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MFN 09-094

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Subject: **Submittal of Revisions to Licensing Topical Reports NEDO-33268, NEDO-33221, and NEDO 33219 Related to ESBWR Design Certification Application – Human Factors Engineering - RAI Number 18.5-27 S03**

The purpose of this letter is to submit revisions to the following GEH Human Factors Engineering (HFE) Licensing Topical Reports (LTRs);

LTR NEDO-33268, *"ESBWR Human Factors Engineering Human-System Interface Design Implementation Plan"*, Revision 4

LTR NEDO-33221, *"ESBWR Human Factors Engineering Task Analysis Implementation Plan"*, Revision 3

LTR NEDO-33219, *"ESBWR Human Factors Engineering Functional Requirements Analysis Implementation Plan*", Revision 2

This submittal is being made under RAI 18.5-27 S03 for tracking purposes only. This is a GEH generated RAI supplement to meet the commitment made in the previous submittal to this RAI. No formal RAI supplement has been received from NRC.

GEH's response to RAI 18.5-27 S03 is addressed in Enclosure 1. Responses to RAI 18.5-27 S02, Revisions 1 and 0 were provided in Reference 1 and 2 respectively, as requested by NRC in Reference 3. Response to RAI 18.5-27 S01 was previously provided via Reference 4 in response to Reference 5. The original RAI response was submitted to the NRC via Reference 6 in response to NRC Letter No. 64 (Reference 7).

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

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

Reference:

1. MFN 07-624, Revision 1 - *Response to Portion of NRC Request for Additional Information Letter No. 113 Related to ESBWR Design Certification Application - Human Factors Engineering - RAI Number 18.5-27 S02, Revision 1*, dated May 19, 2008
2. MFN 07-624 - *Response to Portion of NRC Request for Additional Information Letter No. 113 Related to E5BWR Design Certification Application - Human Factors Engineering – RAI Numbers 18.5-5 S02, 18.5-19 S01, 18.5-26 S01, 18.5-27 S02, and 18.5-30 S02*, January 17, 2008
3. MFN 07-557 - Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, GEH, *Request For Additional Information Letter No. 113 Related To ESBWR Design Certification Application*, dated October 16, 2007
4. MFN 07-334 - Submittal of *"ESBWR DCD Chapter 18, Human Factors Engineering - RAI to DCD Roadmap Document"* dated June 27, 2007
5. Email from AE Cubbage to DL Lewis, *List of Chapter 18 RAIs for Roadmap Request*, dated May 18, 2007
6. 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
7. MFN 06-352, Letter from U.S. Nuclear Regulatory Commission to David Hinds, *Request for Additional Information Letter No. 64 Related to ESBWR Design Certification Application*, dated September 25, 2006

Enclosures:

1. MFN 09-094 - Human Factors Engineering - RAI Number 18.5-27 S03
2. MFN 09-094 - Markup Attachments for RAI Response 18.5-27 S03

cc:	AE Cubbage	USNRC (with enclosures)
	RE Brown	GEH/Wilmington (with enclosures)
	DHHinds	GEH/Wilmington (with enclosures)
	eDRF	0000-0096-9095

Enclosure 1

MFN 09-094

Human Factors Engineering
RAI Number

18.5-27 S03

For historical purposes, the original text of RAI 18.5-27 and any previous supplemental text and GEH responses are included preceding each supplemental response. Any original attachments or DCD mark-ups are not included to prevent confusion.

NRC RAI Number 18.5-27

The topic of minimum inventory is not adequately addressed in NEDO-33221. In Section 1.2, Scope, a commitment to define a minimum inventory is made; however, it is not addressed in the detailed methodology. Additional information is needed as to how the minimum inventory will be identified and what criteria will be used in the selection process.

GEH Response

In the case of safety parameters the top down HLFA, AOF and TA as described in the Addendum to RAIs 18.5 will identify the minimum inventory of information and cues needed to accomplish start up, operation and shutdown and trigger entry into the plant emergency procedures. This pattern for functional and task analyses is followed for the non-safety operational functions (detailed analyses), and then for the conditions for taking equipment out of service for surveillance, maintenance, testing, and repair (preoperational analyses). The output provided by each iteration lists a minimum set of alarms, displays and controls necessary for the crews to perform required functions to meet the requirements of the human tasks in performing system operations as well as developing strategies for adjusting plant states and configurations.

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 Number 18.5-27 Supplement 1

The GE responses to RAIs 18.8 13, 18.8 23 and 18.5 27 all address minimum inventory. While they are not all the same, GE clearly indicate that the minimum inventory will be developed and is not done yet. The response to 18.5 27 sounds very broad and seems to include all the task requirements identified through task analyses in the minimum inventory. This may be excessive. The most complete discussion of the minimum inventory guidance is in the SERs for the new reactors that have undergone design certification; for example Section 18.14, Minimum Inventory, of the AP1000 SER contains the following lead in discussion:

"As part of the general resolution of the issue pertaining to lack of control room detail, the staff requested that applicants for design certification identify the minimum group of fixed position CDAs that are required for transient and accident mitigation. ... It should be noted that the inventory is described as a 'minimum' inventory to indicate that an applicant can add to it but cannot delete from it [without an exemption]", {note: The SER said 'without rulemaking', but a COL applicant or licensee would follow the change process in section VIII of the appropriate appendix to 10CFR52. Generic changes, i.e. vendor proposed, changes to Tier 1 require rulemaking, but applicant requested changes to Tier 1 do not} NUREG 0800, the NRC SRP, Chap. 14.3.9 (Apr. 1996 is the latest available, but it's being updated now) provides review criteria for the minimum inventory, which explains how to determine the minimum inventory. These criteria include: GTGs, PRA, task analyses, RG 1.97 Cat. I items, and important controls and displays for transient mitigation. SRP Section 14.3.9 also includes a minimum inventory for the remote shutdown system (RSS), but the AP 1000 SER accepted non fixed position (computer based) displays for the RSS. Further 14.3.9 specifies that the minimum list should be included in the DCD Tier 1. GE has not committed yet to add the minimum inventory list to Tier 1. The topic of minimum inventory as addressed in these three RAI responses needs further discussion and clarification.

