HITACHI

Proprietary Notice
This letter forwards proprietary information in accordance with 10 CFR 2.390. Upon the removal of Enclosure 1, the balance of this letter may be considered non-proprietary.

GE Hitachi Nuclear Energy

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MFN 09-418

Docket No. 52-010

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U.S. Nuclear Regulatory Commission
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Rockville, MD 20852

Subject: **Response to Portion of NRC Request for Additional Information Letter No. 309 Related to ESBWR Design Certification Application - Human Factors Engineering - RAI Numbers 18.11-3 S03, 18.11-4 S03, 18.11-19 S03, 18.11-22 S03, 18.11-23 S02, 18.11-24 S03, 18.11-27 S03**

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 (RAIs) sent by NRC letter No. 309, dated April 16, 2009 (Reference 1).

GEH response to RAI Numbers 18.11-3 S03, 18.11-4 S03, 18.11-19 S03, 18.11-22 S03, 18.11-23 S02, 18.11-24 S03, 18.11-27 S03 are provided in Enclosure 1.

Enclosure 1 contains GEH proprietary information as defined by 10 CFR 2.390. GEH customarily maintains this information in confidence and withholds it from public disclosure. Enclosure 2 is the public version, which does not contain proprietary information and is suitable for public disclosure.

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

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

D068
NRO

Reference:

1. MFN 09-276 - Letter from U.S. Nuclear Regulatory Commission to Mr. Jerald G. Head, GEH, *Request For Additional Information Letter No. 309 Related To ESBWR Design Certification Application*, dated April 16, 2009

Enclosures:

1. MFN 09-418 -Response to NRC Request for Additional Information Letter No. 309 Related to ESBWR Design Certification Application – Human Factors Engineering - RAI Numbers 18.11-3 S03, 18.11-4 S03, 18.11-19 S03, 18.11-22 S03, 18.11-23 S02, 18.11-24 S03, 18.11-27 S03 – GEH Proprietary Information

2. MFN 09-418 -Response to NRC Request for Additional Information Letter No. 309 Related to ESBWR Design Certification Application – Human Factors Engineering - RAI Numbers 18.11-3 S03, 18.11-4 S03, 18.11-19 S03, 18.11-22 S03, 18.11-23 S02, 18.11-24 S03, 18.11-27 S03 – Public Version

3. MFN 09-418 -Response to NRC Request for Additional Information Letter No. 309 Related to ESBWR Design Certification Application – Human Factors Engineering - RAI Numbers 18.11-3 S03, 18.11-4 S03, 18.11-19 S03, 18.11-22 S03, 18.11-23 S02, 18.11-24 S03, 18.11-27 S03 Affidavit

cc:	AE Cubbage	USNRC (with enclosure)
	JG Head	GEH/Wilmington (with enclosure)
	DH Hinds	GEH/Wilmington (with enclosure)
	eDRF Section	0000-0103-4761 (RAI Numbers 18.11-3 S03, 18.11-4 S03, 18.11-19 S03, 18.11-22 S03, 18.11-23 S02, 18.11-24 S03, 18.11-27 S03)

MFN 09-418

Enclosure 2

Response to Portion of NRC Request for

Additional Information Letter No. 309

Related to ESBWR Design Certification Application

Human Factors Engineering

RAI Numbers 18.11-3 S03, 18.11-4 S03, 18.11-19 S03, 18.11-22 S03, 18.11-23 S02, 18.11-24 S03, 18.11-27 S03

PUBLIC VERSION

NRC RAI 18.11-3 S03

In NEDE-33276P (Rev. 2), Section 4, GEH provides a discussion of their approach to operational condition sampling. Section 4.4.1.2 describes the minimum conditions and tasks to be included in at least one validation scenario. Section 4.4.1.3 describes the representative population of conditions and tasks to be addressed. Together these sections address the sampling dimensions in the NUREG-0711 review criteria. There are additional considerations identified that are appropriate, such as including each first-of-a-kind system. The level of detail provided is generally comparable to that in the review criteria themselves. Thus the level of detail question still exists.

Specific Methodology questions:

1. With respect to the sampling of plant conditions, does the framework include failure events involving automation failures and human-system interface (HSI)?

2. With respect to the sampling of situational factors known to challenge human performance, the concept of "error forcing context" is identified, but not defined with respect to its application in the framework. How are error-forcing contexts defined?

Level of Detail:

While GEH's revised plan and the answers to these questions will further clarify the methodology to be used for operational conditions sampling, it will not fully answer the staff's concern regarding level of detail. Identify the specific operational conditions that are identified through GEH's process.

GEH Response

Specific Methodology

1. *Does the framework include failure events involving automation failures and human-system interface (HSI)?*

Yes. Both types will be included in the set of scenarios. Section 4.4.1.2 [[

]].

Section 4.4.1.2 will be revised to clarify the definition of these events in the section.

2. *How are error-forcing contexts defined?*

Scenarios comprising error-forcing contexts defined in the HRA will be developed in collaboration with the HRA/PRA. Section 3.1 of the HRA Implementation Plan states that the HRA interacts with the HFE verification and validation program to provide test scenarios and updates the HRA/PRA quantitative evaluations based on data from the validation process.

Definitions for "error-forcing context" and "performance shaping factors" will be added to Section 1.3.1.

Section 4.4.2.8 will be added to describe the interface between the HRA/PRA and the V&V program and to define [[ ]] to support the HRA/PRA validation needs. Sections 5.4.3.7 and 5.4.4.2 will be revised to include [[ ]].

Section 4.4.2.8 will be added and Sections 1.3.1, 5.4.3.7 and 5.4.4.2 will be revised to define error-forcing contexts.

Level of Detail

Identify the specific operational conditions that are identified through GEH's process.

GEH cannot provide the specific scenarios and related information including the specific operational conditions at this time because the selection and definition of the scenarios is predicated on the outputs of the HFE design process. The requested information will be provided in the ESBWR HFE design commitment "Integrated System Validation Scenarios". The design commitment is added as DAC ITAAC item 12 as shown in the DCD Tier 1 attached markup.

DCD Impact

DCD Tier 1, Section 3.3 will be revised as noted in the attached markup.

LTR NEDE-33276, Rev 2 will be revised as noted in the attached markup.

NRC RAI 18.11-4 S03

NEDE-33276P (Rev. 2) does not identify the scenarios to be used as requested in the RAI. GEH provides a discussion of how scenarios are identified; however, the process is not clear.

Specific Methodology Questions:

NEDE-33276P (Rev. 2), Section 4.4.2, includes scenario identification in its title, but the material in the section addresses developing the details of the scenario. Clarify how the considerations in Section 4.4.1.2 and Section 4.4.1.3 are used to identify the scenarios to be used in integrated system validation (ISV).

Level of Detail:

While GEH's revised plan and the answers to these questions will further clarify the methodology to be used for scenario identification, it will not fully answer the staffs concern regarding level of detail. Identify the scenarios to be used in support of integrated system validation.

GEH Response

Specific Methodology

Clarify how the considerations in Section 4.4.1.2 and Section 4.4.1.3 are used to identify the scenarios to be used in integrated system validation (ISV).

The considerations of Section 4.4.1.2 are categories of conditions or tasks that will be represented in the final set of selected scenarios. One or more selected scenarios will contain the stated task or condition. For example, from Section 4.4.1.2, one or more scenarios will include each of the human actions identified in the HRA/PRA, DCD, and NRC safety evaluations report as "risk significant".

The considerations in Section 4.4.1.3 are additional operational conditions or tasks that will also be represented in the final set of selected scenarios, but these may be combined with one or more of the items from the minimum set established in Section 4.4.1.2. For example, only one scenario may be identified to include a particular human action identified in the HRA/PRA, but this may also be a scenario that satisfies the conditions for a design basis accident and a historically problematic task identified in the OER.

The final selection will provide one or more scenarios representing the sampling dimensions established in section 11.4.1.2.1 of NUREG-0711.

The elements from Sections 4.4.1.2 and 4.4.1.3 selected for including in the scenarios will be combined into scenarios in Section 4.4.2, Scenario Identification and Development. The final set of scenarios is identified as item 12 in Table 3.3-2 of ESBWR DCD Tier 1.

Section 4.4.1 will be revised to include the response above to clarify how the scenarios for use in the integrated system validation are identified. Section 2.1.1 will be revised to add the ESBWR DCD Tier 1 reference.

Sections 4.4.1 and 2.1.1 will be revised as shown in the attached markups.

Level of Detail

Identify the scenarios to be used in support of integrated system validation.

GEH cannot provide the specific scenarios and related information at this time because the selection and definition of the scenarios is predicated on the outputs of the HFE design process. The list of scenarios to be used in support of integrated system validation will be provided in the ESBWR HFE design commitment "Integrated System Validation Scenarios". The design commitment is added as DAC ITAAC item 12 as shown in the DCD Tier 1 attached markup.

DCD Impact

DCD Tier 1, Section 3.3 will be revised as noted in the attached markup.

LTR NEDE-33276, Rev 2 will be revised as noted in the attached markup.

NRC RAI 18.11-19 S03

In the previous follow-up, the staff asked GEH to "identify what remote actions are needed for the scenarios to be used in validation testing and provide information as to how these actions will be modeled and evaluated for validation." The request is for a specification of the precise actions that will be modeled in specific scenarios.

Specific Methodology Questions:

1. NEDE-33276P, Section 5.4.1.5, discusses the validation of "risk-important local control operations." Section 5.4.3.7 discusses the use of "[.]" How are these three types of tasks related?

2. The validation of "risk-important local control operations" is performed using simulations and mockups and verifies that the cues, indications, communications, and feedback built into the scenario guide are accurate and timely. Do the validations include [ ]

3. Will scenarios model other local tasks such as the opening of a local valve that might not be risk or safety important, but are important to scenario timing and fidelity?

Level of Detail: While GEH's revised plan and the answers to these questions will further clarify the treatment of remote actions, it will not fully answer the staffs concern regarding level of detail. Identify the specific local actions to be modeled in each scenario in support of integrated system validation.

GEH Response

Specific Methodology

1. *How are risk-important local control operations,* [[ ]] *related?*

[[

]]

"Risk-important local control operations" is a general term used to refer to actions performed at risk-important location control panels. This term in Section 5.4.1.5 is not consistent with the proper term "risk significant local control". Risk significant local control station is defined as "a local control station at which risk-important human actions are performed or which control safety related equipment. The risk-important local control operations will be replaced with "risk significant local control operations" to provide the proper name.

