented; however, ease of control operation should be given priority over visibility of control position labels.
All labels should be located externally, in such a pattern that they are not obscured by any hardware. Labels should also be located such that the operator's hand does not obstruct any pertinent label, control, indicator or display during normal operation.
Two labels should not be placed so close together that they look like a continuation of one another. Shared label plates are permissible if clearly delineated.
When selector switches have to be used with a cover panel off, duplicate internal labels should be placed on the internal unit. For any instructions or labels associated with any kind of covered or concealed control, information should be readable with cover off.
Labels on instrument faces should not detract from the important figures of the scale nor detract from the readability of the instrument. No manufacturer's labels or trademarks should be included on the instrument.
If a new equipment is to be used later with an old piece of gear, the new panel should be consistent with the old, unless it is poorly labeled. In the latter case, the old equipment labels should be modified or replaced.

7.3 Rewrite labels as required.

7.4 Review labeling changes.

Schedule: This task will begin on 10 November and be completed 15 December.

2.8 TASK 8 — Annunciator Improvements

Objectives: This task will address annunciator problems identified in the Essex and NRC reviews and will present solutions to these problems.

Inputs:

- Human engineering discrepancies
- NUREG 1580
- GAI concepts
- Task Analyses.

Outputs:

- Backfits to correct annunciator problems
- Specifications to govern the implementation of backfits.

Process:

Overview: A total of 8 of the 127 discrepancies identified in the NRC audit concerned annunciators (6 percent).

The types of generic errors associated with annunciators, as a function of annunciator design features, are listed below:

- Reading Errors
  - location/arrangement
    - . annunciator legend readability at viewing distance
    - . annunciator legend readability at viewing angle
  - annunciator design
    - . luminance level of red annunciator
    - . dyna-tape backfits which cannot be read when illuminated
    - . annunciators have different type fonts
    - . annunciator legends are too complex
- Annunciator Activation Errors
  - annunciator design
    - . annunciators prioritization
    - . annunciators functional grouping
    - . annunciators coding
    - . high annunciator nuisance rates
    - . auditory alarms not coded by location
    - . accessibility of acknowledge controls
    - . unambiguous notification that an alarm is cleared.

With the relabeling of components on the panel, annunciator windows will also be reviewed and relabeled. The annunciator operation logic being developed by GAI will be reviewed for human engineering implications.

Subtasks:

8.1 Review problem with annunciator lights.

8.2 Develop alternate design concepts as backfits.

- Annunciator grouping concepts
- Annunciator prioritization concepts
- Annunciator operation concepts
- Annunciator localization concepts.

8.3 Select optimal concepts.

8.4 Develop annunciator specifications.

Schedule: This task will begin on 1 December and will terminate 31 December.

2.9 TASK 9 — Status/Monitor Light Improvements

Objectives: The objective of this task is to identify the best display configuration of status/monitor lights and the Bypass Inoperable Status Indication (BISI) System.

Inputs:

- Human engineering discrepancies
- NUREG 1580
- Task analyses
- GAI inputs.

Outputs:

- Backfits to resolve problems
- Specifications governing implementation of backfits.

Process:

Overview: As is common in the Westinghouse design the Virgil C. Summer Nuclear Station control room includes several sets of safeguard monitor lights. The configuration of sets of lights, either dim or bright, indicates the status of the appropriate safeguard functions. A number of problems were identified with these lights in the Essex review and in the NRC audit. The Essex preliminary review noted that system monitor lights require difficult pattern recognitions for different system lineups. The NRC audit report stated that status indicators with low and bright glow are not consistent in meaning or intensity and are difficult to use for pattern recognition. The audit report also notes that emergency procedures require operators to rely on pattern recognition to identify train A and train B initiation on 6 status monitoring panels. The patterns were found to be difficult to recognize and interpret.

The Virgil C. Summer Nuclear Station control room will also contain a Bypass Inoperable Status Indication system which will list status of safeguards. This information will be redundant to that presented by the monitor lights but displayed in a less confusing format.

In this task requirements for safeguards monitoring will be established. Trade-off will be conducted to assess two alternate display configurations:

- Bypass Inoperable Status Indication (BISI) system alone
- BISI system with status monitors.

Results of this task will input to improvements of the safeguards monitoring system. The outputs of the task will provide design concepts and criteria for the human engineering aspects of safeguards status display.

Subtasks:

9.1 Review problems with status/monitor lights.

9.2 Develop alternate solutions.

9.3 Conduct trade-offs of solutions, especially BISI system alone vs BISI system and status monitors.

9.4 Develop design criteria for status/monitor indications.

Schedule: 1 December through 15 January.

2.10 TASK 10 — CR Arrangement/Environment Improvements

Objectives:

- To correct problems already identified with the CR arrangement and layout
- To develop design criteria for the SRO monitor console.

Inputs:

- Human engineering discrepancies
- NUREG 1580
- Task analyses
- GAI inputs
- SRO console concept.

Outputs

- Backfits to correct human engineering discrepancies
- Results of the human engineering review of the SRO console
- Specifications for backfits and SRO console.

Process:

Overview: A number of problems concerning CR arrangement were noted in both the Essex review and the NRC audit. The Essex evaluation noted problems with visual search, visual obstructions, panel location and identification, location of safety equipment, communicating and ambient noise. The NRC audit reported problems with visual obstruction, material storage, emergency equipment, and floor mats.

This task will address control room arrangement, environment, and safety problems. Particular attention will be given to:

- Identification of safety hazards
  - structural hazards
  - trip hazards
  - fire hazards
  - electrical hazards
- Identification of traffic problems
  - obstructions
  - patterns
- Identification of control locations which enhance the likelihood of inadvertent activation
- Identification of environmental problems
  - ambient noise
  - alarm signal audio level
  - light levels
  - glare
- Identification of communication problems
  - equipment availability/access
  - speech intelligibility
  - operational problems.

Subtasks:

10.1 Review of human engineering discrepancies.

10.2 Development of backfit concepts to correct discrepancies.

10.3 Review of SRO console design concept.

10.4 Development of backfit recommendations.

10.5 Development of SRO console design recommendations.

10.6 Specification of backfit implementation requirements.

10.7 Specification of console implementation requirements.

Schedule: This task will commence on 17 November and will terminate 10 January.

2.11 TASK 11 — Procedures Improvement

Objective: To identify improvements to procedures to offset problems.

Inputs:

- Human engineering discrepancies
- Task analyses
- Procedures.

Outputs:

- Recommended fixes to procedures
- Specifications governing implementation of fixes.

