US-APWR

Staffing and Qualifications Implementation Plan

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		p.19 (Section 5.0)	Deleted a sentence of the section end. Added reference 5-14. Revised description of references.
2	October 2012	All pages	Revised to incorporate comments by the NRC in March 2012 to keep consistency in technical description with DCD Chapter 18 and MUAP-09019, MUAP-10009, MUAP-10010 and MUAP-10012.

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Abstract

This document presents the implementation plan for the US-APWR staffing and qualifications analysis. The US-APWR staffing and qualifications complies with 10 CFR 50.54 (i) through (m). The staffing analysis covers tasks performed by both licensed operating staff and non-licensed positions (e.g., maintenance and testing staff) directly related to plant safety. Operations crew staffing for the US-APWR is based on the minimum staffing level design constraint for the operating crew. This includes the minimum main control room (MCR) staff of one reactor operator (RO) and one senior reactor operator (SRO) who serves as the MCR Supervisor and Shift Technical Advisor (STA). The minimum MCR staff is supplemented by one additional SRO and one additional RO that are to be at the plant to accommodate abnormal design conditions, including conditions where the human-system interface system (HSIS) is degraded. In addition, the minimum operating crew design constraint includes one more person present at the facility during its operation with SRO or STA qualifications. During emergency conditions, this person will relieve the MCR Supervisor of either the supervisor or STA responsibilities. This person can be shared by multiple units. The minimum operations staffing design constraint is the basis of the Task Analysis, HSI Design and V&V program elements. This Implementation Plan ensures the minimum staffing is properly considered in those program elements and thereby confirms the adequacy of the minimum operations crew.

Staffing levels and qualifications for other non-operations positions are determined through the specific analysis directed by this Implementation Plan. For these positions the analysis begins with a baseline that reflects the staffing levels and qualifications of non-operations personnel at predecessor US 4-Loop PWR plants. The staffing analysis then examines the changes in US-APWR technology and plant system designs to determine any impact on the baseline. The staffing analysis uses as input results of prior human factors engineering (HFE) program elements including operating experience review. The staffing analysis is conducted by experts who have conducted or managed the activities within the scope of these non-operational positions at currently operating US 4-loop PWRs, with support from HFE experts and experts on the design of the US-APWR technology and systems designs.

The result of staffing and qualifications analysis is used as input to other HFE elements including HSI Design, Procedure Development and Training program development.

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List of Acronyms

AOO	anticipated operational occurrence
CBP	computer-based procedure
CFR	Code of Federal Regulations
COL	combined license
COLA	combined license application
DAS	diverse actuation system
DCD	design control document
ECCS	emergency core cooling system
EOF	emergency operations facility
EOP	emergency operating procedure
ERG	emergency response guidelines
FA	function allocation
FRA	functional requirements analysis
FSAR	final safety analysis report
GDC	general design criteria
GTG	generic technical guidelines
HA	human action
HED	human engineering discrepancy
HFE	human factors engineering
HRA	human reliability analysis
HSI	human-system interface
HSIS	human system interface system
I&C	instrumentation and control
ITAAC	inspection, test, analysis, and acceptance criteria
LCS	local control station
MCR	main control room
MHI	Mitsubishi Heavy Industries, Ltd.
NRC	Nuclear Regulatory Commission, U.S.
OER	operating experience review
OSD	operational sequence diagram

PA	postulated accidents
PAM	post-accident monitoring
PRA	probabilistic risk assessment
PSF	performance shaping factor
QA	quality assurance
RG	Regulatory Guide
RIHA	risk-important human action
RO	reactor operator
SER	significant event report
SA	staffing and qualification analysis
SG	steam generator
SOER	significant operating experience report
SRO	senior reactor operator
TA	task analysis
TSC	technical support center
US, U.S.	United States
US-APWR	United States – Advanced Pressurized Water Reactor
V&V	verification and validation
VDU	visual display unit

1.0 PURPOSE

This document describes the staffing and qualifications implementation plan for the US-APWR.

The objective of the staffing and qualifications analysis (SA) is to systematically determine the numbers and qualifications of personnel required for safe and efficient plant operation.

2.0 SCOPE

The plant personnel that are addressed by the staffing and qualifications analysis include licensed control room operators as defined in 10 CFR 50.54(m), and the following categories of personnel defined in 10 CFR 50.120:

- Non-licensed operators
- Shift supervisors or managers
- Shift technical advisor
- I&C technicians
- Electrical maintenance personnel
- Mechanical maintenance personnel
- Radiological protection technicians
- Chemistry technicians
- Engineering support personnel.

Tasks directly related to plant safety are addressed in this analysis in the full range of plant operating modes, including the following:

- Startup / Shutdown
- Normal operations
- Abnormal and Emergency operations
- Transient conditions

The scope of tasks covered by the analysis includes operational tasks, plant maintenance tasks, and plant surveillance and testing.

Personnel required for tasks directly related to plant safety are included in the scope of the analysis. In addition, the analysis ensures that the performance of tasks not directly related to plant safety do not cause an adverse effect on tasks or personnel performing tasks directly related to plant safety.

3.0 APPLICABLE CODES, STANDARDS AND REGULATORY GUIDANCE

Compliance with the applicable codes and standards for the US-APWR human system interface system (HSIS) design and human factor engineering (HFE) Process is identified in section 3.0 of the topical report “HSI System Description and HFE Process”, MUAP-07007 (Reference 5-2).

