GE Nuclear Energy

General Electric Company
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Docket No. STN 52-001

Chet Poslusny, Senior Project Manager
Standardization Project Directorate
Associate Directorate for Advanced Reactors
and License Renewal
Office of the Nuclear Reactor Regulation

Subject: Submittal Supporting Accelerated ABWR Schedule - **Operational Experience Review, DFSER Open Item 18.9.2.2.1-1**

Dear Chet:

Enclosed is a SSAR markup of Appendix 18E plus an attacment to Table 18E.2.1 which GE believes provides a satisfactory resolution of DFSER Open Item 18.9.2.2.1-1.

Please provide a copy of this transmittal to Clare Goodman.

Sincerely,

Jack Fox

Jack Fox
Advanced Reactor Programs

cc: Norman Fletcher (DOE)
Keith Gregoire (GE)

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TABLE 18.E.2.1 HUMAN FACTORS ENGINEERING DESIGN TEAM AND PLANS

d. The HFE Design Team as being responsible for:

(i) the development of HFE plans and procedures;

(ii) the oversight and review of HFE design, development, test, and evaluation activities;

(iii)the initiation, recommendation, and provision of solutions through designated channels for problems identified in the implementation of the HFE activities;

(iv)verification of implementation of solutions to problems,

(v) assurance that HFE activities comply to the HFE plans and procedures, and

(vi)phasing of activities.

e. The methods for identification, closure and documentation of human factors issues.

f. The HSI design configuration control procedures.

2. The HFE Program Plan shall also establish:

a. That each HFE issue/concern shall be entered on the HFE Issue Tracking System log when first identified, and each action taken to eliminate or reduce the issue/concern should be documented. The final resolution of the issue/concern, as accepted by the HFE DesignTeam, shall be documented along with information regarding HFE Design Team acceptance (e.g., person accepting, date, etc.) the individual responsibilities of the HFE Design Team members when an HFE issue/concern is identified, including definition of who should log the item, who is responsible for tracking the resolution efforts, who is responsible for acceptance of a resolution, and who shall enter the necessary closeout data, and

b. That the HFE Issue Tracking System shall address human factors issues that are identified throughout the development and evaluations of the Main Control Room and Remote Shutdown System HSI Design implementation.

3. The HFE Program Management Plan document shall include:

a. The purpose and organization of the plan.

b. The relationship between the HFE program and the overall plant equipment procurement and construction program (organization and phasing).

c. Definition of the HFE Design Team and their activities including:

INSERT NEW ARTICLE e. in attached INSERT D

INSERT NEW ARTICLES C. AND d.
AS PRESENTED IN ATTACHED INSERT A

INSERT A

"c. That the MCR and RSS designs shall be implemented using HSI equipment technologies which are consistent with those defined in Section 18.4.3 of the Standard Safety Analysis Report (SSAR).

d. That in the event other HSI equipment technologies are alternatively selected for application in the MCR and RSS design implementations:

(i) a review of the industry experience with the operation of those selected new HSI equipment technologies shall be conducted;

(ii) the Operating Experience Review (OER) of those new HSI equipment technologies shall include both a review of literature pertaining to the human factors issues related to similar system applications of those new HSI equipment technologies and interviews with personnel experienced with the operation of those systems; and

(iii) any relevant HFE issues/concerns associated with those selected new HSI equipment technologies, identified through the conduct of the OER, shall be entered into the HFE Issue Tracking System for closure."

Insert D

e. That a review of HSI operating experience shall be conducted as follows:

(i) For the first implementation of the ABWR Certified Design:

(a) That the lessons learned from the review of previous nuclear plant HSI designs, as defined by Attachment 1 to this Table 18E.2.1, shall be entered into the HFE Issue Tracking System to assure that problems observed in previous designs have been adequately addressed in the ABWR design implementation.