Process

Subtasks:

11.1 Review discrepancies.

11.2 Develop design criteria for fixes — sample criteria are as follows:

- Procedure designators should be changed to shorter, more usable designators. A breakdown of recommended designators is: SP = System Procedure; 1 = procedure number. Other plant procedures should be as follows: EP = Emergency Procedure; AP = Abnormal Procedure; PP = Plant Procedure or GP = General Procedure; TP = Test Procedure; and HP = Habitability Procedure.

  The use of the word **Procedure** should be used instead of **Instruction** because it implies a sequence of steps to be followed. **Instruction** implies the teaching and/or training of operation.

- Use checksheets for long lists of component status checks that are performed remote from the CR. Incorporate all actions performed by CR Operator within the text of the applicable procedure. This will aid in the correct sequencing of actions without requiring the CR Operator to flip back and forth within his procedure.
- Sequence procedure sections in the most logical sequence of system alignment and operation. This will not require the operator to perform a step in the middle of a procedure prior to performing a step at the beginning of a procedure.
- Integrate limiting factors and precautions for the operation of equipment sequentially within the procedure with the steps that are applicable. This will not require operator to memorize them and the steps to which they apply. This also lessens the chance of overlooking a precaution.
- Use WARNINGS when a precaution is relative to personnel hazard. Use CAUTIONS when a precaution is relative to equipment damage.

Both should be incorporated within a procedure just prior to the applicable performance step.

- Provide a performance checkoff aid for each step. This provides the operator with a memory aid in knowing the exact progression of a procedure. This is especially useful for complex operations where more than one operator and/or multiple systems and/or components are involved.

- Separate performance steps from information. This aids the operator in not overlooking an important step embedded within information. Procedure validation is also made easier.

- Change format to a 3-inch column type. Three-inch column size has been empirically shown to be the most suitable format for information recall. This will become especially important in the use of Emergency Procedures. The use of 3-inch columns also provides a means of addressing information type text separately, yet directly relative, to performance steps.

- Keep references within a procedure to a minimum. Only long cumbersome evolutions contained in other procedures should be referenced. When referencing is required, the direction should be specific, retaining performance step sequencing flow as much as possible. Steps for short evolutions addressed by other procedures should be incorporated within the procedure even at the expense of having redundant information. This will not require the operator to search for and perform applicable steps.

- Develop one line system diagrams to be utilized by operators rather than referencing P&ID drawings. P&ID drawings contain a lot of information not required for aligning operations and are usually very congested. The large size also makes them very cumbersome to use.

- Use writing style convention that permits the development of short concise performance steps. When implementing the following recommendations, it should be recognized that procedures are performance aids for a qualified operator who is familiar with the RTGB. Consistency is the key to this writing style's success. Some examples of writing techniques to accomplish this are:
  - deleting the use of articles and words not necessary for comprehension of ideas.
  - use of common acronyms and abbreviations for proper nouns that are used repeatedly within a procedure.
  - using exact RTGB nomenclature when addressing the operation of a specific component, e.g., LPCS RM FAN COIL UNIT.
  - using upper case print for the following aids in the deletion of words like handswitch, mode select switch, and pushbutton:
    - exact RTGB nomenclature
    - cautions
    - acronyms and/or abbreviations
    - indications
    - annunciators

- use quotation marks to identify indications and annunciators. This aids in the deletion of words like light, lamp, indicator, annunciator, alarm, and position.
- use **ensure** to mean, if performance step has not been accomplished or a status is not as addressed, then make it so.
- use **verify** only when the operator has no manual recourse to a status or operator is not directly responsible for a status.
- use **depress** when addressing pushbuttons.
- use common symbols, e.g., >, <, %, etc., as much as possible.
- use **turn** when addressing the operation of a control switch that changes a component's status, e.g., Stop valves having CLOSE, OPEN, and AUTO. This does not apply to mode select switches for components that have a MANUAL and AUTO position.
- use **shift** when addressing mode select switches for components that have a MANUAL and AUTO position, e.g., Shift MFP control to AUTO.
- use **transfer** when addressing the changing of a component's location of control, e.g., Transfer MFP control to LOCAL.
- use **adjust** when addressing the operation of a potentiometer and process controller type controls, e.g., Adjust FEEDWATER LEVEL MASTER CONT to _____% "OPEN."

11.3 Develop specification for correction of procedures.

Schedule: Begin on 17 November, complete 15 January.

2.12 TASK 12 — Review of Backfit Recommendations

Objectives: To integrate the recommendations for backfits.

Inputs: Improvements already identified.

Outputs: Approved backfits.

Process:

Overview: Backfit recommendations will be reviewed with SCE&G operations and engineering and GAI for impact on operations, engineering and schedule prior to implementation. The NRC will be consulted as required to discuss the acceptability of questionable backfits and schedules.

Subtasks:

12.1 Assemble recommended backfits.

12.2 Identify inconsistencies and conflicts.

12.3 Review with NRC as required.

12.4 Resolve conflicts.

12.5 Revise recommendations.

Schedule: To continue through Phase I and be completed by 15 January 1981.

2.13 TASK 13 — Implement Backfits

Objective: To implement recommended backfits.

Inputs: Approved backfits.

Outputs: Corrections completed.

Process: Implement backfits.

Schedule: To procede immediately following backfit review and to be complete prior to fuel loading or on a schedule approved by the NRC.

3.0 PHASE II — FULL-SCALE CR EVALUATION

3.1 TASK 14 — Control Room Evaluation Planning

In order to meet the NRC long-term requirements of NUREG 0660 for a comprehensive control room review, a number of measurements and observations will be taken in the Virgil C. Summer Nuclear Station control room. Collection of this data requires a realistic plan and management approach. Storage and retrieval of data will require an indexing scheme based on components, systems, and human engineering guidelines and evaluation criteria. Analysis of human engineering data will be valid when current technical descriptions of control panel systems are used as a basis for data interpretation and decisionmaking.

3.1.1 Development of Project Library

One of the initial tasks in the Human Engineering evaluation of the Virgil C. Summer Nuclear Station control room (CR) will be to establish a comprehensive project library.

Objective: To develop a library capable of supporting all aspects of the Virgil C. Summer Nuclear Station CR evaluation.

Inputs:

- List of applicable documents
- Recommended additions to the list.

Outputs:

- Virgil C. Summer Nuclear Station Control Room reference library.

Process: Based on human engineering reviews of nuclear power plant control rooms, Essex has identified several sources of information needed at times during CR evaluation. These include:

- All operator procedures
- System descriptions
- Tech Spec's relevant to the CR
- Failure Modes and Effects Analyses (FMEAs) — if available
- Engineering Drawings of CR and panels

- Piping and Instrumentation Diagrams
- Fault (or success) trees of critical and safety systems — if available
- Samples of computer printouts
- Computer operational procedures and aids
- Descriptions of communications and alarm systems
- Photographs.