4.0 IMPLEMENTATION PLAN

4.1 Overview of Staffing and Qualifications Analysis Approach

The staffing and qualifications analysis begins with assumptions in staffing levels for Pressurized Water Reactor (PWR) plants in the U.S. as modified by the design constraint for the US-APWR minimum operations crew. These staffing assumptions conform to U.S. regulations listed in Section 3.0 and comply with 10 CFR 50.54 (i) through (m).

A systematic process is then used to evaluate these staffing assumptions and to establish the numbers and qualifications of personnel required for safe and efficient plant operation of the US-APWR.

If the staffing and qualification analysis concludes that the design constraint for the minimum operating crew is not adequate, plant and/or HSI design changes will be made to maintain this staffing constraint.

Staffing levels and qualifications for non-operations positions begins with a baseline that reflects the staffing levels and qualifications of non-operations personnel at predecessor US 4-Loop PWR plants. The staffing analysis then examines the changes in US-APWR technology and plant system designs to determine any impact on the baseline. The staffing analysis uses as input results of prior human factors engineering (HFE) program elements including operating experience review and task analysis. The analysis approach utilizes multiple complementary methods, including review of data from operational experience and table top analyses. The staffing analysis is conducted by experts who have conducted or managed the activities within the scope of these non-operational positions at currently operating US 4-loop PWRs, with support from HFE experts and experts on the design of the US-APWR technology and systems designs. Details of this analysis methodology are provided in section 4.4.

The staffing and qualifications analysis utilizes an iterative process. Staffing level and qualifications are reviewed based on inputs from other elements of the HFE plan, including operating experience review; functional requirements analysis, function allocation, Human Reliability Analysis (HRA) and task analysis (TA). Plant or HSI designs are modified as necessary to meeting the minimum operating crew design constraint. Staffing and qualifications for other non-operations positions are modified as necessary to match the plant design.

The result of staffing and qualifications analysis is used as input to other HFE elements including HSI Design, Procedure Development and Training program development.

Issues relating to staffing level or qualifications may be identified during any HFE element of the HFE program, including HSI design, procedure development and training program development. Any identified issues are entered into the human engineering discrepancy (HED) database and evaluated and resolved per the standard HED evaluation process described in Part 1, Section 6 of MUAP-09019. The HED resolution may include modification to the plant design, HSI design, staffing level or staff qualifications requirements.

Section 4.2 specifies the initial US-APWR staffing level and qualifications baseline and their bases. Section 4.3 describes how the staffing and qualifications analysis fits within the overall HFE program, including specification of the HFE elements that feed into the staffing and qualifications analysis, and the HFE elements that rely on the outputs of the staffing and

qualifications analysis. Section 4.4 describes the methodology that will be used to evaluate the staffing level and qualifications baselines.

4.2 Initial Staffing Level and Qualifications Goals and Baselines

The initial staffing levels for the US-APWR staffing and qualifications analysis are based on staffing levels of predecessor PWR plants with modifications reflecting the minimum operating crew design constraint. These initial assumptions for staffing levels are described below and comply with 10 CFR 50.54.

Training and qualifications requirements for the US-APWR staff are consistent with training and qualifications requirements in current U.S. PWR plants and reflected in personnel job titles as described below.

4.2.1 Operating Staff Roles and Responsibilities

For the US-APWR, the plant operating staff is constrained as described below. The operators are responsible for safely operating the US-APWR during normal power operation, as well as during transient and accident events included in the plant design basis. This includes licensed control room operators as defined in 10 CFR 50.54(m) and 50.55.

Operating staff positions and associated qualifications:

- Shift Manager

  The Shift Managers are responsible for supervising the evolutions conducted during their shift and ensuring that they are conducted in accordance with the operating license, station procedures, and applicable directives and policies. The Shift Managers are responsible for supervising shift operations personnel and for conducting on-shift training. During periods when senior management personnel are not on site, the Shift Manager assumes responsibility for all station activities. Each Shift Manager is required to maintain a Senior Reactor Operator (SRO) License pursuant to 10 CFR Part 55.54 “Senior Operator”.

- MCR Supervisor

  The MCR Supervisors (also referred to as Shift Supervisors, Unit Supervisors or Control Room Supervisors) report directly to the Shift Manager, and are members of management who assist the Shift Managers in discharging their responsibilities for supervision of the plant operation. The MCR Supervisors may assume the duties of the Shift Managers in their absence. The MCR Supervisor is required to maintain a SRO License.

- Shift Technical Advisor

  Shift Technical Advisors (STAs) report to the Shift Manager. For minimum staffing, the STA responsibilities may be assigned to the MCR Supervisor during normal operations. To fulfill this role the MCR Supervisor will have both SRO and STA qualifications. During emergency operations, a person present at the facility during its operation with SRO or STA qualifications will relieve the MCR Supervisor of his combined SRO/STA duties, allowing a single focus during emergency conditions. Alternately, STA duties may be assigned to a dedicated STA; this dedicated position is assumed in the maximum staffing configuration. The person fulfilling the role of STA shall have the qualifications described

in Option 1 of the Commission Policy Statement on Engineering Expertise (50 Federal Registry 43621, October 28, 1985).

