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MFN 08-088

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Subject: **Response to Portion of NRC Request for Additional Information Letter Nos. 125 and 135 Related to ESBWR Design Certification Application – Human Factors Engineering - RAI Numbers 18.2-10 S02, 18.2-18, 18.6-13, 18.11-8 S01, 18.11-13 S01, 18.11-25 S01, 18.11-28 S01, 18.11-35, 18.11-37, 18.12-4 S02, and 18.12-7**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) responses to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) Requests for Additional Information (RAI) NRC letter 125, dated December 14, 2007 (Reference 1) and NRC Letter 135, dated January 14, 2008 (Reference 2).

Note that RAIs 18.6-13 and 18.11-37 were received via NRC letter 135 (Reference 2), while the balance of the RAIs were received in NRC letter 125 (Reference 1).

RAIs 18.2-10 S02 were requested by Reference 1, was previously responded to by Reference 3. Reference 7 provided the original response as originally requested by NRC in Reference 8.

RAI 18.11-8 S01, was requested by Reference 1, and was previously responded to by Reference 5. Reference 6 originally requested by NRC this RAI.

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RAIs 18.11-13 S01, 18.11-19 S01, 18.11-23 S01, 18.11-24 S01, 18.11-25 S01, 18.11-26 S01, 18.11-28 S01, 18.11-29 S01, were requested by Reference 1, were previously responded to by Reference 9. Reference 10 originally requested by NRC these RAIs.

RAIs 18.12-4 S02 was requested by Reference 1, was previously responded to by Reference 12 in response to NRC request in Reference 13. Reference 9 originally requested a response to these RAIs. Reference 11 provided the original response to this RAI.

RAIs 18.2-18, 18.6-13, 18.11-35, 18.11-37, and 18.12-7 are original responses provided in this response letter.

GEH's response to RAIs 18.2-10 S02, 18.2-18, 18.6-13, 18.11-8 S01, 18.11-13 S01, 18.11-25 S01, 18.11-28 S01, 18.11-35, 18.11-37, 18.12-4 S02, and 18.12-7 are addressed in Enclosure 1.

Also note that these RAI responses correspond to and answer several open items listed in Reference 14. Please consider these open items to be addressed by this letter.

If you have any questions or require additional information, please contact me.

Sincerely,

James C. Kinsey

James C. Kinsey
Vice President, ESBWR Licensing

References:

1. MFN 07-702 - Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, GEH, *Request For Additional Information Letter No. 125 Related To ESBWR Design Certification Application*, dated December 14, 2007
2. MFN 08-038 - Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, GEH, *Request For Additional Information Letter No. 135 Related To ESBWR Design Certification Application*, dated January 15, 2008
3. MFN 07-334 - Submittal of *"ESBWR DCD Chapter 18, Human Factors Engineering - RAI to DCD Roadmap Document"* dated June 27, 2007
4. Email from AE Cubbage to DL Lewis, *List of Chapter 18 RAIs for Roadmap Request*, dated 5/18/07
5. MFN 06-401, *Response to Portion of NRC Request for Additional Information Letter No. 64 – Human Factors Engineering – RAI Numbers 18.5-1 through 18.5-32*, dated October 28, 2006
6. MFN 06-352, Letter from U.S. Nuclear Regulatory Commission to David Hinds, *Request for Additional Information Letter No. 64 Related to ESBWR Design Certification Application*, dated September 25, 2006
7. MFN 06-163, *Response NRC Request for Additional Information Letter No. 28 – Human Factors Engineering – RAI Numbers 18.2-1 through 18.2-17*, dated June 16, 2006
8. MFN 06-150, Letter from U.S. Nuclear Regulatory Commission to David Hinds, GE, *Request For Additional Information Letter No. 28 Related To ESBWR Design Certification Application*, dated May 9, 2006
9. MFN 06-386, *Request for Additional Information Letter No.74 Related to ESBWR Design Certification Application*, dated October 11, 2006
10. MFN 06-446, *Response to Portion of NRC Request for Additional* Information *Letter No. 74 – ESBWR Human Factors EngineeringNEDO-33276, Rev. 0 HFE Verification and Validation Implementation Plan – RAI Numbers 18.11-1 through 18.11-33*, dated November 22, 2006
11. MFN 06-447, *Response to Portion of NRC Request for Additional Information Letter No. 74 Related to ESBWR Design Certification Application – ESBWR Human Factors Engineering NEDO-33278, Rev. 1, ESBWR HFE Design Implementation Plan - RAI Numbers 18.12-1 through 18.12-6*, dated November 18, 2006
12. MFN 07-499, *Response to Portion of NRC Request for Additional Information Letter No. 105 Related to ESBWR Design Certification Application - ESBWR Human Factors Engineering – RAI Numbers 18.4-1 S02, 18.4-7 S02, 18.7-9 S02, and 18.12-4 S01,* dated October 1, 2007
13. MFN 07-460, *Request for Additional Information Letter No.105 Related to ESBWR Design Certification Application*, dated August 16, 2007

14. MFN 08-194 - Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, GEH, *Economic Simplified Boiling Water Reactor (ESBWR) Chapter 18 Open Items,* dated February 28 2008

Enclosures:

1. MFN 08-088 -Response to Portion of NRC Request for Additional Information Letter Nos. 125 and 135 Related to ESBWR Design Certification Application - Human Factors Engineering - RAI Numbers 18.2-10 S02, 18.2-18, 18.6-13, 18.11-8 S01, 18.11-13 S01, 18.11-25 S01, 18.11-28 S01, 18.11-35, 18.11-37, 18.12-4 S02, and 18.12-7

2. Attachment 1, Markups and Added Text for RAIs 18.6-13, 18.11-13 S01, 18.11-25 S01, 18.11-28 S01, 18.11-35, 18.12-4 S02, and 18.12-7

cc:

AE Cubbage	USNRC (with enclosure)
RE Brown	GEH/Wilmington (with enclosure)
DH Hinds	GEH/Wilmington (with enclosure)
GB Stramback	GEH/San Jose (with enclosure)
eDRF Sections	0000-0080-7858
	0000-0080-7648
	0000-0080-7807

Enclosure 1

MFN 08-088

Response to Portion of NRC Request for Additional Information Letter Nos. 125 and 135 Related to ESBWR Design Certification Application

Human Factors Engineering

RAI Numbers

18.2-10 S02, 18.2-18, 18.6-13, 18.11-8 S01, 18.11-13 S01, 18.11-25 S01, 18.11-28 S01, 18.11-35, 18.11-37, 18.12-4 S02 and 18.12-7

For historical purposes, the original text of RAIs 18.2-10, 18.2-18, 18.6-13, 18.11-8, 18.11-13, 18.11-25, 18.11-28, 18.11-35, 18.11-37, 18.12-4, and 18.12-7 and any previous supplemental text and GE responses are included preceding each supplemental response. Any original attachments or DCD mark-ups are not included to prevent confusion.

NRC RAI 18.2-10

In NEDO-33217, 10/05, the GE HFE Implementation Plan in Section 3.2.2(2) addresses general process management tools. The plan identifies these tools as the subject of later documents. Does GE plan to submit these documents for design certification?

GE Response

GE will provide summary reports as part of the design certification process as defined in the applicable ESBWR HFE Licensing Topical Reports and implementation plans. The process management tools and techniques referred to in these documents will utilize review forms and/or checklists to ensure HFE requirements have been correctly implemented and verified. These forms/checklists will not be submitted for design certification but the results will be included in the summary reports.

Any HFE discrepancies identified shall be added to the Human Factors Engineering Issues Tracking System (HFEITS) that will ensure the issue is reviewed, evaluated, and addressed through design, procedures or training. This tracking system will be utilized from the beginning of the design process through the installation, testing and turnover to the COL applicant. This ensures that all HFE issues identified during the design and validation process are traceable and available for review/ verification. Upon completion of the project, the HFEITS design data is turned over to the COL applicant to maintain the HFE program integrity for the life of the plant.

No DCD changes will be made in response to this RAI.

NRC RAI 18.2-10 S01

Provide detail information or reference specific items regarding the general process management tools?

GEH Response

Chapter 18 Roadmap Document								
RAI NO	SEC	#	NRC Supplemental	DocName/ Question	Resolved	Plan	Section	Resolution Description
18.2-10	2	10	Y	Provide detail information or reference specific items regarding the general process management tools??	From GE response	33217	3.1.4.2	General process tools are contained in GE internal engineering procedures (EOPs, ESIs,). Some of these titles are provided, the detailed procedures are available for NRC review.

