ENCLOSURE 1

MFN 06-063

Licensing Topical Report

NEDO-33266, "ESBWR Human Factors Engineering Staffing and Qualifications Plan," March 2006

GE Energy
Nuclear

3901 Castle Hayne Rd
Wilmington, NC 28401

NEDO-33266
Class I
DRF#0000-0050-9818
March 2006

LICENSING TOPICAL REPORT

ESBWR HUMAN FACTORS ENGINEERING STAFFING AND QUALIFICATIONS PLAN

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Table of Contents

List of Tables

List of Figures

1 Introduction

Plant staff and their qualifications are important considerations throughout the design process. The planned initial staffing level is established based on experience with ABWR reference plants, staffing goals (such as optimizing the staffing levels and their qualification), initial safety function allocation, task analyses, and regulatory staffing requirements for nuclear reactors. ESBWR staffing and qualifications (S&Q) plans are used to re-examine the ESBWR assumptions during task analysis (TA), human reliability analysis (HRA), and human system interface (HSI) design. It is expected that features of the ESBWR, such as passive safety systems and simplified man machine interface information systems and content, will lead to a modification of staff size and qualifications relative to previous BWRs. TA may show that the extended time for safety actions may reduce the number of staff needed for local actions. The HRA may show that some actions that were important in previous BWR designs have be eliminated in the passive design, and improved display features may better clarify the plant state during transient events and reduce the size of the control room staff. Moreover, tasks that indirectly support safety functions, but have no direct interface to the allocated safety functions may be screened from HFE review of the HSI.

The details and content of the procedures and training for safety related tasks will be matched to the final baseline staff and qualifications developed during this human factor engineering (HFE) task.

1.1 Purpose

The purpose of this plan is fivefold. First, it establishes an initial baseline shift operations staff appropriate for managing plant safety during normal operation of the ESBWR. Second, it provides guidance on using the initial staffing assumptions in systematic evaluations of staffing needs and qualifications throughout the design effort. Third, it recommends a refined description of baseline staffing needs and qualifications for using the ESBWR HSI. Fourth, to address the staff that uses the HSI, a screening process will be used to focus the HFE effort on the tasks and staff needed to support reactor safety functions. Fifth, it provides a baseline input for systematic verifications the HSI design, and development of procedures and the training program.

The detailed evaluation of HSI requirements for maintaining plant safety and availability goals over the complete range of transient event conditions will clarify the basis for the staffing and qualifications of the baseline ESBWR. This evaluation will be accomplished through the systematic examination of the design specific ESBWR functions, tasks, known priorities, risk importance, and baseline procedures. Recommendations for changes in the baseline ESBWR plant S&Q will be provided in a results summary report. The recommended staffing level will be reflected in ESBWR procedures and training program design.

1.2 Scope

The scope of this task is to recommend 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. The applicable plant personnel, who will be addressed by the HFE program prior to plant startup, include licensed control room operators as defined in 10 CFR Part 54m and 55. Moreover, the categories of personnel defined by 10 CFR 50.120, who may perform tasks related to plant safety through the HSI, will be screened for tasks involving reactor safety functions allocated to manual operation and that are monitored and controlled through the HSI. The personnel include 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. In addition, any other plant personnel who perform tasks that are directly related to plant safety will be addressed. The tasks they carryout include qualification, repair, maintenance, record keeping, configuration control, monitoring, surveillance and testing of plant equipment during startup, normal operations, abnormal operations, transient conditions, low power, and during shutdown conditions. The initial focus of this task during the design stage is on the shift personnel controlling the plant during normal operations through the applicable man machine interface systems (MMISs) needed for operations and response to transient events (e.g., operator interface in the Main Control Room (MCR), the Remote Shutdown System (RSS) and local stations).

The initial proposed baseline staff for plant operation during shifts will be expanded to include personnel who perform tasks related to plant safety as the design progresses to the combined operating license (COL) and operation. The overall staffing analysis prior to plant start up will recommend the number and background of personnel for the full range of plant conditions and operational tasks (normal, abnormal, and emergency), plant maintenance, and plant surveillance and testing. A COL organizational staff will be recommended by the utility using input from past operational S&Qs experience and the design phase HFE program on specific safety related tasks to address the full range of activities at the plant. For examples, staff needed to plan and conduct work for planned outages or during outages for equipment maintenance, handling and storage of new or spent fuel, and radioactive materials will be addressed using past operational experience with input from the HFE to refine either staff assignments or qualifications. Recommendations for personnel involved in administration, security, training, engineering, fire/hazard response, access monitoring, record keeping, or local services (e.g., cafeteria and janitorial) will reflect operating utility experience and regulatory requirements. During initial design it is assumed that personnel to accomplish these activities are available as needed, but are not included in the baseline operational staff for normal shifts. As the design progresses if a task using the safety system HSI is identified during the HFE analysis for site support staff, recommendations for refinement to the staff and their qualifications will be provided. The operational staffing organization is under the authority of the COL Applicant (e.g. operating utility).

External personnel brought in for special maintenance and repair are assumed to also use elements of the HSI during outages, refueling, and waste handling. Tasks for external personnel may be identified during the HFE process however personnel for these tasks are not included in the baseline staffing for plant operations.

