GE Energy

David H. Hinds
Manager, ESBWR

PO Box 780 M/C L60
Wilmington, NC 28402-0780
USA

T 910 675 6363
F 910 362 6363
david.hinds@ge.com

MFN 06-403

Docket No. 52-010

October 27, 2006

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555-0001

Subject: **Response to Portion of NRC Request for Additional Information Letter No. 64 – Human Factors Engineering – RAI Numbers 18.7-1 through 18.7-15**

Enclosure 1 contains GE's response to the subject NRC RAIs transmitted via the Reference 1 letter. Enclosure 2 contains markups of the changes to the DCD for RAIs 18.7-14 and 18.7-15.

If you have any questions about the information provided here, please let me know.

Sincerely,

Kathy Sedney for

David H. Hinds
Manager, ESBWR

D068

Reference:

1. MFN 06-352, Letter from U.S. Nuclear Regulatory Commission to David Hinds, *Request for Additional Information Letter No. 64 Related to ESBWR Design Certification Application*, September 25, 2006

Enclosure:

1. MFN 06-403 – Response to Portion of NRC Request for Additional Information Letter No. 64 – Related to ESBWR Design Certification Application Human Factors Engineering NEDO-33267, Human Reliability Assessment Program – RAI Numbers 18.7-1 through 18.7-15
2. MFN 06-403 - Response to Portion of NRC Request for Additional Information Letter No. 64 Related to ESBWR Design Certification Application Human Factors Engineering NEDO-33267, Human Reliability Assessment Program Markup Changes for RAIs 18.7-14 and 18.7-15

cc: AE Cubbage USNRC (with enclosures)
GB Stramback GE/San Jose (with enclosures)
eDRF 0000-0059-6716

ENCLOSURE 1

MFN 06-403

Response to Portion of NRC Request for

Additional Information Letter No. 64

Related to ESBWR Design Certification Application

Human Factors Engineering
NEDO-33267, Human Reliability Assessment Program

RAI Numbers 18.7-1 through 18.7-15

NRC RAI Number 18.7-1

The "Purpose" statement included in the HRA Plan states that the Plan describes "how information generated by HRA tools can be used *to support the [human system interface] HSI HFE design goals." The use of this verb implies that applicant does not necessarily need to use the information and that it's merely provided for consideration. Neither the statement (nor the Plan) commit to using the information.*

GE Response

The purpose will be changed to "how information generated by HRA tools *are used* to support the [human system interface] HSI HFE design goals when use of the HSI impacts a significant accident sequence defined in the PRA."

DCD/LTR Impact

LTR NEDO-33267, Rev 0 will be revised as described above.

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

RAI Number 18.7-2

Pages 12-15. What is the origin of the error taxonomy used (i.e., type A, B, C)?

GE Response

This nomenclature was developed to help organize the relationship between the HRA models and the incorporation into the PRA structure. An initial taxonomy was used in EPRI NP-3583 Systematic Human Action Reliability Procedure (SHARP) as 1,2,3,4,5, but was revised to match with pre-, initiator- and post- actions as A, B, and C in EPRI Report TP-101711 (1992) SHARP1. This nomenclature has been applied in many utility PRA submissions to simplify the naming of the error types associated with pre-, initiator- and post- actions, and will be added to the appropriate definitions in the next revision to NEDO-33267.

DCD/LTR Impact

LTR NEDO-33267, Rev 0 will be revised as described above.

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

NRC RAI Number 18.7-3

Page 18. NUREG-1792 is available as of April 2006. Please, reference current version.

GE Response

We will update the reference to NUREG-1792 in the next revision of NEDO-33267. It will be:

> NUREG-1792, Good Practices for Implementing Human Reliability Analysis (HRA), April 2005.

This document is publicly available on the NRC web site.

DCD/LTR Impact

LTR NEDO-33267, Rev 0 will be revised as described above.

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

NRC RAI Number 18.7-4

Page 10, 1.3, "Definitions," what is meant by, "IEEE Working Group?"

GE Response

This definition comes from the NPEC IEEE working group 5 for reliability and human factors working on P1574 "IEEE Recommended Practice for Conducting Human Reliability Analysis for Nuclear Power Generating Stations". The next revision of NEDO-33267 will replace (IEEE working group) with (NPEC IEEE WG 5 on P1574, 2006).

DCD/LTR Impact

LTR NEDO-33267, Rev 0 will be revised as described above.

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

NRC RAI Number 18.7-5

Page 20, reference 20. Is this a publically-available document?