During the initial SCE&G/Essex contract meeting, Essex will ask SCE&G to provide these documents and any others that the SCE&G Technical Monitor sees as important to the effort.

Shortly after contract award, Essex photographers will photograph the CR, panels, system layouts and controls, and displays as necessary to round out the current collection of Virgil C. Summer Nuclear Station CR photos. Photos, documents, or drawings will be used only by Essex personnel assigned to evaluate the Virgil C. Summer Nuclear Station control room and will be returned to SCE&G shortly before contract completion.

3.1.2 Preparation of Management Systems

To understand the amount of information resulting from this evaluation, one need only realize that human engineering assessments will be made at the CR, panel, systems, control/display combination, and component levels. Further, the component-level assessments will subject every panel component to an extensive checklist of human engineering criteria, and most procedures will be walked-through and analyzed.

While the Virgil C. Summer Nuclear Station CR may be better human-engineered than others at the completion of Phase I, there is no doubt that discrepancies will still be found between human engineering standards and practices, and panel design. These discrepancies must be shepherded through several SCE&G and Essex management reviews and decisions before additional backfit implementation.

In the following task, Essex will prepare technical management systems and procedures suitable to the storage, processing, and recovery of data produced by the evaluation. This system will be designed to serve in a timely fashion the technical and management decisionmaking needs of Essex and SCE&G personnel involved in the project, and to assure that SCE&G possesses on contract completion all of the information needed to meet NRC's audit requirements.

Objectives: To develop and install project management procedures designed to assure the timely and successful completion of the Virgil C. Summer Nuclear Station CR evaluation.

Inputs:

- NRC guidelines, forms, checklists
- NRC reporting and auditing requirements for CR evaluations
- Panel drawing/photos
- SCE&G engineering change control system.

Outputs:

- Description of data storage and recovery system
- Description of Human Engineering Discrepancy Report Processing System
- Description of logging and reporting system.

Process: At the outset of the contract, Essex will review with SCE&G the CR evaluation reporting requirements issued by the NRC. Then the Human Engineering Discrepancy review process and Human Engineering Discrepancy (HED) Report will be shaped to meet NRC requirements as well as the requirements of the engineering change control system at SCE&G. Planning of this type will reduce the chance of back-tracking late in the contract to obtain important but overlooked data.

At the end of this contract, Essex will turn over to SCE&G a set of human engineering data suitable for audit by the NRC. These data will fill several file drawers and will be indexed according to a scheme that anticipates data recovery for technical, management, and auditing purposes. Essex and SCE&G personnel will agree on the indexing scheme and approve changes during the contract. Logs of data entries into the files and the format for periodic reports on the status of data collection will be developed once the indexing scheme is selected.

3.1.3 Scheduling of Data Collection

One primary factor determining the final cost and timeliness of this effort is the availability of a realistic schedule for data collection activities.

Objective: To prepare a schedule for human engineering data collection which recognizes various constraints: from the operation and testing of the control room; from the operations required by each type of data collection; and from the personnel available at various times to carry out data collection.

Inputs:

- CR schedules and restrictions
- CR and operator requirements associated with each type of data collection (e.g., interviews, walk-throughs, surveys, etc.)
- Management reviews and other scheduling constraints
- Simulator schedules and constraints (if required).

Outputs:

- Master schedule with milestones for human engineering data collection
- Personnel assignment schedule
- SCE&G support requirements throughout effort.

Process: Within rather broad limits, data collection can be scheduled to meet the joint requirements of SCE&G and Essex. However, there is a need to prepare a well conceived schedule accurate to the week and showing milestones, personnel (Essex) assignments, any extraordinary SCE&G support requirements such as:

- Personnel (Control Room — Other)
- Simulator
- Meetings with Westinghouse, GAI, etc.

This schedule will be prepared by Essex the first week of Phase II and be reviewed and approved by SCE&G. Changes to the schedule will require approval by the SCE&G Contract Technical Monitor and the Essex Program Manager.

3.1.4 Tailoring of Data Collection Instruments

While there are some arrangement similarities within BWR's and PWR's, every control room reviewed by Essex has an operational character of its own. To minimize the time needed to complete this study, Essex will tailor all of its surveys, checklists and procedures walk-through processes to recognize the specific nature of the Virgil C. Summer Nuclear Station control room. Without such tailoring, the time required to complete surveys, checklists and walk-throughs with the necessary detail would be prohibitive and technical quality would be compromised.

Objective: To tailor standard human engineering CR surveys, checklists and procedures walk-throughs to effectively and efficiently evaluate the Virgil C. Summer Nuclear Station CR.

Inputs:

- CR Surveys
- CR Checklists
- Operator Interview Questionnaires
- Procedure Walk-Through Processes.

Outputs:

- Revised surveys, checklists, questionnaires, walk-through processes.

Process: Essex personnel will examine the general layout, system organization, component types, component units (switch plus two indicator lights), manufactured items (Rad Monitors), typical operator tasks and procedural sequences, roles (duties) of each operator. Based on this, surveys, checklists, questionnaires, and walk-through processes will be tailored to fit the engineering and operational characteristics of Virgil C. Summer Nuclear Station. However, no changes will be made to the human engineering guidelines used for evaluation.

3.2 TASK 15 — Operator Interviews

Essex human engineering specialists will interview Virgil C. Summer Nuclear Station control room operators. The operators' insights and concerns as control panel users provide information valuable to the CR operability review.

Objective — The objectives of the operator interviews are to identify the following:

- Most frequently used controls and displays and their location
- Most frequently monitored systems
- Most frequently used control panel segments
- Difficult to execute procedures
- Ambiguous labeling
- Confusing control/display relationships
- Most critical systems and procedures, etc.

Inputs

- o Essex Operator Interview forms, based on NRC Guidelines.

Outputs

- Human Engineering discrepancies (HEDs) identified by operators and the number of times each discrepancy is reported.

Process: Operators will be interviewed and asked questions designed to identify operational problem areas in control room design. They will be asked in the CR to point out specific controls and displays which tend to be confusing or difficult to operator during normal, abnormal, or emergency operating conditions. Procedures difficult to execute because of control panel or workstation design will be identified and will serve as input to the procedures walk-through portion of the review. Information on most critical and most frequently used systems will aid in prioritizing human engineering discrepancies found throughout the evaluation procedure. Problems reported by a majority of operators interviewed will be given particular consideration. Human engineering discrepancies identified as a result of operator interviews will be written as Human Engineering Discrepancy Reports for review by Essex and SCE&G.

3.3 TASK 16 — Control Room Surveys

As part of its contract to NRC, Essex has developed a series of surveys tailored to nuclear power plant control rooms. These provide a capability to quickly examine general CR features (e.g., noise, lighting). Application of CR surveys early in this contract will enable discrepancies to be identified, processed, and implemented in an orderly manner. Also early identification of discrepancies will enable walk-throughs to be tailored to collect specific information which sheds light on the priority of the discrepancy.