GEH Response

Chapter 18 Roadmap Document								
RAI NO	SEC	#	NRC Supplemental	DocName/Question	Resolved	Plan	Section	Resolution Description
	5	27	N	LTR NEDO-33221	From GE response		3.2.4	Minimum inventory is not defined, but information and control needs will be established in the operations analysis for the actions necessary to perform crew tasks
18.5-27	5	27	Y	Identification of Minimum Inventory	From GE response		Tier 1 Table 3.3-1, item 6d	Given the uncertainty about the term "minimum inventory", GE has committed to adding the "list of instruments that complies with RG 1.97" in ITAAC, with the intent that this satisfies "minimum inventory" . GE will abide by the definitions currently under NRC and industry discussions. The GE minimum inventory will be established by task analysis output.

NRC RAI 18.5-27 Supplement 2

In the original RAI, staff requested additional information as to how the minimum inventory will be identified and what criteria will be used in the selection process. The GEH response to RAIs 18.8-13, 18.8-23 and 18.5-27 all address minimum inventory. While they are not all the same, GEH clearly indicates that the minimum inventory will be developed and is not done yet. The response to 18.5-27 sounds very broad and seems to include all the task requirements identified through task analyses in the minimum inventory. This response, needs further explanation.

GEH's tasks analysis methodology in NEDO-33221, Rev. 1 also does not fully address minimum inventory. Provide a discussion and clarification on how minimum inventory is identified consistent with DI&C-ISG-05, "Digital Instrumentation and Controls Interim Staff Guidance on Highly-Integrated Control Rooms - Human Factors Issues (HICR-HF)," dated September 28, 2007.

GEH Response

GEH's original response to the RAI required additional clarification. The response to this supplement request is consistent with DI&C-ISG-05 and will replace the original response.

NEDO-33221 Revision 1 will be revised to define the Minimum Inventory Human System Interface (HSIs) and provide the process for identifying, implementing, and documenting the Minimum Inventory HSIs associated with the Main Control Room and Remote Shutdown Station (see attached markup).

Minimum Inventory HSIs: The Minimum Inventory HSIs are those that are needed beyond the selectable HSIs provided on the nonsafety related, computer-based workstations normally used by the operators to monitor and control the plant as defined by the Minimum Inventory HSI determination process.

A top down approach will be conducted to determine the Minimum Inventory HSIs needed to implement the plant's Emergency Operating Procedures (EOPs), bring the plant to a safe condition, and to carry out operator actions shown to be risk important by the ESBWR PRA. Design bases and requirements for this minimum inventory will be identified.

DCD/LTR Impact

No DCD changes will be made in response to this RAI.
LTR NEDO-33221 Rev 1 will be revised as noted in the attached markup as described above.

NRC RAI 18.5-27 S03

****Note: No letter or email was received for this supplement. It is being internally generated to track the minimum inventory generation issue with the NRC. ****

The minimum inventory list along with supporting information was submitted as supplement 03 to RAI 18.8-47. This RAI response stated in part: "Changes to Licensing Topical Reports (NEDO-33221, "ESBWR Human Factors Engineering Task Analysis Implementation Plan" and NEDO-33268, "ESBWR Human Factors Engineering Human-System Interface Design Implementation Plan") will be addressed as a revision to the GEH response to RAI 18.5-27 and submitted as Supplement 03."

GEH Response

Minimum Inventory

The minimum inventory list was developed as described in RAI 18.8-47 supplement 03 (MFN 09-024, dated January 26, 2009), and not as part of the Functional Requirements Analysis described in NEDO-33219, *"ESBWR Human Factors Engineering Functional Requirements Analysis Implementation Plan"* and Task Analysis as described in NEDO-33221, *"ESBWR Human Factors Engineering Task Analysis Implementation Plan."* Therefore, NEDO-33219 and NEDO-33221 will be revised to remove the reference to minimum inventory. In addition, NEDO-33268, *"ESBWR Human Factors Engineering Human-System Interface Design Implementation Plan"* will be revised to specifically include the minimum inventory as part of the HSI design and results.

Accident Monitoring Instrumentation

The list of instruments that meet RG 1.97 criteria is developed as part of the Task Analysis process of NEDO-33221, *"ESBWR Human Factors Engineering Task Analysis Implementation Plan"* that will be an input to the design process as described in DCD subsection 7.5.1. This is separate from the development of the minimum inventory list. During task analysis, HFE teams analyze systems for operation in normal, abnormal, emergency, and testing configurations. For these configurations, the teams identify the instrumentation needed to successfully operate that system. During phase 1 task analysis, the teams analyze normal operations. During phase 2 of task analysis, the teams analyze the systems for abnormal and emergency operation. It is during phase 2 that the list of accident monitoring instruments is finalized, and each instrument typed in accordance with IEEE Std 497-2002 (endorsed by RG 1.97 rev. 4, subject to certain regulatory positions).