GE Response

The full document is no longer provided by EPRI, however, a comprehensive summary is in the Public Conference record for 1985 IEEE Third Conference on Human Factors and Nuclear Safety, June 23-27, 1985, Monterey, California / editor, Edward W. Hagen. "A Model for Assessing Human Cognitive Reliability in PRA studies," Hannaman, Spurgin and Lukic. The IEEE reference will be substituted for the EPRI reference.

DCD/LTR Impact

LTR NEDO-33267, Rev 0 will be revised as described above.

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

NRC RAI Number 18.7-6

Page 21, states that the "robustness of the HRA depends, in large part, on the analyst's understanding..." How does GE's HRA Plan ensure that the applicants (for design certification and COL) meet this objective, i.e., have qualified analysts?

GE Response

The GE HFE team incorporates sufficient expertise to accomplish this detailed HRA process by including NRC licensed SROs, and engineers/analysts who have performed or managed maintenance activities, have reviewed events and classified human errors, have observed simulated accidents, and have developed procedures.

NEDO-33267 will be revised by creating a new second bullet in Section 3 from the second sentence in bullet one and incorporating the response above. The added bullet is:

> "The robustness of the HRA depends, in large part, on the analyst's understanding of personnel tasks, the information related to them, and the factors, which influence human performance."

Accordingly, the GE HFE team incorporates sufficient expertise to accomplish this detailed HRA process by including NRC licensed SROs, and engineers/analysts who have performed or managed maintenance activities, have reviewed events and classified human errors, have observed simulated accidents, and have developed procedures."

DCD/LTR Impact

LTR NEDO-33267, Rev 0 will be revised as described above.

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

RAI Number 18.7-7

NEDO-33267 and DCD Tier 2, Chapter 18.7 state in several places that the PRA/HRA will provide a listing of potentially risk-important human interactions for use in several portions of the HFE program. The initial PRA/HRA for ESBWR has been completed and submitted to NRC along with Chapter 19 of the DCD. Therefore, sufficient information is available to develop the initial list of risk important actions using the methods discussed in this report. The PRA and DCD Chapter 19 provide very informative lists of risk important structures, systems and components (SSCs), however they note in several places that human actions are not included. It is not clear why human actions were excluded from these importance listings and are not in NEDO-33267. Please provide the initial list of risk important human actions.

GE Response

Risk important operator actions developed from the PRA rev. 1 are listed in Tier 2 Chapter 19 Rev 1, September 2006, in Table 19.2-3 on Risk Insights and Assumptions. The use of the PRA/HRA in human factor engineering (HFE) is an iterative process, and this initial listing will be enhanced with additional actions as the design matures. For example, system level actions that are included within system level reliability models of the design level PRA do not specifically separate the automatic versus manual actions. This use of generic failure rate estimates for the structures, systems and components is adequate for estimating the overall risk in terms of the top down level 1 and 2 PRA. However, an enhanced listing of human actions requires the allocation of manual versus automated actions in each system and modeling within the PRA to expand the initial risk importance listing.

The HRA plan indicates that a process will be established to enhance this listing as an iterative tool to pass between the HFE/HRA assessments and the PRA/HRA risk evaluation. The list will be dynamic as HSI design features are established, and will be upgraded as the design details are established and modeled in the PRA. Listings of risk important actions in Table 19.2-3 will be further enhanced through implementation of the HFE HRA plan.

Reference to Table 19.2-3 in Tier 2 Chapter 19 Rev 1, September 2006 will be provided in the next revision to section 5.2 second paragraph of NEDO-33267.

> "The initial baseline ESBWR PRA study which is described in the ESBWR DCD Chapter 19 will be used as the starting point for defining risk important human actions (e.g., Table 19.2-3 in Tier 2 Chapter 19 Rev 1, September 2006)."

Also the reference for chapter 19 will be updated.

DCD/LTR Impact

LTR NEDO-33267, Rev 0 will be revised as described above.

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

RAI Number 18.7-8

NEDO-33267, Section 4, states that, "These analyses will use a variety of importance measures and HRA sensitivity analyses assumptions to ensure that risk important actions are not overlooked." However, the particular importance measures to be used and the acceptance criteria (or cutoff values), for determining which human actions (HAs) are risk important, are not given in the report. It is noted that cutoff values, using the risk achievement worth (RAW) and Fussell-Vesely (FV) importance measures (IMs), are specified in DCD Tier 2, Section 19.5.2 for important SSCs. Please provide the IMs and the criteria to be used for determining the risk important HAs.