The statement in section 5.4.1.5, "Validations of ~~risk-important~~ risk significant local control operations is performed using simulations and mockups as needed", means that the remote action cues, indications, communications and feedback built into the scenario may be established based on simulations and mockups as needed to render accurate remote actions to support validation of the integrated system HSI. These simulations and mockups will also be used to support the task support verification process for these panels.

These are related as follows:

Once the broader scenario and events are established, [[ ]] are identified in the resulting sequences that (1) [[ ]], (2) possess the additional characteristics defined in Section 4.4.2.7, and (3) occur within the control room or at risk significant local control stations that will be used in the evaluation of validation performance. Specific task information is documented in [[ ]] as described in Section 5.4.3.7 for analysis and special observation in the integrated validation process.

Section 5.4.1.5 will be revised as shown in the attached markup.

2. *The validation of "risk-important local control operations" is performed using simulations and mockups and verifies that the cues, indications, communications, and feedback built into the scenario guide are accurate and timely. Do the validations include all critical and safety significant tasks?*

For the integrated system validation, the scenario selection will include all of the sampling dimensions described in section 11.4.1.2.1 of NUREG-0711, Rev 2. Scenario development will identify all [[ ]] that comprise the sequences selected for the scenario. All of [[ ]] performed at risk-important local control stations will be included in the event simulation. To the extent that the remote action cues, indications, communications, and feedback need further definition to render accurate remote actions, these will be validated. Very simplistic actions, for example, communication of a valve position that has not changed, may not require simulation and mockup validation.

Risk-important local control operations established from [[ ]] are also assessed in the Task Support Verification as described in Section 3.2.4.

There are no document changes as a response to this question.

3. *Will scenarios model other local tasks that might not be risk or safety important, but are important to scenario timing and fidelity?*

Scenarios will model local tasks that might not be risk or safety important, but are important to scenario timing and fidelity. Elements important to scenario timing and fidelity are part of the scenario definition and will be modeled accordingly as described in section 5.4.1.5. The difference in the treatment for safety significant tasks is [[

]] go beyond what is necessary for the accurate rendering of the scenario sequence.

Section 5.4.1.5 will be revised to clarify that local tasks important to scenario timing and fidelity will be modeled as shown in the attached markups.

Level of Detail

Identify the specific local actions to be modeled in each scenario in support of integrated system validation.

GEH cannot provide the specific scenarios and related information including the local actions to be modeled in each scenario at this time because the selection and definition of the scenarios is predicated on the outputs of the HFE design process. The requested information will be provided in the ESBWR HFE design commitment "Integrated System Validation Scenarios". The design commitment is added as DAC ITAAC item 12 as shown in the DCD Tier 1 attached markup.

DCD Impact

DCD Tier 1, Section 3.3 will be revised as noted in the attached markup.

LTR NEDE-33276, Rev 2 will be revised as noted in the attached markup.

NRC RAI 18.11-22 S03

Since NEDE-33276P (Rev. 2) does not identify the scenarios to be used, detailed information about them, as requested in the RAI, cannot be provided at this time. In NEDE-33276P (Rev. 2), Section 4.4.2, GEH provides a discussion of their approach to scenario development and Section 5.4.3 discusses the scenarios definition process. These sections generally cover the topics addressed by the three review criteria in Section 11.4.3.2.4, Scenario Definition, with possible exceptions noted below. NEDE-33276P (Rev. 2) provides a reasonably clear picture of how scenarios will be constructed and what tools are provided to testing personnel to conduct the simulated scenarios. Reference is also made to a more detailed scenario development guide (procedure) that is used by test personnel to define the scenario. However, as noted above, no actual scenario details developed using the approach are provided.

Specific Methodology Questions:

1. Instructions for data collection were not completely addressed. Section 5.4.3.10 does discuss the administration of questionnaires; however, there is other data to collect that should be part of the scenario definition and instruction of test personnel, such as when scenarios are stopped for situation awareness assessment (as per page 59 of the. plan).

2. Minor clarification on page 46, what is meant by "evaluation guide" in "Title of the evaluation guide?"

Level of Detail: While GEH's revised plan and the answers to these questions will further clarify the methodology to be used for scenario definition, it will not fully answer the staffs concern regarding level of detail. Provide the scenario definitions to be used in support of integrated system validation.

GEH Response

Specific Methodology

1. *Clarify instructions for data collection.*

Added information concerning planned stops to Section 5.4.3.3.

A discussion of the data collection instructions is provided in Section 5.4.5.2 in a discussion topic entitled “Data Collection”. Additional details to the topics under this discussion are described in other Sections, including:

[[

{3}]]

The specifics of the data collection elements and other scenario definitions will be included in [[ ]] described in section 5.4.5.2(5) developed for each scenario.

A summary of the data collection forms and observation tools compiled in this response will be provided in Table 3 and referenced from Section 5.4.5.2, Data Collection.

Table 3 will be added, and Sections 5.4.3.3 and 5.4.5.2 will be revised to clarify instructions for data collection.

2. *What is meant by "evaluation guide" in "Title of the evaluation guide?"*

Section 5.4.3.2 will be revised to replace [[
]] as shown in the attached markup.

Level of Detail

Provide the scenario definitions to be used in support of integrated system validation.

GEH cannot provide the specific scenarios and related information including the scenario definitions to be used at this time because the selection and definition of the scenarios is predicated on the outputs of the HFE design process. The requested information will be provided in the ESBWR HFE design commitment "Integrated System Validation Scenarios". The design commitment is added as DAC ITAAC item 12 as shown in the DCD Tier 1 attached markup.

DCD Impact

DCD Tier 1, Section 3.3 will be revised as noted in the attached markup.

LTR NEDE-33276, Rev 2 will be revised as noted in the attached markup.

NRC RAI 18.11-23 S02

In NEDE-33276P (Rev. 2), Section 5.4.4, GEH provides a description of the performance measures that will be used in validation testing. As part of the description, measurement characteristics are provided. In general, this information is acceptably based on a review using NUREG-0711 criteria. However, there are follow-up questions pertaining to the measures themselves (see the discussion for RAIs 18.11-24 below), thus the RAI must remain open until they are resolved. Provide the measurement characteristics for performance measures to be used in support of integrated system validation once the measure are defined per 18.11-24.

GEH Response

[[

]]

Sections 5.4.4.2.1 and 5.4.4.3.1 will be revised to provide the measurement characteristics for the redefined performance measures to be used.

DCD Impact

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

LTR NEDE-33276, Rev 2 will be revised as noted in the attached markups.

NRC RAI 18.11-24 S03

Note that due to their close coupling, the evaluation below addresses both performance measures (RAI18.11-24) and their associated criteria (RAI18.11-26). While this RAI is designated as 18.11-24 S03, NRC will track 18.11-26 S01 as open pending the response to this supplement.

In NEDE-33276P (Rev. 2), Section 5.4.4, GEH provides a description of the performance measures for plant/system level performance, operator task performance, crew communication/coordination, situation awareness, workload, and anthropometric/physiological factors that will be used in validation testing. The descriptions include the performance acceptance criteria to be used for each. Several follow-up questions regarding that material follow.

Specific Methodology Questions:

A. [ ]

Performance Measurement Selection

NEDE-33276P (Rev. 2), Section 5.4.4.1 identifies a [

.] Why is this measure only used for specific events/actions? [

] If so, the approach proposed would fail to identify such an event. [

] Technical specifications, safety limits (as per DCD, Tier 2, p. 2.0-1), limiting conditions of operation (LCOs) pertinent to each scenario, and critical safety function performance may provide a more complete and sensitive assessment of plant and system performance [

] the other more sensitive limits could be used to identify human engineering discrepancies (HEDs) within an overall successful validation.

Acceptance Criteria

NEDE-33276P (Rev. 2), Section 5.4.4.1.2 states that the acceptance criteria for the measures as described is that scenarios [

] As per the comment above, exceeding parameter values should be an acceptance criterion as well

B. Plant Human Reliability Analysis (HRA)/Probabilistic Risk Assessment (PRA) measurement

Performance Measurement Selection

In NEDE-33276P (Rev. 2), Section 5.4.4.2, GEH states that to test HRAIPRA assumptions, scenario events are selected that contain PRA risk significant tasks. [

] What are the ""values"" identified in the measure?

Acceptance Criteria

NEDE-33276P (Rev. 2), Section 5.4.4.2.2 indicates that the acceptability of performance is determined [

] However, is this the correct category of measurement and acceptance criteria to validate the design?

The successful accomplishment of risk-significant actions should be evaluated in ISV. Perhaps this is intended by the statement [

] Clarify the evaluation of risk-significant actions in the ISV.

C. Personnel Tasks

Performance Measurement Selection

NEDE-33276P (Rev. 2), Section 5.4.4.3 states that for each integrated system validation scenario, the tasks that personnel perform during the scenario are identified. Tasks identified during scenario development are assessed during scenario performance to validate that the integrated HSI adequately supports task performance. The MFN 08-672 Attachment 1 chart for Define and Document ISV Scenarios shows a step where [ ] are determined. NEDE-33276P (Rev. 2), Section 4.4.2.7 defines [

]

Characteristics of [ ] are defined, yet the PRAIHRA criteria are not mentioned. Are these tasks the same as those identified in the Plant HRAIPRA measurement section?

[

] Clarify the scope of performance measures.

The NEDE further states that [

] Clarify what is meant by this statement;[

]

[

]

Acceptance Criteria

NEDE-33276P (Rev. 2), Section 5.4.4.3.2 indicates that the integrated system design is validated [

] If tasks are also measured by time, error, frequency, etc., what are the specific criteria used for those evaluations?

Task measures also include many that are subjectively derived via observations by test personnel. How are acceptance criteria developed for these aspects of the task? [

]

D. Situation Awareness

Performance Measurement Selection

NEDE-33276P (Rev 2), Section 5.4.4.5 addresses situation awareness measurement. [

] In the selection of scenario freeze points, the NEDE indicates that the selection of freeze points during a significant event should be avoided because it disrupts the scenario. However, this would seem to be precisely the time one would want to assess situation awareness of the operations. Further, in the discussion of construct validity for this measurement technique, the NEDE states that the approach does not appear to significantly affect performance and research was cited indicating there was no effect due to freezing the simulation. Doesn't this suggest the concern is not warranted? It would seem that stop points could be selected during a significant event to minimize the disruption of ongoing operator actions as we believe is done in [.] Clarify the approach for situation awareness.