1.3 Definitions

Several terms are defined to provide a common basis for developing S&Q recommendations referred to in the subsequent paragraphs.

Accident sequence: a representation in terms of an initiating event followed by a combination of system, function and operator failures or successes, of an accident that can lead to undesired consequences, with a specified end state (e.g., core damage or large early release). An accident sequence may contain many unique variations of events (minimal cut sets) that are similar. (ASME PRA Std.)

Accident situation: from the operator's perspective, an abnormal plant state occurring during an event, which may lead to a new damage condition. Operations staffs' actions can prevent, mitigate or exacerbate the accident progression using the HSI. (IEEE working group)

Action task: The "doing" portion of a task, performed by the control room operators or the plant technicians. This involves use of the HSI to perform physical actions in operating control room switches by the control room operators or manipulating or repairing equipment in the plant by the technicians.

At power: those plant operating states characterized by the reactor being critical and producing power, with automatic actuation of critical safety systems not blocked and with essential support systems aligned in their normal power operation configuration.

Consequences: The results of (i.e., events that follow and depend upon) a specified event.

Control Function: "Keeping measured functional parameters within bounds through a process of manipulating low level functions to satisfy a higher level function" (NUREG-0711, Rev. 2, page 96, [2.3(4)]).

Control Room Design team (CRDT): is a subset of the Design Team. The CRDT is responsible for the overall coordination of the design of the Main Control Room (MCR), Remote Shutdown System (RSD) Panels, and applicable Local Control Stations.

Crew: qualified operations staff at the plant during a shift that manages and performs activities necessary to operate the plant and maintain its safety.

Diagnosis: examination and evaluation of data from the HSI to determine either the condition of a system structures and components (SSC) or the cause of the condition (ASME PRA Std.)

Framework: A systematic organization of tasks or activities used in a specified type of analysis.

Front-line system: an engineered safety system used to provide core or containment cooling, reactivity control or pressure control, and to prevent core damage, reactor coolant system failure, or containment failure (ASME PRA Std.)

Function: An activity or role performed by a human, structure, or automated system to fulfill an objective (System Functional Requirements Analysis Implementation Plan [2.1(3)]).

Human action (HA): A manual response to a cue involving one person to achieve one task or objective. Potentially risk important actions affect equipment or physical systems. Single human actions can be represented as an event in a fault tree or branch point in an event tree.

Human Error Probability (HEP): a measure of the likelihood that plant personnel will fail to initiate the correct, required, or specified action or response in a given situation, or by commission performs the wrong action (ASME PRA Std.)

Human Failure Event: an integrated logic description of HEPs based on the error modes, performance shaping factor assessment, and other qualitative information needed to justify a single input to the risk model (ASME PRA Std.)

Human interaction (HI): A human action or set of actions that affects equipment or physical systems, or an action that influences other human actions. Human interactions can be represented as an event in a fault tree or branch point in an event tree.

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 PRA Std.)

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.

Human-System Interface (HSI): The organization of inputs and outputs used by personnel to interact with the plant, including the alarms, displays, controls, and job performance aids. Generically, this includes maintenance, test, and inspection interfaces as well.

Inherent design features: Reliance on physical properties of systems, structures and components to meet design goals rather than relying on supplemental systems to achieve the design goal functions. For example, using properties associated with neutron flux in reactor cores to control reactivity via introduction of voids in the core versus changing control rod position.

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

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.

MMIS Design Team: The MMIS Design Team (Design Team) is a team of engineers, as defined in the Man-Machine Interface System And Human Factors Engineering Implementation Plan, responsible for the design of the MMIS systems.

Operational experience review (OER): A systematic review, analysis and evaluation of operational experience that can apply to the development of the man machine interface design.

Passive safety system: The design of systems and barriers to achieve a function (safety or operational) or increase a safety margin without using active components (such as pumps, valves that change state, use of external electric power, or a human action to operate the system). For example, use of natural circulation versus forced cooling to remove heat.

Plant-specific data: data consisting of observed sample data from the plant being analyzed (ASME PRA Std.)

Reactor safety: The development of a reactor design that is built and operated to pose no undue risk to public (ANS position paper). This means that the core is protected from damage under design basis events and the risk from PRA core damage sequences is mitigated through design features, backup systems and operator actions. Additional protection from radiation release is from the containment barrier.

Safety systems: those systems that are designed to prevent or mitigate a design-basis accident. (ASME PRA Std. amplified)

Screening analysis: an analysis that eliminates items from further consideration based on their negligible contribution to the probability of a significant accident or its consequences (ASME PRA Std.)

Screening criteria: the values and conditions used to determine whether an item is a negligible contributor to the probability of an accident sequence or its consequences (ASME PRA Std.)

Support system: a system that provides a support function (e.g., electric power, control power, or cooling) for one or more other systems (ASME PRA Std.)

System failure: termination of the ability of a system to perform any one of its critical design functions. Note: Failure of a line/train within a system may occur in such a way that the system retains its ability to perform all its required functions; in this case, the system has not failed. (ASME PRA Std.)

Task: A collection of activities with an identifiable start and end point for which human actions are performed.