GE Response (see also RAI 18.7-10 bullet 5)

The PRA takes advantage of the specialized ranking tools that can be used to rank the inputs to the PRA model relative to their importance. For example, the following three processes are used within the PRA models to determine the importance of human actions that are modeled as basic events. These are:

(1) Fussell-Vesely (FV) Importance is the relative contribution to the system failure probability from a basic event failure at its estimated failure probability,
(2) Risk Achievement Worth (RAW) is the factor increase in the system failure probability when a basic event (or group of basic events) is assumed to be failed, and
(3) Risk Reduction Worth (RRW) is the factor decrease in the system failure probability when a basic event (or group of basic events) is assumed to succeed.

These importance evaluation processes represent simple ways of evaluating the impact of human errors that are represented in the PRA model on the top event such as system availability or core damage frequency (CDF). Other forms of importance measures have been developed. When human action basic events are in cutsets below the top 1000 contributors and the CDF (or large early release frequency (LERF)) is well within the NRC guidelines in RG 1.174, then the human action basic events are not considered risk important. Sensitivity analysis is given to human action basic events in the top 100 risk contributors using any of the importance measures described. This discussion will be added to Section 4 in the next revision to NEDO-33267.

DCD/LTR Impact

LTR NEDO-33267, Rev 0 will be revised as described above.

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

RAI Number 18.7-9

The ESBWR PRA, as submitted, includes both Level 1 and Level 2 analyses and both internal and external events analyses. Clarify why NEDO-33267 does not specifically commit to use all of these analyses in determining the risk important HAs.

GE Response

Because this is a first time application of PRA/HRA to support HFE during the design phase we identify possible methodologies that will match the top down approach in levels 1 and 2 internal and external events PRAs to the bottom up approach used in task analysis. This match up is expected to result in refinements to the proposed methods in NEDO-33267. The development of the importance listing will consider the inputs from levels 1 and 2 of the internal and external events PRA models. The next revision of NEDO-33267 will clarify commitments by making the following changes to the Section 1.2 bullets.

First bullet, new will reference the text provided in RAI 18.7-6 to address the multidisciplinary team:

> "Using a multidisciplinary team as described in Section 3 to analyze human actions within the context of the PRA."

Second bullet, current 1st bullet modified:

> "Developing a process for using PRA/HRA (e.g., level 1, level 2, internal and external events) to support the design of the ESBWR HSI. An initial working process is shown in Figure 2."

Third bullet, current 2nd bullet unchanged.

Fourth bullet, new:

> "Clarifying the role of operators, through obtaining design information related to factors that affect human performance."

Fifth bullet, current 3rd bullet unchanged.

Sixth bullet, current 4th bullet modified to insert the word "probabilistic":

> "Iterating with the probabilistic risk assessment, ..."

The final three bullets remain unchanged.

DCD/LTR Impact

LTR NEDO-33267, Rev 0 will be revised as described above.

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

RAI Number 18.7-10

Several areas of NEDO-33267 were not sufficiently clear:

***Bullet item* from RAI and GE Response**

- *Section 1.1, Purpose, contains a paragraph and 5 bullets that address Regulatory Guide (RG) 1.174. Please clarify the relation of this to the HRA implementation plan.*

These bullets from RG 1.174 provide a framework for interpreting and evaluating changes in risk when design choices are made for the MMIS during the design process.

- *Section 3, 2nd sentence, states "If such a PRA/HRA model is developed,..." Since the model is already developed, clarify the use of the word "if"*

To show that the ESBWR meets the risk goals during the design it may not be necessary to develop detailed HRA models for more than a few actions. With additional detailed PRA/HRA modeling, the plant operators would be able to monitor risk from the control room. The development of this HSI feature is being considered as a possible Main Control Room feature for the ESBWR that has not been included in the base design scope of the previous ABWRs and BWRs.

- *Section 3, first bullet, states that the PRA/HRA will be performed early in the design process. It also discusses iterative nature of the PRA/HRA and how it will be updated as the design progresses. Please clarify where the Rev. 1 PRA submitted for ESBWR, is on this time line.*

The Rev. 2 PRA will include the identification of human actions that are required to start and stop systems, and special actions needed to initiate passive cooling features (e.g., manual depressurization, back up to automatic triggering of the squib valves for gravity feed, etc.) and quantification via HRA screening methods. Detailed HRA modeling will incorporate actions identified from the top down PRA/HRA and bottom up design features considered in the task analysis. PRA version 1 has been submitted without interactions with the HFE team, it will be the starting point for these interactions. The PRA Rev. 2 timeline is being developed and will include interactions with the HFE team.