- Reactor Operators

  The Reactor Operators report directly to the MCR Supervisor, and are responsible for routine evolutions on their assigned unit and for monitoring the status of that unit. They are also responsible for abnormal and emergency operations. Each Reactor Operator is licensed pursuant to 10 CFR Part 55.54 “Operators”.

- Auxiliary Operators (Non-licensed Operators)

  The auxiliary operator works under the direction of a Shift Manager or MCR Supervisor. The auxiliary operator responsibilities include operating and servicing equipment remote from the MCR at the direction of Control Room operators.

4.2.1.1 Minimum and Maximum Operating Staff Numbers

The US-APWR staffing and qualifications complies with 10 CFR 50.54 (i) through (m). No exemption from these requirements is being sought.

The minimum operator staffing roles and responsibilities that are the basis for the US-APWR design are assumed as follows:

- One SRO located at the plant fulfilling the role of Shift Manager.
- One SRO located within the MCR fulfilling the role of MCR Supervisor and STA, during normal operation
- One RO located at the controls of the plant in the MCR
- One RO located at the plant
- At least one more person present at the facility during its operation with SRO or STA qualifications. During emergency conditions, this person will relieve the MCR Supervisor of either the MCR supervisor or STA responsibilities. This person can be shared between multiple units.

The second RO is required to be at the plant, but not in the MCR. The second RO will normally support maintenance and testing activities. The second RO is not credited for any design basis events. The second RO is credited for local control actions during the beyond design basis common cause failure of all digital systems. During other abnormal conditions, the second RO can be used to restore success paths that may not have responded correctly to emergency actuation signals. The second RO can also be used for local control actions during for continued plant operation during loss of all non-safety HSI. [This tells me we will only evaluate the role of the second RO for a single most limiting condition. This is not correct. We need to ensure that a single second RO is sufficient for all conditions where local actions are required. This will come out of the TA.].The minimum operating crew staff is the basis of the TA, HSI Design, Procedures and Training program elements. The minimum staffing is further confirmed during the V&V program element.

The HSI accommodations (i.e., space and layout) and habitability accommodations (i.e. ventilation, lighting and noise) in the MCR are based on the following maximum number of operations personnel:

- Two ROs, responsible for the operation of controls in MCR
- One MCR supervisor (Licensed SRO), responsible for the direct supervision of the operators in MCR
- One shift supervisor (SRO), responsible for overall plant operation
- One shift technical advisor (STA), responsible for providing engineering support

The physical and habitability accommodations within the MCR envelope are based on the following maximum number of active personnel:

- One shift crew assistant, responsible for assisting the shift supervisor and handling communications
- One additional RO, responsible for assisting the above two ROs and interacting with other members of the plant staff
- One NRC employee or representative
- One member of the Plant Owner's management
- Two Auxiliary Operators (Non-licensed Operators)

The maximum staffing is the basis of the HSI Design program element.

4.2.2 Other Plant Staff Roles and Responsibilities

The staffing and qualifications analysis also covers categories of non-licensed personnel defined by 10 CFR 50.120 that are responsible for operations and maintenance directly related to risk-important plant safety.

These additional personnel are not necessarily located in the MCR nor located at the nuclear facility at all times. The minimum qualifications requirements (education and job experience) for the following types of personnel are described in the Appendix A of NUREG-0711 "Human Factors Engineering Program Review Model," ANSI/ANS 3.1 Rev.1 -1999, "Selection, Qualification, and Training of Personnel for Nuclear Power Plants" and ANSI N18.7-1976 / ANS-3.2, "Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants":

- I&C technicians

  I&C technicians conduct maintenance, calibration, periodic test and trouble shooting for digital/analog I&C equipment and instrumentation & control devices (i.e., sensors, transmitters and cables).

- Electrical maintenance personnel

  Electrical maintenance personnel conduct maintenance, calibration, periodic test and trouble shooting for all breakers, motor control centers, batteries and control circuits (time delay relays, aux relays, and switches).

- Mechanical maintenance personnel

  Mechanical maintenance personnel conduct mechanical component maintenance including major component surveillance testing.

- Radiological protection technicians

Radiological protection technicians conduct radiation protection at nuclear facilities dealing with radiation protection activities and programs common to all nuclear power plant designs. These individuals shall be familiar with the design features and operation of nuclear power stations that affect the potential for exposure of persons to radiation. These individuals have the technical competence to establish radiation protection programs and the supervisory capability to direct the work of technicians, and journeymen required to implement the radiation protection programs.

- Chemistry technicians

  Chemistry technicians monitor and maintain the chemistry of the station's fluid systems. They respond to unusual chemistry transients and incidents and implement measures to mitigate such events. They obtain samples manually and analyze them during normal and emergency evolutions. They must be cognizant of the potential impact of chemistry on the plant and be aware of conditions that might compromise safe and reliable plant operation.

- Engineering support personnel.

  Engineering support personnel contribute to the safe and reliable operation of the nuclear power plant by (Engineering support personnel do not repair equipment, only maintenance people do as stated above. You might say: …by providing engineering support functions for nuclear plant equipment and plant activities, including review of operating data and oversight of maintenance programs. They should understand the fundamentals of nuclear power plant technology. Engineering personnel must have a healthy respect for the unique safety challenges posed by nuclear technology and be competent in their roles of supporting plant operation.