2 References

2.1 Supporting Documents

1. ESBWR DCD Chapter 18 revision 0, August 2005 (GE 26A6642BX)
2. Operational Experience Review (OER) Plan
3. System Functional Requirements Analysis Implementation Plan
4. Allocation of Functions Implementation Plan
5. Task Analysis Implementation Plan
6. Human System Interface Design Implementation Plan
7. Human Reliability Analysis (HRA) Plan
8. Procedure Development Plan
9. Training Program Development Plan.

10. Human Factors Verification & Validation Implementation Plan

11. Human Performance Monitoring Plan

2.2 Codes and Standards

1. ANSI/IEEE Std. 1023, IEEE Guide to the Application of Human Factors Engineering to Systems, Equipment and Facilities of Nuclear Power Generating Stations, (IEEE);

2. ANSI/ANS 58.8-1994, "Time Response Design Criteria for Safety-Related Operator Actions"

3. ASME, "Standard for Probabilistic Risk Assessment For Nuclear Power Plant Applications," ASME RA-S-2002, ASME, April 5, 2002;

2.3 Regulatory Requirements and Guidelines

1. NUREG-0700, Rev.2, Guidelines for Control Room Design Reviews, 1981, (US Nuclear Regulatory Commission)

2. NUREG-0711, Rev.2, Human Factors Engineering Program Review Model, 2004, (U.S. Nuclear Regulatory Commission)

3. NUREG-1764 Guidance for Review of Changes to Human Actions February 2004, (U.S. Nuclear Regulatory Commission)

4. NUREG-1123 "Knowledge and Abilities Catalog for Nuclear Power Plant Operators: Boiling Water Reactors. 1995 (US Nuclear Regulatory Commission).

5. NUREG-1649: Reactor Oversight Process 2000; (US Nuclear Regulatory Commission)

6. NUREG-0737, Clarification of TMI Action Plan Requirements (Supplement 1 to R.G. 0737 and Item I.C.5, "Feedback of Operating Experience to Plant Staff"); (US Nuclear Regulatory Commission).

7. NUREG-0933 A Prioritization of Generic Safety Issues, Supplements HF (US NRC 2004).

8. Regulatory Guide 1.8 Qualification and Training of Personnel for Nuclear Power Plants Revision 3 2000.

9. Regulatory Guide 1.174 An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis

10. NUREG-0800: Standard Review Plan: Chapter 19, Use of Probabilistic Risk Assessment in Plant-Specific, Risk-Informed Decision Making: General Guidance (NRC (2002).

11. NUREG-0800, Standard Review Plan, Chapter 18.

12. NUREG-0654 "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, 1980 addenda, 1980.

2.4 Departments of Defense and Energy

1. AD-A226 480, U.S. Army Test and Evaluation Command, Human Factors Engineering, Test Operation Procedure 1-2-610 (Part 1), May 1990.

2. DOE Order 5480.19, Conduct of Operations Requirements for DOE Facilities;

3. MIL-H-46855B, Human Engineering Requirements for Military Systems, Equipment and Facilities (Dept. of Defense) May 1999.

4. MIL-STD 1472C, Human Engineering Design Criteria for Military Systems, Equipment and Facilities, Dept of Defense.

2.5 Industry and Other Documents

1. Advanced Light Water Reactor Utility Requirements Document, Vol. II ALWR Evolutionary Plant, Chapter 10, Man-Machine Interface Systems.

2. EPRI NP-3659, Human Factors Guide for Nuclear Power Plant Control Room Development, 1984.

3. EPRI, NP-4350, Human Engineering Design Guidelines for Maintainability (Electric Power Research Institute);

4. EPRI-NP-1567, Human Factor Review of Power Plant Maintainability, (Seminara, 1981).

5. EPRI-NP-2360, Human Factors Methods for Assessing and Enhancing Power Plant Maintainability, (Seminara, 1982).

6. EPRI-NP-3701 Computer-generated Display System Guidelines (Vol. II and I).

7. IAEA, ASSET Guidelines: Revised. 1991 Edition, IAEA-TECDOC-632, (1991).

8. IAEA-TECDOC-525, Guidebook on Training to Establish and Maintain the Qualification and Competence of Nuclear Power Plant Operations Personnel, Vienna, 1989.

9. INPO 85-017 Rev 2, Guidelines for the Conduct of Operations at Nuclear Power Stations.

10. IP 71715: Sustained Control Room and Plant Observation. (NRC, 1998, periodically updated).

11. NRC IN 95-48 "Results of Shift Staffing Study," 1995

12. NRC IN 97-78 "Crediting of Operator Actions in Place of Automatic Actions and Modifications of Operator Actions, Including Response Times," 1997

3 ESBWR Baseline Staffing

The number of qualified staff for the ESBWR must be adequate to provide safe operation under design basis and risk important accident conditions. To meet this goal, consideration is given to the numbers and functions of the staff needed to safely perform all required plant operations, maintenance, and technical support for each operational mode; and the minimum qualifications of plant personnel in terms of education and training, skill, knowledge, experience, and fitness for duty.