- *Section 4, HRA Methodology, on p. 23 & 24, discusses HRA aspects and approaches, but contains a combination of items that are: completed, will be done, may be done, and others that appear to be listed as "good approaches." The mix of various verbs is confusing. Please clarify your commitment to these various items. In addition, the discussion that begins on p.23 of the "several analysis components..." merely appears to list and describe these components, but does not explicitly state that the GE HRA will include/address these components. Please clarify.*

The discussion on pages 23 & 24 provides information about various approaches to be used to meet commitments during the HRA implementation process. The verb tenses will be reviewed and changed to present tense to reflect commitments in the next revision of NEDO-33267. Each bullet element in section 4 represents a methodology element commitment that the GE human factor team will use in evaluating the risk important actions identified for the ESBWR.

- *Page 27, please explain what are the "ranking tools."*

The PRA takes advantage of the specialized ranking tools that can be used to rank the inputs to the PRA model relative to their importance. For example, the following three processes are used within the PRA models to determine the importance of human actions that are modeled as basic events. There are: (1) Fussell-Vesely (FV) Importance is the relative contribution to the system failure probability from a basic event failure at its estimated failure probability, (2) Risk Achievement Worth (RAW) is the factor increase in the system failure probability when a basic event (or group of basic events) is assumed to be failed, and (3) Risk Reduction Worth (RRW) is the factor decrease in the system failure probability when a basic event (or group of basic events) is assumed to succeed. These importance evaluation processes represent simple ways of evaluating the impact of human errors that are represented in the PRA model on the top event such as system availability or core damage frequency.

- *Section 5.3.1, 5.3.2 and 5.3.3 list "assumptions" for aspects of the HRA. These activities should be characterized as commitments (or in some cases design goals of the HSI) rather than as assumptions.*

These items are listed as assumptions in the ASME PRA standard for PRAs on completed plants and should remain as assumptions for plants analyzed during the design.

- *On page 31, the next to last paragraph is not clear. Should there be an "or" between "...accident sequences" and "become a direct cause of an initiating event?"*

There should be an "or" and this will be changed in the next revision of NEDO-33267.

- *Page 33, paragraph that begins, "Example models for performing detailed estimation..." The Plan does not seem to provide the applicant with direction on how to select the model(s) to use for performing an HRA or HEP estimation. Please clarify/explain.*

The models shown in Appendix A provide a basis for making basic event HEP estimates at different stages of the design, for different action types (e.g., pre-, post-, and initiator triggers), and for different levels of detail (i.e., some of the detailed models are very expensive to use on a action by action basis). The process is to select a model that does not exceed the amount of the information available at the time of the update. If the simple model is sufficient, it can remain in place (for actions that are not risk important) even as the more detailed models are applied to the high risk contributor human actions.

The 3rd sentence of the last paragraph on page 33 will be corrected in the next revision of NEDO-33267 by inserting the word "on" as follows:

> "When estimating HEPs the impact of performance shaping factors on the following ..."

- *Page 37, Figure 1 does not show HRA as being an input to PRA. However, Figure 2 does and page 26, paragraph 2 states that HRA is input to the PRA. Please reconcile/correct.*

The intent of Figure 1 is to show how the HFE HRA task interacts with the HFE tasks assuming a fixed PRA version following the recommendation in NUREG/CR-0711R2. A reverse arrow will be added to this figure in the next revision of NEDO-33267 to illustrate the potential changes to the PRA base model driven by information in the task analysis and results on V&V tests.

- *Page 38, Figure 2. In the box titled, "HRA Update Evaluation," are there arrows missing to show information flow? Please clarify.*

The arrows within the box entitled HRA Update Evaluation were left out on purpose, because the type and nature of this change loop can involve a number of different conditions. The boxes within HRA Update Evaluation provide activities that can be performed individually or in a group. Arrows would imply a specific order, which is not intended in this figure.

- *Page 42. First paragraph begins with, "This paper illustrates..." Clarify what paper is being referenced.*

The word "paper" will be changed to "appendix" in the next revision of NEDO-33267

DCD/LTR Impact

LTR NEDO-33267, Rev 0 will be revised as described above.

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

RAI Number 18.7-11

Section 3 & 5.1 of NEDO-33267 state that "The HRA task will interact with the HFE verification and validation program to provide test scenarios and updating quantitative evaluations based on validation results." This does not provide enough detail to verify that HRA assumptions such as decision making and diagnosis strategies for dominant sequences will be validated by the verification and validation (V&V) program as discussed in NUREG-0711 Criterion 4. Section 4 of NEDO-33267, 2nd bullet on p. 23, provides more detail on this issue, but it is stated as "may be." Clarify why the validation of important HRA assumptions are stated as "may be" and not as a commitment.

