

US-APWR HFE Program NUREG-0711 Compliance Roadmap

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1. Abstract

This document provides a roadmap that would help the staff locate the appropriate sections of MHI HFE program documentation that demonstrates compliance to the review criteria of NUREG-0711 Revision 2. The roadmap is provided in the table of this document.

The following explains the contents of the table:

- The table includes a section for each NUREG-0711 Program Element
- The left most column, labeled “NUREG-0711 Revision 2 Review Criteria”, is the review criteria, copied directly from NUREG-0711.
- The column labeled “Current Documentation” provides pointers to the specific areas of previously submitted MHI documentation, that address the review criteria. The pointers are as focused as possible; typically to no more than one page of specific correlating text. Recognizing that there is not always a direct correspondence between review criteria and MHI documentation, explanatory text may be included in this column to help the staff understand the correlation. This includes cases where NUREG-0711 defines the review criteria at a programmatic level, however MHI’s documentation fulfills this criteria in a lower level document, such as a program element report.
- In some cases the review criteria correlates to detailed HFE program activities that are managed by US-APWR ITAACs, and therefore are not fulfilled by MHI’s “Current Documentation”. For these criteria, explanations of the compliance method and pointers to the appropriate future documentation, are provided in the column entitled “Planned Documentation”.

For NUREG-0711 review criteria that MHI has not fulfilled, and does not plan to fulfill, a justification for non-compliance is provided in the column entitled “Gap”.

2. HFE Program Management

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<p>2.3 Applicant Submittals The applicant should provide the following for staff review: HFE program plan describing the applicant's HFE goals/objectives, technical program to accomplish the objectives, a system to track HFE issues, the HFE design team, and the management and organizational structure to allow the technical program to be accomplished.</p>	MUAP-07007-P (R3) Figure 4.0-2 Submittal and Audit Plan for the US-APWR Design Certification shows an overview for the document submittals	The complete list of documents that will be generated to support this program will be referenced in this Compliance Road Map submittal	
<p>2.4 Review Criteria HFE Program Management review topics include:</p> <ul style="list-style-type: none"> • general HFE program goals and scope • HFE team and organization • HFE process and procedures • HFE issues tracking • technical program 			
<p>2.4.1 General HFE Program Goals and Scope (1) HFE Program Goals - The general objectives of the program should be stated in "human-centered" terms, which, as the HFE program develops, should be defined and used as a basis for HFE test and evaluation activities. Generic "human-centered" HFE design goals include the following:</p> <ul style="list-style-type: none"> • personnel tasks can be accomplished within time and performance criteria • the HSIs, procedures, staffing/qualifications, training and management and organizational support will support a high degree of operating crew situation awareness • the plant design and allocation of functions will maintain operation vigilance and provide acceptable workload levels i.e., to minimize periods of operator underload and overload • the operator interfaces will minimize operator error and will provide for error detection and recovery capability 	<p>DCD Tier 1 Section 2.9.1 Design Description DCD Ch.18 Section 18.1.1 General HFE Program and Scope MUAP-07007-P (R3) Section 1.0 Purpose MUAP-07007-P (R3) Section 5.0 HFE Design Process MUAP-07007-P (R3) Section 5.1 HFE Program Management MUAP-07007-P (R3) Section 5.1.1.1 HFE Program Goals MUAP-09019-P (R0) Part 1 Section 1 Purpose MUAP-09019-P (R0) Part 1 Section 2 Applicability</p>		

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<p>2.4.1 General HFE Program Goals and Scope (2) Assumptions and Constraints - An assumption or constraint is an aspect of the design, such as a specific staffing plan or the use of specific HSI technology, that is an input to the HFE program rather than the result of HFE analyses and evaluations. The design assumptions and constraints should be clearly identified.</p>	<p>DCD Ch.18 Section 18.1.1.1 Assumption and Constraints Identification MUAP-07007-P (R3) Section 4.1 Design Basis MUAP-07007-P (R3) Section 5.1.1.2 Assumptions and Constraints MUAP-09019-P (R0) Part 1 Section 2.3 Excluded HFE Elements</p>		
<p>2.4.1 General HFE Program Goals and Scope (3) Applicable Facilities - The HFE program should address the main control room, remote shutdown facility, technical support center (TSC), emergency operations facility (EOF), and local control stations (LCSs).</p>	<p>DCD Ch.18 Tier 1 Section 2.9.1.1 General HFE Program and Scope DCD Ch.18 Section 18.1.1.2 Applicable Plant Facilities MUAP-07007-P (R3) Section 2.0 Scope MUAP-07007-P (R3) Section 4.2 HSI System Facilities MUAP-07007-P (R3) Section 4.3 Layout Design including Table 4.3-1 Typical HSI Equipment at Various Locations MUAP-09019-P (R0) Part 1 Section 2.2 Scope MUAP-09019-P (R0) Part 1 Section 8.2.2.3 US-APWR HSIS (paragraph 3)</p>		
<p>2.4.1 General HFE Program Goals and Scope (4) Applicable HSIs, Procedures and Training - The applicable HSIs, procedures, and training included in the HFE program should include all operations, accident management, maintenance, test, inspection and surveillance interfaces (including procedures).</p>	<p>DCD Ch.18 Section 18.1.1.3 MUAP-07007-P (R3) Section 3.3 NRC Regulatory Guides (items 10, 18, 42, 47) MUAP-07007-P (R3) Section 5.1.1.4 Applicable HSIs, Procedures and Training MUAP-07007-P (R3) Section 5.1.2.2 Roles and Responsibilities (item 2) paragraph 2) MUAP-07007-P (R3) Section 5.1.5 Human Factors Engineering Technical Program and Milestones MUAP-07007-P (R3) Section 5.4 Task Analysis MUAP-07007-P (R3) Section 5.8 Operating Procedure Development Plan MUAP-07007-P (R3) Section 5.9 Training Program Development MUAP-07007-P (R3) Section 5.10.2.2.4 Integrated System Validation (b. Validation Test Facility) MUAP-07007-P (R3) Section 5.12 Human Performance</p>		