(b) Reviews of operating experience with the following ABWR HSI design areas, in which further development of the industry's experience base can be expected, shall be completed:

- Use of flat panel and CRT displays
- Use of electronic on-screen controls
- Use of wide display panels
- Use of prioritized alarm systems
- Automation of process systems
- Operator workstation design integration

Those operating experience reviews shall include review of specific hardware maintenance and reliability reports provided by industry organizations (i.e., EPRI, etc.); review of applicable research in these design areas, as may be documented in reports from universities and national laboratories, and in proceedings published by HFE professional societies; and review of applicable research and experience reports published by the HSI equipment vendors. Further, the review of operating experience in each of the six above identified areas shall include feedback obtained from actual users. Therefore, if the documents selected for the conduct of the operating experience review for a particular area do not include the results of user feedback, then interviews with users of at least two applications of that particular technology area shall also be conducted. Finally, the results from all these operating experience review activities shall be entered into the HFE Issue Tracking System to assure that the ABWR implementation reflects the experience gained by the resolution of design problems in operating plants.

(ii) For all subsequent implementations of the ABWR design:

(a) If a previously implemented ABWR HSI design is utilized directly and without change, then no further review of operating experience is required, or

(b) If a previously implemented ABWR HSI design is not being utilized directly, then the operating experience of the most recent implementations, up to three, shall be reviewed through the conduct of operator interviews and surveys and the evaluation of Licensing Event Reports and the results of these reviews shall be entered into the HFE Issue Tracking System to assure that previous design problems have been adequately addressed in the ABWR design implementation..

ATTACHMENT 1 to Table 18E.2.1

Results of Operating Experience Review of
Previous Nuclear Power Plant HSI Designs

A. Control Room Design

1. The large size of the control room and console and their configuration contributed to operator dissatisfaction.

2. Traffic flows should not be impeded by placement of consoles.

3. Adequate levels of illumination are necessary to ensure that visual effectiveness is sufficient for task performance. Emergency lighting should be available.

4. Noise levels in the main control room should be maintained within acceptable industry levels.

5. The climate control system in the control room should be capable of continuously maintaining temperature and humidity within the human comfort zone.

6. Convenient storage should be provided so that procedures, logs, and drawings needed for routine job performance are conveniently available. Storage should also be provided for equipment needed for emergency operation.

B. Control Board Design

1. Control boards should be optimized for minimum manning.

2. Panels in the control rooms were observed to have large arrays of identical controls and displays and repetitive labels. The systems, subsystems, and components should be separated by appropriate demarcation methods.

3. Controls and related displays should be located in close proximity so that the two items are readily associated and can be used conveniently with one another. Controls should be placed in an obvious and consistent order. The displays and controls used to monitor major system functions should be assigned to and arranged in functional groups.

4. Flow arrangements between CRT display formats and controls on panels should not differ.

5. Flow mimics should be used to aid (and not mislead) the operators.

6. Panel arrangements for similar systems should be the same.

7. Location of controls in areas and orientations that render them vulnerable to accidental contact and disturbance should be avoided.

8. Unclear, illogical, overly complex, or mirror-imaged control board or panel layout arrangements have been observed to promote operational mishaps and should be avoided.

C. Computer

1. Computer data should be available on CRT and hard copy output.

2. Computer audible alarms should not be distracting.

D. CRT Displays

1. The nomenclature, labeling, and arrangement of systems on the CRT displays should be similar to the panels.

2. CRT display should be comprehensible with a minimum of visual search. When data is presented in lines and columns, the lines of data should be separated by a space (blank line), one character high, every 4-5 lines.

3. Display access should be efficient and error prone with a minimum of key strokes.

4. CRT displays should have convenient brightness, focus, and degauss controls.

5. The character height should be the appropriate height for the viewing distance during normal and emergency conditions.

6. Visibility of CRT displays should not be affected by glare.

E. Anthropometrics

1. Panel dimensions should accommodate the 5 to 95 percentile range of the user population to ensure that personnel can see and reach the displays and controls or the front and back panels. Displays should not be placed beyond the visual range of the operators.

2. Controls should not be located in the control panels that require the operator to lean into the panel. This is a potential health risk to the operator and to the equipment.