3.1 Recommended Pre-design Initial Staffing

The recommended baseline S&Qs come from the ESBWR DCD Chapter 18, the preliminary operational staffing assumption for reactor control and monitoring will consist of the assignments shown in Table 1. During all phases of normal plant operation, abnormal events and emergency conditions, the ESBWR is planned to be operated by two licensed control room operators and one licensed control room shift supervisor (manager). In addition, the operating crew will include one licensed shift manager. Additional operational staff will include non-licensed auxiliary equipment operators. The number and qualifications required for ESBWR staffing will be evaluated as part of the task analysis. During accidents, it is assumed that technical assistance will be available to the operating crew from personnel in the technical support center. Four licensed operators are on shift at all times, consistent with the staffing requirements of 10 CFR 50.54m.

The main control room shift staff size and roles will be re-evaluated through HFE applications during the detailed design to determine if the original plan for the necessary crew to accomplish safety related actions remains applicable to the ESBWR. The demands of operating and maintaining the MCR and other HSIs using procedures will be assessed for their implications for personnel skills and qualifications

3.2 Assumptions for Staffing and Qualification

Throughout the design phases the following assumptions support development of the recommended staffing levels needed to accomplish the key safety functions.

- A licensed control room operator remains in control of plant operation during all states of operation. During normal operation the licensed control room operator will monitor the automated control functions.

- The licensed control room operator will be able to assume manual control of those functions that have been automated for reasons other than regulatory requirements. Each operating crew's training will include manual operation of any automated function that has been returned to manual monitoring and control.

Table 1 Initial Baseline Shift Staffing and Qualifications Matrix

Quantity	Qualification	Assignment
1	Control Room Supervisor[1]	Provides overall supervision of control room operations
2	Reactor Operators[2]	First operator is assigned to normal control actions at MCR HSI. Second operator is assigned to control of testing, surveillance and maintenance activities, including blocking and tagging permits.
1	Senior Reactor Operator (Shift Manager)[1]	Assigned to shift but not necessarily in the Main Control Room (MCR). Acts as manager of and relief for shift supervisor.
2	Auxiliary Operators[3]	Qualified to operate equipment in the plant.

[1] Licensed by the NRC as a Senior Reactor Operator (SRO)
[2] Licensed by the NRC
[3] Non-Licensed, often called Auxiliary Equipment Operators (AEOs)

- During outage periods the licensed control room operators remain in control of plant operations by monitoring the systems that are unavailable during repairs and maintaining sufficient system availability to ensure protection of fuel integrity.
- The shift team will observe appropriate limits and conditions for shift work including overtime, shift duration, and shift rotation.
- The HSI design minimizes the potential for human factor problems that will negatively affect plant safety and performance, (e.g., (1) knowledge, skills and ability of recommended staff can operate and maintain the HSI; (2) the HSI is consistent throughout the MCR and local plant stations; and (3) maintenance, surveillance and calibration activities using the HSI are not unnecessarily complex).

3.3 ESBWR Design Changes

After the ESBWR design is finalized prior to COL acceptance, it is possible that changes to the HSI will be proposed. These post-design plant modifications, occurring prior to COL issue that impact or generates high risk human actions (HAs), will be analyzed to determine impact on Staffing & Qualifications. For these post design plant modifications, the HFE program in conjunction with the operating license holder will include the involvement of experienced plant personnel to provide reasonable assurance that the user's perspective is considered in establishing modification requirements and evaluating the design process's outputs. For example, in the case of shared sites with previous BWR designs, modifications and updates of the ESBWR will include consideration of:

- user's understanding of how plant systems are structured and behave,
- task demands and constraints of the existing work environment, and
- impacts on existing work processes.

Furthermore, the impact of these ESBWR design modifications on the operational staff will be examined by screening or analysis for their impact on implementation and goals for the COL holder. The staffing examination will re evaluate the number and background of personnel for the full range of plant conditions and tasks including operational tasks (normal, abnormal, and emergency), plant maintenance, and plant surveillance and testing when implementing a modification to the ESBWR base design.

4 Staffing and Qualifications Evaluation Plan

The general staffing analysis process with feedback for developing recommendations for staffing and qualifications is outlined in Figure 1. This figure shows possible interactions with other HFE tasks that support the staffing analysis process. Figure 2 provides a set of questions for analyzing specific HFE issues relative to the staffing requirements. Starting with knowledge from past BWR plant operations the S&Q analysis process will address HFE interactions in five phases that permit feedback and updating. These Phases are:

- Development of initial baseline S&Qs
- Apply deterministic rules for S&Qs to ESBWR Design
- Apply probabilistic evaluation to ensure acceptable risk profile
- Recommend S&Qs for ESBWR generic HSI design
- Refinement of S&Qs for customer specific ESBWR conditions.

4.1 Phase 1 Initial baseline S&Qs

This phase has been undertaken and is represented by the initial ESBWR safety analysis reports that have been submitted to the NRC. Based on an operating experience review that examined operational problems and strengths that resulted from staffing levels in ABWR reference systems the starting point for a baseline shift S&Qs is provided in Table 1.

These initial staffing goals and their bases stem from staffing levels for the ABWR reference plants, assuming system level similarities. Where the ESBWR design features give rise to significant differences in plant systems from previous designs (i. e., described in the Baseline Review Records), reexamination of the S&Qs is performed.

The baseline shift staffing recommendations will account for considerations discussed in NRC IN 95-48 and NRC IN 97-78 through a Gap analysis.

