POSITION PAPER

CONTROL ROOM STAFFING FOR SMALL REACTORS

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I. Introduction

Current control room staffing regulations are based upon the experience of existing operating large light water reactors (LWRs) that rely on operator monitoring and control of active safety systems for normal and off-normal operations as well as accident mitigation. The introduction of advanced reactor designs, with an increased use of advanced automation technologies, and the elimination of or significant reduction of active safety systems will likely change the roles, responsibilities, composition, and size of the crews required to operate these advanced reactors.

Small modular reactors (SMRs) are a subset of the advanced reactors currently being designed. SMR designs are using risk-informed insights and human factors engineering to reduce the task loads for control room operators. It is expected that SMRs will not rely on active safety systems for normal, off-normal, or accident operations. Additionally, SMRs are expected to have far fewer total systems than large LWRs and provide significantly longer response time for events, thereby reducing the number and timing of tasks requiring operator control.

Getting the right control room staffing complement is an essential element to the safe and reliable performance of SMRs during normal, off-normal, and accident operations. Task analyses of operator workload for SMRs may indicate an appropriate control room staffing complement different from that of the current LWRs and existing regulations. In performing operator task analyses, consideration must be given to the number of operators per unit as well as the number of reactors controlled from one control room.

II. Purpose

NEI's purpose in developing this position paper is to support NRC efforts to address and resolve policy issues identified by the NRC staff regarding staffing levels for SMRs. These policy issues have been identified in several SECY papers.

In SECY-10-0034, *Potential Policy, Licensing, and Key Technical Issues for Small Modular Nuclear Reactor Designs,* Section 4.1, *Appropriate Requirements for Operator Staffing for Small or Multi-Module Facilities,* the NRC staff assigned a high importance to the review of SMR staffing that should be addressed before submittal of SMR license applications. For FY 2010 and 2011 the NRC staff identified the following tasks to be completed:

- review pre-application white papers and topical reports concerning operator staffing and associated control room design that it receives from the Department of Energy (DOE) and potential SMR applicants
- discuss design-specific proposals to address SMR staffing

- discuss the proposed resolutions with human factors and instrument and control experts
- consider research and development in this area (both by domestic and international community)

Additionally the NRC staff has questioned whether advanced reactor designs should be allowed to control more than two reactors from one control room or operate with a staffing complement less than currently required by regulations (refer to SECY-93-002 and SECY-02-0180). The NRC staff stated that operator staffing may be design-dependent and that they intended to review the justification for smaller control room crew size for advanced reactors designs by evaluating function and task analyses for normal operations and accident management.

In SECY-11-0098, *Operator Staffing for Small or Multi-Module Nuclear Power Plant Facilities*, the NRC staff informed the Commission that processing a limited number of SMR design certifications and operating license applications using exemption requests to address staffing is the best near-term solution for handling the staffing proposals for small or multi-module reactor facilities. The long-term solution is to then refine review guidance and initiate rulemaking to support the broad range of designs and technologies that the NRC may receive for review.

In summary, the purpose of this position paper is to:

- identify current regulations and guidance applicable to licensed operator staffing of SMRs
- identify the regulatory path forward and determine whether new regulations or regulatory policy changes are needed to support licensing SMRs with different staffing levels
- review the process for determining appropriate crew complements for licensed personnel
- identify lessons learned for ensuring appropriate control room staffing is achieved in timeframes that support SMR design, construction and startup

III. Current Regulations and Regulatory Guidance

Current regulations regarding licensed operator staffing are based on existing operating large LWRs that rely primarily on active safety systems and operator actions for design basis accidents. 10 CFR § 50.54 in combination with 10 CFR § 50.47 provide the staffing requirements of nuclear power plants licensed under 10 CFR Part 55.

