ESSEX

Telecopy to Tim... Attn. Marc Grecia & Ray Ramirez

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To: Leo Beltracchi

From: Ken Mallory

Subject: Findings of the CR review at Sequoyah - Unit 1

During the week of February 4-8, 1980, the Essex Corporation in cooperation with the NRC/NRR performed a human engineering review of the control room at TVA's Sequoyah - Unit 1 Nuclear Power Plant. The procedures and guidelines used by Essex were the first generation of those to be included in the guidebook.

Essex had three objectives for this review:

1. To identify features in CR design and procedures that could induce operator error under normal or emergency conditions.
2. To examine evaluation guidelines and procedures for the guidebook and modify accordingly.
3. To identify design and procedural problems and backfits common among control rooms.

1.0 SUMMARY CONCLUSIONS

a. The Sequoyah - Unit 1 control room exhibited a number of design and procedural features that were contradictory to human engineering standards and practices (Described below).

b. The Essex procedures were upgraded as a result of the Sequoyah review:

- Procedures for using checklists were altered
- Walk-through/talk-through procedures were formalized
- Surveys were expanded to include procedures, noise survey, ambient light survey.

2.0 OBSERVATIONS

Each of the objectives described below is given a Subjective Risk Assessment Weight based on the likelihood that a particular aspect of CR design will lead to an operator error in a safety-related activity. The likelihood is based on the opinion(s) of the Essex human engineer(s) reviewing the CR.

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ESSEX CORPORATION • 333 North Fairfax Street, Alexandria, Virginia 22314 • (703) 548-45

Category 1 — High Risk of Operator Error in Safety-Related Activity

Category 2 — Moderate Risk of Operator Error in Safety-Related Activity

Category 3 — Risk of Operator Error is Safety-Related Activity

Category X — Additional evaluation required

a. Communications — Distance and noise interferes with voice communication between the Unit 2 CRO at the panels, and the ASE at the common panels. This problem is particularly acute when a breathing apparatus is worn by both (Category 1).

b. Status Monitoring - Engineered Safety — In the matrix of indicator lights, failure to achieve a proper system status is often given by a light "off." No check is made during EP for failed lights. This could lead the operator to assume that an operating system had failed (Category 1).

c. Status Monitoring - Engineered Safety — In the matrix of lights, spares are intermixed with operating lights. Since the operator's task is to determine "all on," "spares off" creates a requirement for the operator to review all lights to assure that only the spares are off (Category 1).

d. Annunciators — No prioritization, low contrast between flashing and steady lights (Category 1). While an alarm is displayed (no auto clear) no other alarm can be announced unless the operator resets the annunciator (Category 1).

e. Steam Generator Strip Charts — Labels on chart windows contradict those under chart units. Appears that recorders were reinstalled incorrectly after maintenance (Category 2).

f. Inadvertant Actuation — Three "J" handle switches were mounted without protection 3/4" from edge of panel. Could be accidentally actuated (Category 1).

g. Label Obstruction — Discrete rotary star handles obscure switch position legends, and indicators obscure labels when mounted low on vertical panels (Category 2).

h. Convention Fault — The convention of valve "closed" being on the left and valve "open" being on the right is violated on controllers which require a 100% output signal to fully close the valve (Category 3).

i. Violation of Stereotype — Speed controller (panel 1-M-4) has max speed = 0% and min speed = 100% (Category 2).

j. No Labels — Turbine pump indicators have two red lights but no label for either.

k. Violation of Stereotype — Feedwater and condensate system - 480 THOV had a sequence of valves (left to right) CBABA (Category 2).

l. Violation of Stereotype — AMPS display for feedwater pump B is mounted over a vertical string of pump A related switches (Category 2).

m. Display Confusion — Several long strings (greater than 4) of vertical meters. Mounting in strings increases the likelihood that the operator will read the wrong display if it is near the middle of the string (Category 2).