F. Controls

1. Large controls were observed to have been used in place of preferred smaller controls. Larger controls impact panel size and should be avoided.

2. Labeling or coding techniques should be used to differentiate controls and indicator lights of similar appearance.

3. Control configurations should not introduce parallax problems.

4. Control switches that must be held by the operator for operation should be avoided unless necessary.

5. Projecting control handles should not cover or obstruct labels.

6. Key lock switches require administrative control and should be avoided if possible.

7. Control handles should not be difficult to operate and should not cause the operators to resort to using unauthorized mechanical leveraging devices (i.e. "cheaters") so as to achieve reduced difficulty in operation.

8. Controls should be built and installed following standard conventions for OPEN/CLOSE and INCREASE/DECREASE. Setpoint scales should not move up in response to a downward movement of the controller thumbwheel

9. Inadvertent operation of adjacent controls may be reduced through the use of shape coding such as using similar shaped handles for similar functions (i.e. pistol grips for pumps and round handles for valves).

G. Indicator Lights

1. Instances of improper use of qualitative indicators were observed where quantitative displays such as meters would be more effective.

2. Light status (on/off) should be visible to the operator. Extinguished bulbs should be obvious and a test method provided. Lamp designs should allow for easy access for lamp removal.

3. The use of so-called negative indications (the absence of an indication) should not be used to convey information to the operator.

4. Indicator design selection and layout should be standardized to conserve panel space.

5. A color code standard should be established for indicating lights.

H. Display and Information Processing

1. Plant parameter validity should not have to be inferred. In addition to secondary information, the quality or validity of the displayed parameter should be available to allow operators to readily identify improper ESF or other safety equipment status under various operating modes.

2. Necessary information should be available during events such as SBO and LOOP. Systems and indications such as Neutron Monitoring System, control rod position indication, and drywell area radiation indication should all be available during these events.

3. The main control room should contain an integrating overview display. The overview display should provide a limited number of key operating parameters.

5. The same displays that are used during normal operation should be used by the operators during accident conditions to ensure their familiarity with the interface.

I. Meters

1. Proper use of minor, intermediate, and major scale markings in association with scale numerals should be made. Formats should be customized to take into account identification of normal operating values and limits. Scale numerical progressions and formats should be selected for the process parameter being presented.

2. Placement of meters above and below eye level, making the upper and lower segment of the scale difficult to read, (especially with curved scales), can present parallax problems.

3. Meters were observed that fail with the pointer reading in the normal operating band of the scale. The instrument design should allow the operator to determine a valid indication from a failed indication.

4. Placement of meters on panels should prevent glare and reflections caused by overhead illumination.

5. Where redundant channels of instrumentation exist, software-based displays should provide for easy inspection of the source data and intermediate results without the need to display them continuously.

6. Data presented to the operator should be in a usable form and not require the operator to calculate its value. Scale graduations should be consistent and easily readable. Zone markings should be provided to aid in data interpretation.

7. Meter pointers should not obscure the scale on meters.

8. Process units between the control room instruments and the operating procedures should be consistent.

J. Chart Recorders

1. Recorders should not be used in place of meters. Recorders should be selected with consideration given to minimizing required maintenance and high reliability.

2. A recorder designed to monitor 24 parameters was observed to have 42 parameters assigned to it. This makes it extremely difficult to read the numerical outputs on the chart paper. The inputs assigned should be consistent with the design of the recorder.

3. Operational limits should be defined on recorders. Proper selection of recorder scales will eliminate the need for overlays. The units for the process should be labeled on the recorder.

4. Monitored inputs should be assigned to recorder pens in alphabetical order. The correlation of pen color to input parameter should be clearly defined by multi-pen recorder labels.

5. The change of chart speed should also be noted on the chart paper when the paper is changed. The paper scales should match the fixed scales.

6. Recorders should have fast speed and point select capability.

7. Proper placement of recorders and adequate illumination should prevent glare and parallax problems with recorder faces.