For clarification DCD Tier #2, Section 18.5 will be revised to include accident monitoring instrument identification and typing as part of task analysis.

For completeness, NEDO-33221 will be revised to specifically include the identification and typing of RG 1.97 instruments during task analysis.

DCD/LTR Impact

DCD Tier #2, Section 18.5 will be revised in Revision 6 as noted in the attached markup.

LTR NEDO-33268, *"ESBWR Human Factors Engineering Human-System Interface Design Implementation Plan"* will be revised as noted in the attached markup.

LTR NEDO-33221, *"ESBWR Human Factors Engineering Task Analysis Implementation Plan"* will be revised as noted in the attached markup.

LTR NEDO-33219, *"ESBWR Human Factors Engineering Functional Requirements Analysis Implementation Plan*" will be revised as noted in the attached markup.

Enclosure 2

MFN 09-094

Markup Attachments for RAI Response

18.5-27 S03

*** Verified DCD changes associated with this RAI response are identified in the enclosed DCD markups by enclosing the text within a black box.**

Where appropriate, analysts combined alarms, displays, and controls at high levels while still meeting HSI needs identified during task analysis.

Minimum inventory analysts considered:

- HSIs needed to support decision making;
- HSIs needed to support plant manipulations; and
- HSIs needed to support monitoring task success criteria.

Analysts considered what HSIs were needed to successfully complete each task and assigned one or more of the following types of minimum inventory HSIs:

- Alarms - Alert the operator regarding abnormal or degrading conditions that require operator response.
- Displays – Provide information necessary during task performance.
- Controls – Provide the means to change the state of plant equipment.

The result of this analysis is the ESBWR MCR and RSS minimum inventory of HSIs documented in Tables 18.1-1a and 18.1-1b.~~The TA process is conducted in accordance with References 18.5-1 and 18.5-2.~~

~~18.5.1~~ 18.5.2 Detailed Design (including the design , detailed, and economic phases of task analysis) Task Analysis Implementation Plan

The TA implementation plan, Reference 18.5-2, establishes a task analysis process that conforms to ESBWR plans and applicable regulatory requirements. The system-level and plant-level functions are systematically analyzed. The relationships and interaction between human and machine tasks are examined through several iterations of analysis. TA considers all functions identified by the FRA and allocated to human, machine, or shared ownership.

~~18.5.1.1~~ 18.5.2.1 Scope of TA

The TA Implementation Plan establishes the following scope elements.

a. Objectives, performance requirements, and constraints are defined.

b. Methods and criteria for conducting the TA are in accordance with accepted human factors principles and practices.

c. System and function requirements define task sequencing and coordination restraints.

d. TA results establish systems HSI requirements.

e. TA scope defines responsiveness to HRA/PRA and deterministic evaluations.

f. Task sequencing is established for each identified function.

g. Overall system configuration design is described.

h. ~~Methods for identifying Minimum Inventory HSIs.~~ Identifying and assigning types to accident monitoring instruments in accordance with RG 1.97.

i. TA scope includes the full range of plant conditions.

~~18.5.1.2~~ *18.5.2.2 Methods of TA*

The TA Implementation Plan establishes methods to:

a. Conduct the TA consistent with accepted HFE methods.

b. Promote the ESBWR mission, goals, and philosophy.

c. Identify prerequisites to performing a task or task sequence.

d. Identify the parameters required to coordinate tasks and task sequences.

e. Identify the termination criteria to abort a task or task sequence.

f. Identify the parameters that confirm successful completion of tasks or task sequences.

g. Identify and type accident monitoring instruments in accordance with RG 1.97.

~~g.~~h. Sequence tasks to support normal operation.

~~h.~~i. Sequence tasks to support abnormal operation.

~~i.~~j. Sequence tasks to support surveillance functions.

~~j.~~k. Sequence tasks to support maintenance functions.

~~k.~~l. Assess the impact of design, staffing, training, procedure, and HSI changes on the sequence and coordination of tasks.

~~l. Identify the Minimum Inventory HSIs.~~

~~18.5.1.3~~ *18.5.2.3 Results of TA*

The results of the TA activity are summarized in a RSR. The content of the TA RSR is described in Reference 18.5-2. TA RSR may be combined with the FRA and/or AOF RSRs.

~~18.5.2~~ 18.5.3 COL Information

None.

~~18.5.3~~ 18.5.4 References

18.5-1 [*GE Hitachi Nuclear Energy, "ESBWR Man-Machine Interface System and Human Factors Engineering Implementation Plan," NEDE-33217P, Class III (Proprietary), Revision 4, May 2008, and NEDO-33217, Class I (Non-proprietary), Revision 4, May 2008.*]*

18.5-2 [*GE Hitachi Nuclear Energy, "ESBWR HFE Task Analysis Implementation Plan," NEDO-33221, Class I (Non-proprietary), Revision 2, May 2008.*]*

* References that are bracketed and italicized with an asterisk following the brackets are designated as Tier 2*. Prior NRC approval is required to change Tier 2* information.

design process that incorporates industry-accepted HFE principles is used to achieve this objective.

3.1.3 Basis and Requirements

The HFE team develops functional requirements for the HSI to address the concept of operations. The requirements are based on the:

- Personnel functions and tasks defined in the operations analysis
- S&Q analysis
- Requirements for a safe, comfortable working environment

The HSI requirements address the various types of HSIs, for example, alarms, displays, and controls.

The three components of HSI design, concept design, style guide, and detailed design share similar bases and requirements.