GEH also proposes [

.] We are not sure this is an appropriate measure of situation awareness. Operators may have a good awareness of the plant

state, but fail to take appropriate actions for a variety of reasons, e.g., they make an error or they do not know how to best respond. Conversely, operators may take correct actions without precisely knowing the current state of the plant. Clarify the measurement of situation awareness.

Acceptance Criteria

NEDE-33276P (Rev 2), Section 5.4.4.5.2 indicates that [

] This does not provide a specific acceptance criterion. Clarify the acceptance criteria.

E. Physical Workload

Acceptance Criteria

NEDE-33276P (Rev 2), Section 5.4.4.6.1.2 indicates that 'Ergonomics rules established by the State of Washington Department of Labor and Industries provide the basis for determining acceptable workload." Provide a reference to these criteria.

F. Cognitive Workload

Performance Measurement Selection

NEDE-33276P (Rev 2), Section 5.4.4.6.2 indicates [ ] will be used to assess cognitive workload. [ ] To determine when [ ] will be assessed, a task screening methodology will be used. "Tasks known to be free from time pressure, complicated evolutions, and/or considered failsafe, along with other predetermined parameters are screened and eliminated from cognitive workload assessment." While we certainly understand the desire to measure workload of suspected "high-workload tasks," another concern in highly automated plants is underload. Note that the acceptance criteria acknowledge the unacceptability of low workload (see RAI 18.11-26). How does the methodology proposed, identify periods of underload?

To obtain a workload assessment, [

] Will the scenario be stopped? If not, there may be a delay before operators respond, so their ratings will reflect the current workload, not necessarily that associated with the target task. Clarify the workload assessment of selected tasks.

[

] Is this done in real time as the scenario is unfolding? Approximately how much time will be required to obtain all [

]

Acceptance Criteria

NEDE-33276P (Rev 2), Section 5.4.4.6.2.2 indicates that [

] Describe how the zones will be defined?

Level of Detail:

G. *While GEH's revised plan and the answers to these questions will further clarify the methodology to be used for performance measurement selection and the criteria to be used to evaluate integrated system performance, it will not fully answer the staff's concern regarding level of detail. Provide:*

- *the specific performance measures, scenario specific where appropriate, to be used in support of integrated system validation*
- *the specific criteria that will be used to evaluate the acceptability of the integrated system*

<u>GEH Response</u>

A. [[ ]]

<u>Performance Measurement Selection</u>

(1) Clarify why [[ ]] *are not used directly for CD indication.*

It was the intent for [[ ]] to be used as performance measures and to apply [[ ]] as suggested.

Section 5.4.4.1 will be revised as depicted in the attached markup to clarify [[ ]].

(2) [[ ]]*, the other more sensitive limits could be used to identify human engineering discrepancies (HEDs) within an overall successful validation. Technical specifications, safety limits (as per DCD, Tier 2, p. 2.0-1), limiting conditions of operation (LCOs) pertinent to each scenario, and critical safety function performance may provide a more complete and sensitive assessment of plant and system performance* [[ ]].

Applicable operational limits are established for the event in section 5.4.3.5. However, there is not a specific reference to them in the performance measures.

Plant/system performance associated with critical safety functions are established as performance measures under [[ ]].

Sections 5.4.3.5, 5.4.4, and 5.4.4.1, 5.4.4.1.2 will be revised to highlight operational limits [[ ]] as shown in the attached markups.

Acceptance Criteria

(3) Comment on: *"exceeding parameter values should be an acceptance criterion as well."*

[[ ]]

Section 5.4.4.1.2 will be revised as depicted in the attached markups to [[ ]].

B. Plant Human Reliability Analysis (HRA)/Probabilistic Risk Assessment (PRA) measurement

Performance Measurement Selection

(1) What are the "values" identified in the [[ ]] *measure?*

There may be parameter values [[ ]]. In these instances, test personnel will be cued on the parameter value as the action constraint or acceptance criteria. Also, the HRA may result in modifications to training, procedures or HSI intended to increase the reliability of the action. Evaluations of these resolutions and assumptions may include data measures [[ ]], such as [[ ]] that were prepared for the validation. Each specific validation item would need to have its criteria established per section 5.4.3.7 of the plan.

The RAI 18.11-29 S03 changes to the section since the reviewer's comment, now refers to an added section in [[ ]] (Section 5.4.3.7) titled [[ ]]. The added section establishes acceptance criteria for [[ ]].

There are no document changes as a response to this question.

Acceptance Criteria

(2) Is [[.......

]] *the correct category of measurement and acceptance criteria to validate the design?*

Section 5.4.4.2.2 was written to confirm that the plant design (HSIs, procedures, staffing, training, etc.) supports the reliable and successful performance of [[

]]. If the crew failed to adequately perform a [[ ]] as evidenced by a critical parameter established [[ ]], this was considered of importance to fail the scenario, and re-perform after resolutions are implemented. GEH did not account for the situation where [[ ]] could be in error, thereby contributing to the crew's failure. For example, [[ ]].

Sections 5.4.3.7, 5.4.4.2, and 5.4.4.2.2 will be revised to confirm [[ ]] as shown in the attached markups.

(3) The successful accomplishment of risk-significant actions should be evaluated in ISV. Clarify the evaluation of risk-significant actions in the ISV.

The changes to Sections 5.4.3.7, 5.4.4.2, and 5.4.4.2.2 described in the last question, establish an evaluation of the [[ ]] in two parts: (1) [[ ]] and (2) the trained crew with the ESBWR HSI design effectively accomplish the actions.

RAI 18.11-29 S03 response since the reviewer's comment changed the use of [[ ]] as the performance measure to prevent masking performance issues experienced by one or more crews.

There are no document changes as a response to this question.

C. Personnel Tasks

<u>Performance Measurement Selection</u>

(1) Are the [[ ]] *the same as those identified in the* [[ ]] *section?*

No. [[ ]] are defined for the individual scenario as described in section 5.4.3.7 using the corresponding information from [[ ]]. The tasks referred to as "[[ ]]" in the [[ ]] section are [[ ]].

As stated in the previous section, RAI 18.11-29 S03 changes to Section 5.4.3.7 since the reviewer's comment, establishes [[ ]].

There are no document changes as a response to this question.

(2) Clarify the scope of performance measures.

[[

]]

RAI 18.11-29 S03 changes since the reviewer's comment modified section 5.4.4.3 to establish [[

]].

There are no document changes as a response to this question.

(3) [[ ]]

RAI 18.11-29 S03 changes since the reviewer's comment has addressed this comment. Section 5.4.4.3 has been modified to describe how the [[

]]

[[

]]

The RAI 18.11-29 S03 change previously submitted established [[

]]

Section 5.4.4.3 will be revised to clarify [[
]].

(4) [[
]]

[[

]]

Section 5.4.5.2 (8), (9), and (11) will be revised as depicted in the attached markups to address [[ ]].

Acceptance Criteria

(5) What are the specific criteria used for [[ ]]*?*

These measures mentioned in Section 5.4.4.3 as "other measures" are not formally defined nor addressed in Section 5.4.4.3.2, Acceptance Criteria. Section 5.4.4.3 will be revised to clarify that these measures apply to [[ ]].

[[ ]] will be added to Section 5.4.4.3.2. [[

]] will be added to Section 5.4.3.7. [[ ]]

[[ ]] is not a performance measure and Section 5.4.4.3 will be revised to delete [[ ]].

[[ ]] are important to the HFE V&V for their use [[ ]]. Whereas these are pertinent data to the validation and subsequent analysis, [[ ]].

[[

]]

Sections 4.4.2.3, 5.4.4.3, 5.4.4.3.2, 5.4.3.7, and 5.4.7 will be revised as shown in the attached markups.

(6) How are acceptance criteria developed for task measures that are subjectively derived via observations by test personnel?

Subjective ratings are employed on [[

]]

RAI 18.11-29 S03 response submitted since the reviewer's comment, revised sections 5.4.4.3 and 5.4.4.3.2 to establish [[

]] will be made to address the staff's concern.

Section 5.4.4.4.2 will be revised to clarify the acceptance criteria as shown in the attached markups.

D. Situation Awareness

<u>Performance Measurement Selection</u>

(1) Clarify the approach for situation awareness.

GEH agrees with the staff's comment on freeze points. As pointed out, our plan is to conduct the situation awareness method using [[ ]] and we have addressed the concerns about [[ ]] in Section 5.4.4.5.

Section 5.4.4.5 will be revised to remove [[
]] and to clarify the approach for situation awareness in as shown in the attached markups.

(2) GEH also proposes to [[
]]. *Clarify the measurement of situation awareness.*

As stated in the previous question, [[

]].

Section 5.4.4.5, 5.4.4.5.2, and 5.4.7 will be revised to [[
]] as shown in the attached markups.

<u>Acceptance Criteria</u> *(Section 5.4.4.5.2)*

(3) Clarify the acceptance criteria [[

]]

For the specific question concerning [[

]]

The statement in question will be revised.

Section 5.4.4.5.2 will be revised to clarify [[ ]] as shown in the attached markups

E. Physical Workload

Acceptance Criteria

Provide a reference to Ergonomics rules established by the State of Washington Department of Labor and Industries.

Section 2.5 will be revised to add Reference 2.5 (18) to provide the source for the ergonomics criteria. Section 5.4.4.6.1.2 will be revised to reference the source document.

Sections 2.5 and 5.4.4.6.1.2 will be revised as shown in the attached markups.

F. Cognitive workload

Performance Measurement Selection

(1) How does the methodology proposed, identify periods of underload?

[[ ]] is used to identify tasks of [[ ]] low workload. This process is described in RAI 18.5-26 S03 to be added in NEDE-33221P, Rev 4, Appendix A Workload Analysis Process, Section A2. Therefore [[ ]] the process to identify periods of underload.

Sections 4.3, 4.4.1.1, 4.4.1.3, 4.4.1.4, and 5.4.4.6.2 will be revised as shown in the attached markups to reflect [[ ]].