Objective: To review Virgil C. Summer Nuclear Station control room and panel using surveys to identify CR features in disagreement with established human engineering principals or practices (NRC guidelines).

Input:

- Control room and panels
- Operator support
- Survey.

Output:

- Identification of CR features that are not in agreement with NRC guidelines.

Process: Use of the CR surveys and generic checklists is remarkably simple. The human engineer reviews the control room and panels, as specified in the survey, and records the required information. If the findings differ from human engineering guidelines provided by NRC, a discrepancy is noted.

- Annunciator sequence, logic, and display
- Color coding, meanings, and consistency of use
- Communications devices available to operator
- Auditory alarms (identifiability)
- Ambient noise
- Ambient lighting
- Display illumination
- Design conventions
- Emergency garments.

3.4 TASK 17 — Human Engineering Checklists

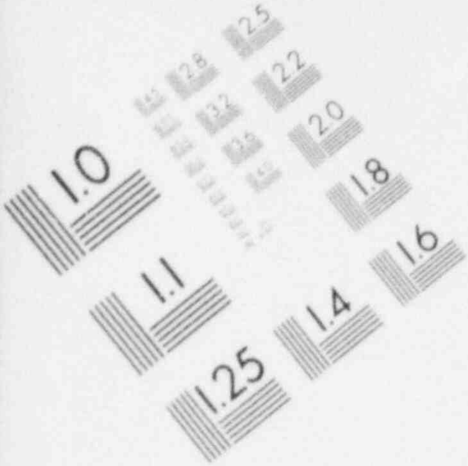
The Human Engineering Checklists are designed to identify and document CR discrepancies from established human engineering practice. Applied to systems or functional groups of controls and displays, the checklists will promote the identification of discrepancies in controls and displays. The checklists will also check for any arrangement on the panel which deviates from established human engineering criteria. Every component will be thoroughly reviewed in terms of functional relationships to other components and its own design. Checklists which address operator/computer interface will identify discrepancies in human engineering practices in computer control/display design.

Objectives:

- Identification of discrepancies from established human engineering practice
- Evaluation of systems operability.

Inputs:

- Essex Human Engineering Checklist forms
- Panel design information regarding system or functionally related components
- Information on criticality of systems
- Panel design drawings.



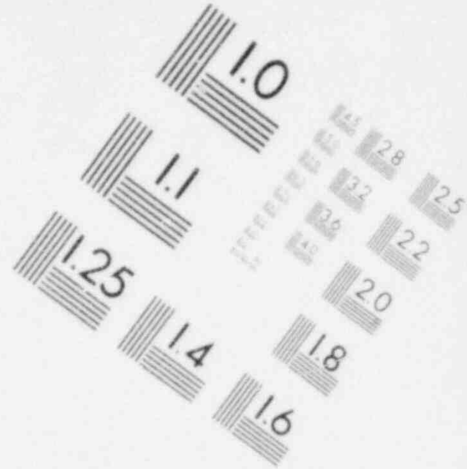
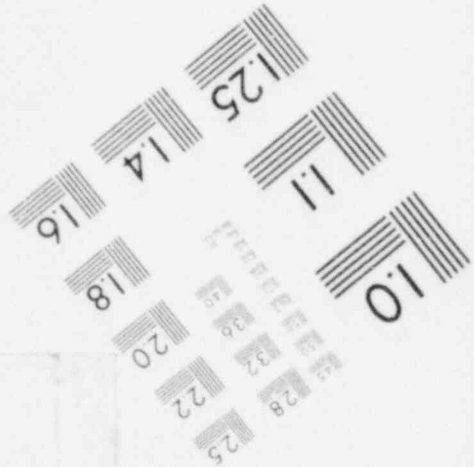
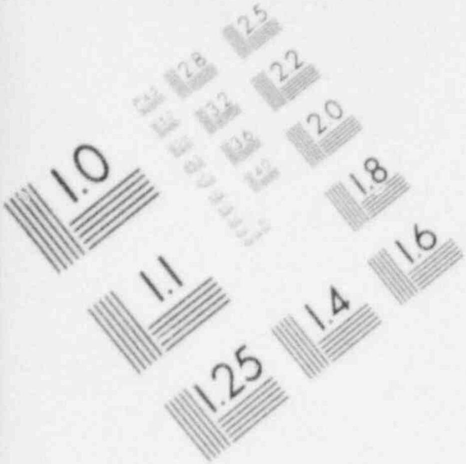


IMAGE EVALUATION
TEST TARGET (MT-3)

6"

MICROCOPY RESOLUTION TEST CHART





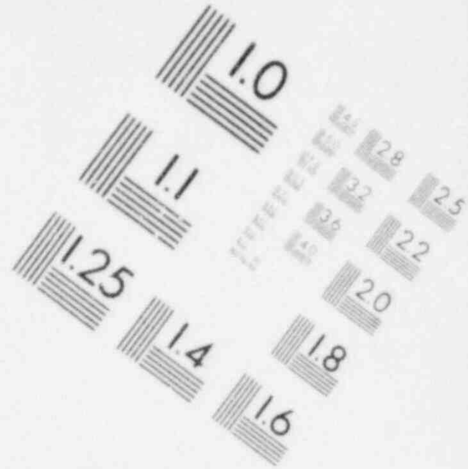
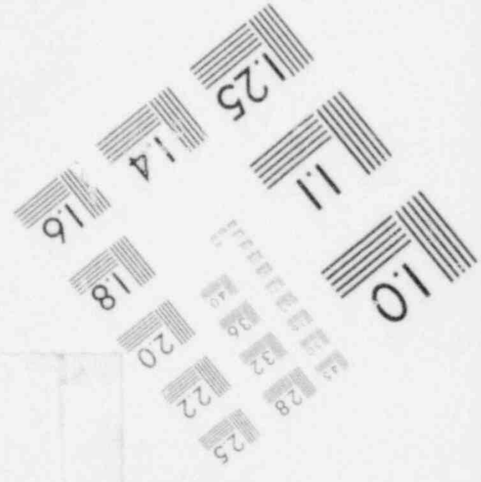


IMAGE EVALUATION
TEST TARGET (MT-3)

6″

MICROCOPY RESOLUTION TEST CHART



Outputs:

- Human Engineering Discrepancy Reports.

Process: Systems and functions within control room operation will be identified.