GE Response

The words "may be" in the 2nd bullet on page 23 will be changed to "shall be" in the next revision of NEDO-33267.

Also the following changes for NEDO 33267 section 5.2.3 are planned for the next revision: (1) HRA inputs include descriptions .... (2) HRA assumptions in risk important actions involving diagnosis, decision-making, and planning and implementation strategies during accident responses will be validated by techniques such as event simulations using experienced crews, or walkthrough analyses using personnel with operational experience to apply procedures for specific scenario conditions. (3) The walk through validation process does not exclude the use of a plant-specific control room mockup or simulator. (4) Such reviews also support final quantification of the PRA/HRA.

DCD/LTR Impact

LTR NEDO-33267, Rev 0 will be revised as described above.

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

NRC RAI Number 18.7-12

Page 26. In the discussion of human error probabilities, the assumption for screening is that "time" is the most important performance shaping factor. Why? Is that always true?

GE Response

As stated on page 26, time is considered as the basis for the HRA screening values for the current stage of the ESBWR design. This is because at this stage of the design the timing of transients, based on water volumes planned for the design, can be better estimated than other performance shaping factors that depend on the details of the HSI. If operators make errors during an event, time available to perform the action gives operators the time resource for making corrective actions. Thus, time available for action is an important performance factor and very useful for screening analysis when details of the HSI such as correct cues for action, procedures, training, implementation process and feedback on actions taken are yet to be established. As the allocation of the functions and HSI details become available for each system and the plant as a whole, the HRA models can be refined to explicitly address other performance shaping factors. These more detailed models may show that time available becomes less important and the HRA model becomes dominated by lack of a cue, poor procedures, lack of training, difficult implementation procedure or no feedback on the action taken. Thus, time is not always the most important performance shaping factor and this will be determined during the detailed HRA modeling.

The following sentence will be added to NEDO-33267 section 5.2.1 paragraph 3 as sentences 2 and 3. "The time available for an action is based on water volumes available to remove heat under the scenario conditions. Sources of water that contribute to time for action are contained in the reactor vessel, the suppression pool, gravity driven cooling supply pool, reactor water cleanup and shutdown cooling, and the auxiliary fuel pool."

DCD/LTR Impact

LTR NEDO-33267, Rev 0 will be revised as described above.

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

NRC RAI Number 18.7-13

Page 29. It seems that there is text missing in second bullet at top of page. Please clarify.

GE Response

The bullet should be:

- Evaluate dependencies at a detailed level (e.g. sequence, timing, procedures, training, and MMIS).

The missing text is "MIS)."

The bullet will be revised at the next revision of NEDO-33267.

DCD/LTR Impact

LTR NEDO-33267, Rev 0 will be revised as described above.

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

NRC RAI Number 18.7-14

The Tier 1 inspections tests analysis and acceptance criteria (ITAAC) for HRA is in Table 3.3-1, Item 8. Item 8.a relates to developing an HRA plan, which has already been completed and is being reviewed as part of design certification of the ESBWR. Therefore 7.a does not belong in the ITAAC. Item 7.b relates to the implementation of the HRA itself. This should be modified to be implementation of the HFE HRA Plan and should be constructed following the guidance on the Standard Review Plan (SRP) Section 14.3.

GE Response

This RAI requests Tier 1 or ITAAC changes and/or additions; therefore, it has been reviewed per GE internal Tier 1 content determination guidelines, which are based on draft SRPs 14.3 through 14.3.11 and DG-1145 (as of July 31, 2006). This response is provided consistent with those guidelines.

DCD, tier 1, Table 3.3-1 Item 8.a
Agree. All of the HFE implementation plans identified in Table 3.3-1 have been submitted for NRC review. In DCD Tier 1 Table 3.3-1, the 8.a entry will be deleted at the next revision as shown in Enclosure 2.

DCD, tier 1, Table 3.3-1 Item 8.b
SRP section 14.3 Appendix A Section IV.B.2.c Column 3, acceptance criteria in the second paragraph states, " For example, the acceptance criteria for the design integrity of piping and structures may be that a report exists that concludes the design commitments are met."

NEDO-33267 commits to providing documentation (in a report) of the HRA suitable for review of the process with example details. This level of detail is commensurate with the safety significance of the human actions evaluated [SRP Section 14.3 guidance].

Based on the availability of the HRA documentation no changes will be made to the DCD, tier 1 Table 3.3-1 item 8b as per your request.