The concept design uses human factor elements, as defined in the DCD Chapter 18 and the MMIS and HFE Implementation Plan, to address HFE issues during the HSI design process. The HSI design, hardware, software, logic, controls, indications and the style guide that governs their creation conform to the principles set forth in regulations including:

- NUREG-0700
- NUREG-0711
- Reg. Guide 1.206, Section C.I.18

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

- The minimum inventory of alarms, displays, and controls presented in DCD Table 18.1-1a and Table 18.1-1b are included in the designs of the MCR and RSS, respectively.
- 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
- Accident monitoring instrumentation for nuclear power plants~~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

The HFE design team reviews and verifies that the HSI concept design uses accepted HFE principles in its form and presentation of information and in its interactions with plant personnel.

- Minimize human error

3.2.3 Basis and Requirements

The design uses human factor elements, as defined in the DCD Chapter 18 and the MMIS and HFE Implementation Plan, to address HFE issues during the HSI design process. The HSI design, hardware, software, logic, controls, indications and the style guide that governs their creation conform to the principles set forth in regulations including:

- NUREG-0700
- NUREG-0711
- Reg Guide 1.206, Section C.I.18

Design considerations relative to NUREG-0711 referenced Regulatory Guides are considered in the HSI design process. These include consideration for control room functions that provide for periodic testing (RG 1.22), display status of bypassed or inoperative safety system indications (RG 1.47), switches or controls required for manual initiation of protective actions (RG 1.62), and aspects of Safety Parameter Display System (SPDS) and continuous display parameters (RG 1.97). Specific requirements and applications result from the functional requirements and tasks analyses. The minimum inventory of alarms, displays, and controls presented in the DCD Table 18.1-1a and Table 18.1-1b are also considered and included in the designs of the MCR and RSS, respectively.

The HFE design team reviews and verifies that the HSI design uses accepted HFE principles in its form and presentation of information and in its interactions with plant personnel. Additionally, the CBPs presented by the HSI conform to the principles set forth in NUREG-0700. The style HSI guide generated in this portion of the process presents design options for use in the ESBWR and the requirements for use and presentation of the HSI elements and CBPs. The HFE design team uses the style guide to properly combine and structure the HSI design elements and operational analysis requirements.

3.2.4 General Approach

The ESBWR HSI style guide is both a product of the HSI design effort and a governing input to it. The style guide is one of the first products generated by the HSI design team. The style guide will be created using input from similar guides from previous designs such as the ABWR, HSI style guides from other industries, NUREG-0700, and other applicable documents. The HSI style guide is a compilation of HSI equipment, control, display, interface, and structures from which designers can select the most appropriate option for a given application. Additionally, the style guide sets requirements for when and how to incorporate the various hardware options.

Similar guidance is provided in the area of HSI software including workstation design and presentation content, format, and logic. Style guide requirements maintain consistency in presentation, navigation, and interface mechanisms between various portions of the HSI. Because human factors criteria and best practices are infused in the style guide requirements, its use ensures HSI design minimizes the likelihood of human error.

5. RESULTS

5.1 RESULTS SUMMARY REPORT

The results of the HSI design process outlined in this plan are summarized in a Results Summary Report (RSR). The RSR provides a list of the design specifications for the HSI, instruments required to comply with regulations, and the HSI style guide developed during implementation of this plan. The RSR is written with sufficient detail to document how the methodology outlined in this plan was implemented to provide the results. In addition, the RSR outlines:

- General approach including the purpose and scope of HSI design
- HFE standards and documents used in the HSI design activity
- Concept of operations from an HSI perspective
- Functional requirement specification for HSIs
- Style guide and design specifications for HSI design including:
  - The development and basis for the guide
  - The scope and topical contents contained in the guide
  - Procedures used to maintain the style guide
- HSIs used in the MCR and RSS for the minimum inventory of alarms, displays, and controls presented in the DCD Table 18.1-1a and Table 18.1-1b, respectively
- List of instruments that complies with RG 1.97 and supporting analysis
- The methods used for the evaluation and verification of the HSI
- Overall assessment of how well the methodology and implementation of the procedure development process and results adhere to this plan

1.1 PURPOSE

The purpose of this implementation plan is to prescribe and guide task analysis for the ESBWR plant design in accordance with the requirements of the ESBWR MMIS HFE Implementation Plan (NEDO-33217).

The TA Plan establishes methods to:

- Conduct the TA consistent with accepted HFE methods
- Promote the ESBWR mission, goals, and philosophy
- Identify prerequisites to performing a task or task sequence
- Identify the parameters required to coordinate tasks and task sequences
- Identify the termination criteria to abort a task or task sequence
- Identify the parameters that confirm successful completion of tasks or task sequences
- Sequence tasks to support normal operation
- Sequence tasks to support abnormal operation
- Sequence tasks to support surveillance functions
- Sequence tasks to support maintenance functions
- Assess the impact of design, staffing, training, procedure, and HSI changes on the sequence and coordination of tasks
- Identify ~~the Minimum Inventory Human System Interfaces (HSIs)~~ Reg. Guide 1.97 instrumentation including the respective variable Type.

1.2 SCOPE

This plan establishes the following scope elements for the analysis:

- Objectives, performance requirements, and constraints
- Methods and criteria for conducting the TA in accordance with accepted human factors principles and practices
- System and function requirements that define task sequencing and coordination restraints
- Resultant systems HSI requirements
- TA responsiveness to HRA/PRA and deterministic evaluations
- Task sequencing for each identified function
- Overall system configuration design
- Methods for identifying ~~Minimum Inventory HSIs~~Reg. Guide 1.97 instrumentation including the respective variable Type.