NRC RAI 18.2-10 S02

GEH's response to RAI 18.2-10 does not adequately address the staff's question. GEH has not provided any detail or referenced specific items. NEDO-33217, Rev. 3, Section 3.1.4.2, #6 of the implementation plan identified process management tools and indicates that these are discussed in Section 4 of the document describing the technical program. However, in MFN 07-428, GEH indicated to the staff that they plan to significantly revise the section of the plan addressing the technical program. GEH provided a markup of the plan's table of contents providing a high-level overview of the changes planned. Please submit Rev. 4 of the plan incorporating these changes.

GEH Response

General process management tools (e.g., review forms) to be utilized by the team in the performance of tasks are described in work instructions finalized by the team before work is commenced. NEDO/NEDE-33217 Revision 3 refers to work instructions as work plans. Section 3.1.4.2(6) of the NEDO states:

> "Process Management Tools - Tools and techniques (for example, review forms) to be utilized by the team to verify application of SPE/HFE efforts are identified in the HFE and Software implementation plans described in Section 4, or in their respective work plans."

The team pilots the initial work instruction and makes final adjustments to forms and instructions before launch of the activity.

The staff has reviewed a sample of the work instructions in draft form at the January and July audits. Work instructions are available for the following activities:

Human Factors Issue Tracking System
Operating Experience Review
System Function Requirements Analysis
Plant Function Requirements Analysis
Task Analysis
Human System Interface Design
Human Reliability Analysis

General work instructions with review forms for Staffing and Qualifications, Procedure Development, Training Development, HF V&V, Design Implementation, and Human Performance Monitoring are under development and will be available as part of the design certification.

The work instructions are proprietary documents that are not included in the NEDO plans, but will be made available for staff review.

Revision 4 to the NEDO/NEDE 33217, MMIS and HFE Implementation Plan, will be submitted on a NEDO revision schedule to be completed after the DCD revision 5 in 2nd quarter 2008. The revised document will replace the term "work plans" with "work instructions".

DCD/LTR Impact

No DCD changes will be made in response to this RAI.

A revision to NEDO/NEDE 33217 will be submitted as described in response to this RAI following completion of staff review of this RAI response.

NRC RAI 18.2-18

Review Based on NEDO-33217P, Rev. 3: In MFN 07-428, GEH indicated to the staff that they plan to significantly revise the section of the plan addressing the technical program. GEH provided a markup of the plan's table of contents providing a high-level overview of the changes planned. These changes will be implemented in Rev. 4 of the plan which has not yet been submitted for staff review. Thus, this criterion will be reviewed upon receipt of the revised plan. The revised plan should reference each of the Human Factors Engineering (HFE) activity detailed implementation plans for detailed methodology descriptions.

GEH Response

In addition to incorporation of other RAI responses, the plan revision will delete material currently in section 4 of NEDO/NEDE-33217 and duplicated in the individual implementation plan documents. The individual implementation plans are currently referenced in section 2.3.1 of NEDO/NEDE-33217 and in the applicable sections of the DCD Tier 2 Chapter 18. A full revision to the NEDO/NEDE will be delivered on a NEDO revision schedule to be completed after the DCD revision 5 in 2nd quarter 2008.

DCD/LTR Impact

No DCD changes will be made in response to this RAI.

A revision to NEDO/NEDE 33217 will be submitted as described in response to this RAI following completion of staff review of this RAI response.

NRC RAI 18.6-13 **(Reference NRC Letter 135)**

Section 18.6.8, References, has the incorrect date for the staffing implementation plan, NEDO-33266, Revision 1. It is listed as March 2007, rather than January 2007.

GEH Response

Section 18.6.8, References, in DCD Rev 4, will be revised in Rev 5 to correct the date for the NEDO 33266 Staffing and Qualifications Implementation Plan.

DCD/LTR Impact

DCD Tier #(2), Section 18.6.8 will be revised as noted in the attached markup (See Attachment 1).

No changes to LTRs will be made in response to this RAI.

NRC RAI 18.11-8

NEDO-33276, Section 4.3.2.4.1 describes the review of panel drawings as part of task support verification. The section states "HSI Task Support Verification of panel drawings is achieved through an iterative process of reviews by several groups and organizations." Please clarify what process these groups use to perform the verification. Also, why are there only sections for drawings and for computer generated displays? How are the other HSI's evaluated?

GE Response

See also responses to RAIs 18.11-2 and 18.11-5 for the process for verification of the entire MMIS including all forms of displays and information to the operator (e.g., VDU, mimics, alarms, tag out and configuration control).

DCD/LTR Impact

No DCD changes will be made in response to this RAI.

No LTR changes will be made in response to this RAI.

NRC RAI 18.11-8 S01

Follow-up RAI based on NEDO-33226, Rev. 1: In the original RAI, the staff requested clarification as to which organization(s) are responsible for task support verification and why the evaluation appears limited to drawings and computer generated displays. GEH's response referred to their response to RAI 18.11-2 and 18.11-5. The staff followed up indicating that those RAIs responses do not pertain to this question. However, the material is unchanged in NEDO-33226, Rev. 1.

GE Response

NEDO-33276 Rev 1 was completely restructured and reworded with sections/subsections renumbered and deleted. This may have resulted in some confusion as to where the change was made.

In response to your question for "which organization(s) are responsible for Task Support Verification," it starts in Activity 2 – HSI Inventory and Task Support Verification. In Section 4.2.3 the participants are identified as both GEH and COL applicant for reviewing the panel drawings, room layout/arrangement and computer generated displays. As the design progresses into Activity 3 through 5, GEH personnel, including HFE team members, previously licensed control room operators, subcontractors and COL applicant operators will perform the other required design requirements, reviews, validations and verifications using approved GEH procedures and/or work instructions.

Note: Based on comments from the COL partners after their review of the RAI responses, GEH will amend the NEDO and any follow-up RAI response to replace "COL applicant" with "licensee, COL holder, customer utility representatives, or COL plant operator".

In our original response to RAI 18.11-5, GEH replaced the scope in section 4.3.2.1 (Rev 0) that limited the scope to drawings and computer-generated displays with a new scope statement, section 4.2.1 (Rev 1) as follows:

> "The scope of the task support verification is the HSIs that provide the annunciators, information, and control capabilities that are required for the tasks identified in the operational analysis, which includes the task analysis.
>
> The criteria for identifying tasks that are safety critical include those tasks with high importance identified through the PRA/HRA, the tasks identified in the EOPs, and those identified as important through the OER process".

The original wording was changed in NEDO-33276 Rev 1. Therefore, the question "appears limited to drawings and computer generated displays" was addressed, as a more inclusive scope has been added to NEDO-33276 Rev 1.

Note:

While this RAI indicates that NEDO-33226 is the affected document, the response from GEH is written under the assumption that this RAI was intended to refer to NEDO-33276. Therefore GEH's response is based on the content in NEDO-33276.

DCD Impact

No DCD changes will be made in response to this RAI.
No changes to NEDO-33276 Revision 1 will be made in response to this RAI.

NRC RAI 18.11-13

NEDO-33276, Section 4.2.3 states "Designs are compared to HFE guidelines to determine whether they account for human characteristics and capabilities. Deviations from accepted HFE guidelines, standards, and principles are documented as HEDs for resolution/correction and acceptably justified on the basis of documented rationale such as trade study results, literature based evaluations, demonstrated operational experience, tests and experiments." This definition is consistent with the staff's review guidance.

Further, Section 4.3.3.6, Acceptance Criteria, states that HFE guidelines are the criteria for verifying the design. But the method described in Section 4.3.3.4 seems to discuss evaluations outside the scope of this definition. Specific concerns are identified below:

A. NEDO-33276, Section 4.3.3.4.2 discusses HFE design verification for panel anthropometrics. This section indicates that measurements from a sample of COL holder personnel will be used. Collecting such measurements in such a way as to be representative of the user population is a tedious and expensive process. HFE design guidelines already provide information suitable for this process. Please clarify precisely how this evaluation is to be performed.

B. NEDO-33276, Section 4.3.3.4.3 discusses design verification for operating procedures. However, the numbered items identified as what procedures are checked for do not involve HFE guidelines.