The initial staffing level for the staffing and qualifications analysis for non-operating staff categories of personnel are based on staffing levels of predecessor US PWR plants, as follows:

I&C technicians	33-45
Electrical maintenance personnel	33-40
Mechanical maintenance personnel	33-50
Radiological protection technicians	36
Chemistry technicians	13-16
Engineering support personnel	33-60

The ranges of numbers represent the staffing level variations in the operating plants to which the US-APWR will be compared.

Analyses described in Section 4.4 will then be used to evaluate the appropriateness of these initial staffing levels.

4.3 Relation of Staffing and Qualifications Analysis to Overall HFE Program

Part 1 of the Technical Report MUAP-09019 “HSI Design” (Reference 5-3) describes the US-APWR Human Factors Engineering (HFE) Overall Program Management Plan, which is described in Chapter 18 of the US-APWR DCD (Reference 5-1).

Figure 4.3-1 shows the relationship between the staffing and qualifications analysis and the other HFE program elements.

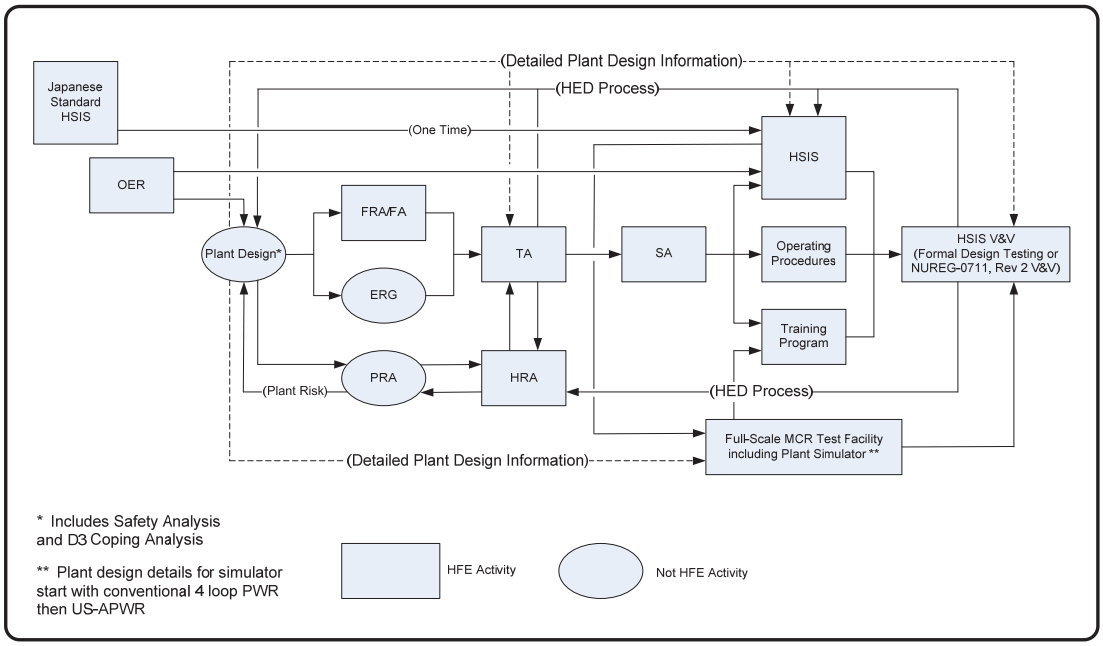

Figure 4.3-1 HFE Overall Work Flow

The staffing analysis starts with initial staffing levels as specified in Section 4.2.1.1 and 4.2.2 of this document. These initial staffing levels are then reviewed, and if necessary modified, in an iterative manner, based on inputs from other HFE elements within the overall HFE program. For the case of the minimum operating crew, plant and HSI design changes will be assessed as a solution to maintain this staffing level.

The task analysis provides the inputs to the staffing and qualifications analysis. Outputs of the staffing analysis are used to inform HSI design, procedure development and training program development. In turn, results of HSI design, procedure development and training program development, are considered, and if necessary modification, to the staffing and qualifications specification.

A primary mechanism for providing input and feedback across HFE elements is the Human Engineering Discrepancy (HED) documentation, resolution, closure and tracking process. Issues concerning staffing levels and qualifications that are identified during any HFE element are documented as HEDs. In turn the staffing and qualification analysis may also identify HEDs that impact staffing and qualification as well as the results from other HFE elements. These HEDs are then reviewed to assess their impact on staffing and qualifications. If warranted, modifications to HSI design, staffing and qualifications may be made.

The HED identification, tracking and resolution process is described in Section 6 of Part 1 of the Technical Report MUAP−09019.

Below are summarized the HFE program elements that provide inputs to the staffing and qualifications element as well as the HFE program elements that will use the outputs of the staffing and qualifications element as an input. It should be noted that several of the program

elements, specifically Operating Experience Review, Functional Requirements Analysis and Function Allocation, Human Reliability Analysis and Task Analysis for RIHAs, have already been completed and documented. The output products of these elements will be used to inform the staffing and qualifications program element.

4.3.1 Operating Experience Review

The US-APWR plant design is based on a conventional 4 loop PWR design currently in operation in the U.S. today. As a consequence, initial staffing levels and qualifications goals for the US-APWR are based on staffing levels and staff qualifications for predecessor U.S. and Japanese PWR plants. The only exception to this is the design constraint for the minimum operating crew.