To accomplish these objectives, system-level and plant-level functions are systematically analyzed. The relationships and interaction between human and machine tasks are examined

Human error: Can be defined as a mismatch between a performance demand and the human capability to satisfy that demand.

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, human tasks, and work environment are compatible with the sensory, perceptual, cognitive, and physical attributes of the personnel who operate, maintain, and support the system.

Human Reliability Analysis (HRA): A structured approach used to identify potential human failure events and to systematically estimate the probability of those errors using data, models, or expert judgment. (ASME RA-S-2000)

Human System Interface (HSI): In general the HSI encompasses all instrumentation and control systems provided as part of the ESBWR for use in performing the monitoring, control, alarming, and protection functions associated with all modes of plant normal operation (i.e., startup, shutdown, standby, at power operation, and refueling) as well as off-normal, emergency, and accident conditions. Specifically, the HSI is the organization of inputs and outputs used by personnel at a location to interact with the plant, including the using of alarms, displays, controls, and job performance aids. Generically, this includes interfaces that support actions for monitoring, controlling, maintaining protection functions, responding to events, and performing maintenance, calibration, inspection and testing activities. The details of the HSI systems are defined in ESBWR DCD, Tier 2, Chapter 7.

Human Task: The activity of a human required to accomplish a function. For example, the human user conserves, reduces, or adds information, and supplies or controls energy.

Maintenance: Activities carried out to keep systems and equipment available. Specific types of maintenance include preventive, and corrective. Activities associated with preventive maintenance include testing, surveillance, inspection, and calibration. Activities associated with corrective maintenance include repair, replace, and modify.

~~**Minimum Inventory HSIs:** The Minimum Inventory HSIs are those that are needed beyond the selectable HSIs provided on the nonsafety-related, computer-based workstations normally used by operators to monitor and control the plant as defined by the Minimum Inventory HSI determination process.~~

Operational Analysis: An iterative process that describes plant, system, and component state changes as a series of tasks including supporting information requirements. This is accomplished through performance of system functional requirements analyses, allocation of functions, and task analyses. The analysis process determines what must be done, who does it (man, machine, or shared), and how it is to be done (controls, indications, supporting information, and so forth). Results of the analyses are design requirements for the HSI, procedures, and training.

Operating experience review (OER): A systematic review, analysis and evaluation of operating experience that can apply to the development of the HSI design.

Reg. Guide 1.97 Instrumentation: Instrumentation identified as being required by the operators in accordance with IEEE Std 497-2002 as modified by Reg. Guide 1.97, rev. 4.

3. METHODS

The task analysis processes shown in Figures 2 & 3 are applied to human only, shared, and machine only (if any) actions. The design task analysis shown in Figure 2 processes tasks at the plant and system levels that support all aspects of all normal operating modes. The detailed task analysis processes tasks that support all aspects of abnormal and emergency operations. The economic task analysis processes tasks that support all aspects of plant maintenance, calibration, inspection, and testing.

The Task Analysis:

- Coordinates and implements plans in accordance with NRC guidelines
- Performs system (including components) and plant-level analyses of functions
- Performs analysis of normal and abnormal functions
- Executes the HFE plans iteratively from the early design phase through turnover to the fleet-wide owners' group and COL Applicants
- Follows accepted HFE and I&C practices and processes
- Follows the activities for HSI design and system hardware/software design
- Meets the commitments of ESBWR DCD, Tier 2, Chapter 18
- Develops the list of Reg. Guide 1.97 instruments including the respective variable Type.

The objective of task analysis is to determine how monitoring, control, and communication is best performed. Functions identified during the Design-phase FRA, which are determined to be human or shared functions during AOF are restated as tasks. Any subtasks that support these tasks are identified during the TA.

Task analysis is applied during many phases of the design as illustrated in Figure 2. The ESBWR HFE designs pass through several phases: from the initial, detailed and economic design phases, through implementation, start-up testing, and operating, and decommissioning phases. This plan discusses the first three design phases: design, detailed, and economic, as shown in Figure 2.

Outputs from each of these three design phases provides or refines:

- Requirements to the HSI Implementation Plan
- Detailed procedure outlines to the Procedure Development Plan
- Task sequence and interlock logic for plant automation and auto control of functions

Task analysis identifies the individual tasks, mental and physical, necessary to support the functions allocated to, or shared by, the plant operator. Human, machine, and shared tasks are subject to interactive analysis.

3.3 IDENTIFYING AND IMPLEMENTING MINIMUM INVENTORY HSIs

3.3.1 Background

This plan provides the methodology for identifying and implementing the Minimum Inventory HSIs for the Main Control Room and Remote Shutdown Station during the plant design process.

3.3.2 Goals

It is the goal of the minimum inventory identification and implementation process to generate the list of minimum inventory HSIs that are needed beyond the selectable HSIs provided on the nonsafety-related, computer-based workstations normally used by operators to monitor and control the plant as defined by the minimum inventory HSI determination process.

3.3.3 Basis and Requirements

The methods and criteria recommended for identifying and implementing Minimum Inventory HSIs are in accordance with a top down review as part of the overall control system design.

3.3.4 General Approach

A top down approach is conducted to determine the Minimum Inventory HSIs needed to implement the plant's Emergency Operating Procedures (EOPs), bring the plant to a safe condition, and carry out operator actions shown to be risk important in the ESBWR PRA. Design bases and requirements for this minimum inventory of HSIs are identified.