C. NEDO-33276, Section 4.3.3.4.3 discusses HFE design verification of HSI components. This section starts off by saying these checks are that the components are built as specified. This would appear to more appropriately fall within the scope of final design verification, as it is defined in Section 4.2.6.

D. NEDO-33276, Section 4.3.3.4.7 addresses workplace layout. The section states that "Final verification against HFE guidelines such as those in NUREG-0700 occurs at the site with the COL Holder." HFE design verification of workplace layout can be performed during the design stage, with detailed drawings and/or mockups. At such time, changes in the design to improve its human factors engineering are more likely to be made. Waiting until the control room is built on site hearkens back to the 1980s NUREG-0700 evaluations of the as built control rooms where the opportunity for improvements were limited. Please, explain the rationale for waiting until such a late date, to conduct this evaluation. Please clarify precisely what methodology and criteria will be used for HFE Design Verification.

GE Response

A. NEDO-33276, Section 4.3.3.4.2 will be modified to better describe the process for HFE design verification for panel anthropometrics. The anthropometric design of digital ABWR control rooms has undergone two evolutions. The balance between VDU space on the control panel and the mimic board has been clearly

refined. The ESBWR MCR design will use the current control rooms as a starting point and verify that physical changes for ESBWR conditions don't violate anthropometric issues for the US operators. This process diminishes the use of a mock up for HFE anthropometric evaluations of the MCR and RSS panels.

B. NEDO-33276, Section 4.3.3.4.3 will be revised as follows.

"The objective of the HFE V&V is to verify that the operating procedures are clearly usable by the control room crew in performing the key tasks determined from the operational analysis, risk important tasks from the PRA/HRA, actions from the OER, and actions identified in the procedures. The HFE guidelines for procedure verification focus on the dynamic usability given cues from the MMIS.

Verification criteria are ease of locating the procedure, space for using the procedure, names and symbols in the procedures match those on the MMIS and VDU screens, and response actions can be identified and performed for allowed configurations of the plant.
The operating procedures include the following specific types of procedures:

1. Integrated Operating Procedures (IOP)
2. System Operating Procedures (SOP)
3. Abnormal Operating Procedures (AOP)
4. Emergency Operating Procedures (EOP)
5. Annunciator Response Procedures (ARP)
6. Surveillance Test Procedures (STP)

EOPs undergo a significant degree of development and verification before the HFE verification process. For example, procedures are based upon the ESBWR Plant Specific Technical Guidelines (PSTGs) that, in turn, are derived from the BWR Owners' Group Emergency Procedure and Severe Accident Guidelines (EPGs/SAGs), Revision 2, dated March 2001. The EOPs consist of EOP Support Procedures and EOP Flowcharts. The EOP Support Procedures may consist of certain SOPs and AOPs containing detailed instructions for abnormal system operation or abnormal overrides of interlocks. EOP flowcharts address the four main guideline controls (RPV Control, Primary Containment Control, Reactor Building Control, and Radioactivity Release Control) and the three contingencies (Emergency RPV Depressurization, RPV Flooding, and Level/Power Control). The flowcharts also include EOP graphs.

Prior to the HFE Verification written procedures are developed in accordance with the procedure writer's approved QA program. Procedures are checked for:

1. Compliance with the Procedure Development Implementation Plan, ESBWR Procedure Writer's Guide and other requirements and guidelines (e.g., BWR Owners Group Emergency Procedure Guidelines and Severe Accident Guidelines, BWROG EPGs/SAGs)

2. Technical accuracy and format quality
3. Correct references to HSI components"

C. HFE design of HSI components is addressed in Section 4.3.3.4.4 and will be revised in the next revision to address task evaluation as follows. The 1st sentence of Section 4.3.3.4.4 in NEDO-33276 will be revised to read: "...checks that the full-scope simulator components are built as specified." The objective of the HFE V&V for HSI components is to verify that they are clearly usable by the control room crew in performing the key tasks determined from the operational analysis, risk important tasks from the PRA/HRA, the OER, and actions identified in the procedures. The verification focus for HSI components is on their dynamic usability to provide monitoring of the plant state, cues for actions, feedback on actions taken (including the process of changing state), and response of the plant to the changed condition. Verification criteria are ease of monitoring key parameters, clarity of plant status, clarity of cues for taking actions, consistency of the process for implementing control actions through VDU, hand switches or push buttons, clarity of dynamic feedback of component response to a control action, and ease of monitoring the overall plant response to a change in configuration. In the next revision to NEDO-33276, the current information in Section 4.3.3.4.4, will be moved to Section 4.2.6.

D. Section 4.3.3.4.7 last sentence will be changed to: "Final verification against HFE guidelines such as those in the ESBWR Human Factors Guidance Manual (based on NUREG-0700) occurs during the final design verification as described in NEDO-33278."

DCD/LTR Impact

No DCD changes will be made in response to this RAI.

LTR NEDO-33276, Rev 0 will be revised as described above at the next revision.

NRC RAI 18.11-13 S01

In the original RAI, the staff requested clarification of various aspects of HFE Design verification in NEDO-33226. GEH's responses and changes in Rev. 1 to items B and D were acceptable. The following questions remain:

Regarding A. Section 4.3.4.1 discusses HFE design verification for panel anthropometrics. Rather than discussing the comparison of panel characteristics to HFE guidelines, the section discusses the validation of operator actions. Thus it is unclear how the verification will be performed.

Regarding C. Section 4.3.4.3 discusses HFE design verification for HIS components. Rather than discussing the comparison of HSI characteristics to HFE guidelines, the section discusses verification criteria such as ease of monitoring and usability. Thus it is unclear how the verification will be performed. Thus, the RAI remains open.

GEH Response

A. GEH agrees that section 4.3.4 and 4.3.4.1 was not properly organized. The discussion concerning the validation of operator actions in section 4.3.4.1 should have been an introduction to the Methods and Procedures under section 4.3.4 using the term "verification" rather than "validation". Additional information concerning the anthropometric evaluation for the panel will be provided. The attachment provides the changes to NEDO 33276 to incorporate the response.

C. GEH agrees that section 4.3.4.3 should address comparison of HSI characteristics to HFE guidelines and not validation topics. This section will be revised as depicted in the attachment in the next revision to NEDO-33276.

Note:
While this RAI indicates that NEDO-33226 is the affected document, the response from GEH is written under the assumption that this RAI was intended to refer to NEDO-33276. Therefore GEH's response is based on the content in NEDO-33276.

DCD/LTR Impact

No DCD changes will be made in response to this RAI.
LTR NEDO-33276, Rev 1 will be revised as noted in the attached markup (See Attachment 1).

NRC RAI 18.11-25

Three additional areas of evaluation are discussed and performance measures are identified: automation, procedures, and displays. It is not clear that these represent three areas of performance measurement or three aspects of the design that will be evaluated.

In either event, the following additional information is requested.

A. Automation - NEDO-33276, Section 4.3.4.7.7 provides a list of performance measures for automation, such as operator cognition. Please indicate how these items will actually be measured.

B. Procedures - NEDO-33276, Section 4.3.4.4.8 discusses the validation of operating procedures. The section indicates that the validation is completed during operator training phases. What training phases are being referred to in this statement? Section 4.3.4.7.8 on performance measures for operating procedures, states "refer to operate a performance measures regarding situation awareness." Please explain this statement. Based on the earlier discussion of situation awareness, the questions asked of operators appear to relate to awareness of plant status. How then can they be used to validate procedures?

C. Displays - NEDO-33276, Section 4.3.4.7.9 states that there are no performance measures for graphical displays. Please explain.

GE Response

A. The following statement will be added to NEDO-33276, Section 4.3.4.7.7, "Observers will measure operator cognition and monitoring of automated states as indicated by the MMIS by observation of when the operators acknowledge changes in operational mode, by release of automation break points, or by debrief of the operators at the end of the simulation response session."

B. The training phases are those shown in Figure 2 of NEDO-33276. They consist of using the three types of simulation interfaces (e.g., GETS mockups for simulation of system operation (SOPs), BS for simulation of alarms (AOPs) and FSS for all others.

Validation of procedures confirms that the procedures such as EOP flowcharts effectively integrate with the MCR MMIS arrangement and work environment. The methods used in the situational awareness based on the MMIS information will be applied to determine position in the procedures. In addition the procedure validation addresses usability of layout space in the MCR and that procedure names and symbol match the names and symbols in the MMIS.