DCD/LTR Impact

DCD Tier 1, Table 3.3-1 will be revised as noted in Enclosure 2.

RAI Number 18.7-15

The bullet items in Section 18.7.3 are characterized as "analysis components that increase the quality of the HRA." Clarify why these items are not described as they "will be" accomplished for ESBWR.

GE Response

The bullet items appear on pages 23 and 24 of NEDO-33267 and the DCD 18.7.3. The level of detail listed for some of the bulleted items may not be needed to address all HRA elements for all human actions modeled. All of the bullets may apply in only a few cases. The quality items identified are expected to apply primarily to the HFE identified items and the risk important actions identified in the PRA screening analysis. This matches the level of the analysis to the level of risk. This will be clarified in the next revision of NEDO-33267.

Section 18.7 will be revised as shown in Enclosure 2 to address the scope, the methods, and summary reporting. Details such as the bullet items shown on pages 23 and 24 of NEDO-33267 will not be repeated in the DCD. The level of detail is provided in NEDO-33267 and is summarized in chapter 18.7.

NEDO-33267 commits to providing documentation (in a report) of the HRA suitable for review of the process with example details. This level of detail is commensurate with the safety significance of the human actions evaluated [SRP Section 14.3 guidance].

DCD/LTR Impact

LTR NEDO-33267, Rev 0 will be revised as described above.

DCD Tier #(2), Section 18.7 will be revised as noted in Enclosure 2.

ENCLOSURE 2

MFN 06-403

Response to Portion of NRC Request for

Additional Information Letter No. 64

Related to ESBWR Design Certification Application

Human Factors Engineering
NEDO-33267, Human Reliability Assessment Program

Markup Changes for RAIs 18.7-14 and 18.7-15

Table 3.3-1
ITAAC For Human Factors Engineering

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
7. a. A Staffing and Qualification Plan is developed which establishes a baseline staff and their qualifications for safely operating the ESBWR during normal power operation, as well as during transient events included in the plant design basis.	7. a. The Staffing and Qualification Plan will be reviewed.	7. a. The Staffing and Qualification Plan establishes: i. The assumptions and initial baseline staffing for reactor control and monitoring. ii. The process and methods for evaluating staffing and qualifications including the considerations from other elements of the HFE Program Plan and Risk Assessment.
7. b. An analysis of the staffing and qualifications is conducted.	7. b. The analyses of the staffing and qualifications will be reviewed.	7. b. The staffing and qualification analyses, as corrected to account for , are conducted in accordance with the requirements of the Human Factors Engineering Program Plan and the Staffing and Qualification Plan.
8. ~~a. A Human Reliability Assessment Implementation Plan is developed which establishes how human error identified and quantified in the PRA will be analyzed to determine if new or modified HSI design features are needed to reduce, the~~	8. ~~a. The Human Reliability Assessment Implementation Plan will be reviewed.~~ DELETE	8. ~~a. The Human Reliability Assessment Implementation Plan establishes:~~ ~~i. The Methods to support/conduct PRA/HRA to identify significant risk reduction improvements relating to~~

Table 3.3-1
ITAAC For Human Factors Engineering

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
likelihood and impact of errors.	DELETE	the reliability of core and containment heat removal systems that can be practically implemented during the plant design. ii. The method for identifying the risk-important human actions to be used as input to the HFE design effort. iii. The methods for analyzing the human actions with respect to the design information, human error mechanisms, and available technology. iv. Methods to integrate the PRA and HRA activities into the HFE and plant design activities. v. Methods for documenting the HRA efforts.
8. b. A Human Reiliability Analysis is conducted.	8. b. The Human Reliability Analysis will be reviewed.	8. b. The Human Reliability Analysis, as corrected to account for nonconformances, is conducted in accordance with the requirements of the Human Factors Engineering Program Plan and the Human Reliability Analysis Implementation Plan.

18.7 ~~18.7~~ HUMAN RELIABILITY ANALYSIS

Human reliability analysis (HRA) is ~~a required activity~~performed in support of a probabilistic risk assessment (PRA) for both pre- and post-initiator human actions. ~~[ASME, 2002].~~

18.7.1 ~~18.7.1 Purpose~~ Objectives and Scope of Human Reliability Analysis

This section describes the how the HFE program uses the Human Reliability Analysis (HRA). An initial "design level" ESBWR PRA is provided in DCD Chapter 19 to support NRC certification information requirements. The performance of the HRA quantification is addressed in DCD Chapter 19. The impact of the risk important human actions and human-error mechanisms on the HSI design is addressed in the DCD Chapter 18.

