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Subject: Response to NRC Request for Additional Information Related to ESBWR Design Certification Application – Human Factors Engineering - RAI Numbers 18.4-26, 18.5-18 S01, 18.6-11, 18.6-12, 18.8-12 S01, 18.8-43 S01, 18.8-44 S01, 18.8-45 S01

Enclosure 1 contains GE-H's response to the subject NRC RAIs 1 transmitted via the Reference 1 letter.

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

Sincerely,



James C. Kinsey
Project Manager, ESBWR Licensing

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URO

Reference:

1. MFN 07-317, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 98 Related to ESBWR Design Certification Application, May 29, 2007*
2. MFN 06-401 - *Response to Portion of NRC Request for Additional Information Letter No. 64 – Human Factors Engineering – RAI Numbers 18.5-1 through 18.5-32, dated October 28, 2006*
3. MFN 06-443 - *Response to Portion of NRC Request for Additional Information Letter No. 71 – ESBWR Human Factors Engineering NEDO-33268, Rev. 1, Human-System Interface Design Implementation Plan – RAI Numbers 18.8-1 through 18.8-49, dated November 20, 2006*

Enclosure:

1. Enclosure 1 - Response to Portion of NRC Request for Additional Information Related to ESBWR Design Certification Application Human Factors Engineering - RAI Numbers 18.4-26, 18.5-18 S01, 18.6-11, 18.6-12, 18.8-12 S01, 18.8-43 S01, 18.8-44 S01, 18.8-45 S01

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Enclosure 1

MFN 07-408

Response to NRC Request for

Additional Information

Related to ESBWR Design Certification Application

Human Factors Engineering

**RAI Numbers 18.4-26, 18.5-18 S01, 18.6-11, 18.6-12, 18.8-12
S01, 18.8-43 S01, 18.8-44 S01, 18.8-45 S01**

For historical purposes, the original text of RAIs 18.5-18 S01, 18.8-12 S01, 18.8-43 S01, 18.8-44 S01, and 18.8-45 S01 and the GE responses are included preceding each supplemental response. Any original attachments or DCD mark-ups are not included to prevent confusion.

NRC RAI 18.4-26

Rev. 0 of NEDO-33219, Sections 7.1 and 7.2 described a method and the documentation that was to be developed for plant performance requirements and for system level functions. Sample tables were provided that included functions, parameters, ranges and limits on parameters, and related comments. This detail was judged to acceptably address NUREG-0711, Section 4, Criterion 4. This information no longer exists in NEDO-33219, Rev. 1, and it is not clear if or where the information on the parameters and functions will be provided when the functional requirements analysis (FRAs) are completed. Section 5 of Rev. 1 provides a brief description of the results summary report but does not include the parameters of Criterion 4. Please clarify where this information will be provided.

GE-H Response

Detailed guidance for the conduct of the Plant Functional Requirements Analysis (PFRA) is contained in the PFRA Work Instruction that has been drafted to implement NEDO-33219, Revision 1. The work instruction requires that the information specified in NUREG-0711, Section 4, Criterion 4 be determined and documented for each high level function. This data for each high level function will be an integral part of the PFRA structure, and as such will be validated and summarized along with the PFRA data structure. A draft copy of the PFRA Work Instruction will be available for review during the on-site audit scheduled for July 25, 2007.

DCD Impact

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

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

NRC RAI Number 18.5-18

(A) *Section 3.6.10, Workload Assessment, states that "[t]o assist in the task assessment and rating, the Table-Data Form (Section 3.6.2) may be used." (p. 56). Explain how this form can be used for workload assessment.*

(B) *Section 3.6.10, Workload Assessment, discusses graphical depictions of workload on p. 56. Provide an example of such a depiction.*

(C) *Section 3.6.10, Workload Assessment, states that "[t]he time is associated with the timeline for each task element (first column of the Figures 13 through 15)." (p. 57). Should this reference be limited to Fig 13?*