C. The word "human" will be inserted after "no" in the 1st line of 4.3.4.7.9. The following paragraph will be added to NEDO-33276, Section 4.3.4.7.9:

"However, the graphical displays on the MMIS provide situational awareness to the operators. Therefore, display cues and navigation must support timely operator actions. The performance measures for graphical displays are that the status of valves and pumps is known during all phases of a control interaction. Color changes and symbol changes that represent the system configuration are consistent throughout the VDUs. Each stage of a control action is clearly observable through MMIS (e.g., selection of a controlled element, defining the action to take, sending the signal, feedback on the change and verification of the position during the change period, and the final new state)."

DCD/LTR Impact

No DCD changes will be made in response to this RAI.

LTR NEDO-33276, Rev 0 will be revised as described above at the next revision.

NRC RAI 18.11-25 S01

GEH's response to the RAI and NEDO-33276, Rev. 1, provided some clarification of how automation will be addressed, but the procedures and displays aspects of this RAI were not clarified. Please provide additional clarification.

GEH Response

A. Operating Procedures

NEDO-33276, Section 4.4.7.8 references situational awareness performance measures (Section 4.4.7.3). To clarify which of these performance measures also apply to procedures, the applicable performance measures for procedure integration V&V will be stated in Section 4.4.7.8. Other applicable performance measures will also be added to this list.

The following will be added to NEDO-33276 Section 4.4.7.8:

> "Procedure validation confirms that the procedures, such as EOP flowcharts, effectively integrate with the MCR MMIS arrangement and work environment. Procedure integration with the HSI will be evaluated by analysis of one or more of the following measures at different phases of the V&V:
>
> 1. Timing of operator actions (i.e., how long a procedure took compared with how long a procedure should have taken)
> 2. Appropriateness of operator actions
> 3. Consequences (good or bad) of operator actions
> 4. Observation of operator actions, procedure use and communications
> 5. Compatibility of procedures with HSIs (e.g., checking that the procedure names and symbols match the names and symbols in the MMIS)
> 6. Post scenario video reviews and interviews

Measures of performance are the operator's effectiveness at tasks that include:

1. Selecting a procedure. An example is:
   a. Referring to, and transitioning among the appropriate procedures in a timely manner.
2. Executing a procedure, which includes:

a. Adhering to procedures, cautions, and limitations (i.e., no deviating even if the deviation appears to have no detrimental consequences).

b. Executing procedural steps in correct sequence.

c. Including all procedural steps

d. Locating and accessing controls and information correctly and efficiently.

e. Using controls in a timely and effective manner.

Observers will record operator actions, procedure use, and communications. The amount of time taken to complete a task will be recorded, along with any errors of omission or commission. Observers will record details of occurrences in which procedures do not match the HSI. Operator feedback will be used to supplement observations."

B. Display Validation

The following will be added to NEDO-33276 Section 4.4.7.9:

"The quality of the graphical displays is assessed relative to operator performance. The measures used to quantify tasks are chosen to reflect the important aspects of the task with respect to operator and system performance, such as:

1. Enhanced ease of operating procedures use
2. Reduced time demands
3. Increased accuracy
4. Reduced errors (graphical displays allow operators only to perform correct behaviors)
5. Reduced cognitive demands
6. Quantified benefits (how much more can be accomplished by operators using graphical displays)
7. Observed use of graphical displays
8. Evaluated graphical display efficacy (are graphical displays acting as a job performance aid or detriment)
9. Post scenario video reviews and interviews"

DCD/LTR Impact

No DCD changes will be made in response to this RAI.

LTR NEDO-33276, Rev 1 will be revised as noted in the attached markup (See Attachment 1).

NRC RAI 18.11-28

NEDO-33276, Section 4.3.4 .4.1 states that "Operator crews are subjected to a set of test scenarios run on the simulator. The test scenarios have predefined initial conditions, applicable symptoms, and expected system responses and plant behavior. Each crew is subjected to a given scenario at least twice. Each crew is also subjected to the same set of scenarios for purposes of comparing crew performance under similar uses, and conditions, of the HSI." If a crew is subject to the same scenario twice, what will prevent it from simply being recognized. Once recognized, any data collected for the rest of the scenario may not be valid. Please clarify.

GEH Response

The following paragraph will be inserted into section 4.3.4.4.1.
"Crews may be subjected to a given scenario twice prior to the final V&V process. The reuse of a scenario for the same crew for MMIS validation is used to capture the improvement in the use of the MMIS. The data is not being collected to evaluate crew capabilities, but rather to validate that the MMIS can be used to effectively manage the normal operation and accident situations. If information is available to the crew and it is not understood initially, then the second run provides a second look at the MMIS. If the same issue continues, then improvements to the MMIS are considered and an HED is initiated as appropriate. Data from the second session are not used to support HRA evaluations."

DCD/LTR Impact

No DCD changes will be made in response to this RAI.

LTR NEDO-33276, Rev 0 will be revised as described above at the next revision.

NRC RAI 18.11-28 S01

GEH has not addressed the staff's concern regarding scenario reuse. Further, Section 4.4.9.1, of NEDO-33226, Rev. 1, discusses the presentation of scenarios to crews, but does not address how scenarios will be assigned to crews or scenario sequencing. Please provide a high-level discussion of scenario sequencing and address the staff's concern about scenario reuse.

GEH Response

A. Scenario Reuse

GEH is aware that scenario reuse can lead to problems in system integration validation testing. If the same scenario is presented to the same crew more than once there will be increased scenario familiarity and practice effects, which may cause inferences based on the data collected from the second presentation of a scenario to be invalid.

The following will be added to NEDO-33276, section 4.4.4.1 (as noted in Attachment):

"If an error or exception occurs during system integration testing, the decision of whether to present the scenario to the same crew or to a different crew will be made on a case-by-case basis. The nature of the error or exception, and the effects of scenario reuse on the data in question, are both taken into account."

The following will be added to NEDO-33276, section 4.4.9.1.1 (as noted in Attachment):

"Presentation of the same scenario to the same crew for a second time may only occur under very limited conditions and only under circumstances that would have minimal effects on validation. Scenario reuse on the same crew is not part of the intended validation test design and should only be used in cases where errors or exceptions have occurred that prevented the intended testing from being accomplished during the first presentation of a scenario."

B. Scenario Assignment and Sequencing

The following will be added to NEDO-33276, Section 4.4.9 (as noted in Attachment):

"Test design is the process of developing plans and conducting validation tests once the integrated system has been defined and measures have been selected. Test design permits the observation of integrated system performance in a manner that avoids or minimizes bias, confounds, and noise (error variance)."

The following new sections will be added, and the former Section 4.4.9.1 "Presentation of Scenario to Crews" will become section 4.4.9.2:

"4.4.9.1 Coupling Crews and Scenarios

The coupling of crews and scenarios determines how the test participants experience the test scenarios.

4.4.9.1.1 Scenario Assignment

> Scenario assignment to crews is made by the HF Verification & Validation lead. Because a limited number of crews are available for system integration testing, an incomplete block design is used, in which a given crew participates in some but not all scenarios. The set of scenarios selected by the validation team and presented to a crew is carefully balanced to ensure that each crew receives a similar and representative range of scenarios (i.e. difficult scenarios are not only assigned to above average crews).
>
> Scenario selection and balancing is accomplished by using the operational conditions sampling dimensions described in NEDO-33276, section 4.1.4.1. This sampling methodology is used to identify the different types of scenarios that are assigned to crews. By balancing scenarios across crews, spurious design validation due to confounding scenario type with individual crew performance is avoided.

4.4.9.1.2 Scenario Sequencing

The validation team balances the order in which scenarios are presented to crews. The same type of scenario is not always presented in the same linear position (i.e. always presenting the easy scenarios first) and the same scenarios do not always occur in the same sequence. Control of scenario sequencing is used to prevent confounds that may occur because of crew learning and other systematic behavior changes."

More detailed information regarding how scenarios will be assigned to crews and scenario sequencing will be provided in the HF Verification and Validation work instructions.

Note:

While this RAI indicates that NEDO-33226 is the affected document, the response from GEH is written under the assumption that this RAI was intended to refer to NEDO-33276. Therefore GEH's response is based on the content in NEDO-33276.