Checklists will address operability of control/display panels and panel layout. Most critical and most frequently used components should be easily accessible. Controls and displays with similar functions or meanings should be similar in design and layout across systems and panels. Workspace layout should enhance operability under normal, abnormal, or emergency operating conditions. Workspace design checklists address:

- Guarding of sensitive controls
- Location with reference to operator of controls used without visual reference
- Design similarity of functionally similar control/display groups
- Conspicuity of differentiating labeling of similar control/display groups
- Potential of inadvertent actuation of controls
- Accessibility of frequently used controls/displays
- Arrangement of components on panels by function or sequence of use
- Agreement with conventions of sequential operations
- Operability by operators using protective clothing and equipment
- Adequacy of workspace and panel design to accommodate number of operators required to work panel simultaneously
- Efficiency of traffic flow through control room
- Accommodation of panel size and layout to at 5th to 95th percentile operators
- Uniformity/adequacy of illumination
- Adequacy of storage space for procedures, references, operator protective equipment, fire fighting equipment, etc.
- Adequacy of emergency lighting
- Accessibility of sanitary facilities
- Adequacy and accessibility of communications equipment.

Each control within a system will be evaluated, using the checklists, to determine its operability in relationship to the system and other controls/displays within the functional group. Checklists address:

- System feedback to control operation
- Control/display movement relationships

- Meaning of directionality of control movement
- Clarity/completeness of control labeling
- Visibility/readability of labeling
- Physical relationsnip to other controls/displays on panel
- Uniformity of control coding
- Accessibility of controls
- Ease of operation of control
- Usability by fifth percentile male
- Usability in protective clothing.

Checklists will address each display component within each functional group identifying areas of discrepancy from human engineering criteria for display design and use. Addressed will be:

- Relationship to controls
- Location in respect to related controls
- Functional grouping
- Arrangement as related to sequence of use
- Visibility/readability from normal operating position
- Accuracy requirements
- Accessibility of most frequently used displays
- Requirements for decoding or interpretation
- Recognition of display failure
- Display of equipment response rather than control activation
- Separation/prominence of critical warning or alarm indicators
- Internal instrument lighting
- Consistency of information displayed with system requirements
- Use of legend lights
- Effect of display failure on equipment
- Directional reading of sequential displays
- Consistency of scale values and direction of increase or decrease.

Within systems, labeling should be consistent, clearly identifying components as part of a functional group. Labels should also be clearly seen and easily understood by operators. Checklists on labeling address:

- Conspicuity of cautionary or warning labels
- Clarity/conciseness of label language

- Use of arabic numerals in numbering
- Labeling of functional groups
- Consistency of labeling format within functional groups
- Font size of print
- Spacing of letters/words
- Contrast of print to background color
- Wearing or obscuring of labeling
- Label location with respect to labeled component
- Consistency of label location conventions
- Use of summary labels or demarcation
- Illumination of labels
- Language of label consistency with procedure document and operator terminology
- Consistency of abbreviations.

Computers utilized by the control room operator should be easily accessed and operated. Information presented should be clear and readily comprehended. Operability checklists on the operator/computer interface address the following:

- Consistency of format with task requirements of operator
- Usability of display format
- Consistency of language with CR and procedures terminology
- Readability of display in terms of resolution, contrast, symbol, size, etc.
- Organization of data presented
- Use of highlighting of information in display
- Operator access of information
- Operator initiated computer response
- Feedback or prompting of system to operator
- Usability of data entry devices
  - input formats
  - data fields
  - input modes
  - error correction.

The data recorded on the Human Engineering Checklists will provide information on discrepancies from HE criteria   1 will be written up by research staff as HE Discrepancy Reports. These reports will be submitted to the Essex Program Manager for review by Essex and SCE&G.

3.5 TASK 18 — Procedures Walk-Throughs

Procedures walk-throughs are simulated performances of procedures by a control room operator. These simulations are performed with the use of a control room simulator if at all possible (and if plant specific) or "walked-through" in the CR. If the CR is used for the simulation, no manipulation of controls occurs. The operator instead points to relevant controls and displays and describes how they would be utilized at the particular step in the procedure. Videotaped, these walk-throughs provide a very useful source of information on CR operability for critical operations and on control and displays used in emergency and abnormal procedures.

Objectives:

- To identify human engineering discrepancies in panel arrangement.

Inputs:

- Copies of normal, abnormal, and emergency operating procedures
- Team(s) of operators.

Outputs:

- Videotapes of operator performance of procedural actions
- Human engineering discrepancy reports (HEDs).

Process: The team of operators will be briefed prior to the procedures walk-throughs on several points to be closely examined in the process. These refer to information which should be clearly indicated by the operator during the simulation. They include:

- All controls/displays, including annunciators and audible alarms, associated with the procedure
- Traffic patterns of each operator in the CR for each procedure
- Explanation of each operator action, including manipulation of controls, monitoring of displays, etc.
- Description of each operator action performed but not stated within the procedure
- Identification of each step stated in the procedure but not performed by operator
- Contingency operational requirements and associated equipment
- System response which cues operator to proceed from one step to another.

During the operators' walk- and talk-through of each procedure, an Essex technician will videotape each action, focusing on controls and displays indicated by operators as integral to the procedure. Each procedure will be walked through twice, videotaped each time. In the first walk-through, the operator will be asked to walk through the procedure in a real time mode and pace, performing all steps as if responding to the procedural condition. Subsequent walk-throughs will be performed with frequent pauses in action while the operator explains in detail each of his actions, including annunciators/displays read, controls operated, etc. A third walk-through may be performed if confirmation is required of times and actions.

The procedures walk-throughs will be a major source of information for both the development of task analyses in and the identification of HE discrepancies. Some performance aspects identified in the walk-throughs providing discrepancy and task analysis information include:

- Number of steps required of memory
- Identification of conditional and/or sequential steps in each procedure
- Accessibility/usability of reference information
- Inconsistencies between procedure and CR panel layout
- System feedback to operator in response to operator actions
- Organization of components on panel.

3.6 TASK 19 — Special Studies

Special studies may be performed to address specific areas of concern as required by SCE&G.

3.7 TASK 20 — Human Engineering Discrepancy Report Evaluation Process

The plan assures that human engineering evaluations identify discrepancies throughout rather than at the end of the program. A general description of the discrepancy review process is described below; however, Essex and SCE&G personnel will review this process and make changes early in the effort.

Objective: To utilize a management process, including at least SCE&G and Essex representatives, to review human engineering discrepancies found by Essex in the Virgil C. Summer Nuclear Station control room. The results of this review will be identification of backfit requirements and schedules based on safety, regulatory, operational, operator performance, and cost considerations.

Inputs:

- Human Engineering Discrepancies (systems, components, etc.)
- Data from walk-throughs on system/component use in emergencies
- Cost estimating elements
- Potential human error induced by discrepancy
- Impact of human error on safety and operations.

Outputs:

- HED Report
- Disposition of HED
- Implementation of Disposition.