n. Labeling — Font was too small, contrast poor, and information inconsistently placed on specific lines (Category 1).

o. Printers — One computer was out of alignment, printing all characters ½ black and ½ red. Should be checked regularly and corrected (Category 3).

p. Protective Clothing — There are several problems (Category 1):

- Donning is difficult.
- Changing air tanks is a two-man operation.
- With the five minute warning bell, there is perhaps too little time to change.
- Mask virtually prohibits the wearer from speaking to anyone.
- There are too many steps to don gear.

q. Procedures — Problems include (Category 1):

- Need for improved diagnostic aids
- One instruction per numbered step
- Need for all steps to be included
- Cross-references
- Steps CAUTIONS & PRECAUTIONS
- Synonyms
- Long, complex instructions
- Data, charts, etc., referenced
- Sequential deviations as shown in procedures and walk-throughs
- Ambiguous and confusing wording
- Locations of infrequently used components not given in procedure
- Text layout, font.

r. Reach — Short (five percentile) operators have difficulty in reaching a number of switches on vertical panels. Some switches require the operator to stand on one foot very close to the panel and other switches cannot be reached (on Power Distributor Panel) (Category X).

s. Readability Envelopes — TVA should examine the requirements to read various meters, annunciators windows, and labels against readability (distance-from-display) envelopes (Category X).

t. Pushbuttons & Legends — Difficult to visually distinguish between pushbuttons and backlighted legends (Category 3).

u. Acknowledge — The ACK-RESET switch for the permissive interlock is at the opposite end of 1-M-4 panel from the display (Category 3).

v. Switch Confusion — Large strings/matrices of switches are located at several places on panels (Category 2).

1) Component cooling water
2) Water service systems
3) Essential raw cooling water
d) Ventilation panel

w. Violation of Convention — SB switches on Electrical Distribution Panel reverse the trip/close convention for other switches (Category 3).

x. ASE Area — Tables may interfere with operations (Category X).

y. Operator View of Panel — Consoles on right and left of seated operator obstruct view of panels (Category X).

z. SMS — Display does not appear to replicate conditions as they are in the plant (Category X).

aa. SMS — There does not appear to be a display line reserved for checking keyed inputs to SMS (Category X).

bb. Violation of Stereotype — Operator must push control in (towards vertical part of console) for rods to move out, and pull back on control to move rods in. This is a definite violation of stereotypical response (Category 1).

cc. Confusion — There is no special indication for throttle controls (vs discrete controls) (Category X).

dd. Room Coloring — There are no clear visual boundaries between the control boards, overhead, and floor (Category X).

ee. Charging Pumps — Layout of charging pumps does not follow sequence of operation (Category X).

ff. Mirror Images — Shared (Unit 1 and 2) panels in common area are often nearly mirror images and could induce transfer of training errors (Category 1).

gg. Rest Room — Access to rest room requires passage through security port (could increase time off the panel significantly) (Category X).

hh. Phone Jacks — Phone jacks on panel provide little channel capacity to the operator (Category X).

ii. Vertical Meters — Pointer conspiguity of vertical meters is low, particularly at distances (Category X).

jj. Pressurizer Indicators — Pressurizer displays are difficult to read accurately at a distance, as may be required in a LOCA (Category X).

kk. Acknowledgement — Location of annunciator acknowledge switches may not be optimum during emergency operations (Category X).

ll. Lamp Test — A lamp test capability is not available for most lights on consoles and verticals (Category 1).

3.0 HUMAN ENGINEERING STRENGTHS

The following items of exemplary human engineering were noted at Sequoyah:

a. The Safety Status Monitor provides reasonably complete and current information on safety system status.

b. With some exceptions the annunciators are grouped above the systems they monitor.

c. Color coding of switches will help the relatively inexperienced operators to locate specific switches.

d. Vertical meters have pointers flush with the scale; therefore, parallax is not a serious problem.

e. First-out panel should help in problem diagnosis.