(D) *Section 3.6.10, Workload Assessment states that "It is usually acceptable to have very short periods of high workload. As a rule of thumb, for sustained tasks, workloads of between 50% and 75% can be considered acceptable." (p. 58). What is the technical basis for this statement? Also, if the analysis is limited to system level task analyses, how can the overall workload level be assessed, given that operators are often performing multiple tasks involving more than one system?*

(E) *Section 3.6.10, Workload Assessment, states that "Workload differences measured by physiological means must be used to infer that performance breakdown would result or to infer how the operator would feel about the task.." (p. 62). Please clarify this statement. Section 3.6.10, Workload Assessment, provides a discussion of many different approaches to workload measurement. Which approach will the ESBWR analysis use?*

GE Response

In general the most important workload assessments will be for risk important actions involved in managing accidents. For other actions during normal operation the schedule can be adjusted to match standard crew member availability. Thus, the workload assessment involves developing a basis for estimating the ratio of being involved in necessary tasks to the time available during event scenarios. This approach follows the Addendum to RAIs 18.5 and will be reflected in the next revision of NEDO 33221. This addresses all of items above. In addition:

(A) The inputs to the time required to carry out a task considers information from the TA results which are presented in Appendix A. The main data will be timing estimates for each task assigned to a specific person or job category. This will be clarified in the next revision of NEDO 33221.

(B) In complex activities a graphical depiction of workload would illustrate the paths that each individual in the control room and the plant would take to verify conditions, to read instruments, and to operate controls or valves. This tool may be used for complex risk important actions that need special evaluation. Such an example will be provided in the task analysis report, if it used to illustrate the complexity of actions in dealing with an

accident scenario. It is expected that design simplifications will be made prior to developing this graphical workload illustration.

(C) Figure 13 Sheets 1 – 3 provides the example of the graphical depiction of workload.

(D) Yes, the timeline reference is Figure 13 or an equivalent. The task performed during normal operation have flexibility in scheduling whereas actions required during event scenarios are time limited with little flexibility. The analysis using PRA/HRA defined scenarios and TA critical actions (Enclosure 2, Addendum to RAIs 18.5) will be used to identify multiple actions in more than one system. These tasks will be examined in detail using a work load assessment.

(E) As outlined in Enclosure 2, Addendum to RAIs 18.5, the top down High-level FRA, AOF and TA approach will identify multiple tasks that will need to be performed during the same time interval. The reference for the workload measurement statement comes from Meister, David (1985). Behavioral Analysis and Measurement Methods. New York: John Wiley & Sons [ISBN 0-471-89640-3]. This reference will be added to the reference listing in NEDO-33221. A technical basis for the statement about workload acceptability can also be found in NUREG/CR-1278, 1983 chapter 17. The discussion relates workload as a contributing performance factor to stress when estimating human error probabilities. The optimum stress is in the midrange of workload activities. The evaluation will consider the qualitative impact of cognitive and physical energy expended during emergency task performance and over time prior to an emergency event, the number and duration of rest periods during the day, and length of the workday for the routine tasks that have a flexible schedule.

(F) It is expected that workload differences measured by physiological means is used as a last resort. This judgment basis process supports analysis of complex high risk actions such as those involving fire scenarios.

(G) The ESBWR FRA, AOF and TA will start with the top-down approach to ensure that time and human resources are sufficient to address tasks in risk important event scenarios. One or more of methods described in NEDO-33221 will be selected to address the complexity and timing of the actions as appropriate for the case being analyzed. For example, timing analysis of human actions using operational sequence diagrams (OSDs) may be based on the cue from the displayed information, the cognitive workload and operator control actions assigned to each CR staff against a postulated scenario time/event-line that defines the human response requirements.

DCD/LTR Impact

LTR NEDO-33221, Rev 0 will be revised as described above.

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

NRC RAI 18.5-18 S01

The response states " the workload assessment involves developing a basis for estimating the ratio of being involved in necessary tasks to the time available during event scenarios. This approach follows the Addendum to the TA RAIs 18.5 and will be reflected in the next revision of NEDO 33221." Please clarify what ratio being identified. Does this mean the workload is defined in terms of time? In addition, clarify what is meant by the approach following the Addendum. The Addendum does not discuss workload.