The table provided in 10 CFR § 50.54(m) specifies the minimum requirements for on-site staffing by licensed operators and senior operators based on the number of reactors (maximum of two) that can be controlled from one control room. This table is reproduced below (footnotes are retained for completeness):

Minimum Requirements[1] Per Shift for On-Site Staffing of Nuclear Power Units by Operators and Senior Operators Licensed Under 10 CFR Part 55

Number of nuclear power units operating[2]	Position	One Unit	Two units		Three units	
		One control room	One control room	Two control rooms	Two control rooms	Three control rooms
None	Senior Operator	1	1	1	1	1
	Operator	1	2	2	3	3
One	Senior Operator	2	2	2	2	2
	Operator	2	3	3	4	4
Two	Senior Operator	--	2	3	3[3]	3
	Operator	--	3	4	5[3]	5
Three	Senior Operator	--	--	--	3	4
	Operator	--	--	--	5	6

As given in the table above and further clarified in SECY-02-0180, *Legal and Financial Policy Issues Associated with Licensing New Nuclear Power Plants*, current regulations do not address the control of more than two reactors from one control room. Therefore, SMR designs that include provisions to control more than 2 reactors from a single control room will need to address the safety implications to demonstrate that more than two reactors can be adequately controlled from one control room.

If appropriate SMR operator staffing levels are determined to be less than those specified in 10 CFR § 50.54(m), a license applicant may request an exemption to these

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[1] Temporary deviations from the numbers required by this table shall be in accordance with criteria established in the unit's technical specifications.

[2] For the purpose of this table, a nuclear power unit is considered to be operating when it is in a mode other than cold shutdown or refueling as defined by the unit's technical specifications.

[3] The number of required licensed personnel when the operating nuclear power units are controlled from a common control room is two senior operators and four operators.

requirements in accordance with 10 CFR § 50.12 or 10 CFR § 52.7. NRC guidance for requesting operator staffing levels different than the minimum specified in 10 CFR § 50.54(m) is provided in NUREG-1791, *Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m)*.

As discussed in SECY-11-0098, proposed SMR operator staffing requests will be reviewed by the NRC applying the guidance of NUREG-0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition*, Chapter 18, *Human Factors Engineering*, and NUREG-0711, *Human Factors Engineering Program Review Model*. These documents provide guidance for the staff's review of the 12 elements of an applicant's human factors engineering (HFE) program. This guidance does not presume a specific technology or control room configuration, and, therefore, provides a means for addressing the challenge of applying the NRC's staffing requirements to facilities that do not meet the assumptions or limited scope of 10 CFR § 50.54(m). Additionally, NUREG-1791 includes guidance that the NRC staff will use to review an applicant's concept of operations, operational conditions analyzed, applicable operating experience, functional requirements and function allocation, task analysis, job definitions, and staffing plan.

In addition to the staffing requirements identified in 10 CFR § 50.54, 10 CFR § 50.47 establishes requirements for nuclear power plant emergency response plans. Specifically, 10 CFR § 50.47 subparagraph (b)(2) states standards for on-shift licensee responsibilities. Here, the requirement is that "adequate staffing" be provided, with no regulatory requirement specified as to the number of licensed operators required to provide for on-shift accident response. NUREG-0654, *Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants*, provides evaluation criteria for determining what constitutes adequate staffing and provides guidance on staffing levels that the NRC has determined to be acceptable. Specifically, Table B-1 of NUREG-0654 addresses "Minimum Staffing Requirements for NRC Licensees for Nuclear Power Plant Emergencies." Recently, NEI transmitted to the NRC a revised draft of NEI 10-05, *Assessment of On-Shift Emergency Response Organization Staffing and Capabilities*. NEI developed this document to establish a standard methodology for performing analyses of the ability of on-shift staff to perform all required functions and tasks necessary to respond to a declared emergency. NEI 10-05 also identifies a number of additional references pertaining to shift staffing that an SMR applicant will need to address.

IV. Regulatory Path Forward

Each SMR applicant will need to perform a task analysis as part of an HFE program to determine the appropriate staffing complement accomplishing the functions allocated to licensed control room operators. The introduction of advanced reactor design and the increased use of advanced automated control systems can substantially affect the task analysis and, ultimately, the roles, responsibilities, composition and size of the crews required to control plant operations. This task analysis may identify a different distribution of qualifications for control room operators (e.g., more senior reactor operators, fewer reactor operators) than prescribed by current regulations.

Because of the differences in SMR designs and previously licensed LWR design, SMRs may require different operator tasks. For multiple reactor units, the task analysis will need to consider operating multiple units in different modes of operation. For some SMR designs, operators will face the situation of managing the operation of additional units as they are placed on line (i.e., staffing plans will need to address the addition of units during the construction period). Integration challenges in defining not only tasks required for operating the unit but also for interacting with other on-site maintenance and support organizations for multiple units will need to be considered in the task analysis.