3.3.5 Application

The Systems and Plant-Level Task Analysis for identifying and implementing the minimum inventory HSIs provides the minimum inventory and classification of equipment, such as alarms, controls, and indications, needed to do the following:

- Implement the plant's EOPs.
- Bring the plant to a safe condition.
- Carry out operator actions shown to be risk important in the ESBWR PRA.

4. IMPLEMENTATION

4.1 SYSTEM-LEVEL TASK ANALYSIS

The TA process is illustrated in Figure 3.

4.1.1 Assumptions

System level assumptions include:

- Tasks required to start-up and shutdown the ESBWR automation
- Common sequence, priority, and logic are employed by the SOPs and each system's automatic control

4.1.2 Inputs

Task analysis inputs include:

- System configurations from SFRA
- Configuration changes from SFRA
- SFRA function flow data structure
- Functions allocated during AOF
- HRA/PRA

4.1.3 Process

4.1.3.1 *Task Identification*

Convert functions and configuration changes identified in the SFRA into tasks.

4.1.3.2 *Sequence Tasks*

Order tasks logically considering:

- System requirements
- System limitations
- Industrial safety
- Nuclear safety
- Resource allocation (time, staff, and urgency)

4.1.3.3 *Parameters*

Identify Parameters through:

- Assessing what information is necessary for task completion, including which parameters meet Reg. Guide 1.97 criteria.
- Determining how information is provided

4.1.4 Outputs

System-level task analysis outputs include:

- Communications requirements
- HSI descriptors
- Availability and arrangement of indicators
- Display requirements
- Control requirements
- Alarm requirements
- List of instruments meeting Reg. Guide 1.97 criteria along with the respective variable Type
- Data processing requirements
- Access requirements
- Workplace and workstation design considerations
- Environmental considerations
- Equipment requirements
- Activities required for successful completion of tasks
- Sequences that serve as both procedure outlines and automation logic
- Task input to the training development
- Task input to the staffing and qualification process

4.2 PLANT-LEVEL TASK ANALYSIS

4.2.1 Assumptions

Plant level assumptions include:

- Tasks required to start-up and shutdown the ESBWR automation
- Common sequence, priority and logic are employed by the IOPs and plant automation

4.2.2 Inputs

Task analysis inputs include:

- Plant configurations from PFRA
- Configuration changes from PFRA
- PFRA function flow data structure
- Functions allocated during AOF
- HRA/PRA

4.3 IDENTIFYING AND IMPLEMENTING MINIMUM INVENTORY HSIs

4.3.1 Assumptions

Minimum inventory HSI identification and implementation process assumptions include:

- Task analyses at the plant and system levels are completed to the level of detail needed to identify functions, parameters, and controls required for the minimum inventory of HSIs.
- ESBWR EOPs are sufficiently developed to provide input to the process.

4.3.2 Inputs

- Plant design basis
- Overall concept of operation of the plant
- Initial concepts for the overall I&C and information systems architecture
- ESBWR Emergency Operating Procedures
- Plant Probabilistic Risk Assessment
- Industry and regulatory standards and guides applicable to the plant design
- Defense-in-Depth and Diversity (D3) evaluation results
- Plant functions supporting the plant safety sub goals (including critical functions)

4.3.3 Process

Minimum inventory HSI identification and implementation process steps include:

(1) Identify applicable Regulatory Guides, standards, and other supporting documents necessary for identification and implementation of the minimum inventory HSIs. Supporting documents used in the process include:

- DI&C-ISG-05 Digital Instrumentation and Controls (highly integrated Control Rooms-Human Factors Issues), September 2007
- IEEE Std 497-2002 Standard Criteria for Accident Monitoring Instrumentation for Nuclear Power Generating Stations, September 2002
- Regulatory Guide 1.97, Rev 4, Criteria for Accident monitoring instrumentation for Nuclear Power Plants, June 2006

5. RESULTS

5.1 RESULTS SUMMARY REPORTS

The results of the Task Analysis are summarized in a Results Summary Report (RSR). This report is the main source of information used to demonstrate that efforts conducted in accordance with the implementation plan satisfy the applicable review criteria of NUREG-0800. The report contains the following:

- General approach including the purpose and scope of Task Analysis
- A list of task descriptions
- A description of the process for documenting and retaining detailed task analysis results
- Examples of detailed task analysis results
- ~~Definition of the minimum inventory of alarms, displays, and controls~~

TA Results Summary Reports (RSR) may be combined with the FRA and/or AOF RSRs.

FRA results are entered into a data structure during initial design. This data structure is shared with PRA and plant simulation efforts during the pre-operational and operational phases to evaluate the impact of design changes on the HFE aspects of ESBWR.

1.3 DEFINITIONS AND ACRONYMS

1.3.1 Definitions

Configuration Change: An allowable realignment of system components from one configuration to another.

Function (Sub function): An activity or role performed by man, structure or automated system to fulfill an objective.

Functional analysis: The examination of the functional goals of a system with respect to available manpower, technology, and other resources, to provide the basis for determining how the function may be assigned and executed.

Functional goal: The performance objectives that shall be satisfied by the corresponding function(s).

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.

~~**Minimum Inventory HSIs:** The Minimum Inventory HSIs are those that are needed beyond the selectable HSIs provided on the nonsafety-related, computer-based workstations normally used by operators to monitor and control the plant as defined by the Minimum Inventory HSI determination process.~~

Operational analysis: A structured, documented study and evaluation of plant goals to identify a hierarchy of system functions for operations, and the optimal means by which these functions can be accomplished.