4.2 Phase 2 Deterministic Considerations for S&Qs

The second Phase for determining that the recommended baseline S&Qs are adequate to maintain ESBWR safety is to consider the deterministic rules established in regulations and by previous nuclear plants. Previous ABWR systems have addressed human factors considerations that have been explicitly defined for consideration in the design process of new plants as a result of the lessons learned from worldwide operating experience of all reactors and specifically BWRs. The deterministic rules for S&Qs are taken from NRC and industry reports such as NUREG 0700 r2, and NUREG 0800. As shown in Figure 1 the systematic process for evaluating S&Qs relative to the deterministic rules involves the three technical elements to be applied during the design process that are discussed below.

4.2.1 System Functional Requirements Analysis

The ESBWR design provides significant improvements in operational simplicity and passive safety features. The development of specific system functional requirements for the detailed design can establish a basis for reducing operational staffing requirements. A Gap analysis will be used to identify changes to operational staffing requirements compared to the ABWR reference design.

4.2.2 Function Allocation

The simplification of systems for the ESBWR will permit additional automation and reduced requirements for human decision-making and manual operation. The function allocation process will identify mismatches between functions allocated to personnel and their qualifications. This can result in changes to roles of personnel due to plant system and HFE modifications. Adjustment of the roles and responsibilities will depend on the use of automatic versus manual operations.

4.2.3 Task Analysis

Because of the ESBWR changes to natural circulation and passive cooling, there will be additional time for on-site staff to react and for off-site personnel to reach the plant during a significant transient event defined in the design basis and risk assessment. Therefore, the number of onsite and control room staff might be adjusted for a normal ESBWR shift, as compared to that for ABWR plants. Adjustments to requirements are addressed by the task analysis in the following areas:

- Knowledge, skills, and abilities needed for personnel tasks addressed by the task analysis
- Personnel response time and workload
- Personnel communication and coordination, including interactions between them for diagnosis, planning, and control activities, and interactions between personnel for administrative, communications, and reporting activities
- The job requirements that result from the sum of all tasks allocated to each individual both inside and outside the control room
- Ability of personnel to coordinate their work through the plant HSI (e.g., directing local valve control from a remote display monitor)

- Availability of personnel, considering other activities that may be ongoing and for which licensed control room operators may take on responsibilities outside the control room (e.g., fire brigade)
- Staffing considerations described by the application of ANSI/ANS 58.8-1994
- Adequate planning to ensure that the information systems, personnel knowledge, procedures and emergency planning actions identified in 10 CFR 50.47, NUREG-0654, provide initial accident response in key functional areas as identified in the ESBWR emergency plan.

4.3 Phase 3 Probabilistic Evaluation

The third Phase in verifying the adequacy of the recommended S&Qs involves the use of risk assessment tools that will be initially applied during the design and updated in future phases. An evaluation of the impact of changes to the baseline S&Qs will be used to adjust, where appropriate, the HRA assumptions and quantification. These changes will be re-evaluated in the PRA/HRA model accident sequences to determine changes in the importance of key human actions. This requires both qualitative and quantitative assessments within the HRA models and re-quantification of the baseline PRA/HRA model to produce an updated importance listing. By demonstrating that the change in risk from the baseline risk is within acceptable limits, the recommended S&Qs pass a risk informed test. There are two connected technical elements needed to evaluate the risk importance and change in risk. These are the human reliability analysis and the PRA/HRA ESBWR model.

4.3.1 Human Reliability Analysis

One of the considerations in evaluating actions such as maintaining or restoring shutdown cooling (SDC) is the number of operators available and their qualifications in terms of skills, knowledge and training; and applicability of procedures. The required level of skill and knowledge can vary significantly depending on the accident sequence. For example, restoration of the SDC during a normal shutdown can be considered routine, whereas the same action during a loss of station electric power or during a fire can be more challenging and require a significant level of adaptability to effectively use the procedures. This difference is due to the specific HSIs used to provide cues for action and feedback, available crewmembers, their skill and knowledge, and the time allowed for the action. These factors are reflected in the qualitative human action logic and application of sublevel human error probabilities (HEP) to identify overall HEP-related changes to the HRA inputs to the PRA/HRA model.

Updates to the HRA models provide a means for evaluating the risk importance of overall staffing levels and crew coordination for risk-important HAs. Also, the effect of overall staffing levels and the coordination of personnel on human errors associated with the use of advanced technology can be evaluated for risk importance combined with the PRA/HRA baseline model.

4.3.2 PRA/HRA

The baseline PRA/HRA model, which is based on screening HEP values for many human actions that are modeled, will be adjusted to include changes in the HRA data, possible logic adjustments within systems or accident sequences, and fine-tuning the analysis of dependencies between actions. Thus, the effect of overall staffing levels on plant safety and reliability will be assessed via importance ranking and measures determined by the PRA/HRA model.

4.4 Phase 4 Screening

Everyone who works in a nuclear power plant has a role in safety from the safety culture viewpoint. For example, some staff members have a major role involving public safety in responding to events whereas others must address their own personnel safety. The focus for HFE support of the HSI design addresses the management and control of reactor safety for those key actions allocated to manual tasks.