The SMR applicant's task analysis that results in staffing levels consistent with current regulations can proceed without the need of an exemption request or petition for rulemaking. Furthermore, SMR applicant's task analysis that result in a determination that the appropriate staffing levels are either a different distribution of control room operators or less than those required by 10 CFR § 50.54(m), can in the near term submit an exemption request in accordance with 10 CFR § 50.12 or 10 § CFR52.7, following the guidance of NUREG-1791.

It is anticipated that exemption requests for each SMR design will be unique, reflecting the specific demands and capabilities of the design for which the exemption is being requested. This will present an added complication for NRC reviewers to understand the full scope of each SMR design, concept of operations, and the operator's roles and responsibilities. To assist the reviewers, it is NEI's understanding that the NRC plans to update the guidance in NUREG-0711 to better prescribe the scope of tasks the staff would expect in a thorough task analysis. Upon completion of updating NUREG-0711, the NRC will then update NUREG-1791 with examples of full-range task analyses for SMRs.

Exemption requests, where possible, should be made as part of a SMR's Design Certification Application (DCA), thereby obviating the need for combined construction and operating license (COL) applicants to request individual exemptions. Where staffing exemption requests are approved, the Design Certification Document (DCD) Technical Specifications can specify the minimum staffing requirements.

The experience gained in processing near term exemption requests will allow the NRC to gain insights about the range of acceptable methods and level of information needed to support review of SMR staffing levels. For a long term solution, this will help the NRC develop the regulatory basis to support rulemaking.

V. Determining Appropriate SMR Licensed Operator Staffing

Staffing determination is an important outcome of the Human Factors Engineering (HFE) program. The HFE program review model described in NUREG-0711 consists of five phases: analysis, design, verification and validation, and implementation.

The analysis phase of the model includes Operating Experience Review, Functional Requirements Analysis and Function Allocation, Task Analysis, Staffing and Qualification and input to the Human Reliability Analysis (HRA). The design phase includes the Human-System Interface (HSI) Design, Procedure Development and Training Program Development. The verification phase includes HFE Verification and Validation. Finally the implementation phase includes HFE Design Implementation and Human Performance Monitoring. A summary of each of the 11 technical elements covered in these four phases of the HFE process is provided in the following paragraphs.

The determination of the appropriate staffing levels is one output of a strong HFE program and is a product of the entire HFE program not just the Staffing and Qualification element. In determining the appropriate staffing levels, the elements of the HFE program will be iteratively applied. Once the appropriate staffing levels are determined, the Human Performance Monitoring element of the HFE program monitors that the staffing levels remain appropriate throughout the life of the facility as design or operating procedures change.

A summary of each of the eleven elements of the HFE program is provided.

Operating Experience Review

The purpose of conducting an operating experience review is to identify HFE-related safety issues. The issues and lessons learned from operating experience provide a basis for improving the plant design in a timely way; i.e., at the beginning of the design process.

The objective is to identify and analyze HFE-related problems and issues in previous designs that are similar to the current design under review. In this way, the new design will avoid negative features associated with predecessor designs, and will retain the positive features.

The development of guidance containing operating experience and lessons learned that can be applied to SMRs should be continued by the industry and the NRC similar to NUREG/CR-6400, *Human Factors Engineering Insights for Advanced Reactors Based Upon Operating Experience.*

Use of a simulator during analysis, design, and validation phases of the HFE process may provide input to the operating experience for new designs in an interactive manner.

Functional Requirements Analysis and Function Allocation

The purpose of the Functional Requirements Analysis and Function Allocation is to define the plant's safety functional requirements and that the function allocations take advantage of human strengths and avoid allocating functions that would be negatively affected by human limitations. The operator's role is examined in two steps: functional requirements analysis and function allocation (assignment of levels of automation).

Functional requirements analysis is the identification of those functions which must be performed to satisfy the plant's safety objectives, i.e., to prevent or mitigate the consequences of postulated accidents that could cause undue risk to the health and safety of the public. This analysis determines the objectives, performance requirements, and constraints of the design, and sets a framework for understanding the role of controllers (whether personnel or system) in regulating plant processes.

Function allocation is the analysis of the requirements for plant control and the assignment of control functions to (1) personnel (e.g., manual control), (2) system elements (e.g., automatic control and passive, self-controlling phenomena), and (3) combinations of the two (e.g., shared control and automatic systems with manual backup).