The scope for using HRA in HFE activities includes: (1) an assessment of the potential for and mechanisms of human error that may affect plant safety, particularly the risk important HAs; (2) a discussion of potential human errors in the design of HFE aspects of the plant to address the likelihood of personnel error, to detect errors and recover from them; (3) human errors identified and quantified in the PRA are further evaluated to determine if new or modified HSI design features are needed to reduce the likelihood and impact of errors and (4) the HRA activity quantitatively integrates the HFE program into the PRA and the PRA insights into the HFE program.

~~This section describes how the HRA information and tools are used to support the HSI HFE design goals. An initial "design level" ESBWR PRA/HRA will be submitted in support of NRC licensing requirements using the ABWR reference HFE design documentation. The HRA will address the impact of human-error mechanisms on the HSI design. . Human error identified and quantified in the PRA will be analyzed to determine if new or modified HSI design features are needed to reduce the likelihood and impact of errors. The HRA activity will quantitatively integrate the HFE program into the PRA and risk analysis . In addition, the results will be design input to the software safety plan activities described in Section 5.1.6.~~

~~18.7.2 HRA Requirements Development~~

~~The specific requirements for the HRA implementation plan will be developed by the MMIS design team following the iterative links with the HFE program shown in Figure 4.7-1, which leads to an "as designed PRA/HRA" at the completion of design. The HRA will be performed iteratively as the design progresses. The PRA and HRA will be performed early in the design process to provide insights and guidance both for systems design and for HFE purposes. The robustness of the HRA depends, in large part, on the analyst's understanding of personnel tasks, the information related to them, and the factors, which influence human performance.~~

~~Accordingly, the HRA will be carried out interactively as the design progresses. At the very least, the initial PRA/HRA phase will be finalized when the plant design and HFE are complete.~~

~~The HRA is conducted to screen for important human actions and evaluate their potential for and mechanisms of human errors that impact the frequency of key accident scenarios for the PRA. Thus, HRA is an essential tool for identifying, screening and evaluating specific human actions based on the impact of potential errors on plant safety. The HRA also supports the HFE design goal of minimizing personnel errors, detecting errors when they do occur, and recovering from errors and hardware failures through careful design of the HSI. HRA is expected to provide valuable insight into desirable characteristics of the HSI design as the design evolves. Consequently, the HFE design effort will give special attention to those plant scenarios, risk- important human actions, and HSIs that have been identified by PRA/HRA as being important to plant safety and reliability.~~

~~The HRA will interact with the verification and validation program by designing test scenarios and updating quantitative evaluations based on validation results. The HRA models will establish a basis for future human performance monitoring and help prioritize corrective actions~~.

18.7.2 ~~18.7.3 18.7.2 Methodology~~ Methodology of Human Reliability Analysis

The PRA/HRA results and the risk-important HAs are addressed by the HFE design team (through HSI design, procedural development, and training) to minimize the likelihood of operator error and provide for error detection and recovery capability. The use of passive cooling systems, increased automation and computer-based HSIs change the way that operators interact with the ESBWR compared with previous BWRs. For example, passive cooling eliminates the need for operating and controlling forced cooling ~~systems., and Tthe~~systems. The operators concentrate on monitoring and deciding on a course of action.

The PRA/HRA is used to identify the risk-important human actions for evaluation in the HFE process. The process for determining the risk-important HAs includes the use of:

- ~~Level 1 (core damage),those design level PRAs for the~~ Level 1 (core damage), design level PRAs,
- Level 2 (release from containment) and post-core damage actions, ~~i~~I
- Internal and external events portions of the PRA, and
- ~~Tthe~~The low-power and shutdown PRA.

The importance of each HA is determined by using an importance measure (e.g, Fussell-Vesely, achievement worth or risk reduction worth), HRA sensitivity analyses, and threshold criteria for selecting the PRA accident scenarios (or cutsets) considered to maintain a list of risk-important actions.

During the HFE design process HFE team verifies that HRA assumptions, such as decision-making and diagnosis strategies for dominant sequences and important actions can be performed using the MMIS for the risk important human actions. The methods include discussions and walkthrough analyses with personnel having operational experience and the~~appropriate~~ use of a plant-specific control room mockup or simulator.