Differences in technology, plant design or planned operations will be identified and analyzed to determine whether these differences impose significant changes in performance demands or if those changes can result in a reduction in staffing. These differences will also be considered to determine any impact on personnel.

The [this section is not related to operating staff] plant system changes from predecessor PWR plants may also impact the roles, responsibilities, and qualifications requirements for maintenance and plant surveillance and testing personnel. [There is no reason to delete the following examples. These are good examples that help to explain the sentence above.]For example:

- The change to a four train system (from two trains used in predecessor PWR plants) will increase the number of safety-related components/valves that need to be maintained/tested by maintenance personnel. However, it is expected that this increase in workload will be counter-balanced by a reduction in peak workload associated with periodic inspection because of the application of on-line maintenance and testing. This suggests that it may be reasonable to assume the same number of maintenance staff, but this will be evaluated in detail through the staffing and qualifications analysis.
- Qualifications of I&C maintenance personnel will change because of the adoption of full digital protection and control system. This impact on maintenance personnel qualifications requirements will be documented in the staffing and qualifications report. But the staffing numbers may be reduced due to the features of digital technologies, such as self-diagnoses, automatic test function and elimination of manual tests for setpoints.
- The replacement of diesel generators with gas turbine generators will impose different knowledge and skill requirements on maintenance personnel. This impact on maintenance personnel qualifications requirements will be documented in the staffing and qualifications report. However, the gas turbine generator system is simpler in view of components to be maintained than that of diesel generator system. As a consequence and with consideration of on-line maintenance, this change is not expected to increase the number of staff required in spite of the increase in the number of generators in total.

The discussion above provides examples of US-APWR features that may result in staffing or qualifications changes. The impact of these features on staffing requirements will be more

fully evaluated as part of the staffing and qualifications analysis. The methodology to be used is described in Section 4.4.

Another major change from predecessor plants relates to the application of fully digitalized I&C system and computerized HSI. These are key features of the US-APWR design, and may have impacts on the roles, responsibilities and knowledge and skill requirements, of operations, maintenance and plant surveillance and testing personnel. As a consequence, the impact of changes to the I&C and the HSI on staffing levels and qualifications requirements will also be analyzed.

In addition, operating experience at predecessor U.S. and Japanese PWRs is reviewed as part of the Operating Experience Review HFE element, to identify any issues in staffing levels or qualifications in current plants that need to be addressed by specifying new US-APWR staffing level and qualifications requirements.

The operating experience review (OER) report documented as MUAP-08014 Part 1 identifies and analyzes HFE related problems in conventional PWR plants in the U.S. and Japan. This OER reviews multiple sources including NUREG/CR-6400, IN 95-48, IN 97-78 (Reference 5−9, 11, and12). The OER also analyzes non-nuclear industrial applications of digital technology which employ screen based HSI.

The OER identified aspects of the US-APWR HSI System, as documented in Topical Report MUAP-07007, that adequately address historical human factors problems. Where a problem is not adequately resolved by the US-APWR HSI System, a Human Engineering Discrepancy (HED) was generated to document the problem and potential solutions. The HED is used to track the issue until it is adequately addressed in the US-APWR HSI design, staffing levels and qualifications, operating procedures or training program.

4.3.2 Function Requirements Analysis and Function Allocations

The functional requirements analysis (FRA) determines the plant functions that must be performed to satisfy the plant safety objectives. The FRA also identifies the plant power production functions since power production is an important aspect of plant performance. The function allocation (FA) allocates the identified functions for plant safety and plant power production either to human system resources, considering personnel characteristics, or to automated resources.

The FRA/FA of the US-APWR has been completed and is documented in Part 2 of the Technical Report MUAP−09019 “HSI Design” (Reference 5−3). It serves as an important input to the staffing and qualifications analysis in that it identifies the primary changes in plant system design from predecessor PWR plants that will impact the roles, responsibilities, and qualifications requirements of plant personnel – including operations, maintenance, and plant surveillance and testing personnel.

The major changes of the US-APWR functions from the convention PWR plant’s functions are:

- An automatic Emergency Feedwater isolation of the faulted steam generator (SG).
- Elimination of recirculation of ECCS and Containment Vessel Spray
- Four train safety system configuration (Contribute to high reliability, redundancy)
- Improved equipment designs including advanced steam generators and accumulators,
- Use of gas turbine generators for backup electrical power and

-The application of a digital I&C system and digital HSI

The changes listed above are expected to reduce operating staffs' workload and, as a result, the potential for human errors increasing confidence that the minimum operating crew staffing level assumptions documented in subsection 4.2.1.1 is acceptable. These staffing constraints are further evaluated as part of the task analysis HFE element, and will be definitively confirmed in the Phase 2b US-APWR V&V test.

The design staffing assumptions for the MCR and system changes from predecessor PWR plants may also impact the roles, responsibilities, and qualification requirements for maintenance and plant surveillance and testing personnel.

The application of the fully digitalized I&C system and computerized HSI are key features of the US-APWR design, and may have an impact on the roles, responsibilities and knowledge and skill requirements of operations, maintenance and plant surveillance and testing personnel. Analysis will be performed to fully understand the impact of changes to the I&C and the HSI on staffing levels and qualifications requirements.