New and different functions associated with SMR designs (e.g. passive features, design simplicity, increase in required response time, monitoring and control of multiple modules) need to be evaluated thoroughly.

Task Analysis

Task analysis is the identification of task requirements for accomplishing the functions allocated to plant personnel. The task analysis should (1) provide one of the bases for making decisions on design, (2) verify that human-performance requirements do not exceed human capabilities, (3) be used as basic input for developing procedures, (4) be used as basic information for developing the staffing, training, and communication requirements of the plant, and (5) form the basis for specifying the design requirements for the displays, data processing, and controls needed to carry out tasks.

The NRC should work transparently with the industry to establish standardized and accepted operator workload levels by gathering data from existing operating plants with acceptable levels of workload so that these standards of mental and physical workload would be available for analysis and evaluation of task analysis. Future regulation could call for use of standardized workload levels with a process for addressing exceptions. This would allow for the evaluation of design-specific considerations.

Staffing and Qualifications

Plant staffing and qualification requirements are developed by a systematic analysis that includes a thorough understanding of both task requirements and regulatory requirements. This process supports the plant's operations concepts and identifies any requirements for new or augmented knowledge and skill elements.

The analysis should use the HFE process to consider the design-specific number of required operators. Staffing and qualifications should be based on the design and performance of a specific SMR design based on analysis, validation, or performance.

Human Reliability Analysis

Human reliability analysis (HRA) seeks to evaluate the potential for, and mechanisms of, human error that may affect plant safety. Thus, it is an essential element in achieving the HFE design goal of providing operator interfaces that will minimize personnel errors, allow their detection, and provide recovery capability. The HRA should be conducted as an integrated activity to support both the HFE design and plant probabilistic risk assessment (PRA). Special attention should be paid to those scenarios, critical human actions, and HSI components that were identified by HRA and PRA analyses as being important to the plant's safety and reliability. This process informs design with the objectives assuring that of (1) human-error mechanisms are addressed in the design of the HFE aspects of the plant to minimize the likelihood of personnel error, and verify that errors are detected and recovered from; and (2) the HRA activity effectively integrates the HFE program with the PRA and risk analysis.

SMR unique functions and systems should be evaluated to determine if there are any human significant actions that need to be included in the HRA that informs the PRA.

Human-System Interface Design

This is the process by which the Human-System Interface (HSI) design requirements are developed and HSI designs are identified and refined to appropriately translate functional and task requirements to the detailed design of displays, alarms, controls, and other aspects of the HSI. The HSI should be designed using a structured methodology that should guide designers in identifying and selecting candidate HSI approaches, defining the detailed design, and performing HSI tests and evaluations. Standardized evaluation should be called out with criteria that would be repeatable and acceptable across the industry.

It should cover the development and use of HFE guidelines that are tailored to the unique aspects of the applicants' design, e.g., a style guide to define the design-specific conventions. The use of a simulator during the development of the HSI will increase the ability to evaluate new or unique design ideas that support the unique SMR designs.

Procedure Development

Procedures should be developed from the same design process and analyses as the HSIs and training. This will result in a well-integrated design with a high degree of consistency. Human factors engineering principles and guidance are applied, along with all other design requirements, to develop procedures that are technically accurate, comprehensive, explicit, easy to use, and validated. This includes the option of incorporation of online procedures.

Training Program Development

A systematic approach to training also requires that training be based on the analysis of job and task requirements. The HFE analyses provide valuable input to the understanding of such task requirements. Specially, the training requirements for new plant process, plant equipment, or unique knowledge and abilities items identified during the staffing and qualifications element of the HFE program process model:

- establishes an approach for developing personnel training that incorporates the elements of a systems approach
- evaluates the knowledge and skill-requirements of personnel
- coordinates the development of the training program with the other elements of the HFE design process
- implements the training effectively in a manner consistent with human factors principles and practices

The training programs for the SMR staff will be developed by building on the output of the HFE analyses using an industry-proven approach. This approach is described in ACAD 08-001, *The Process for Initial Accreditation of Training in the Nuclear Power Industry*.