Process: Human Engineering surveys, checklists, interviews with operators, and walk-throughs/talk-throughs all identify Human Engineering Discrepancies (HEDs).

3.7.1 Prepare HED Report

Once a discrepancy is found and reported, the Essex Human engineer identifying the HED will prepare a HED report providing at least the following information.

- A description of the deficiency (components, locations, labels, etc.)
- Human engineering guideline violated
- Type of human error induced
- Systems affected by error
- Backfit concept(s).

HED repor will be prepared within two days after a discrepancy is found.

3.7.2 Review of HED Report (Essex and SCE&G)

Once a week Essex and SCE&G personnel will meet to review HED reports. To make a decision on whether the discrepancy should get immediate, near-term, long-term, or no action, the following factors will be weighed:

- NRC regulations
- Safety and operation impact of error
- Frequency of errors in normal and emergency conditions
- Probable cost to backfit
- Effect of discrepancy on other factors such as operator retraining.

Based on these, the committee will recommend a backfit schedule for each discrepancy selected for action and will assign personnel to prepare an Engineering Change Proposal (ECP).

3.8 TASK 21 — Reporting

When the NRC audits the Virgil C. Summer Nuclear Station control room comprehensive human engineering evaluation, two topics will be of primary concern: 1) the completeness of the evaluation with respect to the components, systems, procedures, etc., reviewed and the guidelines used; and 2) the disposition of discrepancies found during the review and the rationale for selecting backfits for immediate, near-term, long-term, and no action.

The reports outlined below, each prepared by Essex and SCE&G, attempt to anticipate the NRC's audit and to collect the required information into three easily used summary documents.

3.8.1 Project Summary

This report will provide a "quick-look" review of the entire human engineering evaluation effort, including:

- Guidelines applied
- Evaluations made
- Schedule of activities (actual)
- Discrepancies found and their disposition
- General statement of the human engineering fitness of Virgil C. Summer Nuclear Station (optional)
- Human factors enhancements.

In addition, specific recommendations will be made with respect to:

- Improved communications
- Status monitoring
- Enhancement of controls and displays.

3.8.2 The Disposition of Human Engineering Discrepancy Reports

This report will document the pattern followed by each HED from initial identification through HED report to ECP to final disposition. Files containing supporting technical and management materials will be identified for easy access. Based on current information, this document will meet one of the two primary concerns of the NRC audit.

3.8.3 End-to-End Description of Process

This report will contain a detailed, annotated flow chart of all evaluation activities with cross references to supporting documentation files.

In addition several matrices will be prepared to show the results of comparing specific devices, systems and procedures at Virgil C. Summer Nuclear Station to specific NRC guidelines. These matrices will also contain the location of supporting documents and files.

APPENDIX A

HFE REVIEW OF THE V.C. SUMMER NUCLEAR POWER STATION CONTROL ROOM

Prepared For:

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August 6, 1980

INTRODUCTION

Background

The Essex Corporation has performed a preliminary assessment of the V.C. Summer control room for the purpose of identifying conspicuous human factors engineering (HFE) design problems in the Summer control room.

The evaluation consisted of:

- Operator interviews
- Surveys of the physical characteristics of the control room
- Comparison of Summer design features with generic nuclear control room HFE discrepancies
- Videotaping and analyzing walk-throughs of Summer 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 V.C. Summer personnel should otherwise contend with the temporary provisions having HFE design problems; and (3) evaluation of existing conditions can aid Summer engineers in implementing planned changes without introducting the HFE problems found in the current, temporary provisions.

Data collection and evaluation spanned approximately 12 days and involved eight Essex personnel and numerous Summer 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 V.C. Summer 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, system 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 V.C. Summer operations staff members. Descriptive data, regarding:
  - ambient noise (measured of 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. V.C. Summer 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, V.C. Summer personnel and documentation were required to address specific design areas and issues. Individual activities during this phase included:

- Analysis of procedures. 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 for individual procedural steps and sequences.

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

  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
  - CRTs
  - 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 where 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, etc.) 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 Summer control room. These briefly state:

- The problem areas dealing with:
  - control room
  - controls
  - displays
  - annunciators
  - communications
  - labels
  - procedures
  - 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. Safety Gear — CR does not presently provide personal protective equipment (e.g., air pack, fire extinguishers, etc.). Fire Fighting equipment is not easily accessible; only three portable fire extinguishers are available. (Category 1)

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

3. Visual Search Aid — CR panels (system level) not demarcated, but rather run together. Subsystems and components are not demarcated. Sometimes Bezels around two controls associate unrelated components. Performance can be degraded by increasing search time with the probability of control and display substitution errors increased. (Category 1)

4. Visual Obstructions — Control room (CR) has several structures, notably a support column, bookshelf, and drawing layout table, which visually obscure portions of the control boards. Performance from behind these obstructions can be degraded by: increased time to visually access controls, displays; increasing traffic in CR to attain visual access; and disrupting a task sequence to attain visual access. (Category 3)

5. Position of Heating, Ventilation, and Air Conditioning Panel (HVAC) — As information or control capability is required during normal and emergency operations, a reactor operator (RO) or senior reactor operator (SRO) must exit the main control area, thereby temporarily reducing manning. Furthermore, monitoring of HVAC status is not possible without leaving the CR rendering positive monitoring and status checking to a "catch as catch can" situation. (Category 2)

6. Safety — CR mats are a hazard in that personnel may trip over edges. Page phone cords are also a traffic hazard. Potential exists for personnel to injure themselves or actuate controls as a result of tripping. (Category 4)

Positive Design Features

1. Control Board Profile — The general control panel profile employed 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. Systems Layout — With the exception of the HVAC panel, controls and displays are physically located in the main operating area. Especially positive is the availability of radiation monitoring equipment in the CR. Layout of boards in a dogleg type arrangement promotes the reduction of traffic and facilitates visual access to controls and displays.

3. 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:

- Syncroscope handles and position indicating arrows ("SYN Main Transformer #1" on panel 18) (Category 3)
- Pistol grip controllers and position indicating arrows (e.g., recorder channel selectors) (Category 3)
- Target (control set flag) on pistol-grip controls and control background (e.g., FW Booster pumps and Transformer controls on panel 16) (Category 3)
  - maroon on black, or
  - deep red on black, or
  - black on black (locked out).

Performance decrement can include difficulty in determining control position.

2. Legends, Labels, and Position Indicators — Legend plates of discrete controls with transilluminated labels (all CMC type switches) are interchangeable; transilluminated pushbutton legends are also interchangeable. (Category 3)

3. Control Access — Some controls on vertical portion of control boards are not easily accessed by 5 percent of operators (examples, Rx Trip, PRZR level record SW, and steam dump mode select).