(2) Clarify the workload assessment of selected tasks. Is [[ ]] *done in real time as the scenario is unfolding? Approximately how much time will be required to obtain all* [[ ]]?

[[

]]

There are no document changes as a response to this question.

Acceptance Criteria

(3) Describe how the zones [[
]] *will be defined?*

Section 5.4.4.6.2.2 will be revised to describe zones [[
]]. Reference 2.5 (19) will be added to provide source of acceptance zones.

Section 5.4.4.6.2.2 will be revised and Reference 2.5 (19) will be added.

G. Level of Detail

Provide:

- *the specific performance measures, scenario specific where appropriate, to be used in support of integrated system validation*
- *the specific criteria that will be used to evaluate the acceptability of the integrated system*

GEH cannot provide the specific scenarios and related information including the scenario specific performance measures and criteria at this time because the selection and definition of the scenarios is predicated on the outputs of the HFE design process. The requested information will be provided in the ESBWR HFE design commitment "Integrated System Validation Scenarios". The design commitment is added as DAC ITAAC item 12 as shown in the DCD Tier 1 attached markup.

DCD Impact

DCD Tier 1, Section 3.3 will be revised as noted in the attached markup.

LTR NEDE-33276P, Rev 2 will be revised as noted in the attached markups.

NRC RAI 18.11-27 S03

NEDE-33276P (Rev. 2), Section 5.4.5 provides information on test design. The plan's treatment of participant training and pilot testing acceptably addressed the staff's review criteria. Follow-up questions on the aspects of test design are considered separately below.

Specific Methodology Questions:

1. Section 5.4.5.1 addresses the presentation of scenarios to crews. With respect to scenario assignment, GEH indicates that scenarios should be carefully balanced across crews to ensure each crew receives a representative range of scenarios. This will be accomplished using a checklist; however, the specific way in which balance is achieved is not discussed. Describe the method(s) used to balance scenarios across crews. With respect to scenario sequencing, GEH indicates that the order in which scenarios are presented to crews should be balanced. However, the specific way in which balanced sequencing is achieved is not discussed. Describe the method(s) used to balance scenarios sequences for individual crews.

2. With regard to minimizing bias, GEH plans to use well-developed procedures including scripted responses which should serve to minimize bias. As part of crew briefing, crews will be asked to refrain from discussing the scenarios with other crews, which should also help minimize bias. Also, the introduction of tester bias is discussed as part of test personnel training. While all these features of the test program should minimize bias, a final determination cannot be made until the specific details of the procedures are available. For example, Section 5.4.5.2, Item 2 indicates that test objectives are part of the crew briefing. Since little additional information is provided about what this is, it is possible that communicating detailed scenario objectives could give information to the crew about what is going to happen and this will bias their responses. Clarify this aspect of the crew briefing.

Level of Detail:

In summary, GEH has provided a description of their approach to test procedures. However, it is difficult to evaluate precisely how the procedures will work in the absence of specific details about the scenarios or a concrete example to illustrate their application.

While GEH's revised plan and the answers to these questions will further clarify the test design, it will not fully answer the staff's concern regarding level of detail. Identify the specific test design details to be used in support of integrated system validation."

GEH Response

Specific Methodology Questions

1. Describe the method(s) used to balance scenarios across crews. Describe the methods used to balance scenario sequences for individual crews.

NEDE-33276P Rev 2 will be revised as follows to describe the methods used to balance scenarios across crews and sequences for individual crews:

[[

]]

2. Clarify the crew briefing procedures with regard to minimizing bias (e.g., test objectives are part of the crew briefing).

"Test objectives" in this context is [[

]]

Section 5.4.5.2(2) will be revised [[ ]].

<u>Level of Detail:</u>

Identify the specific test design details to be used in support of integrated system validation.

GEH cannot provide the specific scenarios and related information including test design details to be used at this time because the selection and definition of the scenarios is predicated on the outputs of the HFE design process. The requested information will be provided in the ESBWR HFE design commitment "Integrated System Validation Scenarios". The design commitment is added as DAC ITAAC item 12 as shown in the DCD Tier 1 attached markup.

<u>DCD Impact</u>

DCD Tier 1, Section 3.3 will be revised as noted in the attached markup.

LTR NEDE-33276P, Rev 2 will be revised as noted in the attached markups.

Event: Any planned (for example, power change) or unplanned (for example, process system component failure) occurrence that impacts operation of process systems in such a way that achievement of required safety and productivity levels is jeopardized.

EPG/SAG: Emergency Procedure Guidelines are documents that identify the equipment or systems to be operated and list the steps necessary to mitigate the consequences of transients and accidents and restore safety functions. Severe Accident Guidelines define strategies for responding to emergencies and severe accidents when primary containment flooding is required.

Error-Forcing Context: The situation that arises when particular combinations of performance shaping factors and plant conditions create an environment in which unsafe actions are more likely to occur. **18.11-3 S03 Q2**

Extent of Condition: The extent to which the HED condition exists with other processes, HSIs, or human performance. It is expected that the level of effort in determining and documenting the extent of condition is commensurate with the significance of the HED.

Feedback: System or component response (for example, visual, auditory, and/or tactile) indicating the extent to which the user's desired effect was achieved. Feedback can be either intrinsic or extrinsic. Intrinsic feedback is what the individual senses directly from the operation of the control devices (for example, clicks, resistance, and/or control displacement). Extrinsic feedback is what the individual senses from an external source that indicates the consequences of the control action (for example, indicator lights, display changes, and/or aural tones).

Full-Scope Simulator (FSS): A high-fidelity simulation environment that includes physical and environmental aspects, and HSIs of the operating environment. Typically this refers to the main control room simulator and meets the requirements of Regulatory Guide 1.149 and ANS-3.5.

Functional requirements: Quantitative performance criteria that systems must satisfy.

Functional requirements analysis: The examination of plant or system goals to determine what functions are needed to achieve them.

Global features: HSI features relating to the configurational and environmental aspects of the HSI, such as MCR layout, general workstation configuration, lighting, noise, heating, and ventilation. Global feature HEDs relate to general problems concerning human performance.

HFE Issue Tracking System (HFEITS): An electronic database used to document human factors engineering issues not resolved through the normal HFE process and human engineering discrepancies (HEDs) from the design verification and validation activities. Additionally, the database is used to document the problem resolutions.

Human Engineering Discrepancy (HED): A departure from some benchmark of system design suitability for the roles and capabilities of the human operator. This may include a deviation from a standard or convention of human engineering practice, an operator preference or need, or an instrument/equipment characteristic that is implicitly or explicitly required for an operator's task but is not provided to the operator. (NUREG 0700, Rev 2)

Human Factors: A discipline concerned with the systematic study and application of what is known about human behavior to system development decisions.

Human Factors Engineering (HFE): The application of knowledge about human capabilities and limitations to plant, system, and equipment design. HFE ensures that the plant, system, or equipment design, tasks, and work environment are compatible with the sensory, perceptual, cognitive, and physical attributes of the personnel who operate, maintain, and support it (see human factors).

Human Reliability Analysis (HRA): A structured approach used to identify potential human failure events and to systematically estimate the probability of those events using data, models, or expert judgment.

Human-System Interface (HSI): The human-system interface (HSI) is that part of the plant through which personnel interact to perform their functions and tasks. Major HSIs include alarms, information displays, controls, and procedures. Use of HSIs can be influenced directly by factors such as,

(1) The organization of HSIs into workstations (for example, consoles and panels).

(2) The arrangement of workstations and supporting equipment into facilities such as a main control room, remote shutdown station, local control station, technical support center, and emergency operations facility.

(3) The environmental conditions where the HSIs are used, including temperature, humidity, ventilation, illumination, and noise. HSI use can also be affected indirectly by other aspects of plant design and operation such as crew training, shift schedules, work practices, and management and organizational factors.

Input: The term input is context contingent and may take these forms:

(1) Information entered into a system for processing.

(2) The process of entering information.

(3) Pertaining to the devices that enter information.

Local Control Station: An operator interface related to process control that is not located in the main control room. This includes multifunction panels, as well as single-function LCSs, such as controls (for example, valves, switches, and breakers) and displays (for example, meters) that are operated or consulted during normal, abnormal, or emergency operations.

Monitoring: Purposefully observing displays to assess plant operations. If available information suggests abnormality, additional information is sought and a diagnosis of the difficulty is performed.

Panel: Any surface upon which measures of equipment behavior are displayed or controls that directly affect equipment operations are contained. This includes display pages presented on video display units (VDUs), as well as conventional console panels containing hard controls.

Parameter: Any physical property whose value reflects a plant condition.

<u>**Performance Shaping Factors**: A set of influences on the performance of an operating crew resulting from the human-related characteristics of the plant, the crew, and the individual operators. Example characteristics include procedures, training, and human-factors aspects of the displays and control facilities of the plant.</u> 18.11-3 S03 Q2

2. APPLICABLE DOCUMENTS

Applicable documents include supporting documents, supplemental documents, codes and standards, and are given in this section. Supporting documents provide the input requirements to this plan. Supplemental documents are used in conjunction with this plan. Codes and standards are applicable to this plan to the extent specified herein.

2.1 SUPPORTING AND SUPPLEMENTAL DOCUMENTS

2.1.1 Supporting Documents

The following supporting documents were used as the controlling documents in the production of this plan. These documents form the design basis traceability for the requirements outlined in this plan.

(1) ESBWR DCD, Chapter 15, ~~Rev 5~~ (26A6642BP).

(2) ESBWR Design Document Control, Tier 2, Chapter 18, ~~Rev 5~~ (26A6642BX).

(3) ESBWR Design Document Control, Tier 1, Section 3.3, (26A6641AB). 18.11-4 S03

~~(3)~~(4) NEDE-33217P and NEDO-33217, Rev 4, ESWBR Man-Machine Interface System and Human Factors Engineering Implementation Plan.

2.1.2 Supplemental Documents

The following supplemental documents are used in conjunction with this document plan.

(1) NEDO-33219, Rev 2, ESBWR HFE Functional Requirements Analysis Implementation Plan.

(2) NEDE-33220P and NEDO-33220, Rev ~~2~~3, ESBWR HFE Allocation of Function Implementation Plan.

(3) NEDE-33221P and NEDO-33221, Rev ~~2~~3, ESBWR HFE Task Analysis Implementation Plan.