Human Factors Verification and Validation

Verification and validation (V&V) evaluations comprehensively determine that the final design conforms to HFE design principles, and enables personnel to successfully and safely perform their tasks to achieve operational goals. These goals are identified in the functional requirements analysis and task analysis elements of the HFE program model process. This element involves three evaluations, the objectives of which are to verify that the applicant has performed the following activities:

- HSI Task Support Verification - an evaluation to verify that the HSI supports personnel task requirements as defined by task analyses
- HFE Design Verification - an evaluation to verify that the HSI is designed to accommodate human capabilities and limitations as reflected in HFE guidelines such as those provided in NUREG-0700, *Human-System Interface Design Review Guidelines*
- Integrated System Validation - an evaluation using performance-based tests to determine whether an integrated system design (i.e., hardware, software, and personnel elements) meets performance requirements and acceptably supports safe operation of the plant

Design Implementation

This step addresses implementation of the HFE aspects of the plant design. The implementation phase is well defined and carefully monitored through start-up procedures and testing. The objectives are to verify that:

- the applicant's implementation of modernized plant systems, HSIs, procedures, and training considers their effect on personnel performance and provides the necessary support to verify safe operations
- the applicant's as-built design conforms to the verified and validated design that resulted from the HFE design process

Human Performance Monitoring

A human performance monitoring strategy will help to verify that the confidence developed by the completion of the integrated system validation is maintained over time. There should be sufficient evidence to provide reasonable confidence that personnel have maintained the skills necessary to accomplish the assumed actions.

The applicant prepares a human performance monitoring strategy for ensuring that no safety degradation occurs because of any changes that are made in the plant and to verify that the conclusions that have been drawn from the evaluation remain valid over time. This information may be used to iteratively feedback to the other elements of the HFE program model.

VI. Important Considerations for New Plant Operator Training for SMRS (including lessons learned from the New Plant Operator Licensing Task Force)

This section describes important steps in the development of staffing and training plans for small modular reactor operators and is based on the experience to date of the NEI New Plant Operator Licensing Task Force. Attachment 1, Representative Timeline for Licensed Operator Training, provides a generic visual timeline for the important points discussed below.

Job and Task Analysis for Operations Positions

The systems approach to training (SAT) foundation and starting point is to conduct job/task analysis for each operator position. Based on existing operating large LWRs, these positions are: licensed reactor operator (RO), licensed senior reactor operator (SRO), non-licensed operator, shift manager (shift supervisor), and shift technical advisor (STA). The analysis may need to confirm that each operator position is well-founded. Additionally, these job/task analyses have been historically conducted by the utility licensee who will eventually become the accredited entity and not by vendors. However, for SMR designs there should be job and training input from the vendors to uniformly guide the utility licensees around new design features and functions. Job/task analysis needs to involve training, line operators (to the extent experience base exists), and new plant design engineers. Since many operator jobs/tasks are procedure-based, normal, abnormal, and emergency operating procedures must be developed to a degree that will allow job/task analysis.

<u>New Plant Operator Licensing Task Force Experience:</u> Job/task analysis must be conducted very early in the training development process. For example, new plant AP-1000 and ABWR utility

training and line personnel began these activities in 2007 to support 2015/2016 fuel load dates. Normal, abnormal, and emergency operating procedures must be developed and at least in early draft stages to support job/task analysis.

Knowledge and Ability Catalog Development

The unique design and operating features of SMRs likely will warrant development of a knowledge and ability (K/A) Catalog specific to SMR design and operation along with leveraging other modern passive plant design K/A Catalogs. Further, since K/A Catalogs are published as NUREGs, considerable review and approval time is needed for catalog publishing. Note that for the existing new plants, the NRC has agreed to hold the initial wave of licensed operator examinations with the AP-1000 K/A Catalog or the ABWR K/A Catalog in draft before finalizing the respective NUREGs based on initial experience.

New Plant Operator Licensing Task Force Experience: The new K/A Catalogs need to be developed in parallel or immediately following job/task analysis. The AP-1000 and ABWR new plant Catalogs required about 1.5 years to develop prior to submittal to the NRC with initial NRC approval to use in draft form expected in about 2.0 to 2.5 years.

Creation of Learning Objectives

The learning objectives for training on the jobs and tasks are developed after completion of the job/task analysis or in parallel with the analysis after a delayed start. The learning objectives provide the translation of the jobs and tasks into the specific learning the student must attain, providing the "bridge" between job/task analysis and lesson materials. As such, the learning objectives are a foundational part of the SAT process and must be well-defined and specific enough to clearly enunciate the knowledge, skills, and abilities the operator must attain to support their job.