As specified in Section 4.4, the FRA/FA will be reviewed to identify significant changes from predecessor plants that may have an impact on staffing levels and qualifications. These changes will then be further analyzed using a combination of table top analyses and simulator studies to determine how they impact US-APWR staffing level and qualifications.

4.3.3 Task Analysis

The functions assigned to plant personnel define their roles and responsibilities. Human actions are performed to accomplish these functions. Human actions can be combined into groups. A task is a group of related activities that have a common objective or goal. The purpose of the TA is to identify requirements for accomplishing identified tasks. The identified requirements, in turn, inform the HSI design including display screens, alarms, controls, data processing, operating procedures, and training programs that support the accomplishment of tasks.

MUAP-09019, Part 2, Section 3 documents the US-APWR task analysis methodology and results for risk important human actions. Additional task analyses are conducted in Phase 2b. Phase 2b task analyses will cover the remaining tasks from the areas of operations, maintenance, test, inspection and surveillance for a broad range of operating modes.

The task analyses provide important inputs to the staffing and qualifications analysis in that they specify:

- The number and complexity of cognitive and physical activities that are required to perform a task,
- Communications and coordination requirements,
- Time requirements and workload, job requirements,
- Required qualifications and
- An evaluation of the minimum operating crew design constraint.

The results of the task analyses provide the basis for assessing the adequacy of staffing level and qualifications. As is explained in Section 4.4, task analysis results will be used as input to table top analyses that will be conducted to determine whether the assumed staffing levels and qualifications are adequate for safe and efficient plant operation

4.3.4 Human Reliability Analysis

The Human Reliability Analysis (HRA) identifies risk-important human actions (RIHA) from the PRA/HRA. It generates probabilistic human reliability estimates for these risk-important human actions, based on assumptions of the quality of HSI and related task support and assumptions regarding plant staffing and their qualifications. This includes explicit or implicit assumptions regarding the number of personnel and their skill level.

The HRA serves as an important input to the staffing and qualifications analysis. As specified in Section 4.4.4, table top analyses are conducted to confirm the adequacy of staffing and qualifications assumptions which were credited in minimizing the potential for error on all RIHA. Factors to be considered include:

- Number of personnel

  The number of personnel required to perform actions as specified in the HRA/PRA is determined. Stated or implied assumptions used in the HRA/PRA are identified and potential issues listed. These include:

  - Conflicts between tasks and personnel (simultaneous/parallel tasks performed by a single individual or simultaneous/parallel tasks that require multiple operators to use the same controls)
  - Workload issues addressing whether tasks can be accomplished within time and performance criteria
  - Personnel interactions involving decision making, coordination and feedback within the control room and between the control room and local control stations and support centers.

- Personnel skill level

  Information is extracted from the HRA/PRA relative to stated or implied operator capabilities. This information is reflected in operator qualifications (i.e., SRO, RO, Auxiliary Operator, fire brigade, Emergency Medical) and is used to support an HA being classified as Skill-of-the-craft or justifying the designation of an HA as a memorized action. Training requirements are implicitly reflected in personnel job titles.

  Results of the staffing analysis will be used to confirm the adequacy of the staffing assumptions in the HRA.

  Results from the staffing analysis that are considered to be discrepancies with staffing assumptions in the HRA will result in an HED being generated and entered into the HED data base for resolution

4.3.5 HSI Design

The US-APWR HSIS is designed based on the FRA/FA, TA and staffing analysis results. In turn feedback from HSI design activities, including person-in-the-loop evaluations are used to confirm staffing level and qualifications as well as to identify potential issues. Considerations include:

- Staffing demands resulting from the locations and use (especially concurrent use) of controls and displays

- Coordinated actions between individuals in the MCR, or temporarily working in the MCR and staff located outside of the MCR.
- Physical configuration of the control room, control consoles and other facilities for operating staff as well as other staff temporarily working in the MCR
- Availability of plant information from individual workstations and group-view interfaces and communication methods.
- The design of the monitoring and control screens
- The availability of plant information and the potential decrease in information needs

Issues that arise during HSI design related to staffing level or qualifications are entered into the HED database and evaluated and resolved per the standard HED evaluation process described in Part 1, Section 6 of MUAP-09019.

4.3.6 Procedure Development

Staffing level and qualifications are also used as input to procedure development. The US-APWR procedures assume specific personnel numbers, skills, knowledge, abilities, and authority.

During procedure development, issues may be identified related to staffing levels and qualifications. Requirements for the concurrent use of multiple procedures and its impact on staffing assumptions will be evaluated along with the qualifications (i.e. knowledge, skills and abilities) needs. The actions called for in a procedure may require additional knowledge or skills.

Issues that arise during procedure development related to staffing level or qualifications are entered into the HED database and evaluated and resolved per the standard HED evaluation process described in Part 1, Section 6 of MUAP-09019.

4.3.7 Training Program Development

Staffing and qualifications analysis also serves as input to training program development. The US-APWR Training Program is developed based on staffing level and required qualifications to be acquired and maintained by the plant staffs.

Training program development will identify issues related to staffing or qualifications. Work load, crew communications and crew coordination issues will result in issues being identified that will impact the staffing and qualifications analysis. Knowledge, skill or abilities requirements will be identified as needs for different staff qualifications.

Issues that arise during training program development related to staffing level or qualifications are entered into the HED database and evaluated and resolved per the standard HED evaluation process described in Part 1, Section 6 of MUAP-09019.