The response to Subquestion B states "In complex activities a graphical depiction of workload would illustrate the paths that each individual in the control room and the plant would take to verify conditions, to read instruments, and to operate controls or valves." How does such a path analysis relate to workload, especially if workload is defined in terms of time? Also, the ESBWR control room is primarily a computer-based control room where operators perform most of their tasks at sit-down workstations. How will such an analysis be useful?

The response to Subquestion D (labeled E in the responses - see format note below) referenced Swain and Guttman and Meister (1985) as the source of the criteria for acceptable workload. We were unable to locate the criterion in Swaine and Guttman and Meister. Please provide more a more specific reference.

The response to Subquestion E (labeled F in the responses - see format note below) on physiological workload is still unclear. What types of physiological measures of workload are planned and how they will be evaluated? Side note on format: In the interest of facilitating communication and avoiding confusion - the NRC RAIs are not reproduced quite right. In the last paragraph, "Please clarify this statement" belongs to Subquestion E. And the remainder of that paragraph is Subquestion F. In GE's responses, Response C is really the last sentence to Response B. Then the remaining responses, labeled D through F, should be labeled C through E.

GE-H Response

The addendum refers to the revised operations analysis approach, and the response was intended to state that the workload assessment approach will be integrated into the new approach. The paths referenced in the response was intended to imply that the activities derived from the task analysis and assigned to specific operators would be tracked. In previous approaches the tool for this use was called the operational sequence diagram (OSD), and this supported both spatial and timeline analysis.

A revised approach will not rely on OSDs, but will be integrated into the task analysis.

The task analysis form will collect information concerning workload and perform an initial screening of the task demands on the operator. Workload will be addressed for both physiological and cognitive demands. The tasks that exceed a threshold score will be documented as HEDs and assigned to the Human Factors specialists for evaluation and possible corrective actions. A brief summary follows; the proprietary process will be documented in the task analysis work instruction and will be available in the near future. A draft approach to workload analysis and the draft task analysis data gathering tool which will be used in the workload screening will be available for review at the July 25, 2007 audit.

Project Senior Reactor Operators (SROs) will identify the tasks and rate the estimated physical [e.g., force, posture, repetitive or prolonged exertions] and cognitive [e.g., attentional resource demand, flexible (operator paced) vs. time critical (process driven) scheduling] demands. A total score based on criteria established for each workload factor is established. HEDs will be written for tasks which exceed a raw score threshold.

As the analysis moves from normal to abnormal and emergency operations, it is expected that higher cognitive workload scores may result. Higher physiological scores may result when activities outside the control room are analyzed during the economic phase of the task analysis.

Finally, individual crew members will be allocated to perform a series of the tasks in response to defined events. The task workload demands for each operator will be examined to determine if sufficient time is available to perform the task sequence given the initial workload demands. For a given workload demand, a time interval will be established for the performance of the task. If the number of decisions and/or control actions within a specified period exceeds threshold values, then HEDs will be generated for evaluation by the human factors specialists. Likewise, physiological demands will be examined for the cumulative effect of the combined physical stresses.

DCD Impact

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

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

NRC RAI 18.6-11

NEDO-33266 addresses the minimum staffing of 10 CFR 50.54(m)(2)(i). The other staffing aspects of 50.54 are contained in 50.54(i) through (m) and are typically addressed in Chapter 13, Conduct of Operations, of an SAR/DCD. These other aspects are not discussed in either Chapter 13 or Chapter 18 of the ESBWR DCD or in NEDO-33266. Section 13.1 of the ESBWR DCD, Organizational Structure of the Applicant, states that this section is the responsibility of the COL applicant. Please provide a COL item for Chapter 18.6 that addresses the COL's responsibility to provide a full explanation of compliance with 50.54(i) through (m).