DCD/LTR Impact

No DCD changes will be made in response to this RAI.

LTR NEDO-33276, Rev 1 will be revised as noted in the attached markups (See Attachment 1).

NRC RAI 18.11-35

A. The material in DCD Tier 2, Section 18.11, is not completely consistent with NEDO-33276, Rev. 1. For example, B. the DCD discusses HED identification and resolution, while no such language is used in the NEDO. C. Also, the DCD does not reference the V&V implementation plan. Please update the DCD accordingly.

GEH Response

A. In order to provide more consistency throughout the DCD, the opening description of the section 18.11 will be changed to properly reflect the layout of NEDO-33276: ESBWR HFE Verification and Validation Implementation Plan. The five main activities of HFE V&V were changed to match NEDO-33276. Other parts of this description were deleted. The Figure referenced was deleted since this figure in no longer in the DCD.

B. NEDO-33276 describes Human Factors Engineering issue identification and resolution. The language of the DCD will be changed to reflect the content of NEDO-33276.

C. The DCD referenced the wrong NEDO. The DCD will be changed to reflect the correct references by number and title. Reference 18.11-1 was deleted and reference 18.11-2 was renamed as reference 18.11-1.

DCD/LTR Impact

No changes to the subject LTR will be made in response to this RAI.

DCD Tier #2, Section 18.11 will be revised as noted in the attached markup (See Attachment 1).

NRC RAI 18.11-37 (Reference NRC Letter 135)

DCD Revision 4, Section 18.11, Human Factors Verification and Validation does not reference the V&V implementation plan (NEDO-33276) in the discussion of V&V implementation in Section 18.11.1. NEDO-33276 should be referenced in Section 18.11.1. NEDE 33217P should not be referenced. Note that NEDO-33276 is included in the references listed in Section 18.11.4. (The issue of referencing the implementation plans existed with the earlier version of the DCD and has been corrected in the other HFE program elements.)

GEH Response

See response to RAI 18.11-35. The DCD will be changed to reflect the correct reference by number and title. Reference 18.11-1 was deleted and reference 18.11-2 was renamed as reference 18.11-1.

DCD Impact

No changes to the subject LTR will be made in response to this RAI.

DCD Tier # 2, Section 18.11 will be revised as noted in RAI response 18.11-35.

NRC RAI 18.12-4

NEDO-33278, Section 1.3 identifies the COL as the lead and manager of this effort. However, in Section 4.1.3, it appears that GE may be conducting these evaluations. Please clarify the roles of the COL and GE in this process.

GE Response

Since this activity will occur after the COL submittal, it is considered the COL holder's lead. However, Section 4.1.3 refers to the members of the HFE team as the resources. Currently the HFE team does consist of GE and COL representatives, and COL membership will increase as time continues. At the Design Implementation, there will be both GE and COL membership, and the HFE Team will still be guided by the established processes and procedures outlined in the MMIS and HFE Implementation Plan. Either qualified COL holder or GE personnel on the HFE team may perform the roles of Task Leader, Responsible Engineer, etc.

DCD/LTR Impact

No DCD changes will be made in response to this RAI.

No changes to the subject LTR will be made in response to this RAI.

NRC RAI 18.12-4 S01

(1) Section 1.2 of NEDO-33278 Rev-2 describes a somewhat different organization than was identified in the RAI response. It states that the verifications are the responsibility of the COLOG. Clarify the role of the COLOG and the COL license applicant.

(2) Section 1.2 of NED0-33278 Rev-2 indicates that the verifications described for the plan "apply to the initial COL plants associated with the ESBWR design effort." The staff's position is that "as-built" verifications are needed for every new plant construction. Please explain why only the initial plants will be verified.

GEH Response

(1) The role of the COL Owners Group (COLOG) was established after the writing of the NEDO-33278 Rev 1 and the response to the original RAI. The role of the COLOG is described in the MMIS and HFE Implementation Plan (NEDO-33217 Rev 3) sections 3.1.4, 3.1.4.2(15), and 3.1.4.2(16) with additional details in the Human Performance Monitoring Implementation Plan (NEDO-33277 Rev 2). The COL license applicant has the responsibility to comply with the regulatory obligations of the design implementation activity, with the COLOG serving as the entity that facilitates and supports the performance of the activity.

The NEDO-33278 will be revised in the next revision to the document, as noted in the attached markups, to clarify that the COL applicant (with the support of the COLOG) is responsible for the design implementation of new plants constructed from the ESBWR standard design.

(2) The wording of the scope is not clear and NEDO-33278 will be revised in the next revision to the document, as noted in the attached markup, to clarify that the design implementation applies to all new plants constructed from the ESBWR standard design.

DCD/LTR Impact

No DCD changes will be made in response to this RAI.

LTR NEDO-33278, Rev 2 will be revised as noted in the attached markup (See Attachment 1).

NRC RAI 18.12-4 S02

GEH's RAI response acceptably addressed the role of the COL and GEH as part of the HFE team. However, in reviewing NEDO-33278, Rev. 2 of the plan two follow up questions were identified.

(1) Section 1.2 of the plan describes a somewhat different organization than was identified in the RAI response. It states that the verifications are the responsibility of the COLOG. Will the COLOG be the COL license applicant?

(2) Section 1.2 of the plan indicates that the verifications described for the plan "apply to the initial COL plants associated with the ESBWR design effort." The staff's position is that "as-built" verifications are needed for every new plant construction. Please explain why only the initial plants will be verified.

GEH Response

(1) The section was amended in supplement 1 to this RAI to indicate that the COL applicant (with the support of the COLOG) has the responsibilities. GEH wants to amend the wording in the response from "COL applicant" to "COL holder" and "COLOG" to "COL owner's group". The COLOG is the name given to the owner's group that will support the COL holder in the completion of the design implementation. The verifications are the responsibility of the COL holder. To avoid confusion, the term "COLOG" will be replaced with "COL owner's group" throughout the NEDO-33278 and globally replaced in the NEDO-33277 and NEDE/NEDO-33217P, the only other HFE plan documents that contain the term "COLOG". No attachments for the global replacements are provided.

(2) GEH agrees that all new plants based on the ESBWR standard plant design need to be verified. Supplement 1 to this RAI addressed this issue and the response is repeated below. See the attachment and response to RAI 18.12-4 S01.

RAI 18.12-4 S01 response stated:

> "The wording of the scope is not clear and NEDO-33278 will be revised in the next revision to the document, as noted in the attached markup, to clarify that the design implementation applies to all new plants constructed from the ESBWR standard design."

DCD/LTR Impact

No DCD changes will be made in response to this RAI.

LTR NEDO-33278, Rev 2 will be revised as noted in the attached markup (See Attachment 1).

LTR NEDO-33277, Rev 2 will be revised as described above.

LTR NEDO/NEDE-33217P, Rev 3 will be revised as described above.

NRC RAI 18.12-7

Design implementation activities are described in DCD Tier 2, Section 18.12. The Tier 2 description is not fully consistent with NEDO-33278, Rev 2, and should be revised. Note that the resolution of other remaining open 18.12 RAIs may necessitate additional revisions to the DCD.

GEH Response

GEH has reviewed DCD Rev 4 section 18.12 and NEDO-33278, Rev 2 and most inconsistencies have been resolved in the revised DCD. The inconsistencies with Rev 3 of the DCD primarily concerned the role of an owners group (COLOG) for design implementation activities. These were removed in Rev 4. The following differences were found with the Rev 4 of the DCD:

- The Purpose in the NEDO includes turnover of items to the COLOG, whereas the turnover of items is addressed in the DCD section 18.12.3 as turnover to licensee. GEH will revise the DCD in the next revision to remove reference to the licensee so that NEDO-33278 addresses how the turnover of items is accomplished.
- Title in 18.12.2.4 of DCD does not include "transfer of HFEITS" (section 3.4 of NEDO). The turnover is addressed in the DCD section 18.12.3. The DCD will be revised to include "transfer of HFEITS" and state that the NEDO-33278 (Reference 18.12-2) describes the transfer of HFEITS.
- The NEDO includes an implementation section and additional details. Changes in approach and differences in these sections with the DCD are addressed in RAI 18.12-3 S01.

The attachment to this RAI provides the changes to the DCD to resolve the above differences. The changes to the DCD implementing the revised methodology for the as-built verification are described in RAI 18.12-3 S01.