8. The pointers should not cover the graduation marks.

9. When upper and lower pens coincide, the printout of the upper scale should still be visible.

K. Annunciator Warning Systems

1. Annunciators should be located near the control board panel elements to which they are related. Divisional arrangements should be consistent. Annunciators should be functionally located near the applicable system..

2. "Advisory alarms" reporting expected conditions should not be grouped with true alarms. The audio and visual warning system signal should be prioritized to reduce the audio and visual burden placed on the operators during an event.

3. Some alarms were observed to lack specificity. Multi-input alarms, e.g. xyz pressure/levels, hi/lo, frustrate, rather than inform the operator.

4. Excessive alarms were observed during emergency conditions. Auditory signals should be coded to aid the operator in determining the panel location.

5. Alarm operating sequence controls should be placed at specific locations to encourage operator acknowledgment.

6. For standing and sit-down workstations, window size and lettering height should be consistent with the viewing distance.

7. The labels should use consistent abbreviations and nomenclature and not be ambiguous.

8. For traceability to response procedures, the windows should be identified with a location reference code.

9. A consistent color coding convention should be employed.

10. A "First Out" feature should be provided that presents prioritized parameters important to safety parameters for immediate operator response .

11. Means should be provided for identification of out-of-service annunciators.

12. Annunciators for conditions which signal an EOP entry condition should be located based on the functional analysis.

L. Coding of Displays and Controls

1. The color codes for the control boards should be systematically applied. Effective color coding should be used to aid in differentiating between identical controls placed in close proximity.

2. The coding of indicators should inform the operator whether a valve is open or closed.

3. Systematic approach to color and shape coding of controls should be taken.

M. Labeling

1. Label abbreviations, numbering, and nomenclature should be consistent. A label placement standard for the control room should be established.

Labels should be placed consistently above or below the panel elements being identified and not placed between two components.

2. Hierarchical labeling schemes including size coding or differentiation of labels should be used to identify major console panels, sub-panels, and panel elements. Hierarchical labeling will eliminate the need to place redundant labels on control or display devices.

3. The content of the labels should be consistent with the procedures used by the operators.

4. The labels should meet the readability guidelines and should not be obscured by the equipment that they mounted near. A control room standard for labels should be established that addresses label character size and font.

5. Maintenance tags should not obscure labels or panel components such as displays.

6. To minimize the mispositioning of valves and other equipment, the controls and displays should be labeled with the unique number or name of the valve or piece of equipment.

N. Communications

1. Communications in the control room should consider the ambient noise levels in the control room and plant. The control room operator should be able to communicate with necessary personnel in the plant. Communication equipment should also be provided at the remote shutdown panel.

2. Communications equipment design should not limit the operator's access to the controls or displays.

3. The communication system should be accessible from the operator's workstations.

O. Task Analysis

1. Controls and displays should be located for effective operator response to postulated events. Information needed by the operator in the control room should be readily available and not located at remote panels in the plant.

2. In addition to normal and emergency conditions, plant displays and controls should also consider low power and shutdown scenario information requirements.

P. Procedures

1. The measurement units in the procedure and the values indicated on display scales should be consistent.

2. Control board designs should make provisions for the operator's simultaneous referral to the procedures and the operation of the control boards.

3. The parameters displayed on electronic information systems or on the control boards should be designed to support the EOPs as well as other required monitoring tasks.

4. The safety function parameter status should be presented in an organized, readily accessible format compatible with the EOPs.

5. A procedure should address operator action in the event of computer, CRT, or printer problems or complete failure.

Q. Operator Errors

1. Operator mishaps were observed to be caused by the absence of a timely, attention-getting indication (either qualitative or quantitative) that informs the operator that some element of the system is not operating properly.

2. Operator mishaps were also observed to result from incorrect lineup of valves.

R. Maintenance and Testing

1. The main control room should be designed in such a way that minimizes the need for maintenance and test personnel to work, or at least limit their presence, in the control room.

2. rol room displays should be designed and installed for easy ration and replacement.

3. Access for inspection, operation, and routine maintenance of components should not be restrictive.