~~(4)NEDE-33226, Rev 3, ESBWR I&C Software Management Plan Manual.~~

~~(5)~~(4) NEDE-33226P and NEDO-33226, Rev 4, ESBWR I&C Software Management Program Manual~~NEDO-33245, Rev 3, ESBWR I&C Software Quality Assurance Plan Manual~~.

~~(6)~~(5) NEDO-33262, Rev 2, ESBWR HFE Operating Experience Review Implementation Plan.

~~(7)~~(6) NEDO-33266, Rev 2, ESBWR HFE Staffing and Qualifications Implementation Plan.

~~(8)~~(7) NEDO-33267, Rev 3, ESBWR HFE Human Reliability Analysis Implementation Plan.

~~(9)~~(8) ~~NEDO~~ NEDO-33274, Rev 3, ESBWR HFE Procedures Development Implementation Plan.

~~(10)~~(9) ~~NEDO~~ NEDO-33275, Rev ~~2~~3, ESBWR HFE Training Development Implementation Plan.

~~(11)~~(10) NEDE-33268P and ~~NEDO~~ NEDO-33268, Rev ~~3~~4, ESBWR HFE Human-System Interface Implementation Plan.

(4) Endsley, M. R. (1989). Final report: Situation awareness in an advanced strategic mission (No. NOR DOC 89-32). Hawthorne, CA: Northrop Corporation.

(5) Endsley, M. R. (1990). Predictive utility of an objective measure of situation awareness. Proceedings of the Human Factors Society 34th Annual Meeting (pp. 41-45). Santa Monica, CA: Human Factors Society.

(6) Endsley, M. R. (1995a). Measurement of situation awareness in dynamic systems. Human Factors, 37(1), 65-84.

(7) Endsley, M. R. (1995b). Toward a theory of situation awareness in dynamic systems. Human Factors 37(1), 32-64.

(8) Endsley, M. R. (2000). Theoretical underpinnings of situation awareness: A critical review. In M. R. Endsley & D. J. Garland (Eds.), Situation awareness analysis and measurement. Mahwah, NJ: LEA.

(9) Endsley, M. R. & Garland, D. J. (Eds.) (2000). Situation awareness analysis and measurement. Mahwah, NJ: Lawrence Erlbaum Associates.

(10) Endsley, M. R. & Bolstad, C. A. (1994). Individual differences in pilot situation awareness. International Journal of Aviation Psychology, 4(3), 241-264.

(11) Hartel, C. E. J., Smith, K., & Prince, C. (1991, April). Defining aircrew coordination: Searching mishaps for meaning. Paper presented at the 6th International Symposium on Aviation Psychology, Columbus, OH.

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(14) Hogg, D.N., Torralba, B., & Volden, F. S. (1993). A situation awareness methodology for the evaluation of process control systems: Studies of feasibility and implication of use (1993-03-05). Storefjell, Norway: OECD Halden Reactor Project.

(15) Merket, D. C., Bergondy, M., & Cuevas-Mesa, H. (1997, March). Making sense out of teamwork errors in complex environments. Paper presented at the 18th Annual Industrial/Organizational-Organizational Behavior Graduate Student Conference, Roanoke, VA.

(16) Nullmeyer, R. T., Stella, D., Montijo, G. A., & Harden, S. W. (2005). Human factors in Air Force flight mishaps: Implications for change. Proceedings of the 27th Annual Interservice/Industry Training, Simulation, and Education Conference (paper no. 2260). Arlington, VA: National Training Systems Association.

(17) Sanders, M. S. & McCormick, E. J. (1993). Human Factors in Engineering and Design (7th Ed.) McGraw-Hill, Inc.

(18) Washington State Department of Labor & Industries. (2004). Evaluation Tools. Retrieved March 12, 2008, from http://www.lni.wa.gov/Safety/Topics/Ergonomics.

18.11-24 S03 Part E

(19) Hogg, D., Sturrock, F., & Wykes, K. (2002) HMI assessment of the Nimrod MRA4 Flight Deck. In P.T. McCabe (Ed.), Contemporary Ergonomics (pp. 361-366).

18.11-24 S03 Part F(3)

4. OPERATIONAL CONDITIONS SAMPLING

The purpose of the operational condition sampling process is to ensure that a broad and representative range of operating conditions is included in the sample population of integrated system validation scenarios. To ensure a representative sample that emphasizes safety significance, risk, and challenges to the operating crew, a weighted list of operational conditions is developed.

4.1 SCOPE

The scope of the operational condition sampling process is the full range of conditions that are representative of the events that could be encountered during operation of the ESBWR. Using the structured and risk informed process described below, a representative sample set of operation conditions is selected and then used as the basis for integrated system validation scenarios.

4.2 OBJECTIVES

The objective of the operational conditions sampling process is to identify a sample of operational conditions that includes conditions from a representative range of events. These conditions reflect characteristics expected to contribute to performance variation and take into account the safety significance of HSI components.

4.3 INPUTS

Input from a variety of different areas is used to perform operational conditions sampling. Areas of input for include:

- HRA/PRA – Used to determine risk-significant scenarios and risk-significant human actions and also to weight scenario selection criteria.
- Task Analysis – Indicates areas of high and low workload, high stress, [[ ]]. 18.11-24 S03 Part F(1)
- Normal, abnormal, and emergency procedures and SAMGs.
- ANSI/ANS-3.5 Nuclear Power Plant Simulators for Use in Operator Training and Examination – Provides operational conditions used for simulator fidelity verification that also merit consideration for inclusion in integrated system validation scenarios.
- [[ ]]
- HED resolutions that warrant inclusion in or re-performance of integrated system validation scenarios.

4.4 METHOD

4.4.1 Establish Sampling Dimension Criteria

The ESBWR operational condition sampling process occurs in four major phases:

- Define the weighting factors used in integrated system validation scenario selection.
- [[
]]
- Develop a representative population of operational conditions and tasks used in the selection integrated system validation scenarios.
- Perform weighted selection of scenarios from the defined population used to validate the integrated ESBWR systems and their controls.

The considerations of Section 4.4.1.2 are categories of conditions or tasks that will be represented in the final set of selected scenarios. One or more selected scenarios will contain the stated task or condition. The considerations in Section 4.4.1.3 are additional operational conditions or tasks that will also be represented in the final set of selected scenarios, but these may be combined with one or more of the items from the minimum set established in Section 4.4.1.2. 18.11-4 S03

The elements from Sections 4.4.1.2 and 4.4.1.3 selected for including in the scenarios will be combined into scenarios in Section 4.4.2, Scenario Identification and Development. The final selection will provide one or more scenarios representing the sampling dimensions established in section 11.4.1.2.1 of Reference 2.3 (5). The final set of scenarios is identified as item 12 in Table 3.3-2 of Reference 2.1.1 (3).

4.4.1.1 Weighting Factors

The scenario selection process uses multidimensional selection criteria to identify integrated system validation scenarios that maximize relevance and significance while ensuring all operational condition diversity is met. To accomplish this, the following weighting factors are used to sort scenarios (list presented in order of lowering weight):

- HRA/PRA significance of the event scenario.
- Presence of HRA/PRA risk-significant human actions.
- Presence of D3 credited human actions.
- Task analysis results indicating high and low workload, high stress, [[
]] 18.11-24 S03 Part F(1)
- [[ ]]

These factors are used later in the process to select the most significant and relevant scenario when analysts encounter situations where more than one scenario can be used to validate the same operational conditions.

4.4.1.2 [[

18.11-3 S03 Q1

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4.4.1.3 Representative Population of Operational Conditions and Tasks

In order to develop a satisfactory multidimensional sampling of conditions resulting in the selection of integrated system scenarios that thoroughly evaluate the ESBWR design, one or more operational conditions or tasks representing each of the following are identified:

Plant control

- Design basis accidents identified in the ESBWR DCD.
- Additional risk-important scenarios within the scope of the EOPs and SAMGs.
- License basis document abnormal operational occurrences.
- Additional ~~risk-~~risk-important abnormal events and transients within the scope of AOPs.
- Additional ~~risk-~~risk-important equipment degradations and failures within the scope of ARPs.
- Normal plant operating manipulations ranging from cold shutdown/refueling to full power operations.

Personnel tasks

- Human actions identified in the HRA/PRA, DCD, and the NRC safety evaluation report as being risk-significant.
- Historically problematic tasks as identified in the operating experience reports generated using the ESBWR operating experience process.
- Procedures from each class used in the operation of the plant including administrative, emergency, abnormal, alarm response, general operating, system operating, surveillance and testing, maintenance, chemistry control, and radiation control (those portions involving the MCR, RSS, or risk significant LCS).
- [[

  ]]
- Tasks representing a broad range of human cognitive activities. Tasks in this population are those that analysts identified as containing the following attributes as in the response requirements portion of detailed task analysis.
  - Detection and monitoring.

- Diagnosis and situation assessment.
- Decision making and planning.
- Plant manipulation.
- Monitoring plant response.

- Tasks involving a range of human interactions and communications as identified in the ESBWR task analysis. Tasks in this population are those that analysts identified as containing communication interactions between the primary task performer and other personnel.
- Tasks performed with high frequency as identified in the ESBWR task analysis. [[

]]

Situational factors

- Operationally difficult tasks as identified in the operating experience reports generated using the ESBWR operating experience process.
- Scenarios specifically designed to generate human errors. This allows evaluation of error tolerance and error recovery.
- Scenarios performed with varying crew sizes. Variance between minimum and nominal crew size as discussed elsewhere in this document.
- Instances of high and low workload as identified in the ESBWR task analysis. Tasks in this population are those that analysis identified as high workload in the workload determination portion of the detailed task analysis. 18.11-24 S03 Part F(1)
- Instances of varying workload. Tasks in this area can vary by their nature (e.g., a scram during normal operations, or the cessation of work following the shutdown of a system the crew is controlling), or may vary due to sequencing high and low workload tasks.
- Fatigue and circadian factors. Tasks in this population are those performed with crews that are fatigued and off their normal circadian sleep cycles.
- Environmental factors such as poor lighting, high noise, radiological contamination, or other factors such as operator physical position identified in the ESBWR task analysis. [[

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4.4.1.4 Weighted Selection of Integrated System Validation Scenarios

Scenarios are selected from the representative population that together fulfills all of the minimum condition and task requirements. When more than one scenario can be used to validate an operational condition or task, the scenario with the highest multidimensional weight is selected.