GE-H Response

Chapter 18 DCD in sections 18.6.5 and 18.6.6 provides commitment to compliance with 10 CFR 50.54 (i) through (m). DCD section 18.6.6 describes the Staffing and Qualifications results summary report as including an output that demonstrates compliance with 10 CFR 50.54. This report is ITAAC item 4 in Table 3.3-1, DCD Tier 1. The NEDO-33266, section 1.2, references CFR 50.54m and addresses the staffing and qualification requirements to support the operation of the ESBWR. The operational criteria represented in 10 CFR 50.54 (i) through (m) falls within the scope of Chapter 13.

Chapter 13 will be revised to address commitment to the operational aspects of 10 CFR 50.54 (i) through (m) in section 13.1.1. Section 13.1.1 COL Information will be revised as follows:

13.1.1 COL Information

COL applicant referencing the ESBWR will submit documentation that demonstrates that their organizational structure is consistent with the ESBWR Human Factors Engineering (HFE) design requirements and complies with the requirements of 10 CFR 50.54 (i) through (m).

DCD Impact

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

DCD Tier 2, Section 13.1.1 will be revised as noted above.

NRC RAI 18.6-12

Rev. 3 to DCD, Section 18.6 provides a high-level description of the Staffing and Qualifications for the ESBWR. More detail is provided in NEDO-33266. One area was noted where a discrepancy exists between the two documents. DCD Section 18.6.2 and the Plan both list the categories of personnel addressed by the staffing and qualifications program in accordance with 10CFR 50.120. However, Section 18.6.2 is missing the shift technical advisor (STA). This should be corrected.

GE-H Response

DCD Section 18.6.2 will be amended in revision 4 to read:

“The personnel considered are addressed in the scope and addresses licensed control room operators as defined in 10 CFR 50.54 and the categories of personnel defined by 10 CFR 50.120 including non-licensed operators, shift supervisor, shift technical advisor, instrument and control technicians, electrical and mechanical maintenance personnel, radiological protection technicians, chemistry technicians, and engineering support personnel.”

DCD Impact

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

DCD Tier #2, Section 18.6.2 will be revised as noted above.

NRC RAI 18.8-12

NEDO-33268, p. 29 states that the information processing functions should support "Expanding availability information to cover implicit data." Please clarify this statement.

GE Response

The phrase *"Expanding availability information to cover implicit data."* is being removed from NEDO-33268.

DCD Impact/LTR Impact

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

LTR NEDO-33268 Rev. 2 will include a revision as described above.

NRC RAI 18.8-12 S01

The response is OK and we will need to confirm its incorporation in the NEDO modification.

GE-H Response

GE-H original response stated that the phrase *"Expanding availability information to cover implicit data."* is being removed from NEDO-33268.

GE-H has released Rev. 2 to NEDO-33268 prior to implementing this change. This change will be implemented at the next revision to the plan.

DCD Impact

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

LTR NEDO-33268, Rev 3 will be revised as described above.

NRC RAI 18.8-43

NUREG-0711 Section 8.5 references several other regulatory documents that specify HSI-related systems in the control room or other control facilities for the power plant.

Please describe the ESBWR-specific implementation of HSI for the following six key aspects of the plant HSI:

- 1. Provision for periodic testing of protection systems actuation functions, as described in Regulatory Guide 1.22.*
- 2. Bypassed and inoperable status indication for NPP safety systems, as described in Regulatory Guide 1.47.*
- 3. Manual initiation of protective actions, as described in Regulatory Guide 1.62.*
- 4. Instrumentation for light-water-cooled nuclear power plants to access plant and environmental conditions during and following an accident, as described in Regulatory Guide 1.97.*
- 5. Instrumentation setpoints, as described in Regulatory Guide 1.105.*
- 6. HSIs for the emergency response facilities (TSC & EOF), as described in NUREG-0696.*

GE Response

These six key aspects of the plant HSI are in the design phase and as development and implementation unfolds such questions can be answered. These provisions will be added as pre-operational testing requirements in NEDO-33268 to be addressed in the activity and the methodology and results will be summarized in the results summary report.

DCD Impact/LTR Impact

DCD changes will be revised as appropriate.

LTR NEDO-33268 Rev. 2 will include a revision as described above.