The ESBWR design represents a major shift in management of reactor safety from active systems that are controlled by both automation and operational staff to passive safety functions that rely primarily on inherent features of the design. These inherent features shift the fundamental operator tasks from manual back up on many active systems to monitoring and supporting operation of the natural circulation systems during transient events. Thus, development of the S&Qs for personnel involved in reactor safety is expected to change to meet different needs for the ESBWR.

4.4.1 Existing staff and qualifications

The first step in screening is to determine the staffing requirements to interact with the plant systems. By regulation any nuclear power plant must establish and maintain a training program as defined in 10 CFR 50.54m and 10 CRF 50.120. The training program must provide for the training and qualification of the following categories of nuclear power plant personnel:

1. Reactor Operator
2. Senior Reactor Operator (Shift Manager)
3. Shift Technical Advisor
4. Shift Supervisor. (Control Room Supervisor)
5. Non-licensed operator (Auxiliary Operator)
6. Instrument and control technician

7. Electrical maintenance personnel
8. Mechanical maintenance personnel
9. Radiological protection technician
10. Chemistry technician
11. Engineering support personnel.

4.4.2 Qualitative assessment of safety functions

The second step in screening is to evaluate the likely importance of manual tasks defined in the function allocation process and identified through other means relative to reactor safety. Table 2 provides example screening criteria for evaluating task interactions with the plant that have some type of safety role. The types of tasks derived from IEEE 497, and listed in S&Q regulatory requirements are screened for their impact on reactor safety by noting the expected analysis type used for screening in the HFE tasks for TA, HRA, S&Qs and HSI. In many cases it is expected that the design will use previously developed standard BWR design interfaces for typical power plant systems such as pumps and turbines used in the steam supply systems. The ESBWR is expected to reduce the number of required safety function tasks by relying more on the inherent features designed to cover plant safety functions, and passive safety systems that reduce the number of automated and manual tasks required for operation.

As can be seen from Table 2 the key HSI design elements involve tasks that qualitatively impact reactor safety and also have the potential for reducing risk. This table can be updated and modified through use in the HFE program. The specific tasks related to reactor safety are assigned to the specific job categories listed in the previous section.

Table 2 Manual task screening matrix for HFE HSI detailed design importance

	Generic Task Descriptions [1]	Example	Human Factors Engineering for Human System Interface: TA	HRA	S&Q[3]	HSI.
1	Operator tasks required to start, control and stop equipment to prevent core damage or limit significant radioactive release	Manual control of containment venting to reduce steam pressure in containment prior to core damage	Yes	Yes	Yes	Yes
2	Operator tasks that backup automated systems used to prevent core damage or limit significant radioactive release	Manual control rod insertion should the automated system fail to respond	Yes	Yes	Yes	Yes
3	Operator tasks for short term surveillance and testing of active equipment to prevent tripping the reactor or electrical systems.	Monitor turbine generator vibration	Depends on circumstance	In failure data [2]	Personnel assigned	Standard interface
4	Operator tasks for surveillance and testing of standby equipment to verify availability.	Test for diesel generators operability	Use previous assessments	Depends on response time	Personnel assigned	Standard interface
5	Operator tasks for surveillance and testing of structures to verify that protective margins are maintained.	Verify piping thickness and welds meet the code requirements for the pressures used.	Use previous assessments	In failure data	Personnel assigned	Standard interface
6	Operator tasks for repair or replacement of systems, structures and components.	Replace a feedwater pump	Use previous assessments	In failure data	Personnel assigned	Standard interface
7	Provide in plant radiation detection, monitoring and access control to measured radiation areas.	Heath physics detecting, monitoring, and controlling areas with radiation readings.	Use previous assessments	No	Personnel assigned	Standard interface
8	Tasks for meeting OHSA requirements for personnel safety.	Keeping plant areas clean.	No	No	Personnel assigned	Standard interface
9	Maintaining security restrictions to specific areas of the plant.	Plant access via security control	No	No	Personnel assigned	Standard interface
10	Operator tasks for maintaining record keeping	Maintaining records for all personnel that enter the plant and radiation records	No	No	Personnel assigned	Standard interface
11	Tasks for supporting personnel involved in reactor safety.	Food service.	No	No	Personnel assigned	Standard interface
12	All other tasks		No	No	Personnel assigned	Standard interface

[1] The tasks are derived from IEEE 497, and requirments for staffing in 10CFR50.54, 50.55, 50.120, and 50.47

[2] If necessary the failure data can be mapped to specific human actions.

[3]Personnel assigned refers to application of the activity only to those appropriate staff

4.4.3 Quantitative evaluation by risk assessment

The HFE program will identify specific qualifications needed to address reactor safety issues by reviewing the issues that are listed in the HFE issues tracking (HFEITs) program, and through interactions with the PRA to determine the quantitative importance of specific manual actions that can impact the risk profile. The process for using the PRA/HRA model is described in the HRA implementation plan. It is expected that the specific training and qualifications will be identified through interactions with the PRA.

4.5 Phase 5 S&Qs for ESBWR

As shown in Figure 1 the HFE HSI design process includes a fifth Phase. This phase determines if the recommended S&Qs are adequate to safely operate the ESBWR. The HFE design team will verify that the recommended plant staffing is adequate for using information available through the HSI to identify abnormal situations, take corrective actions and obtain feedback on the impact of corrective actions that are taken.