The scenario selection process uses multidimensional selection criteria to identify integrated system validation scenarios that maximize relevance and significance while ensuring all operational condition diversity is met. To accomplish this, the following weighting factors are used to sort scenarios (list presented in order of lowering weight):

- HRA/PRA significance of the event scenario.
- Presence of HRA/PRA risk-significant actions.
- Presence of defense-in-depth and diversity (D3) credited human actions.
- Task analysis results indicating high and low workload, high stress, [[ ]]. 18.11-24 S03 Part F(1)
- [[ ]]

4.4.2 Scenario Identification and Development

Integrated system validation scenarios that exercise the selected operational conditions are developed using a structured process to ensure consistency, quality, and the minimization of bias. Procedures governing the performance of the integrated system validation process contain guidance regarding the requirements for development and documentation of all scenario attributes including:

- Objectives.
- Initial conditions.
- Selecting and documenting events.
- Scenario attributes, both qualitative and quantitative.
- Determining scenario endpoint.
- Validation of the scenario itself.
- Critical task determination.

Each of the major activities that contribute to dynamic simulator scenario development is completed in accordance with the ESBWR simulator scenario development guide and is summarized below.

4.4.2.1 Identifying Scenario Objectives

Scenarios are assigned a predetermined set of specific objectives based upon the events that take place during the scenario and the attributes, abilities, procedures, and training to be validated. The basic objective of the scenarios is to evaluate the operators' ability to effectively use the ESBWR HSI to respond to the event being simulated. Specifically, each scenario validates the attributes of the associated HSIs and procedures, and the operators' training experiences with them, through observations of:

- Operator knowledge of integrated plant operations (gained through training).
- Operator ability to use the integrated HSI to gather and validate indication and plant performance data.
- Operator ability to diagnose abnormal plant conditions.
- Operator ability to formulate mitigation strategies.
- Operator ability to locate and use the appropriate procedures.

Scenario designers pre-determine each planned operation, malfunction, and transient and document them as a scenario timeline.

Scenario documentation includes:

- Event descriptions.
- How and when the event is initiated.
- A listing of the event cues, indications, and symptoms ~~that are~~that is available to operators.
- Expected actions to be taken.
- Expected communications.
- Procedures to be used.
- Scenario endpoint.
- Required operator actions to be observed, including any critical tasks contained within the scenario.
- Expected task times for required actions to be observed 18.11-24 S03 Part C(5)
- Other variable actions and behaviors that provide useful basis for evaluating operator and integrated HSI performance.

4.4.2.4 Scenario Attributes, both Qualitative and Quantitative

Integrated system validation scenarios are constructed to accurately test:

- Each individual operator's abilities and skills.
- Crewmember's team dependent abilities and skills.
- The integrated HSIs support of safe and efficient operation.
- Procedures.
- Staffing and qualification criteria.

Each scenario is of sufficient length, scope, and complexity to allow differentiation between acceptable and unacceptable performance. Scenario attributes consist of both qualitative and quantitative elements. Experienced scenario developers use scenario attributes to both construct and assess the quality of ESBWR integrated system validation scenarios. This assessment, combined with scenario validation, ensures the scenario is an acceptable tool to validate the integrated HSI and crew operating it. The following attributes used to develop and assess scenario acceptability are described in greater detail in the ESBWR Scenario development procedures:

Scenario Qualitative Attributes

- Realism/Credibility – Initial conditions, external communications, plant response, and other similar scenario details are sufficiently similar to actual plant performance that the crew performance observed is representative of what is expected in an operating ESBWR.

4.4.2.6 Validation of the Scenario

The structure, timeline, flow, and all other aspects of integrated system validation scenarios are validated prior to use of the scenario in ESBWR V&V. Scenario validation ensures that the scenario runs as intended and that supporting scenario development and execution materials are accurate.

4.4.2.7 [[

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4.4.2.8 [[

18.11-3 S03 Q2

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18.11-3 S03 Q2

4.4.3 Measures Taken to Eliminate or Control Bias

Bias represents any influence, condition, or set of conditions that singly or together distort the data. Bias can produce systematic (but unexpected) variation in a research finding, and can invalidate any conclusions made based on a biased sample. Therefore, when selecting operational conditions and developing scenarios, care must be taken to avoid creating a biased sample.

Qualified test personnel control scenario bias through a number of means. These include:

- Procedurally controlled scenario development and validation process.
- Ensuring validation tests are performed using scenarios that are developed by selecting from the full range of operational conditions, and that cover a representative range of conditions.
- Scenario validation, which includes an evaluation of scenario attributes and their distribution.
- Pilot studies to identify possible sources for scenario bias and for developing controls.
- "Backcasting"- Part of the scenario identification and development process that involves identifying a future state (both desirable and undesirable) as identified in SAMGs, EOPs, AOPs, ARPs, and normal operating conditions. It also involves constructing paths that connect the specified end condition to the conditions and actions required to achieve or avoid it.

  This approach reduces the risks of hidden bias in construction of scenarios. By selecting both desirable and undesirable outcomes, and by developing scenarios with conditions and events that vary the likelihood of reaching the outcome, a representative and balanced set of scenarios is identified.

After scenario development is complete, the resulting set of scenarios is evaluated to identify selection bias in any of the following areas:

- Scenarios for which only positive outcomes are expected – This is avoided in part by selecting operating conditions for use in scenarios that are identified in the HRA/PRA as risk-important, risk-important accident scenarios within the scope of EOPs and SAMGs, and conditions known to challenge human performance. This type of bias is also avoided by following the "backcasting" methodology.
- Scenarios that are relatively easy to conduct administratively (scenarios that place high demands, data collection or analysis are avoided) – Scenarios are developed that best accommodate all of the selected tasks and conditions and not just those scenarios that are the easiest to conduct.
- Scenarios that are familiar and well structured (e.g., those which address familiar systems and failure modes that are highly compatible with plant procedures such as "textbook" design-basis accidents) – Because scenarios are developed from selected operational conditions, and because event sequencing is built in as part of scenario definition, it is not expected that scenarios will follow highly familiar sequences.

If development bias is detected, scenarios are analyzed for alternatives to create a more fair and representative range of events. Any occurrences of significant sampling bias are logged as HEDs in the HFEITS for tracking and resolution.

4.4.4 Scenario Attribute Classification

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18.11-27 S03 Q1

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4.5 OUTPUTS AND RESULTS DOCUMENTATION

The output of the operational condition sampling process is a group of simulator scenarios that thoroughly evaluates the ESBWR design. The scenario administrative information sheet is prepared for the selected scenarios documenting the key development attributes. 18.11-27 S03 Q1

The site-specific training simulator has an instructor station providing the full functionality required for ANSI 3.5 certified training simulators.

Scope

The site-specific training simulator is an ANSI 3.5 certified and Reg Guide 1.149 compliant full scope simulator for operator training and testing.

The site-specific training simulator contains consoles and panels with the same form, fit, and feel as the ESBWR main control room.

5.4.1.4 Remote Shutdown System

The remote shutdown panel is verified in accordance with the task support verification and HFE design verification processes. Additionally, integrated system validation of the remote shutdown panel is performed utilizing a high fidelity remote shutdown panel simulator meeting the requirements of ANSI 3.5 and Reg Guide 1.149

The remote shutdown station (RSS) and its HSIs are verified in accordance with the task support verification and HFE design verification processes. All of the factors associated with RSS operations incorporated into a scenario are specified, in detail, in the scenario guide written to govern performance of the simulation. The scenario validation process verifies that cues, indications, communications, and feedback built into the scenario guide are accurate and timely. In this way, scenarios containing RSS actions are accurately rendered and support validation of the integrated system HSI.

5.4.1.5 Risk Significant Local Control Panels

Risk significant local control stations and their HSIs are verified in accordance with the task support verification and HFE design verification processes. Additionally, integrated system validations that require actions to be performed at local control stations are performed utilizing action durations, simulated feedback indications in the HSI, and communication mechanisms used in the plant. Scenarios will model local tasks important to scenario timing and fidelity as well as the local tasks important to risk or safety. 18.11-19 S03 Q3

Validation of risk ~~important~~ significant local control operations is performed using simulations and mockups as needed. All of the factors associated with local operations incorporated into a scenario are specified, in detail, in the scenario guide written to govern performance of the simulation. The scenario validation process verifies that remote manual action cues, indications, communications, and feedback built into the scenario guide are accurate and timely. Thus, scenarios that contain remote actions are accurately rendered and support validation of the integrated system HSI. 18.11-19 S03 Q1

5.4.2 Participant Selection

The participants selected for early validation activities using PTS can include trainers, licensed SROs, licensed operators from other BWRs, start up engineers, I&C engineers, HRA/PRA engineers and human factors engineers. The crews used during the later integrated system validation activities include people trained to become ESBWR operators and SROs. The sample of participants used in testing reflects the characteristics of the population from which the sample is drawn.

Scenario definition is used to provide a consistent, objective, and high fidelity environment in which to validate performance of the integrated systems. The defined scenarios involve major plant evolutions or transients, reinforce team concepts, and identify the role each individual plays within the team.

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18.11-22 S03
Q2

18.11-22 S03
Q1

18.11-24 S03
Part A(2)

18.11-3 S03
Q2

18.11-24 S03
Part C(5)

18.11-24 S03
Part B(2)

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5.4.3.13 Staffing Objectives

Staffing for the performance of integrated system validation testing scenarios uses licensed personnel for crewmembers or participants enrolled in training classes for the purpose of ESBWR licensing. Crews are selected to ensure that both experienced and new operators are evaluated and provide input regarding the HSI. Test participants are not allowed to act as a crewmember in a given scenario more than once.

Scenario events and tasks that result in common problems for test participants are documented as HEDs in HFEITS to track the HFE or HSI factors that are changed to resolve the problem. Tasks that result in the failure of the plant or crew to meet established acceptance criteria are also added as HEDs and tracked to resolution in HFEITS.