New Plant Operator Licensing Task Force Experience: Learning objectives initially developed by vendor organizations are often "generic" (such as "state the purpose of the system") and do not provide the granularity needed to develop the detailed and specific SAT-based training material expected for accredited training programs. A lesson learned from the AP-1000 and ABWR new plant efforts was that considerable resources and effort by professional utility trainers was required to expand the vendor-provided "generic" learning objectives to that needed to support accredited SAT-based training.

Simulator Development and Evolution to a Certified Simulator

Simulators are needed to allow development of training materials; validate normal, abnormal, and emergency procedures; and conduct human factors evaluation. Simulator evolution should closely mirror plant design evolution, evolving from early limited scope use through final full-scope certification to ANS.3-5, *Nuclear Power Plant Simulators for Use in Operator Training* *and Examination*. Training personnel rely on the simulator heavily to develop training materials including lesson plans, simulator scenarios, and job-performance measures. A certified simulator is required by regulation for any license examinations.

<u>New Plant Operator Licensing Task Force Experience:</u> The importance of having a simulator as early in the plant design evolution as possible. Simulators are needed to allow development of training materials; validate normal, abnormal, and emergency procedures; and conduct human factors evaluation. All of these activities must be underway (and some completed) before beginning actual plant construction.

Training Material Development

Training material development includes lesson plans, simulator scenarios, and examination bank questions. This is the primary focus of the "design" phase of the ADDIE process[4]. Development occurs following (or delayed parallel) with job/task analysis. Training department administrative process/procedures for each program should be in place to guide the development of the training materials (that is, formats, expectations for content, interweaving operator fundamentals and operating experience into training materials, and so forth). Examination questions are developed as part of the training material design phase based on the learning objectives.

<u>New Plant Operator Licensing Task Force Experience</u>: A close relationship must exist between the utility training material developers and the vendor design organization. Plant design features may not be fully finalized at the time of training material development and the utility developers and vendor design organizations must continually communicate to allow training material development to progress. As the plant design changes and evolves, utility training material developers must continue to remain aware of the changes and factor those changes into the training material. As such, training material is less a discrete line item task and more of a continual process through design finalization and plant construction. Do not underestimate the close communications and resources necessary to develop training material that is solid enough to gain accreditation and to begin accredited SAT-based training of the operators.

Instructor Training and Certification

Prior to any training of operators, instructors must be trained and qualified to conduct the operator training. Instructor training and qualification is the responsibility of the utility but heavily involves the vendor organization to impart the technical and design knowledge, skills, and abilities to the instructors. Utility instructor training has two aspects: (1) SRO-level knowledge of plant operations, and (2) instructional capabilities. Typically, the SRO-level knowledge is provided by the vendor organization through training of the utility instructors in both classroom (systems and procedures) and simulator (plant operations) settings. This aspect of instructor training is not accredited (again, vendors are not accredited by the National

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[4] The ADDIE model is the generic process traditionally used by instructional designers and training developers. The five phases – analysis, design, development, implementation, and evaluation – represent a flexible guideline for building effective training and performance support tools.

Academy for Nuclear Training) but is expected to be rigorous and follow accredited SAT training objectives and criteria. Guidelines for accredited training programs require that instructors who instruct licensed operators have SRO-level knowledge (either SRO-licensed or SRO-Certified). As such, vendors are expected to have training for the utility instructors that imparts SRO-Certification level of knowledge. The utility is expected to develop the training program and conduct the second phase involving instructional capabilities and to qualify the instructors.

New Plant Operator Licensing Task Force Experience: The AP-1000 and ABWR new plant training efforts identified that simulator development is a significant component of instructor training that may delay instructor SRO-level certification and subsequent ability to begin training of the operators. Further, since initial instructor training on plant design/systems is conducted prior to finalizing plant/system design, subsequent gap training (or repeat training) of instructors will be necessary prior to their instructing operator classes.

Overview of the Process for Initial Accreditation of Training

The initial accreditation process begins when an INPO member informs INPO of its intent to submit an Initial Accreditation Data Package that contains specified training materials, process descriptions, and implementation plans; and an Initial Accreditation Utility Report describing the INPO member training program status. At that time, dates for initial accreditation activities including an appearance before the National Nuclear Accrediting Board will be set. The process of accreditation validates training program content and structure and results in the determination of accreditation status early in the training implementation phase. The independent National Nuclear Accrediting Board makes the final determination to award or defer accreditation.