NRC RAI 18.8-43 S01

The response indicates that the methodology will go in the results report, but it should be in the NEDO.

GE-H Response

GE-H has released Rev. 2 to NEDO-33268 prior to implementing this request. The NEDO-33268 will be amended in the next revision to include the following references from the RAI in the Regulatory Guidelines listed in section 2.3: RG 1.22, RG 1.47, RG 1.62, RG 1.105 (RG 1.97 and NUREG-0696 are already referenced).

Also a paragraph will be added to section 3.1.3 before the last paragraph to read:

“In addition, the HSI design for the control room and applicable facilities addresses the guidance for the following six key aspects of the plant HSI:

- ***Provision for periodic testing of protection systems actuation functions, as described in Regulatory Guide 1.22.***
- ***Bypassed and inoperable status indication for NPP safety systems, as described in Regulatory Guide 1.47.***
- ***Manual initiation of protective actions, as described in Regulatory Guide 1.62.***
- ***Instrumentation for light-water-cooled nuclear power plants to access plant and environmental conditions during and following an accident, as described in Regulatory Guide 1.97.***
- ***Instrumentation setpoints, as described in Regulatory Guide 1.105.***
- ***HSIs for the emergency response facilities (TSC & EOF), as described in NUREG-0696.”***

DCD Impact

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

LTR NEDO-33268, Rev 3 will be revised as described above.

NRC RAI 18.8-44

NEDO-33268 discusses the Safety Parameter Display System (SPDS) for ESBWR and compares it to NUREG-0737, not the more recent set of criteria in NUREG-1342, 1989 and NUREG-0700, Revision 2, Section 5, 2002. Please provide information on how the proposed implementation of SPDS for ESBWR compares to the criteria of NUREG-0700, Revision 2, Section 5.

GE Response

As the SPDS design evolves, the regulatory guidance will be met as appropriate and will follow the most current relevant criteria as set forth in NUREGs and other industry specific documents. These most recent criteria identified in the question will be added in NEDO-33268.

DCD Impact/LTR Impact

No DCD changes will be made in response to this RAI.
LTR NEDO-33268 Rev. 2 will include a revision as described above.

NRC RAI 18.8-44 S01

The response is OK and we will need to confirm its incorporation in the NEDO modification.

GE-H Response

GE-H has released Rev. 2 to NEDO-33268 prior to implementing this response. The NEDO-33268 will be amended in the next revision to include NUREG-1342 as a reference in the Regulation Guidelines listed in section 2.3.

Also section 3.3.5.18 SPDS, paragraph 2 will be amended to read:

“All of the continuously displayed information necessary to satisfy the requirements for the SPDS are included in the fixed-position displays and the SPDS design is implemented using the guidance from NUREG-0737, Supplement 1, NUREG-1342 and NUREG-0700 Rev 2, section 5 to confirm that all applicable criteria are met.”

DCD Impact

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

LTR NEDO-33268, Rev 3 will be revised as described above.

NRC RAI 18.8-45

NEDO-33268 states that the SPDS "may" be provided in the TSC and "optionally" in the EOF. However, NUREG-0696, Section 8, Emergency Response Facility Integration, specifies that the variables displayed by SPDS and the RG 1.97 Type A, B, C, D, & E variables shall be available for use in the TSC and the EOF. Please update the document to address this or provide justification as to why your proposal is acceptable.

GE Response

The words "may" and "optionally" will be deleted in the revision to NEDO-33268. The SPDS variables that are displayed in the MCR will be available in the TSC and EOF.

DCD Impact/LTR Impact

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

LTR NEDO-33268 Rev. 2 will include a revision as described above.

NRC RAI 18.8-45 S01

The response is OK and we will need to confirm its incorporation in the NEDO modification.

GE-H Response

GE-H has released Rev. 2 to NEDO-33268 prior to implementing this response. The NEDO-33268 will be amended in the next revision to delete the words "may" and "optionally" with regard to providing the SPDS in the TSC and EOF.

DCD Impact

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

LTR NEDO-33268, Rev 3 will be revised as described above.