5.4.4 Performance Measures

A hierarchal set of performance measures are selected to assess the adequacy of the integrated system. The plant/system performance measures selected for integrated validation are selected based on the prevention or mitigation of transients and accidents, as described in DCD Tier 2, Chapter 15 - Transient Analysis. Tasks and events with high HRA/PRA risk significance are selected for measurement. Two types of performance measures are defined for the integrated system validation; (1) Decisive measures are used to pass or fail the validation test for the scenario under investigation thus confirming that the integrated elements of the design are effective in achieving the goals of the scenario, and (2) Supplemental measures are collected to provide additional information in support of validation efforts and to refine/enhance the design.
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Supplemental performance measures are developed to provide additional dimensions of information. A multidimensional approach to integrated system validation allows test personnel to view data outcomes in a richer context. This creates a greater understanding of crew performance in the varying scenario conditions, leading to more valid, well-informed conclusions and to an increased ability to diagnose and fix performance problems.

Supplemental performance measures are primarily used to provide additional information regarding the results of other performance measures. Significant problems in these areas are evaluated and addressed as well. Potential performance concerns identified in supplemental measurement areas are evaluated in the context of overall scenario performance and HEDs are written if needed. Supplemental measures include:

- Performance to plant operational limits 18.11-24 S03 Part A(2)
- Crew communication and coordination.
- Situation awareness.
- Workload (both physical and cognitive).
- Anthropometrics and physiological factors.

Satisfactory completion of integrated system validation and its associated performance measures, and criteria validates the ESBWR HSI and the context in which it is used. This includes automation, training, procedures, and staffing and qualifications.

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18.11-24 S03 Part A(1)

18.11-24 S03 Part A(1)

18.11-24 S03 Part A(2)

18.11-24 S03 Part A(3)

18.11-24 S03 Part A(2)

18.11-24 S03 Part B(2)

18.11-3 S03 Q2

18.11-23 S02

18.11-24 S03 Part B(2)

18.11-24 S03
Part B(2)

18.11-24 S03
Part B(2)

18.11-24 S03
Part B(2)

18.11-24 S03
Part C(3)

18.11-24 S03
Part C(3)

18.11-24 S03
Part C(3)

18.11-23 S02

18.11-23 S02

18.11-24 S03 Part C(5)

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18.11-24 S03 Part C(6)

5.4.4.5 *Situation Awareness*

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Procedure

During testing, crews should attend to tasks as during all other simulations, with SA ~~questions~~ queries being considered secondary. No displays or visual aids should be visible while participants are answering questions (therefore screens should be blank during testing, or test participants should be asked to turn away from screens). If participants do not know or are uncertain about the answer to a question, they are encouraged to make their best guess. If participants are not comfortable enough to make a guess, they are permitted to skip that question and go to the next question. Talking or sharing of information between participants is not permitted. All participants are queried at the same time.

18.11-24 S03 Part D(1)

During a freeze point, all screens should go blank except for one screen in a central location at each workstation. On this screen a series of situation awareness questions are presented, and the operator's type in/ select their responses. _[[

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18.11-24 S03 Part D(1)

Selecting Freeze Points

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18.11-24 S03 Part D(1)

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18.11-24 S03
Part D(1)

Freezes should generally last less than two minutes, and regardless of the number of questions presented, at least five seconds should be given before a scenario is resumed after a freeze. Operators should not be aware of when exact freeze points are going to occur.

Selecting Questions

Questions given during a freeze point are relevant to the information that is available to operators prior to that freeze point. Questions should be constructed in terms of operating procedures and phrased using language standard to the nuclear industry.

Questions during each freeze point cover three different levels of situation awareness: perception of data, comprehension of meaning, and projection of the near future. Questions include how the system is functioning and system status.

Situation awareness questions reflect requirements that are developed based on information provided by TA, training, and operating procedures. These requirements indicate what information an operator needs to be aware of in order to successfully complete all of the required tasks in a scenario.

Performance Measures

The operators' situation awareness, as determined by answers to freeze point questions, are compared to situation information recorded on the simulation computers just prior to, and at the same point in time as the freeze.

Situation awareness should be measured in terms of:

- Perception of data:
  - The proportion of correct answers relative to the total amount of data requested by the freeze point questions for each scenario
    - o The proportion of unanswered data questions relative to the total number of data questions
    - o The proportion of incorrect answers relative to the total number of data questions

- Comprehension of meaning:
  - Awareness is adequate to correctly comprehend the meaning of the data attended to. (Yes/No)
    - Accurate or inaccurate judgment of plant/ plant system status
    - Accurate or inaccurate selection of procedure in response to data.
- Projection of the near future:
  - Awareness is adequate to correctly predict events occurring in the plant in the near future (based on data attended to and conclusions drawn from that data). (Yes/No)
    - Accurate or inaccurate selection of procedure in response to data.
    - Accurate or inaccurate prediction of plant/ plant system status in the near future.

Perceived operator information, as determined by the above analysis, should be compared to the information requirements needed to select the appropriate procedures to follow, and to successfully complete required tasks, as determined by the TA and operating procedures.

~~**Supplemental Situation Awareness Information**~~

~~Because situation awareness data using freeze points is not used during significant events, supplemental data is used to measure operator situation awareness during events.~~

~~During events, subjective SA data is gathered by test personnel using behavioral measures. Observers infer SA from the actions that operators chose to take, based on the assumption that good actions (following the correct procedure) follow from good SA and vice versa.~~

~~[[~~ 18.11-24 S03 Part D(2)

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~~To establish reliability, each participant should be rated by more than one observer, and test personnel observations should be compared. Observed ratings can also be compared to videotapes of the test session, to confirm accuracy of observations. Observations should be recorded from locations that are unobtrusive.~~

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]] 18.11-24 S03 Part D(3)

In addition, operator situation awareness levels must be high enough to obtain the information required to determine correct operating procedures. If SA is not sufficient to select correct operating procedures, validation cannot occur, and a HED is entered into the HFEITS.

~~For supplemental situation awareness measures, an average crew SA rating of at least 3.5 should be attained to determine that a crew is displaying adequate situation awareness. For ratings less that 3.5, a HED is entered into the HFEITS.~~ 18.11-24 S03 Part D(2)

~~Beyond the aforementioned criteria, situation awareness performance is used as a supplement to better understand the results of other performance measures.~~ 18.11-24 S03 Part D(2)

5.4.4.6 Workload

Workload represents the cost incurred by an operator to achieve a particular level of performance. Workload can be divided into two elements: physical workload and cognitive workload.

5.4.4.6.1 Physical Workload

Because of the digital nature of the ESBWR control room, physical workload is not expected to have an impact on control room operator performance. However, to ensure that physical workload does not negatively impact crew performance, physical workload evaluations are conducted during validation testing.

To evaluate physical workload impact on operator performance, video recordings and observations by test personnel are used to identify conditions that represent any of the following (number of occurrences per day are predicted using the sample of occurrences during the time frame of a scenario):

Force

- Heavy, frequent, or awkward lifting:
  - Any lift of 75 pounds or more.
  - Lifting 55 pounds or more 10 times per day.
  - Lifting 10 pounds or more 2 times per minute over 2 hours total per day.
  - Lifting 25 pounds or more 25 times per day and lift is above the shoulders, below the knees, and/or at arm's length.
- High hand force:
  - Task results in any of the following for more than 2 hours per day: pinching an unsupported object(s) weighing 2 or more pounds per hand, or pinching with force of 4 or more pounds per hand.
  - Gripping an unsupported object(s) weighing 10 or more pounds per hand, or gripping with a force of 10 pounds or more per hand.
- Repeated impact:
  - Using the hand or knees as a hammer more than 10 times per hour for more than 2 hours total per day.

Posture

- Awkward posture - tasks that results in any of the following postures for more than 2 hours per day:
  - Working with the hand(s) above the head or the elbow(s) above the shoulder(s).
  - Repetitively raising the hand(s) above the head or the elbow(s) above the shoulder(s) more than once per minute.

- Working with the neck bent more than 45° (without support or the ability to vary posture.
- Working with the back bent forward more than 30° (without support, or the ability to vary posture).
- Squatting, kneeling.

Repetitiveness

- Highly repetitive motion:
  - Using the same motion with little or no variation every few seconds (excluding keying activities) for more than 2 hours total per day.
  - Intensive keying or use of mouse for more than 4 hours total per day.

Vibration

- High hand or whole body vibration:
  - Using hand tools that typically have high vibration levels more than 30 minutes total per day.
  - Using hand tools that typically have moderate vibration levels more than 2 hours total per day.

Test personnel document the type, frequency, and context of high physical workload occurrences. To determine weight, vibration, and other environmental characteristics that impact workload, measurements may be taken by test personnel before or after a scenario. Measurements are conducted in a manner that does not interfere with simulator testing activities.

5.4.4.6.1.1 [[

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5.4.4.6.1.2 Acceptance Criteria

Ergonomics rules established by the State of Washington Department of Labor and Industries [Reference 2.5(18)] provide the basis for determining acceptable workload. 18.11-24 S03 Part E

Due to the digital nature of the ESBWR control room, significant heavy lifting, high hand force, repeated impact, or high hand/ whole body vibration aspects of physical workload should not have significant impact or should not be applicable. Other aspects of physical workload, such as posture and repetitive motion, may be significant factors in a digital control room.

Any observations of physical workload occurrences that exceed the aforementioned criteria are documented as HEDs in the HFEITS.

5.4.4.6.2 Cognitive Workload

Mental or cognitive workload refers to the information processing resources required of an operator in achieving task goals. Because excessive cognitive workload is associated with decreased situation awareness and decreased ability to perform safety significant tasks, knowledge of an operator's mental workload is required to ensure that it is within acceptable limits. Because of the relationship between cognitive workload and situation awareness, both measures are evaluated in the context of one another.

Selecting Tasks

TA is an important component of workload measurement. TA is used to determine the critical tasks requiring workload assessment. As such, the results of the operational analysis, including TA is used as a screening mechanism by which tasks, scenarios, and situations can be meaningfully selected for cognitive workload assessment.

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18.11-24 S03 Part F(1)

~~Then~~For the HFE V&V, tasks and event sequences are chosen for development of ISV scenarios representing high and low workload that preliminary evaluations have indicated may have the ~~possibility of~~greatest potential for error, burden the operator, have associated time pressures or other constraints ~~and are those that are most meaningful relative to garnering information~~ relative to ~~mental loading~~operator workload.