Consistent with initial accreditation conducted in the 1980s, initial accreditation focuses on establishing foundational systems approach to training (SAT) processes that will ensure that sound, effective training is implemented as new plant workers are hired and trained in accredited positions. Each utility that seeks initial accreditation may accredit programs early in the training process; or may wait until training is implemented, graduates from initial training are performing incumbent duties (as allowed by the applicable license), and continuing training programs are implemented.

New Plant Operator Licensing Task Force Experience: Timing of initial accreditation for new plant training programs needs to be carefully considered with respect to student training. Existing new plant build organizations have chosen to accredit early in the training process to assure the quality and rigor of the training programs such that any weaknesses in training are identified and corrected early. If initial accreditation is conducted well-into student training, any weaknesses identified by the National Academy for Nuclear Training and/or the National Nuclear Accrediting Board may call into question the training conducted up to that point.

Initial Licensed Operator Training

Staffing and training is described in Chapter 13 of the licensing submittal and, for the AP-1000 and ABWR new plants, is described in NEI-06-13A, *Template for an Industry Training program Description.* Revision 2 was completed in March 2009 and remains the currently NRC-approved template for use by new license applicants. This document describes control room staffing levels of licensed operators acceptable to the NRC and also re-establishes the cold licensing process. SMR vendors and utility personnel likely will be expected to use this NEI template for license applications, modifying it as warranted for SMR-specific considerations. With compressed construction schedules anticipated with SMRs (approximately 36 months), the staffing and training for licensed operators may have to begin about the same time as construction begins.

<u>New Plant Operator Licensing Task Force Experience:</u> The AP-1000 and ABWR new plants are planning on approximately 45 licensed operators (mix of RO and SRO) to begin fuel loading for the first unit. Once fuel loading for a second unit at the same site commences, the size of the control room operator staff is estimated to be approximately 80 licensed personnel. Careful consideration of class size, the number of simulators available for training, staffing lead times, initial licensed operator class duration, industry experience with licensed operator training weaknesses, and so forth must be made when planning and scheduling operator staffing and training. For the AP-1000 and ABWR new plants, these factors dictated 4-6 overlapping classes, using two simulators for training, and beginning the hiring and staffing of operators well before the combined operating licenses are received, and significant construction begun. To support this early training schedule, operations training must be staffed, instructors qualified, and the Analysis, Design, and Development components of a SAT-based training program largely completed. This represents a considerable investment in resources for training at an early date in any new-nuclear build project. For example, AP-1000 and ABWR new plants began staffing training organizations in 2006, approximately 10 years before anticipated fuel load dates for the first units.

VII. Conclusions

The introduction of advanced reactor designs with increased use of advanced automation technologies will likely change the roles, responsibilities, composition, and size of the crews required to control plant operations. Identifying the appropriate control room staffing complement is an essential element of the safe and reliable performance of small modular reactors. The initial review of operator workload indicates that appropriate control room staff complement will be different from that of the large LWRs that comprise the existing operating fleet due to the new and different functions associated with the SMR design features (e.g., passive features, design simplicity, increase in required response time).

Due to the need for operational experience, SMRs that are deployed in the near term will be licensed using existing regulations. As appropriate, exemptions to existing requirements may be pursued using the exemption process outlined in NUREG-1791 which appears reasonable. Exemption requests, where possible, should be made as part of the Design Certification Application, thereby supporting the combined construction and operating license applicants request for individual exemptions. For follow-on SMRs, generic rulemaking may be petitioned using a process similar to that outlined in the NUREG.

Staffing determination is an important outcome of the Human Factors Engineering (HFE) program. The model for HFE program review described in NUREG-0711 provides a reasonable basis for analysis, design, verification and validation, and implementation of the HFE process. An iterative design process based on a systems approach supports identification of appropriate control room staffing complement. The NRC should work transparently with the industry to establish standardized and accepted levels of operator workload by testing existing acceptable operating plants so that these standards of mental and physical workloads would be available for detailed analysis and evaluation of the task analysis required for new SMR designs.

The early development of a plant reference simulator is important. The use of a simulator during the HFE process provides input to the operational task analysis for new designs in an interactive manner. Use of the simulator during the development of the human-system interface will increase the ability to evaluate new or unique design ideas that support the unique SMR functions. Training personnel rely heavily on the simulator to develop training materials and to conduct initial instructor training on plant operations and instructor SRO-level certifications. The simulator can also be used to validate normal, abnormal, and emergency procedures. Simulator evolution should closely mirror plant design evolution, evolving from early limited scope use through final full-scope certification to ANS.3-5 standards.