4.5.1 S&Qs for the baseline ESBWR

Adequacy of the recommended S&Q level for the baseline ESBWR can be demonstrated by showing that:

- Staffing level is adequate to meet operational and accident demands resulting from the locations and use (especially concurrent use) of controls and displays
- The HSI supports coordinated actions between individuals at different strategic locations
- The plant system HSI (with HFE modifications) provides timely information that is accessible and focused as needed by qualified personnel
- The physical configuration of the control room and control consoles supports the organization and number of recommended staff
- The plant information from HSI both individual workstations and group-view interfaces is available during transient events to the baseline staff as well as technical support centers.

4.5.2 S&Qs for Customer Specific ESBWR

The baseline S&Qs adequacy also involves the utility customer and is developed after the baseline HSI design approach is determined. As shown in Figure 1 the technical elements for this phase are procedure development and training. By this time the baseline S&Qs for operational staff will be well established, but other plant staff can be added to address other staffing needs.

During this phase the plant specific procedures and training will be developed for the shift operations staff and other support staff. Furthermore, the staff needed for outage planning, outage maintenance, refueling and waste handling will be addressed after details of the system designs are developed. Also, recommendations for personnel involved in administration, security, training, engineering, fire departments, access monitoring, record keeping, or local services (e.g., cafeteria) will be based on the operating utility and regulatory requirements. As shown in Figure 1 adequacy of the recommended S&Qs will be systematically checked during procedure development and training programs.

4.5.3 Procedure Development

During procedure development and refinement from previous designs the adequacy of the recommended S&Qs will be checked by:

- Confirming that the staffing demands are adequate to avoid concurrent use of multiple procedures to meet normal operational or transient event requirements by one member of the crew, and
- Confirm that the level of personnel skills, knowledge, abilities, and authority for each crewmember is suitable to identify, evaluate and carry out tasks identified in the procedures.

4.5.4 Training Program Development

During development of the training program, issues for refinement of the recommended S&Qs through HFE review can be identified by:

- Addressing the ability of the crew to communicate and coordinate successfully using the HSI to carryout the tasks and actions that protect the plant assets and public safety, and
- Developing training modules that continually enhance and reinforce the skills, knowledge, and abilities needed to accomplish each task identified in the procedures.

4.6 Results Summary Report

Upon completion of the process outlined in this implementation plan, a results summary report will be prepared. It will include a HFE evaluation of the number and qualifications of personnel needed to operate the ESBWR based on the HSI design features.