Performance Measures

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5.4.4.6.2.2 Acceptance Criteria

For the ISV, workload assessment is directed at confirming that previous efforts to address concerns have resulted in acceptable workload for the operators. **18.11-24 S03 Part F(3)**

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18.11-24 S03
Part F(3)

18.11-24 S03
Part F(3)

Additionally, cognitive workload can be used to understand other integrated validation results. For example:

- Cognitive workload should be used when evaluating situation awareness (and vice-versa) because the two measures have been found to have a significant inverse correlation with one another.
- During a scenario or task, operators could not perform procedures correctly and within established time constraints, and that task was recorded as having high/low cognitive workload for one or more of the operators. If this occurs, it may be determined that high/low cognitive workload contributed to the unacceptable performance.

~~If any workload concerns are identified, the identified concern is entered as a HED into the HFEITS for tracking and resolution.~~Results of the workload assessments along with resolutions to any identified concerns are documented in a Workload Assessment report. 18.11-24 S03 Part F(3)

5.4.4.7 Anthropometric and Physiological Factors

Control room ergonomics using anthropometric data are evaluated as part of HSI development (See Reference 2.1.2(10)~~NEDO-33268~~, ESBWR HFE Human System Interface Design Implementation Plan) and HFE design verification to ensure compliance to the anthropometric guidelines contained in the ESBWR HFE style guide.

System-specific and integrated validation testing confirms during simulation the adequacy of the HSI anthropometric design for the population of operators in a real plant.

Validation tests to ensure that no significant negative impact on crew performance occurs within the context of the integrated system. Validation tests also ensure that no problems arise during HSI use that may not have been evident when HSI components were verified without reference to specific tasks.

  - Changing posture in order to move between controls or between displays and controls.
- Operator posture during tasks (using 5-point rating scale where 1 = Very poor and 5 = Very good).
  - Brief description of type of posture problem(s).
- Written description of any additional significant anthropometric problems as identified by test personnel, such as:
  - Visibility of displays being obstructed by operators reaching across displays to engage controls. This is especially important when working with fine motion controls and feedback from control input is provided through the obstructed display.
  - Interference with controls created by reaching for other controls. (e.g., inadvertently pressing the keys on a keyboard when reaching for a control switch on panel).

Observation data is supplemented with post-scenario operator questionnaires:

- Operators are asked to rate each anthropometric element using a 5-point rating scale (1 = Very poor, 5 = Very good). Questionnaire items include:
  - Reach and accessibility of control devices.
  - Visibility of indications.
  - Distance.
  - Seating comfort: Work surface height, chair adjustability, and/or overall level of comfort.
  - Ease of control.
  - Ease of device manipulation.
  - Overall perception of system usability.
  - Overall satisfaction with workspace layout.
- Additional comments.

5.4.4.7.1 [[

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5.4.4.7.2 Acceptance Criteria

If anthropometric design of the physical panels and layout of elements in the control room degrade crew performance such that procedures could not be accomplished correctly and within time constraints by operators representing the range of physical measurements, the integrated design fails validation. This criteria is based on established operating procedures and timelines.

If anthropometric design of the HSI represents a risk to operator safety or well-being, a HED is entered into the HFEITS. This determination is based on established anthropometric guidelines and subject matter expert judgments. This should be done in conjunction with workload analysis.

Beyond this, anthropometric data is used to better understand the results of other performance measures. Evaluation of this data should be based on established anthropometric guidelines, expert judgment, and the ESBWR HFE style guide.

5.4.5 Test Design

Test design is the process of developing the integrated validation test such that the required attributes for scenario assignment and the qualifications of the test personnel and participants permit the observation of integrated system performance in a manner that avoids or minimizes bias, confounds, and noise (error variance).

5.4.5.1 Coupling Crews and Scenarios

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

Scenario Assignment

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18.11-27 S03 Q1

]] 18.11-27 S03 Q1

Presentation of the same scenario to the same crew for a second time may not occur in the context of integrated system validation.

Scenario Sequencing

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] 18.11-27 S03 Q1

5.4.5.2 Test Procedures

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18.11-27 S03 Q2

18.11-24 S03
Part C(4)

18.11-24 S03
Part C(4)

18.11-22 S03 Q1

5.4.5.3 Training

Test Personnel

Test personnel receive training, similar to the training required by ACAD97-014 for simulator instructors/evaluators, prior to initiation of the integrated validation tests. Some components of this training include:

A pilot study is performed prior to the initiation of the V&V process in the simulator. This study is used to test the process for determining adequate design, determining the correct data collection techniques, and verifying appropriate testbed completeness and fidelity.

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Personnel used during pilot testing differ from those used as test participants during integrated validation tests. If a pilot testing participant is used in integrated system validation, the scenario sets must be different from those developed for pilot testing. Participant exposure to the data collection process is minimized.

5.4.7 Data Analysis and Interpretation

Data analysis is conducted in accordance to the established four-tier hierarchical set of performance measures with the greatest weight placed on data coming from the highest performance measure tiers. Analysis is dependent on the type and quality of data that can be acquired. Actual data collection and analysis may be subject to variation during the course of testing.

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For each tier, it can be seen that the performance measures and their associated criteria range from pass/fail ~~quantitative analysis~~decisive criteria at the highest significance level ([[

]]) to ~~a qualitative analysis at~~ the supplemental criteria level.
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To provide additional information, timelines and movement pattern diagrams (when applicable) for each crew are constructed for each simulated scenario using video recordings and visual observation records. Test participants may provide assistance by interpreting videotaped sessions and interrelating recorded events with test data.

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18.11-24 S03 Part C(5)

Additional information collected by test personnel observations regarding qualitative assessments of influencing factors such as lighting level, noise level, communication clarity, HSI information clarity, and other factors that influence detection, analysis, planning and implementation of actions may also be used to better understand results and data.

For performance measures used as pass/fail indicators, failed indicators must be resolved before the design can be validated. Where performance does not meet criteria for supplemental performance measures, the results are evaluated using the HED resolution process.

When making inferences from observed performance to estimated real-world performance, test personnel allow for a margin of error (some allowances are made to reflect the fact that actual performance may be slightly more variable than observed validation test performance).

Verification

Analysis inputs are verified by comparing test personnel observations to each other and by comparing personnel observations to the computer-generated event logs. Data analysis and the conclusions drawn are independently verified.

Establishing Convergent Validity

During data evaluation and analysis, convergent validity can be established by comparing data from performance measures that are intended to measure the same or closely related aspects of performance. ~~For instance, SA ratings from test participants should have moderate to high association with SA ratings from test personnel.~~Likewise, posture data obtained from physical workload performance measures should have moderate to high association with related anthropometric data. 18.11-24 S03 Part D(2)

If instances occur in which two performance measures that are intended to measure the same thing have no apparent association, a HED is entered into the HFEITS.

Controlling Bias

ESBWR subject matter experts and human factors specialists control bias during evaluation stages of design and during validation and verification. The intent is to eliminate sources of bias. When that is not possible, sources of bias are measured, and are included as additional predictors in statistical analysis to statistically control for bias.

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5.5 OUTPUTS AND RESULTS DOCUMENTATION

The output from integrated system testing is validation of the following:

- Integrated procedures.
- Integrated HSIs.
- Integrated training.

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18.11-27 S03 Q1

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18.11-22 S03 Q1

MFN 09-418

Enclosure 3

Response to Portion of NRC Request for

Additional Information Letter No. 309

Related to ESBWR Design Certification Application

Human Factors Engineering

RAI Numbers 18.11-3 S03, 18.11-4 S03, 18.11-19 S03, 18.11-22 S03, 18.11-23 S02, 18.11-24 S03, 18.11-27 S03

AFFIDAVIT

GE-Hitachi Nuclear Energy Americas LLC

AFFIDAVIT

I, Larry Tucker, state as follows:

(1) I Manager, ESBWR Engineering, GE Hitachi Nuclear Energy ("GEH"), and have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in Enclosure 1 of GEH's letter, MFN-09-418 Mr. Richard E. Kingston to U.S. Nuclear Energy Commission, entitled *"Response to Portion of NRC Request for Additional Information Letter No. 309 Related to ESBWR Design Certification Application - Human Factors Engineering - RAI Numbers 18.11-3 S03, 18.11-4 S03, 18.11-19 S03, 18.11-22 S03, 18.11-23 S02, 18.11-24 S03, 18.11-27 S03*" dated July 7, 2009. The proprietary information in enclosure 1, which is entitled "1. MFN 09-418 -Response to NRC Request for Additional Information Letter No. 309 Related to ESBWR Design Certification Application – Human Factors Engineering - RAI Numbers 18.11-3 S03, 18.11-4 S03, 18.11-19 S03, 18.11-22 S03, 18.11-23 S02, 18.11-24 S03, 18.11-27 S03 – GEH Proprietary Information," is indicated as the content contained between opening double brackets ([[) and closing double brackets (]]), and the text is red in color. [[This sentence is an example.[{3}]]]. Figures and large equation objects containing GEH proprietary information are identified with double square brackets before and after the object. In each case, the superscript notation [{3}] refers to Paragraph (3) of this affidavit, which provides the basis for the proprietary determination.

(3) In making this application for withholding of proprietary information of which it is the owner or licensee, GEH relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4), and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.390(a)(4) for "trade secrets" (Exemption 4). The material for which exemption from disclosure is here sought also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by GEH's competitors without license from GEH constitutes a competitive economic advantage over other companies;

b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;

c. Information which reveals aspects of past, present, or future GEH customer-funded development plans and programs, resulting in potential products to GEH;

d. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a. and (4)b. above.

(5) To address 10 CFR 2.390(b)(4), the information sought to be withheld is being submitted to NRC in confidence. The information is of a sort customarily held in confidence by GEH, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GEH, no public disclosure has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge, or subject to the terms under which it was licensed to GEH. Access to such documents within GEH is limited on a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist, or other equivalent authority for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GEH are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information identified in paragraph (2) above is classified as proprietary because it contains details of GEH's design and licensing methodology. The development of the methods used in these analyses, along with the testing, development and approval of the supporting methodology was achieved at a significant cost to GEH.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GEH's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GEH's comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical and NRC review costs comprise a substantial investment of time and money by GEH.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

GEH's competitive advantage will be lost if its competitors are able to use the results of the GEH experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to GEH would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive GEH of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing and obtaining these very valuable analytical tools.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information, and belief.

Executed on this 7th day of July 2009.

Larry Tucker

Larry Tucker
GE-Hitachi Nuclear Energy Americas LLC