The existing industry guidance on operator training, NEI 06-13A, *Template for an Industry Training Program Description*, is expected to be modified for SMR-specific considerations for control room staffing levels of licensed operators acceptable to the NRC. With the compressed construction schedules anticipated for SMRs (approximately 36 months), the staffing and training for licensed operators may have to begin at the same time or prior to the start of construction.

Lessons learned from the near-term advanced light water reactors have been captured by the NEI New Plant Operator Licensing Task Force:

- Knowledge and Ability Catalogs need to be developed in parallel or immediately following job/task analysis.
- The initial accreditation process for new training programs can be used to identify and correct training deficiencies before training of first students.
- Training task analysis must be comprehensive and complete prior to starting training design phase.
- A close relationship must exist between the utility training material developers and the vendor design organizations.
- Careful consideration of class size, simulator availability, staffing lead times, initial class duration must be factored in to the planning and scheduling.

VIII. References

1. Code of Federal Regulations, Title 10, "Energy," Part 50, "Domestic Licensing of Production and Utilization Facilities, Sec. 50.12, "Specific Exemptions," U.S. Nuclear Regulatory Commission.
2. Code of Federal Regulations, Title 10, "Energy," Part 50, "Domestic Licensing of Production and Utilization Facilities, Sec. 50.47, "Emergency Plans," U.S. Nuclear Regulatory Commission.
3. Code of Federal Regulations, Title 10, "Energy," Part 50, "Domestic Licensing of Production and Utilization Facilities, Sec. 50.54, "Conditions of Licenses," U.S. Nuclear Regulatory Commission.
4. Code of Federal Regulations, Title 10, "Energy," Part 50, "Domestic Licensing of Production and Utilization Facilities, Sec. 52.7, "Specific Exemptions," U.S. Nuclear Regulatory Commission.
5. Code of Federal Regulations, Title 10, "Energy," Part 55, "Operators Licenses," U.S. Nuclear Regulatory Commission.
6. NUREG-0654, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants (FEMA-REP-1), U.S. Nuclear Regulatory Commission, (multiple revisions, addenda and supplements).
7. NUREG-0700, Human-System Interface Design Review Guidelines, U.S. Nuclear Regulatory Commission, Revision 2, May 2002.
8. NUREG-0711, Human Factors Engineering Program Review Model, U.S. Nuclear Regulatory Commission, Revision 2, May 2002.
9. NUREG-0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition, U.S. Nuclear Regulatory Commission.
10. NUREG-1791, Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m), U.S. Nuclear Regulatory Commission, July 2005.
11. NUREG/CR-6400, Human Factors Engineering Insights for Advanced Reactors Based Upon Operating Experience, U.S. Nuclear Regulatory Commission, January 1997.
12. SECY-93-0092, Issues Pertaining to the Advanced Reactor (PRISM, MHTGR, and PIUS) and Canadian Deuterium Uranium Reactor (CANDU) 3 Designs and Their Relationship to Current Regulatory Requirements, U.S. Nuclear Regulatory Commission, April 6, 1993 (Correction issued April 28, 1993).
13. SECY-02-0180, Legal and Financial Policy Issues Associated with Licensing New Nuclear Power Plants, U.S. Nuclear Regulatory Commission, October 7, 2002.
14. SECY-10-0034, Potential Policy, Licensing, and Key Technical Issues for Small Modular Nuclear Reactor Designs, U.S. Nuclear Regulatory Commission, March 28, 2010.
15. SECY-11-0098, Operator Staffing for Small or Multi-Module Nuclear Power Plant Facilities, U.S. Nuclear Regulatory Commission, July 22, 2011.
16. ANS.3-5, Nuclear Power Plant Simulators for Use in Operator Training and Examination, American Nuclear Society, 2009.
17. NEI 06-13A, Template for an Industry Training Program Description, Nuclear Energy Institute, Revision 2, March 2009.
18. NEI 10-05, Assessment of On-Shift Emergency Response Organization Staffing and Capabilities, Nuclear Energy Institute, November 2010.

Attachment 1: Representative Timeline for Licensed Operator Training