GEH will continue to update the DCD with any changes to the implementation plans as a result of revisions and RAIs.

DCD/LTR Impact

DCD Tier 2, Sections 18.12.2.4 and 18.12.3 will be revised as noted in the attached markup (See Attachment 1).

No changes to the subject LTR will be made in response to this RAI.

MFN 08-088

Attachment 1

Markups and Added Text

For RAIs
18.6-13, 18.11-13 S01, 18.11-25 S01, 18.11-28 S01, 18.11-35, 18.12-4 S02, and 18.12-7

Attachment for RAI

18.6-13

e. Bases for S&Q ensuring that issues and concerns raised in other HFE activities are addressed.

The S&Q results summary report is included as ITAAC item 4 of Table 3.3-1 in DCD Tier 1.

18.6.7 COL Information

None

18.6.8 References

18.6-1 GE Energy, "ESBWR Man-Machine Interface System and Human Factors Engineering Implementation Plan," NEDE-33217P, Class III (Proprietary), Revision 3, March 2007, and NEDO-33217, Class I (non-proprietary), Revision 3, March 2007.

18.6-2 GE Energy, "ESBWR HFE Staffing and Qualifications Implementation Plan," NEDO-33266, Class I (non-proprietary), Revision 1, ~~March~~ January 2007.

18.6-3 American National Standards Institute, "Time Response Design Criteria for Safety-Related Operator Actions," ANSI/ANS 58.8-1994, August 1994.

Attachment for RAI

18.11-13 S01

4.3.4 Methods and Procedures

The HFE Design Verification begins with the part task simulator, which provides an accurate control room interface for each system, and continues as the design matures to the full scope simulator. In the verification activities, interfaces at local system control stations are evaluated using drawings or mockup panels. The evaluations at this time confirm the HSI system level requirements for annunciation, information, control capabilities, and data processing functions as identified in the operational task analysis and that the HSI and environment conform to the HFE guidelines contained in the HF Style Guide.

The verification of integrated interfaces is accomplished with the full scope simulator (which may use electronic versions of back panels and the RSS) and dynamic performance testing that continues into Activity 4, "Implementation of Integrated System Validation". This testing utilizes the emergency, abnormal, and system operating procedures to ensure that the HSI and environment conform to the HFE guidelines contained in the HF Style Guide.

If some complex actions cannot be fully verified during the HF V&V, the process is extended to the plant itself to be accomplished in the Design Implementation activity "Final HFE Design Verification Not Performed in the Simulated HF V&V Activity" described in Reference 2.1.2(13). For these instances, the V&V team describes the verifications to be performed, establishes the acceptance criteria, and documents the requirement in the V&V results summary report (see section 5.1(13) and HFEITS.

4.3.4.1 Panel Anthropometrics

Verification of the anthropometrics is accomplished as an integral part of the HFE evaluations performed with mockups and simulator versions of the MCR and RSS panels.

The anthropometric design of digital ABWR control rooms has undergone two evolutions. The balance between VDU space on the control panel and the mimic board has been clearly refined. The ESBWR MCR design uses the ~~current~~ latest ABWR control room~~s~~ as a starting point and ~~verify~~ verifies that physical changes for ESBWR conditions do not violate anthropometric ~~issues~~ guidelines for the US operators.

A full anthropometric evaluation is performed on the panels and workstations during the design verification to ensure compliance to anthropometric guidelines contained in the HF Style Guide, including:

- Reach and accessibility
- Visibility
- Seating comfort–

~~The design of the ESBWR attempts to minimize complex actions by providing a large time interval to take the action, by using natural circulation for cooling and maintaining a passive heat removal system for decay heat.~~

~~The validation of actions begins with the part task simulator, which provides an accurate control room interface for each system. In this case, outside actions at local system control stations are evaluated using drawings or mockup panels.~~

~~The validation of integrated actions begins with the full scope simulator (which may use electronic versions of back panels and the RSS).~~

~~If some complex actions cannot be fully validated during full scope simulation the process can be extended to the plant itself to verify that complex coordinated actions between the control room and local stations can be carried out using the plant procedures and HSI.~~

4.3.4.2 Operating Procedures

The objective of the HFE Procedures V&V is to verify that the operating procedures are clearly usable by the control room crew in performing the key tasks determined by the operational analysis, risk important tasks from the PRA/HRA, actions from the OER, and actions identified in the procedures. The HFE guidelines for procedure verification focus on the dynamic usability given cues from the HSI. Verification criteria are ease of locating the procedure, space for using the procedure, names and symbols in the procedures match the HSIs, and response actions can be identified and performed for allowed configurations of the plant.

The operating procedures include the following specific types of procedures:

1. Integrated Operating Procedures (IOP)
2. System Operating Procedures (SOP)
3. Abnormal Operating Procedures (AOP)
4. Emergency Operating Procedures (EOP)
5. Annunciator Response Procedures (ARP)
6. Calibration, Inspection and Test Procedures

EOPs undergo a significant degree of development and verification before the HFE verification process. For example, procedures are based upon the ESBWR Plant Specific Technical Guidelines (PSTGs) that, in turn, are derived from the BWR Owners' Group Emergency Procedure and Severe Accident Guidelines (EPGs/SAGs), Revision 2, dated March 2001. The EOPs consist of EOP Support Procedures and EOP Flowcharts. The EOP Support Procedures may consist of certain SOPs and AOPs containing detailed instructions for abnormal system operation or abnormal overrides of interlocks. EOP flowcharts address the four main guideline controls (RPV Control, Primary Containment Control, Reactor Building Control, and Radioactivity Release Control) and the three contingencies (Emergency RPV Depressurization, RPV Flooding, and Level/Power Control). The flowcharts also include EOP graphs.

Prior to the HFE Verification, written procedures are developed in accordance with the procedure writer's approved QA program. Procedures are checked for:

1. Compliance with the Procedure Development Implementation Plan, ESBWR Procedure Writer's Guide and other requirements and guidelines (e.g., BWR Owners Group Emergency Procedure Guidelines and Severe Accident Guidelines, BWROG EPGs/SAGs)
2. Technical accuracy and format quality
3. Correct references to HSI components

4.3.4.3 HSI Components

The objective of the HFE V&V for HSI components is to verify that the HSI and the environment conform to the HFE guidelines contained in the HF Style Guide.~~they are clearly usable by the control room crew in performing the key tasks determined from the operational analysis, risk important tasks from the PRA/HRA, the OER, and actions identified in the procedures. The verification focus for HSI components is on their dynamic usability to provide monitoring of the plant state, cues for actions, feedback on actions taken (including the process of changing state), and response of the plant to the changed condition. Verification criteria are ease of monitoring key parameters, clarity of plant status, clarity of cues for taking actions, consistency of the process for implementing control actions through VDU, hand switches or push buttons, clarity of dynamic feedback of component response to a control action, and ease of monitoring the overall plant response to a change in configuration.~~

~~Verifications of HSI component designs and implementations are checks that the full-scope simulator components are built as specified. Design specifications such as., P&IDs, Logic Diagrams, Display Descriptions and associated Change Descriptions (CDs), and unincorporated Engineering Change Notices are consulted as needed for understanding component operation, design changes, and investigation of findings.~~

Based on the characteristics of the HSI components, checklists comprised of guidelines from the HF Style Guide are completed and applied against the appropriate equipment. Applications consider global (layout, workstation configuration, lighting, noise, etc.), standardized (display screen organization, display format conventions, coding, etc.), and detailed (individual HSI not addressed by general HFE guidelines) HSI features.

Discrepancies are documented as HEDs denoting the HSI component involved and how its characteristics depart from a particular guideline. HEDs involving standardized features are evaluated further to identify potential discrepancies across HSIs with similarities in the standardized characteristics. For example, identifying an inappropriate format for presenting data on an individual display could be a potential sign that other display formats could be incorrectly used or that the observed format is inappropriately used elsewhere.

4.3.4.4 Industrial Television

Industrial Television (ITV) is a stand-alone system with a user console adjacent to the Shift Supervisor Console and two television units mounted in the Wide Display Panel (WDP). The ITV system is verified in accordance with ESBWR GEEN EOPs that include requirements for verification. HFE Design Verification confirms that the console design, and televisions at the

WDP, meets user requirements, exhibit proper HFE design practices, and effectively integrate with the MCR arrangement and work environment. The HSI at the ITV user console is not subjected to HFE V&V because it is an off-the-shelf product that does not perform process control and monitoring functions.