Physical system (Subsystem): An organization of components working together to achieve a common goal(s), such as a function.

System Operating Configuration: A prescribed lineup of system components to complete a function under specified conditions.

System Process: An action or set of actions that must take place to complete a system operation or task.

System Process Element: An individual part or piece of a process whose availability or service is necessary for completion of the process.

System Component Requirement: An individual component required to complete the availability or service of a system process element.

System Support Requirement: A condition, not necessarily a part of the system, that is required to maintain a component available, (i.e. electrical power, isolation signal, etc.)

3. METHODS

The Functional Requirements Analysis (FRA):

(1) Coordinates and implements plans in accordance with NRC guidelines

(2) Performs a "top down" plant-level analysis of the plant functions

(3) Performs a per-system analysis of the design functions

(4) Performs a gap analyses to reconcile the top-down and per-system analyses

(5) Executes the HFE plans iteratively from the early design phase through turnover to the COL Applicants

(6) Follows accepted HFE and I&C practices and processes

(7) Follows the activities for HSI design and system hardware/software design

(8) Meets the commitments of ESBWR DCD Chapter 18

3.1 PLANT-LEVEL FUNCTIONAL REQUIREMENTS ANALYSIS

The PFRA addresses defense-in-depth, system interdependence, and interaction. PFRA is performed in three phases:

(1) High-level PFRA

(2) Design PFRA

(3) Detailed PFRA

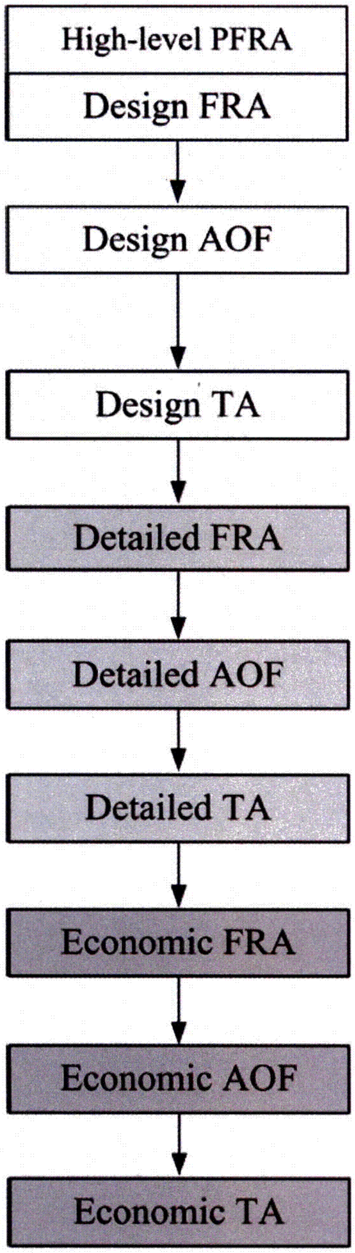
The High-level PFRA is performed early in the design process and identifies critical safety functions, Emergency Operating Procedure (EOP) outlines, and an inventory of accident monitoring parameters. ~~This identification provides input to the Minimum Inventory HSIs.~~ The Design PFRA includes plant goals and functions that support the ESBWR mission of generating safe economic electric power during all plant operating modes (shutdown, refueling, startup, and run) and provide the basis for the plant operating procedures.. The Detailed PFRA, the third iteration of FRA, provides high-level Abnormal Operating Procedure (AOP) outlines.

3.1.1 Background

The PFRA is the first step of the "top down" approaches to the HFE design, as illustrated in Figure 3, Functional Requirements Analyses Flowchart. The process begins with the ESBWR mission and analyzes plant functions for all operating modes to determine functions that must be completed to meet the plant goals.

3.1.2 Goals

The PFRA yields data structure that describes the plant function requirements. This data structure is rendered to provide inventories of required parameters and outlines for EOPs and AOPs. PFRA provides required inputs to AOF and TA.



Outputs

- Critical safety functions & system functions
- Design inputs logic, SDS, P&ID
- System alignments/alignment changes
- Identification of high-level functions and tasks

- Safety/Non-safety
- Automation
- Auto
- Human

- Task description and sequence
- Procedure outlines
- Inventory of indication and controls

- Inventory of indication and controls
- support function and task identification
- Maintenance and testing functions

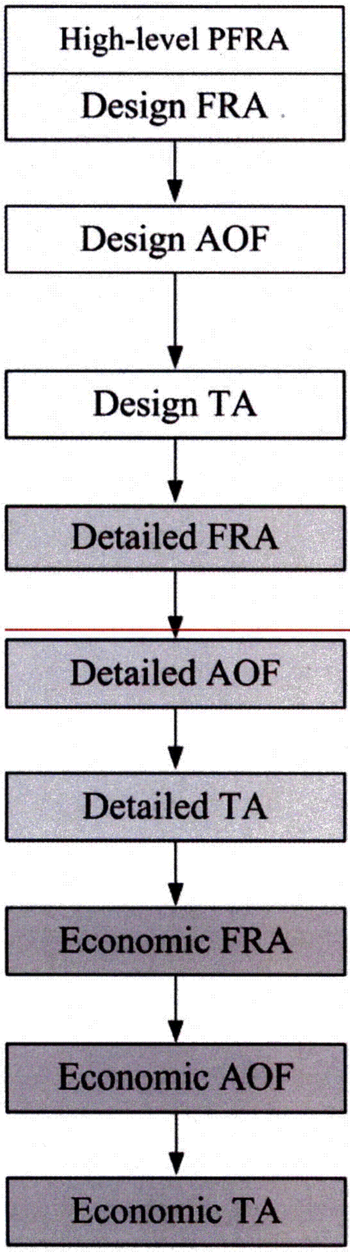
- Control hierarchy
- Alarm presentation and priority
- DCIS diagnostics