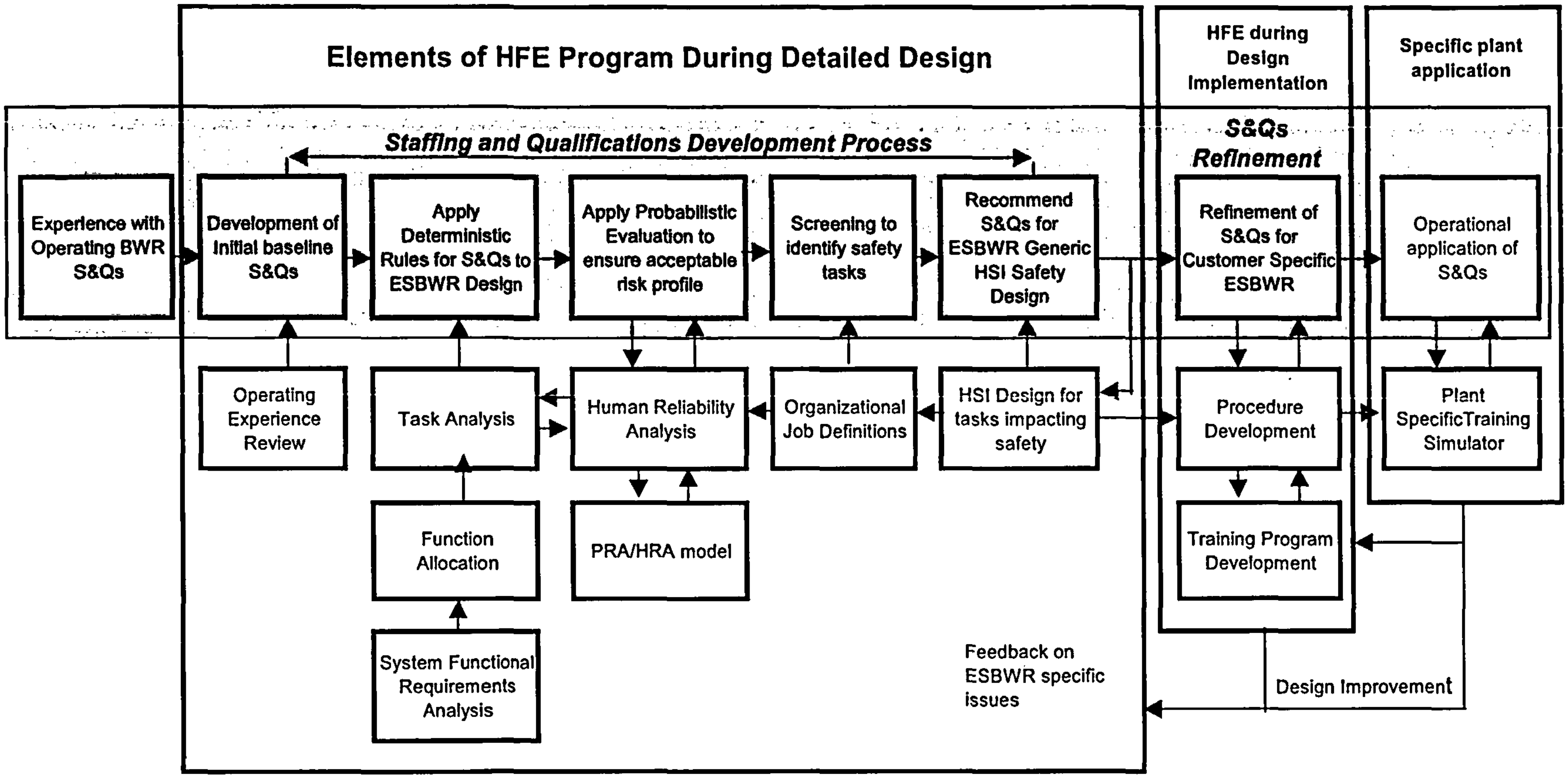

Figure 1 Process for development of ESBWR Staffing and Qualification recommendations

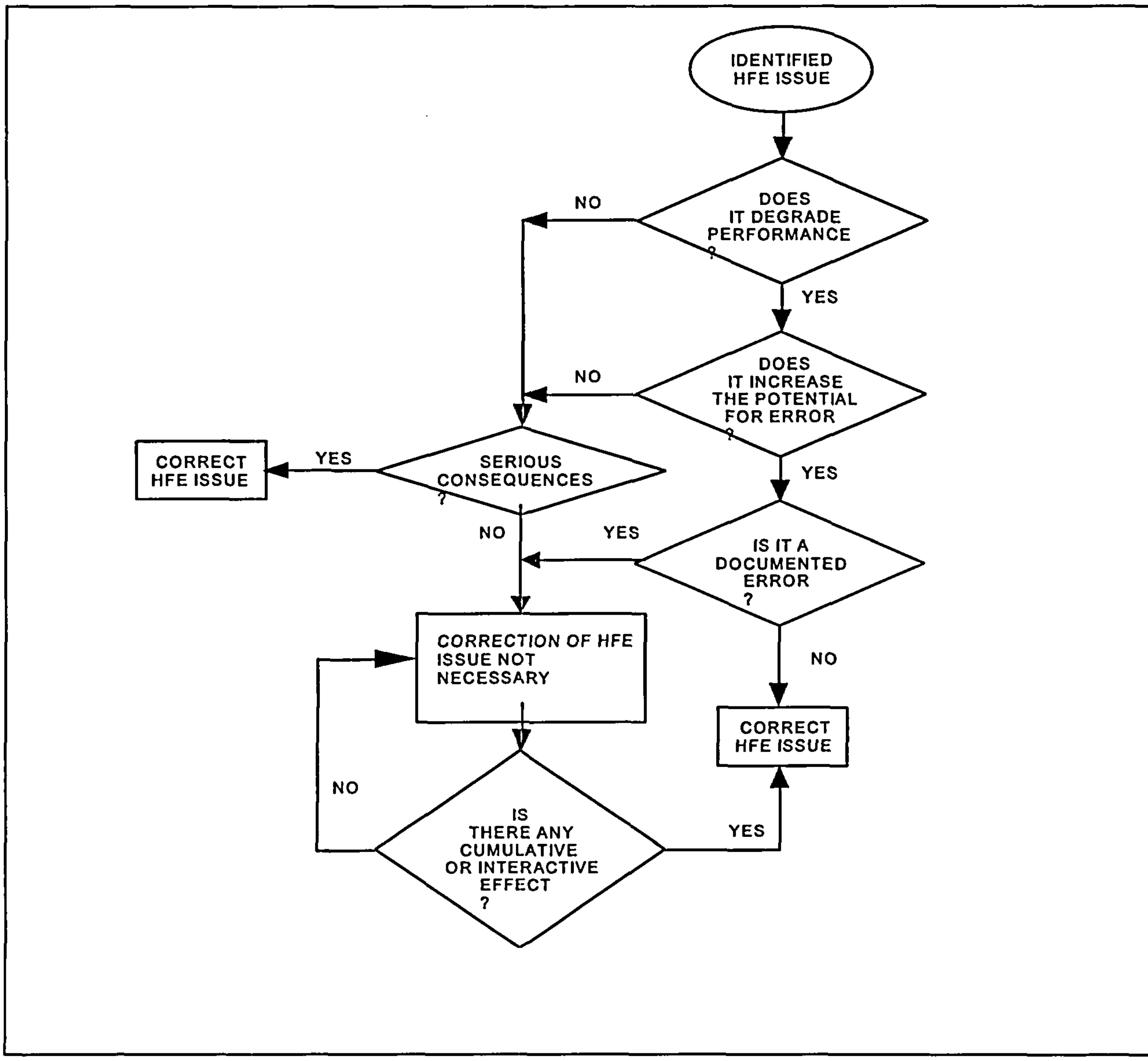

Figure 2 HFE Issue Evaluation Process