4.3.4.5 Work Environment

HFE design verification of MCR, RSS, and LCSs critical to safety work environment aspects (e.g., lighting, space, air conditions, floor design, noise mitigation) is part of the normal engineering, design change, and verification process. Final verification against the ESBWR Style Guide occurs during the final design verification as described in NEDO-33278.

4.3.4.6 Workplace Layout

HFE design verification of MCR, RSS, and LCSs critical to safety workplace layout is conducted as part of the ~~normal engineering, design change, and~~design verification process. Final verification against the ESBWR Style Guide for some issues may not be able to be performed in the simulated V&V. In these instances, design verification occurs during the final design verification as described in NEDO-33278.

Attachment for RAI

18.11-25 S01

4.4.7.8 Operating Procedures

Procedure validation confirms that the procedures, such as EOP flowcharts, effectively integrate with the MCR HSI arrangement and work environment. Procedure integration with the HSI will be evaluated by analysis of one for more of the following measures at different phases of the V&V:

1. Timing of operator actions (i.e., how long a procedure took compared with how long a procedure should have taken)
2. Appropriateness of operator actions
3. Consequences (good or bad) of operator actions
4. Observation of operator actions, procedure use and communications
5. Compatibility of procedures with HSIs (e.g., checking that the procedure names and symbols match the names and symbols in the MMIS)
6. Post scenario video reviews and interviews

Measures of performance are the operator's effectiveness at tasks that include:

1. Selecting a procedure. An example is:
   a. Referring to, and transitioning among the appropriate procedures in a timely manner.
2. Executing a procedure, which includes:
   a. Adhering to procedures, cautions, and limitations (i.e., no deviating even if the deviation appears to have no detrimental consequences).
   b. Executing procedural steps in correct sequence
   c. Including all procedural steps
   d. Locating and accessing controls and information correctly and efficiently
   e. Using controls in a timely and effective manner

Observers record operator actions, procedure use, and communications. The amount of time taken to complete a task is recorded, along with any errors of omission or commission. Observers record details of occurrences in which procedures do not match the HSI. Operator feedback may be used to supplement observations.
~~Refer to operator performance measures regarding situation awareness.~~

4.4.7.9 Display Validation

~~Performance measures for graphical displays is a developing art which involves software and there are no human performance measures for graphical displays because the behavior of the graphics is a function of software programming, hardware performance, and overall system throughput and response.~~

The graphical displays on the HSI provide situational awareness to the operators. Therefore, display cues and navigation must support timely operator actions. The performance measures for graphical displays are that the status of valves and pumps is known during all phases of a control interaction.

Color changes and symbol changes that represent the system configuration are consistent throughout the VDUs. Each stage of a control action is clearly observable through HSI (e.g., selection of a controlled element, defining the action to take, sending the signal, feedback on the change and verification of the position during the change period, and the final new state).

The quality of the graphical displays is assessed relative to operator performance. The measures used to quantify tasks are chosen to reflect the important aspects of the task with respect to operator and system performance, such as:

1. Enhanced ease of operating procedures use
2. Reduced time demands
3. Increased accuracy
4. Reduced errors (graphical display allow operators only to perform correct behaviors)
5. Reduced cognitive demands
6. Quantified benefits (how much more can be accomplished by operators using graphical displays)
7. Observed use of graphical displays
8. Evaluated graphical display efficacy (are graphical displays acting as a job performance aid or detriment)
9. Post scenario video reviews and interviews

Attachment for RAI

18.11-28 S01

4.4.4.1 Evaluating Operational Safety and Task Performance

Operator crews are subjected to a set of test scenarios run on the simulator. The test scenarios have predefined initial conditions, applicable symptoms, and expected system responses and plant behavior. Test subjects are not told what particular scenario will be simulated. The evaluation team observes the simulated exercise and documents crew performance. Debriefings and structured interviews are held after the simulated scenarios. Evaluators take notes on these discussions to supplement video recordings and visual observations. If an error or exception occurs during system integration testing, the decision of whether to present the scenario to the same crew or to a different crew is made on a case-by-case basis. The nature of the error or exception, and the effects of scenario reuse on the data in question, are both taken into account.

~~Crews may be subjected to a given scenario twice prior to the final V&V process. The reuse of a scenario for the same crew for HSI validation is used to capture the improvement in the use of the HSI. The data is not collected to evaluate crew capabilities, but rather to validate that the HSI can be used to effectively manage the normal operation and accident situations. If information is available to the crew and it is not understood initially, then the second run provides a second look at the HSI. If the same issue continues, then improvements to the HSI are considered and a discrepancy is initiated as appropriate. Data from the second session is not used to support HRA evaluations.~~

It is recognized that simulator testing environments cannot fully replicate the influence that Performance Shaping Factors (PSFs) such as stress and noise have on operator human performance in real situations. Simulator testing environments can also bias operator behavior. For example, during a simulator test scenario, the operator anticipates an abnormal situation occurring. The anticipation heightens the operator's attention and alertness to an abnormal event. Operator responses are also shaped by adherence to procedure and the absence of potential conflicts between rote procedure compliance and economic demands (e.g., maximizing the unit's capacity factor). However, these factors are not expected to have the same influence on all personnel and thereby significantly denigrate the overall results.

Validation is a progressive, cumulative activity. ESBWR procedures play a vital role in validation during the integrated system test program on the full scope simulator. This testing is performed after the part task simulations of systems are used to verify that the system level procedures are consistent in form, style, and accuracy. System procedures guide responses to cues that may require system level responses in the MCR and local control stations. Until ESBWR procedures are fully developed, existing procedures for similar systems may be useful in system level validation testing.

When scenarios are used to challenge multiple system operation, the ESBWR EOPs are verified as usable in whatever form they are in (e.g., electronic or paper), names in procedures match the component and HSI component names, and required actions are clearly defined. The integrated procedures should have a consistent style and

maneuvering process as all the procedures and their input and output names need to match with each other.

The ESBWR operating procedures are defined in activity 3 and refined in activity 4. A standard design feature of the ESBWR is the Safety Parameter Display System (SPDS) function integrated into the MCR HSI as displays and fixed-position indicators at the Wide Display Panel (WDP). Validation demonstrates that the ESBWR SPDS aids operators during abnormal and emergency conditions in:

1. Determining the unit safety status
2. Assessing whether abnormal conditions warrant corrective actions by operators to prevent core damage
3. Monitoring the impact of engineered safeguards or mitigation activities
4. Executing symptom-based emergency operating procedures

4.4.9 Test Design

Test design is the process of developing plans and conducting validation tests once the integrated system has been defined and measures have been selected. Test design permits the observation of integrated system performance in a manner that avoids or minimizes bias, confounds, and noise (error variance).

4.4.9.1 Coupling Crews and Scenarios

The coupling of crews and scenarios determines how the test participants experience the test scenarios.

4.4.9.1.1 Scenario Assignment

Scenario assignment to crews is made by the HF Verification & Validation lead. Because a limited number of crews are available for system integration testing, an incomplete block design is used, in which a given crew participates in some but not all scenarios. The set of scenarios, selected by the validation team and presented to a crew, is carefully balanced to ensure that each crew receives a similar and representative range of scenarios (i.e. difficult scenarios are not only assigned to above average crews).

Scenario selection and balancing is accomplished by using the operational conditions sampling dimensions described in section 4.1.4.1. This sampling methodology is used to identify the different types of scenarios that are assigned to crews. By balancing scenarios across crews, spurious design validation due to confounding scenario type with individual crew performance is avoided.

Presentation of the same scenario to the same crew for a second time may only occur under very limited conditions and only under circumstances that would have minimal effects on validation. Scenario reuse on the same crew is not part of the intended validation test design and should only be used in cases where errors or exceptions have occurred that prevented the intended testing from being accomplished during the first presentation of a scenario.

4.4.9.1.2 Scenario Sequencing

The validation team balances the order in which scenarios are presented to crews. The same type of scenario is not always presented in the same linear position (i.e. always presenting the easy scenarios first) and the same scenarios do not always occur in the same sequence. Control of scenario sequencing is used to prevent confounds that may occur because of crew learning and other systematic behavior changes.