- Task sequence priority
- Procedure outlines

- Identification of testing and maintenance functions
- Incorporation of design, analysis and task changes

- Auto tasks for surveillance, testing and calibration
- Human tasks for surveillance, testing and calibration

- Integration of maintenance and testing with operation
- Surveillance procedure development
- Maintenance procedure development
- Tagout/Lockout process



Outputs

- Critical safety functions & system functions
- Minimum inventory of indications and controls
- Design inputs logic, SDS, P&ID
- System alignments/alignment changes
- Identification of high-level functions and tasks

- Safety/Non-safety
- Automation
- Auto
- Human

- Task description and sequence
- Procedure outlines
- Inventory of indication and controls

- Inventory of indication and controls
- support function and task identification
- Maintenance and testing functions

- Control hierarchy
- Alarm presentation and priority
- DCIS diagnostics

- Task sequence priority
- Procedure outlines

- Identification of testing and maintenance functions
- Incorporation of design, analysis and task changes

- Auto tasks for surveillance, testing and calibration
- Human tasks for surveillance, testing and calibration

- Integration of maintenance and testing with operation
- Surveillance procedure development
- Maintenance procedure development
- Tagout/Lockout process

Figure 2 Operational Analysis Iterations

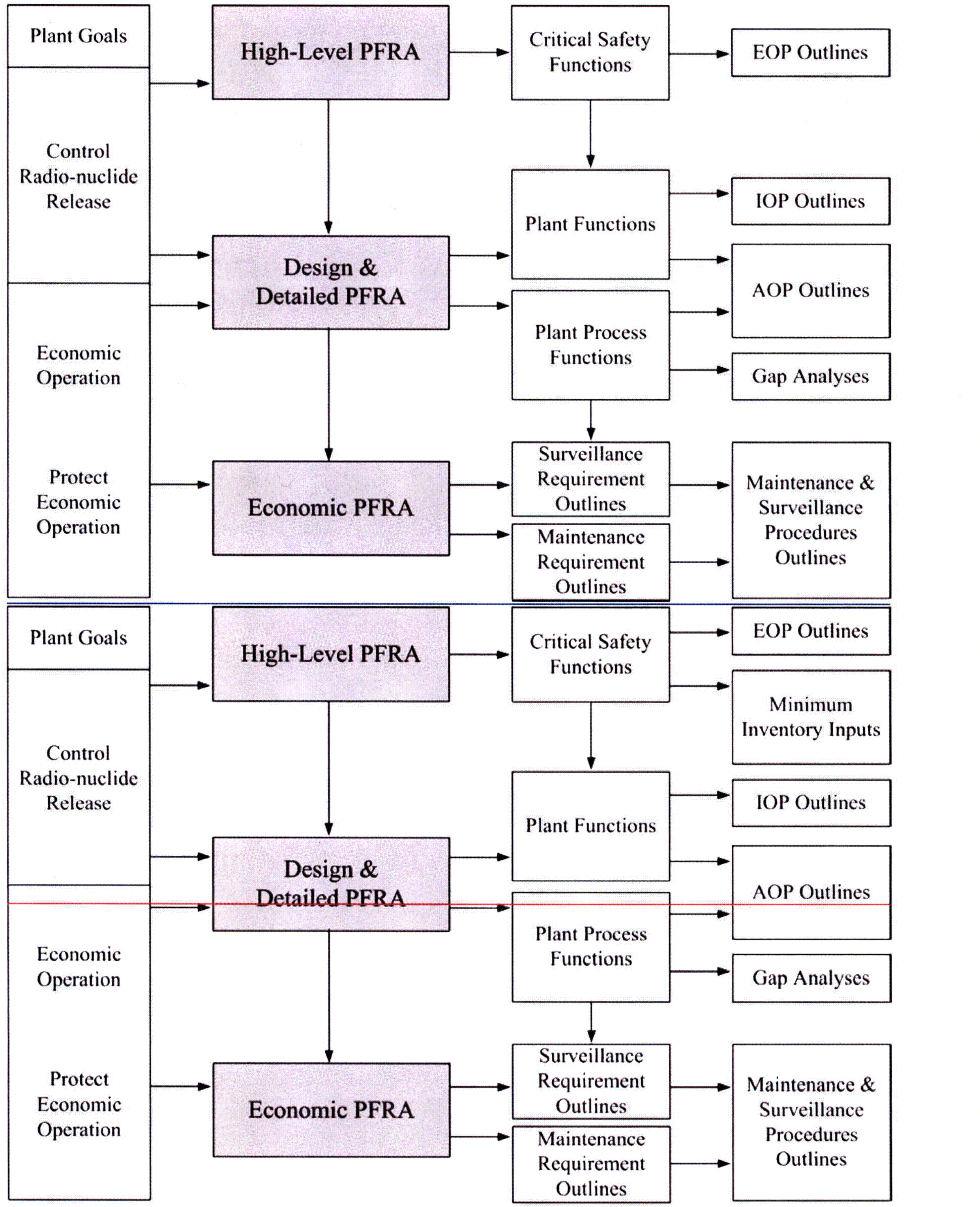


Figure 4 Plant-level FRA Iterations