4.4 Methodology for Establishing Staffing Levels and Qualifications

The objective of the staffing level and qualifications analysis is to evaluate staffing levels and qualifications design constraint for the minimum operating crew and to evaluate the baseline staffing and qualifications in the staffing plan for non-operations personnel. The output of the analysis are documented results, which establish the staffing levels and qualifications for safe and efficient of the plant.

The analysis will employ a combination of methods that include:

- Data from Operational Experience
- Table top analysis which employs task analysis tables
- Results of Simulator Studies (e.g., conducted as part of HSI Design Element)

Overview descriptions of these staffing and qualifications analysis methods can be found in NUREG/CR-6838 as well as standard human factors methods handbooks (Reference 5-10, 13).

The analysis will be conducted by a interdisciplinary team; Expert Panel, that includes, as a minimum, a composite make up of a minimum of 5 years of experience in each of the following:

- US-APWR plant design, including reactor system design, turbine system design, and HSI and I&C design
- Plant operations in a U.S. PWR plant across all modes of operation including, outage, startup, low power and normal operation
- Plant maintenance and plant surveillance and testing practice in a U.S. PWR plant
- PWR Operator training
- Human Factors

The Expert Panel will add additional expertise depending on the staff positions being analyzed. For example, when analyzing I&C staffing, the team will expand to include expertise in system design as well as in maintenance of I&C. Similarly, for analyzing tasks related to pump testing, the team will be expanded to include expertise in mechanical systems design and maintenance. At all times the core multidisciplinary team will have the basic composition of the five backgrounds listed above. The team will be managed by a group leader who is responsible to assure the quality, completeness and schedule of the results and to coordinate with other elements of the HFE program and the designers.

The multidisciplinary team will be responsible for:

(1) Identifying significant differences from predecessor plants that may impact staffing levels and qualifications;
(2) Analyzing the impact of the minimum operating crew design constraint.
(3) Identifying representative operations, maintenance, and plant surveillance and testing tasks to be analyzed to evaluate appropriateness of staffing level and qualifications assumptions and determining analysis method(s);
(4) Identifying relevant operational experience that can be used to inform evaluation of staffing level and qualifications for the tasks identified in (2);

(5) Conducting table top analysis to evaluate appropriateness of staffing levels and qualifications for the tasks identified in (2) for evaluation via table top Task Analysis results;
(6) Recommending modifications to the HSI design, staffing levels and qualifications, if warranted based on staffing and qualifications analysis results.

4.4.1 Identify Differences from Predecessor Plants

The staffing and qualifications analysis begins with a baseline for the US-APWR staffing level and qualifications assumptions. The minimum operating staff is explicitly presented in Section 4.2.1. As explained in Section .4.2.2, for non-operating staff, the baseline staffing level and qualifications are based on staffing in predecessor plants. Relevant predecessor plants are U.S. four loop PWR plants.

The first step in the analysis is to identify differences between the US-APWR and predecessor plants in technology, design, staffing or operating practice that, based on the expertise of the team, have the potential to impact staffing or qualifications.

Plant differences are documented that have the potential to affect the number, roles, responsibilities, or qualifications of personnel needed to support operations, maintenance or plant surveillance and testing activities relative to number and qualifications of personnel required for corresponding activities in predecessor plants.

The Expert Panel is responsible for identifying differences from predecessor plants in design, staffing, or operating practice that have the potential to impact staffing numbers or qualifications. Identification of differences between US-APWR and predecessor plants will be accomplished via review of the FA/FRA report provided in Part 2, Section 1 of MUAP-09019, the results from the TA, the RIHAs, as well as the description of the US-APWR HSI and conduct of operation provided in DCD Chapter 13.

The output of this activity, contained in the results summary report, is an itemization of differences between the US-APWR and a U.S. PWR plant in plant design, HSI design, I&C design, and operating practice, from the perspective of impact on staffing numbers and qualifications, and a justification for that determination. (i.e., why a given difference is considered to impact staffing) Note that design differences need not be major, in themselves, to impact staffing numbers. Several small differences can also impact the staffing numbers. In combination these would be considered pertinent from a staffing level or qualifications perspective and so noted in the analysis results.

4.4.2 Identify Tasks to be Analyzed and Analysis Technique

The next activity is to identify specific representative operations, maintenance, and plant surveillance and testing activities associated with each of the differences from predecessor plants, that need to be evaluated to assess impact, if any, on staffing levels and qualifications from Section 4.4.1, above. This includes tasks directly related to plant safety across all modes of plant operations including:

- Startup / Shutdown
- Normal operations
- Abnormal and Emergency operations

- Transient conditions

This activity will be led by the Expert Panel. The Expert Panel will review each difference item identified in 4.4.1. For each item the Expert Panel will:

- Identify specific representative operations, maintenance and plant surveillance and testing activities that could potentially be affected by this change. This will include representative tasks across all operating modes.
- Ensure availability of a task analysis for each of these tasks. (These task analyses will be performed as part of the Task Analysis HFE element.)
- Specify the method(s) for evaluating the staffing and qualifications requirements for each task.

In addition to the review of the items identified as significant differences from predecessor plants, the team will also review the outputs of OER, HRA and TA elements of the HFE program for additional specific operating, maintenance and/or plant surveillance and testing tasks that need to be included in the staffing and qualifications analysis.