   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 accidentially actuating another control, Category 3 for increased time and control selection.)

4. Control Effect Consistency — Process controllers can have opposite system effects, e.g., control setting increase can either open or close a valve, increase or decrease pump output, etc. Examples include FW Pumps A, B, & C speed controls, PRZR press. and level controls.

   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 1)

5. Control Feedback — 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). Other system feedback should be immediately available: where not, 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.)

6. Control Use Coding— Rotary controls with transilluminated legends not consp cuous as to method of operation, that is, whether control is:

   - Momentary contact closure to fully close or open valve, or
   - Continuous contact to throttle valves.

   For example, Chg Pump discharge valves, RHR sump pump, and steam seal feed valves anticipated operation error is a failure to set a throttle valve to correct position. (Category 4)

Positive Design Features

1. Direction of control use conventions consistent with population stereotypes.

2. Highly consistent application of control motion conventions (in terms of direction of control use, not system res onse).

3. Most controls accessible by 95 percent of operators.

Displays

Problem Areas

1. Display Readability — Scale increments and numbers are often too small, resulting in very small readability envelopes (examples: source range counts, SG Levels, SG Control Signal). (Category 1)

   Legends on permissive lights — particularly the black print on green background with green portion backlighting extinguished (e.g., Bank 1-3 Main Steam Lines and Headers on panel 14) (Category 1).

   Fe dback dis lays on proc s controllers located on lower portion of board have a moderate glare problem (e.g., SG Level set point, Turb Oil Res temp). (Category 4)

2. Visual Access — Displays totally or partially obscured include:

- Trend recorders by labels placed over windows (turbine temp. expansion) and permanent scales (Category 3)
- Radiation monitors, by drawing table, support column, and bookcase (Category 2)
- HVAC status mimic and displays are obscured by control room boards. (Category 2)

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

- EHC Temperature/closed cycle temperature (Category 3)
- Reactor building dewpoint (Category 4)
- Circ water valve positions. (Category 4)

4. Color Coding — Color of ink in trend recorders (e.g., Loop A&B temps on panel 6, containment pressure on panel 4) not consistent with labeled colors. (Category 4)

5. Lamp Test — Except for annunciators and system monitor lights, there are no provisions for direct testing of indicator bulbs. (Category 4 — more data is required to evaluate operator performance using the V.C. Summer lamp test logic system.)

6. Display Failures — Scales fail on scale (not below zero or lowest point). When failed, displays may not be detected as such, and any control actions taken as a result of displayed value will most likely be incorrect. (Category 4)

7. Information Presentation — Displayed information is often such that high level information processing is required. For example condensate flow is displayed in GPM, while Feed Flow is displayed in lbs/hr ($X10^6$). (Category 4)

   System monitor lights require difficult pattern recognitions for different system lineups. (Category 1)

Positive Design Features

1. Displays are designed to avoid parallax
2. Display glare generally is low due to placement of units and board profile.
3. Displays for control feedback are provided from system responses, not control settings (except process controllers).

4. Information displayed (ranges of values, etc.) is consistent with system and operational requirements.

Annunciation System

Problem Areas

1. Placements — Several annunciator tiles are located away from relevant system controls and related displays.

   - RCP bearing
   - RCP cooling
   - Train A&B SI sequence complete.

   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)

2. Auditory Signals — Although different auditory signals are provided for Trains A, B, & X, 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)

3. Prioritization — Alarms are not visually or audibly prioritized; further the first-out panel is not distinctively marked (by means of label, bezel color, etc.) from other annunciator panels. (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.

4. Readability — Titles small, excess printing:

   1. BATCHING
TANK
HIGH/LOW
TEMPERATURE

   2. LOW PRESSURE
LETDOWN
HIGH FLOW
HIGH PRESSURE

3. BORON THERMAL REGENERATIVE SYSTEM HEADER TEMPERATURE

Low contrast when not back-light. (Category 1)

5. Related Controls — Dedicated acknowledge and resets are not provided (by system or location). Anticipated operational error is the likelihood of alarms being acknowledged prior to detection. (Category 1)

6. Test Functions — The three (3) separate test functions (for Trains A, B, & X) do not coincide. That is, when all tiles are being tested, tiles alternately flash without being in sync. There is a high probability of failing to detect spent bulbs. (Category 4)

Positive Design Features

1. Tiles directed down towards operators.
2. First-out panel provided.
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. (Category 2)

   Errors anticipated include: failure to accurately communicate between HVAC and CR, temporal errors in accessing phones, errors of omission due to operators being restricted to two relatively broad areas. (Category 3)

   Relatively high ambient noise levels exist and will mask and garble voice communications. (Category 2)

   No page phone provided on panels 5 through 9, requiring operator to walk to phone on panel 10 to access communications. No page phone provided at PRODAC or operator's desk. (Category 4)

2. Plant — Page phone channels shared, possibly leading to competition for communications. Major potential error is failure to send/receive communicated messages. (Category 4)

   Radio systems do not penetrate areas of plant, limiting communications. (Category 4)

3. Policy — Operators serve as switchboard operators during off-hours. Performance decrement/errors include:

   - Failure to monitor plant
   - Failure to detect plant anomalies
   - Temporal errors in detecting/responding to abnormal plant conditions. (Category 4)

Labels

Problem Areas

1. Consistency — Multiple abbreviations for 1 term, e.g.,

   HX - HT. EXCH.

   RB - R.B. - Reactor Bld. - Reactor Bldg.

   ISO - ISOL - ISOLAT

   CONT - CNTRL - CONTRL (Category 2)

   Variable pattern for presentation of information; same order should be followed consistently, e.g.,

   FLOW LOW. . . LOW FLOW (Category 2)

   Dynatape additions, operators' markings in pen, e.g.,

   VCT TEMP operators' note

   VCT TEMP engraving (Category 3)

2. Accuracy — Many labels misspelled; result = confusion, e.g.,

   - BWST should be RWST
   - MINIMUN should be MINIMUM
   - RH MU WTR should be RX MU WTR
   - LTON should be LTDN

- % A FLUX should be % Δ FLUX
- INLET TD LP HTR should be INLET TO LP HTR (Category 2)

3. Meaning — Several abbreviations have multiple meanings:

- CONT = containment, control or controller
- COND = condenser and condensate (CO also means condensate)

Many labels describe engineering features primarily (for example, RB cooling fan controls). (Category 2)

4. Spacing — within labels causes confusion, e.g.,

LOOP A - LOOPA - LP A - LPA
RCP A - RC PA (Category 2)

5. Presence — Summary labels not provided at panel or functional group level increases visual search times. (Category 1)

Symbols on mimics (electrical distribution) are not labeled, e.g., transformer numbers, switch numbers. (Category 3)

Many labels not provided, e.g, EHC. Errors include control substitutions, display substitutes, and temporal errors in locating components. (Category 2)

6. Visibility and Readability — Many labels obscured by controls and displays (e.g., PRODAC recorders, rod control banks election). Operational performance decreased in terms of: time to locate, manipulate and verify. (Category 2)

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

- Generator Varmeter
- Generator Wattmeter
- Unit Aux XFMR Ameter. (Category 3, a high likelihood of display substitution errors exists)
- DA storage tank level.