4.4.9.2~~1~~ Presentation of Scenarios to Crews

A discussion prior to the simulations is conducted to describe the overall objective of the testing process which is to validate the HSI and for operating team to consider difficulties and issues they have in using the HSI for the planned scenarios (e.g., normal operational

startups, shutdowns, accidents from full power or partial power, and management of outage conditions). A shift turnover process is used to define the plant status including possible equipment tagouts. The use of the simulation freeze capability for questions about situational awareness is discussed.

Attachment for RAI

18.11-35

18.11 HUMAN FACTORS VERIFICATION AND VALIDATION

This section describes the following:

- The five main activities of HFE V&V:
  - (1) Operational Conditions Sampling (per NUREG 0711r2);
  - (2) ~~Design Verification;~~HSI Inventory and Task Support Verification

~~a. Inventory and Characterization;~~

~~b.HSI Task Support Verification; and~~

~~c.~~(3) HFE Design Verification;

~~(3)~~(4) Integrated System Validation; and

~~(4)~~(5) Human Factors Issue Resolution Verification; ~~and~~

~~(5)Final Plant HFE/HSI Design Verification.~~

~~□Relationship between HFE V&V and hardware/software V&V;~~

~~□HFE V&V team;~~

~~□End-users as participants and test subjects; and~~

~~□Documentation, reporting, performance measurement, and integration of results.~~

~~Figure 18.1-1 provides an overview of the integrated HFE V&V activities with their associated inputs and outputs.~~

18.11.1 Human Factors Verification and Validation Implementation

The ESBWR ~~MMIS and~~ HFE Verification and Validation Implementation Plan, Reference 18.11-1, establishes:

(1) Human factors V&V methods and criteria consistent with accepted HFE practices and principles;

(2) The scope of the evaluations of the integrated HSI including:

a. HSI, addressing both the interface of the operator with the HSI equipment hardware and the interface of the operator with the HSI equipment's software-driven functions;

b. Plant normal and emergency operating procedures; and

c. HSI work environment.

(3) The process for static and/or "part-task" mode evaluations of the HSI equipment to confirm that the controls, displays, and data processing functions identified in the task analyses are designed per accepted HFE guidelines and principles;

(4) The integrated system validation of HSI equipment with each other, with the operating personnel, and with the plant normal and emergency operating procedures through the conduct of dynamic task performance testing. The dynamic task

performance testing and evaluations are performed over the full scope of the integrated HSI design using dynamic HSI prototypes (that is, prototypical HSI equipment which is dynamically-driven using real time plant simulation computer models). When a new HSI design is compared to a previous HSI design differences can be identified. Existing test and evaluation results can be compared to new analysis results. A limited scope dynamic task performance is adequate to satisfy the V&V requirements. The methods for defining the scope and application of the dynamic HSI prototype, past test results and other evaluation tools are documented in the ESBWR HFE V&V implementation plan;

(5) The process by which Human Factors issues are identified and tracked; and

(6) Final plant HFE/HSI Design Verification performed and documented as a basis to human performance monitoring.

18.11.2 Results of HFE V&V

The results of the HFE V&V activities are summarized in the RSR including Human Factors Engineering (HFE) ~~Discrepancy (HED)~~ issue identification and resolutions.

The HFE V&V results summary report is included as ITAAC item 9 of Table 3.3-1 in DCD Tier 1.

18.11.3 COL Information

None

18.11.4 References

~~18.11-1 GE Energy, "ESBWR Man-Machine Interface System and Human Factors Engineering Implementation Plan," NEDE-33217P, Class III (Proprietary), Revision 3, March 2007, and NEDO-33217, Class I (non-proprietary), Revision 3, March 2007.~~

18.11-~~2~~1 GE Energy, "ESBWR HFE Verification and Validation Implementation Plan," NEDO-33276, Class I (non-proprietary), Revision 1, March 2007.

Attachment for RAI

18.12-4 S02

1 OVERVIEW

The Design Implementation Plan, NEDO-33278, addresses the final "as-built" implementation of the Human Factors Engineering (HFE) guidance into ESBWR standard plant design. The ESBWR overall HFE design process is depicted in Figure 1. The standard design includes standardized Human System Interfaces (HSIs), procedures, and training. The ESBWR Combined Operating License ~~Owners~~ owner's ~~Group~~ group ~~(COLOG)~~ is responsible for establishing and maintaining the standard plant design and good human factors practice.

Figure 2 depicts the design implementation process described in this plan. The COL holder (with the support of the ~~COLOG~~COL owner's group) is responsible for design implementation of new plants constructed using the ESBWR standard plant design. The implementing organizations execute their responsibilities under the plans described in the ESBWR Man-Machine Interface Systems and Human Factors Engineering Implementation Plan (MMIS and HFE Implementation Plan), NEDO-33217. The design implementation, startup, and operational duties of the COL applicants include aspects of these plans, which are transferred to the COL applicant under their license obligations to ensure the integrity of the HFE infrastructure is maintained throughout the life cycle of the plant.

The HFE aspects of the ESBWR standard plant including design of the HSIs, standard plant procedures, and standard plant training documentation, are verified and validated using the Full Scope Simulator (FSS) during the HFE Verification and Validation (HF V&V) process. The Design Implementation as described in this plan is performed to assure that the "as-built" HFE design conforms to the design that was used in the ESBWR standard plant V&V efforts.

1.1 Purpose

The purpose of this document is to:

1. Confirm that the final HSIs, procedures, and training (as-built) HFE design conforms to the ESBWR standard plant design resulting from the HFE design process and V&V activities. Any identified human engineering discrepancies (HEDs) are assessed and properly addressed.
2. Verify aspects of the design that may not have been evaluated previously in the V&V process. This includes any hardware/software, new or modified displays that were absent from the simulator-based integrated V&V process, and any physical or environment (e.g., noise, lighting, etc.) differences between those present at the V&V process and the "as-built" Main Control Room (MCR).
3. Verify resolution of remaining HEDs and open items from the Human Factors Engineering Issue Tracking System (HFEITS).
4. Transfer design implementation responsibility to the ~~COLOG~~COL owner's group.
5. Transfer responsibility for HFEITS to the COL holder (with the support of the ~~COLOG~~COL owner's group).

1.2 Scope

The "as-built" confirmations, verifications, and validations described in this plan apply to the ~~initial~~ COL plants ~~associated with~~constructed from the ESBWR standard design ~~effort~~. The COL holder (with the support of the ~~COLOG~~COL owner's group) is responsible for:

Attachment for RAI

18.12-7

Some changes to the standard plant procedures and training may result from the HFE V&V. The approach to perform the "as-built" confirmation for the procedures and training is to conduct an audit of the standard plant procedures and training.

18.12.2.3 *Final HFE Design Verification Not Performed in the Simulated HFE V&V Activity*

HFE design aspects that are not addressed in the simulated HFE V&V such as modification of the reference plant to the standard design, and HFE aspects not feasible to perform in the simulated environment are included in the Design Implementation Report. These include:

- Communication equipment interfaces (phones, radios, intercoms, and so forth);
- Lighting (normal and emergency);
- Habitability systems (for example, noise, lighting, ventilation and so forth);
- Use of plant-specific training manuals and procedures;
- Data and video interfaces with the TSC and equipment to duplicate or link the EOF to the plant process database; and
- Procedure/P&ID drawing laydown area.

18.12.2.4 ~~*Resolution of Remaining HEDs and Open issues in HFEITS*~~*Resolution of Remaining HEDs and Open issues and transfer of HFEITS*

The HFE V&V of the standard plant design addresses the issues from the HFE design and development. The Design Implementation process is used to close out remaining issues from the MMIS/HFE Implementation Process. Reference 18.12-2 describes the transfer and the responsibilities for maintaining HFEITS.

18.12.3 Design Implementation Results Summary Report

The results of the Design Implementation activities are summarized in the RSR. The RSR provides an introduction, background, and summary of results and outputs of the activities performed.

The RSR Design Implementation Plan outputs include:

- Final "as-built" HSI verification;
- Confirmation of procedures and training design implementation;
- Resolution of HEDs and open issues;
- Design implementation team members and background;
- Verification of design not performed in the V&V; and
- Turn over ~~to licensee~~ and tracking of the remaining open HED/HFEITS issues.

The design implementation results summary report is included as ITAAC item 10 of Table 3.3-1 in DCD Tier 1.