~~The specific methodology and modeling approaches will be established by the design team using information from HRA reports on data, models and methods [e.g. from sources such as NUREG/CR-1278, 1983, EPRI NP-3583, 1984, NUREG/CR-4772, 1987, EPRI NP-6560-L 1990, EPRI TR-100259, 1992, NUREG/CR-6350, 1996, Hollnagel, 1998, Julius, 2001, NUREG-1792, Draft 2004, and NUREG/CR-6883, 2005]. Standards include ASME RA-S-2002, IEEE Std. 1082-1997, and IEEE Draft Std 1574, which is in development.~~

The HRA modeling for the PRA benefits from the HFE team descriptions and analyses of operator functions and task requirements which become inputs~~will~~ to quantification model. The HRA model updates consider~~include descriptions and analyses of operator functions and task requirements,~~ previous PRA identified actions and errors, performance factors associated with the operational characteristics of HSI design, procedures for normal, startup, shutdown and emergency operations as well as training programs.

~~Although there are many different approaches for conducting HRAs, there are several analysis components that increase the quality of the HRA. These include:~~

~~□ Performing a design specific PRA/HRA to identify significant risk reduction improvements relating to the reliability of core and containment heat removal systems that can be practically implemented during the plant design.~~

~~□ The PRA will include both internal and external events to the extent possible during the design phase. The main output will be a listing of potentially risk-important human actions from the PRA/HRA.~~

~~□ Risk important human actions from the PRA/HRA will be used as input to the HFE design effort (i.e., to support function allocation analyses, task analyses, HSI design, procedure development, and training). The design effort will demonstrate how these human actions are well supported by the HSI design and that there is suitable crew availability and time to accomplish the action given that the need is detected.~~

~~□ Using a multidisciplinary team to analyze human actions within the context of the PRA.~~

~~□ For some actions the level III requirements in ASME, 2002 may be applied to support quantification of the risk important human actions in dominant accident sequences. The HRA assumptions involving diagnosis, decision-making, and planning and implementation strategies during accident responses may be validated by event simulations using experienced crews, walkthrough analyses using personnel with operational experience to apply procedures for conditions in plant-specific control room mockup or simulator. Such reviews may be conducted to support final quantification of the PRA.~~

~~□ Obtaining design information related to those factors that affect human performance.~~

~~□ These include: accident analyses from design basis events, operational experience, and PRAs to define quantification elements such as the time available for action, HSI design details that indicate the cue for an action and the feedback of the effects of taking the action, task analyses to determine the steps, timing and special tools required to carry out the sub steps of the human action, and the applicability of general or specific written procedures.~~

~~□ Evaluating the effects of HSI advanced technology on human performance and the potential to change the human error mechanisms due to advanced technology. The evaluation of new design features will assess at a minimum the following effects on the existing HRA:~~

- ~~The original HRA assumptions and assessed error mechanisms are valid for the modified design~~
- ~~The human errors analyzed in the existing HRA are still relevant~~
- ~~New error mechanisms may become important that were not modeled by the existing HRA/PRA~~
- ~~The probability of errors by operators and maintenance personnel may change, which may require use of a different modeling construct and~~
- ~~The consequences of errors, established in the existing HRA, may change.~~

~~□ Analyzing human actions with an emphasis on human error mechanisms.~~

~~□ The likelihood of operator error will be minimized for risk-important HAs by identifying key error mechanisms and then providing means for error detection and recovery capability within the HSI design, procedures, and training elements under the HFE program.~~

~~□ Obtaining appropriate sources of human error data for the types of human actions and associated error mechanisms that are modeled including human to human dependencies and dependencies between human actions and hardware failures.~~

~~□ Performing sensitivity and uncertainty analyses on the human success and error probability estimates within the PRA sequences to evaluate the impact of human errors on the plant systems.~~

~~□ These analyses will use a variety of importance measures and HRA sensitivity analyses assumptions to ensure that risk important actions are not overlooked.~~

~~□ Integrating the PRA and HRA activities into plant design activities by defining safety important actions, supporting HIS design, procedures and training element development to ensure that HRA performance factor assumptions are met in the design.~~

~~□ Providing a thorough documentation of the HRA process, integration with the HFE elements, methods used, assumptions made and the database for the human error probabilities that feed into the PRA. Such document will support evaluation of future COL applicant changes to the HSI design.~~

18.7.3 ~~18.7.3 Results~~Results of Human Reliability Analysis

The HRA results summary report discusses how the Human Reliability Analysis is applied in the HFE process. The report provides the list of risk important HAs and

summarizes how the risk-important HAs and their associated tasks and scenarios are addressed during the various phases of the design process (e. g., in allocation of functions analyses, task analyses, HSI design, procedure development, and training). The HFE process ensures that the tasks identified are well supported by HSI design features and are within acceptable human performance capabilities. The summary results report also discusses the results of the validation of the HRA assumptions.