The Expert Panel will identify each task to be evaluated. Reference 5-10 will be used to guide the analysis using operating experience data from the OER plus expert judgment, table top analysis using the results from the TA, or simulator studies (reference sections 4.4.3, 4.4.4 and 4.4.5. Factors to be considered in selecting evaluation method(s) include availability of relevant operational experience data; suitability of table top analysis; need for data on cognitive, collaborative, and physical task demands that can only be obtained via walk-through/talk-through exercises using a simulator and/or dynamic person-in-the-loop simulator exercises.

4.4.3 Identify Relevant Operational Experience Data

Operating experience reviews are a common practice within the nuclear industry for identifying issues, comparing performance and assessing best practice, including issues associated with staffing levels and qualifications (see Reference 5-10). Experience from predecessor plants will be drawn upon in evaluating US-APWR staffing and qualifications goals. This includes experience from U.S. PWRs as well as experience from Japanese PWR plants.

Since the operating experience review program element for the US-APWR has been completed, the operating experience information will be drawn from the results of this operating experience review element as well as from the personal experiences of the individuals on the Expert Panel.

4.4.4 Conduct Staffing and Qualification Evaluation from Table Top Task Analyses Results

Table top analyses will be conducted to evaluate the appropriateness of staffing and qualifications assumptions (for the tasks designated in 4.4.2 for evaluation by table top analysis).

The table top analysis will be conducted by the Expert Panel, which, as a group, consists of people with expertise in the US-APWR plant, HSI and I&C design and planned operating

practice; current staffing levels, qualifications and operating practice in U.S. PWRs (reference section 4.4).

A group leader will walk the Expert Panel through each of the tasks contained in the TA; in each case reviewing the results of the task analysis for that task. The Expert Panel will discuss the task analysis results and determine if the proposed staffing complement is adequate to meet the safety needs for the plant.

The Expert Panel will review the proposed numbers and types of personnel and the job definitions for each of the positions. The group leader will step the group through the task analysis soliciting more detailed information about personnel tasks and performance. The group may have access to additional data, such as data from operating plant experience (from section 4.3.3) to assist in making informed assessments.

After reviewing the task analysis, the group will form a consensus regarding whether or not the task can be safely performed with the proposed number and qualifications of personnel. The consensus conclusion, supporting data and the rationale supporting the decision are documented in a traceable manner in the results summary report.

If warranted, the Expert Panel will recommend modifications to staffing levels and qualifications based on the results of the table top Task Analysis.

4.4.5 Review Relevant Simulator Study Results

Another source of data to be used to support a staffing and qualifications analysis is simulator study results. The simulator studies will include operator walk-throughs/talk-throughs of task scenarios using a part task and high fidelity simulator, as well as dynamic person-in-the-loop exercises using a simulator. The dynamic evaluation studies are conducted in the HSI integrated system validation test and the HSI design, and the results provide data in support of staffing and qualifications analysis. Those studies examined the ability of two-person operator crews to handle a range of representative normal, abnormal and emergency scenarios. Performance measures included both objective outcome measures (e.g., ability to take control actions; time to take actions), as well as process measures such as situation awareness and workload.

4.5 Results

The Staffing and Qualifications results which are described in Sections 4.1 through 4.4 will be summarized in a Staffing and Qualifications results summary report. This report is also intended to fulfill the requirements of the Inspections, Tests, Analyses, and Acceptance Criteria defined in Tier 1 of the DCD.

The US-APWR Staffing and Qualifications results summary report will describe:

- Methods and results of the staffing level and qualifications analyses that were conducted
- Final specification of staffing levels and qualifications for the standard US-APWR plant

5.0 REFERENCES

5-1 Design Control Document for the US-APWR, Chapter 18, Human Factors Engineering, MUAP-DC018, Revision 3, MHI, March 2011

5-2 HSI System Description and HFE Process, MUAP-07007, Revision 5, MHI, November 2011

5-3 US-APWR Human System Interface Verification and Validation (Phase1a), MUAP-08014, Revision 1, MHI, May 2011

5-4 US-APWR HSI Design, MUAP-09019, Revision 2, MHI, October 2012

5-5 US-APWR HSI Design Implementation Plan, MUAP-10009, Revision 2, MHI, October 2012

5-6 Deleted

5-7 Deleted

5-8 US-APWR Verification and Validation Implementation Plan, MUAP-10012, Revision 2, MHI, October 2012

5-9 HFE Insights for Advanced Reactors Based Upon Operating Experience, NUREG/CR-6400, U.S. Nuclear Regulatory Commission, 1997

5-10 Technical Basis for Regulatory Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m), NUREG/CR-6838, U.S. Nuclear Regulatory Commission, February 2004

5-11 Results of Shift Staffing Study, Information Notice 95-48, U.S. Nuclear Regulatory Commission, 1995

5-12 Crediting of Operator Actions in Place of Automatic Actions and Modifications of Operator Actions, Including Response Times, Information Notice 97-78, U.S. Nuclear Regulatory Commission, 1997

5-13 A Guide to Task Analysis, Kirwan, B. and Ainsworth, L. K., London, UK: Taylor & Francis, Ltd, 1992

5-14 Advanced Light Water Reactor Utility Requirements Document, Volume II, ALWR Evolutionary Plant, Chapter 10, Man-Machine Interface Systems, EPRI, Revision 8, January 1999