Procedures

Problem Areas

1. Control Room Compatibility — Procedure nomenclature often does not agree with CR labels (e.g., procedure statement "Loss of Containment Integrity," boards use RB (= reactor building) as reference to containment). Potential for control and display selection errors exist (procedural reference to controls and displays with different board labels). (Category 1)

   Procedures specify control room operator actions that are plant operator activities, communications commands are actually required. (Category 1)

   Plant operator activities require communications with plant operators instead of direct control room indication (circ. water valve position for example). Errors of omission are likely. (Category 1)

   Procedural steps are sequenced without regard to CR layout and traffic. Performance decrement (time, step performance reliability) due to excess traffic will be observed. (Category 1)

2. Information Presentation — Procedures used are in column format with notes and cautions embedded between steps. There is a high likelihood of procedural steps being omitted. (Category 1)

   Procedures are not highly accessible, bound in three-ring binders and stored on bookshelf. (Category 1)

   Cross referencing to other procedures (See EOP-1, Step 1.1 and EOP-6, Step 3.1.3 for examples) reduces accessibility. (Category 1)

   Cross-referencing to other procedures and tech specs requiring an operator to simultaneously perform steps from several sources, results in a high probability of omitting steps. (Category 1)

   Steps frequently unclear ("If for some reason. . ." and "verify SG level, if not off scale. . ." as examples). Probability of misinterpretation of steps. (Category 1)

   Notes and cautions contain operational steps (See EOP-8, Step 1.2.B.2 and EOP-12, Step 3.2.3 for examples), which increase probability of step omission. (Category 1)

Steps embedded in narratives and lengthy sentences, "Observe that only the misaligned control rod of the affected Control Bank will start to move as verified on the Digital Rod Position Indication display and will continue to move as long as the Control Rod In-Hold-Out lever is held in either the rod Out or rod In position" from EOP-10, page 7, step 7. (Category 1)

Diagnostic aids, graphics, charts, etc., are not presented with referencing text but in the back of procedures or in other references, e.g., Attachments I & II EOP-10. Performance decrement includes: time loss, step omission, memory errors, and reading/interpretation errors.

Information is incomplete, e.g., EOP-5, page 3, step 3.3.1.A.3 says to de-energize rod drive MG sets, and not that this is performed by tripping breakers 1B1 and 1C1. (Category 1)

Operator-Computer Interface

While the computer in the V.C. Summer control room is not a safety related system, it can be used to display information about safety systems which is in addition to safety instruments in the control room. Category 2 discrepancies are cited here since the computer can display information from safety related systems.

Problem Areas

1. Job Aids — Address index is divided by P (pressure), T (temperature), and F (flow), but listings within each category are not alphabetized, requiring operator to randomly search lists to locate addresses of parameters. (Category 2)

   PRODAC trend recorders have no provisions for supplying alphabetic labels, and address valves not displayed. High likelihood exists for misinterpreting information. (Category 2)

   Numeric displays on PRODAC recorder have no provisions for temporary labels. (Category 2)

2. Information Presentation — Print speed on the printer is slow, leading to: 1) potential loss of information due to print buffer overload during transients, and 2) information loss due to print queue. (Category 2)

Page formatting of printer leads to lowered readability (column format employed, columns run together). (Category 2)

Printer prints over holes punched in paper (for binding) which lowers readability and causes information loss. (Category 2)

Nomenclature is inconsistent (e.g., "CONDENSATE PUMP" is also written as "COND PUMP," etc.). (Category 2)

3. Physical Design — PRODAC desk not fit for 95 percentile of operators (in terms of stature), desk top too low, insufficient horizontal knee clearance. Performance decrement of a variety of types will be evidenced due to operator discomfort. (Category 2)

   Controls have low label contrast, promoting the potential for substitution and reading errors. (Category 2)

   Alarm bell is sufficiently loud, but failure to acknowledge immediately will lead to failure to acknowledge for long periods of time. (Category 2)

Panel Layout

Problem Areas

1. Location Consistency — There are many inconsistencies in layout. Examples are:

   - RB cooling unit fans and associated motor amp meters (noncompatible matrices)
   - FF controls (horizontal) and SG level controls (vertical)
   - PRZR relief valves, arranged thus:

     ISO A B C

     PORV's C A B

   - Seal Inj. stop valves and meters arranged:

     Stop Valves A B
C

     Meters A B C

   Very high likelihood exists for control and display substitution errors. (Category 1)

2. Visual Search -- Layout of components of subsystem levels can cause excessive visual search requirements:

- Steam dumps
- Charging pumps
- RHR controls and displays
- Component cooling to RHR control
- Emergency boration control and indication.

Operational errors will include control/display substitution, display reading errors, and temporal errors. (Category 1)

RECOMMENDATIONS

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

1. Provide aids for visual search. This may extend to color coding 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.

2. Improve communicators betwen HVAC panel and main control area by means of a permanently installed page phone or other device.

3. 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.

4. Improve control position coding in terms of:
   - Contrast of control pointers and handles
   - Flag (or target) figure/ground contrast on pistol grip controls (e.g., Sw pumps on panel 2).

5. 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, e.g., SBN switches.

6. Provide annunciator controls which are functional for specific boards, not the entire boards.

7. Prioritize alarms by means of color, spacial locations within bezels, or other means.

8. 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.

9. Improve procedures in terms of:

   - Format employed
     - 2/3 column with headings
     - placements of notes and cautions
     - indexing and accessibility
   - Sentence style and length
   - Placement of diagnostic aids, graphs and figures
   - Extent of cross-referencing.

APPENDIX B

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
Nuclear Operations
South Carolina Electric and Gas Company
Post Office Box 764
Columbia, South Carolina 29218

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

Robert L. Tedesco
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).

POOR ORIGINAL

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 <u>setpoint</u> and <u>flow/temp</u> 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 m' :,‾particularly at the top of HVAC panel (Category 2).

e. Mimic board is too ' 'nh 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 r.merics 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 =

A	B
C	

EF Isolation From TDP to SG =

B
A
C

(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 R IATION MONITORING SYSTEM

Detectors are not associated with their related annunicators, such as, detectors RM 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. and 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 Shutdown Reset" 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)

POOR ORIGINAL

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.