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	Monitoring Plan MUAP-07007-P (R3) Appendix C Phased Implementation Plan (Phases 2b & 3b) MUAP-09019-P (R0) Part 1 Section 2.2 Scope MUAP-09019-P (R0) Part 1 Section 3.1 HSIS Design Manager (paragraph 5) MUAP-09019-P (R0) Part 1 Section 4.2 HSI Inventory MUAP-09019-P (R0) Part 1 Section 5.4 TA (paragraph 1) MUAP-09019-P (R0) Part 1 Section 5.6 SA MUAP-09019-P (R0) Part 1 Section 8.2.2.2 Development of Operating Procedures MUAP-09019-P (R0) Part 1 Section 8.2.2.3 US-APWR HSIS (paragraph 4) MUAP-09019-P (R0) Part 1 Section 8.2.2.4 Phase 2b Procedures MUAP-09019-P (R0) Part 1 Section 8.2.3 US-APWR Documents MUAP-09019-P (R0) Part 1 Section 8.3.2 Phase 3b MUAP-09019-P (R0) Part 1 Section 8.3.3 Phase 3 Procedures		
2.4.1 General HFE Program Goals and Scope (5) Applicable Plant Personnel - Plant personnel who should be addressed by the HFE program include licensed control room operators as defined in 10 CFR Part 55 and the following 9 categories of personnel defined by 10 CFR 50.120: nonlicensed operators, shift supervisor, shift technical advisor, instrument and control technician, electrical maintenance personnel, mechanical maintenance personnel, radiological protection technician, chemistry technician, and engineering support personnel. In addition, any other plant personnel who perform tasks that are directly related to plant safety should be addressed. For plant modifications, the HFE program should include the	DCD Ch.18 Section 18.1.1.4 Applicable Plant Personnel MUAP-07007-P (R3) Section 4.1-g. Applicable Plant Personnel MUAP-07007-P (R3) Section 5.5.1 Operator Staffing Level MUAP-07007-P (R3) Section 5.10.2.2.4 Integrated System Validation (c. Plant Personnel) MUAP-09019-P (R0) Part 1 Section 8.1.1 Phase 1a (paragraph 3) MUAP-09019-P (R0) Part 1 Section 8.1.2 Phase 1b paragraph 6 MUAP-09019-P (R0) Part 1 Section 8.2.2.3 US-APWR HSIS (paragraph 4) MUAP-09019-P (R0) Part 1 Section 9.1 Inclusion in the HFE process		

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<p>involvement of plant personnel to provide reasonable assurance that the following are considered from a user's perspective in establishing modification requirements and evaluating the design process's outputs:</p> <ul style="list-style-type: none"> • user's understanding of how plant systems are structured and behave • task demands and constraints of the existing work environment • existing work processes • organizational goals that affect the implementation and use of the modification 			
<p>2.4.1 General HFE Program Goals and Scope (6) Effects of Modifications on Personnel Performance - The goals of the HFE program should address the need to consider the effects that the modification may have on the performance of personnel. The transition from the existing plant configuration to the modification configuration can pose demands on human performance that differ from either the initial or final configurations. Therefore, it should be planned so it places minimal demands for adapting to the change. The considerations should include the following:</p> <ul style="list-style-type: none"> • planning the installation to minimize disruptions to work • coordinating training and procedure modifications with implementing the modification to provide reasonable assurance that both accurately reflect its characteristics. • conducting training to maximize personnel's knowledge and skill with the new design before its implementation 	DCD Ch.18 Section 18.1.1.5 Effects of Modifications on Personnel Performance MUAP-07007-P (R3) Section 4.1 Design Basis MUAP-07007-P (R3) Section 5.1.1.1 Human Factors Engineering Program Goals MUAP-07007-P (R3) Section 5.1.4 Human Factors Engineering Issues Tracking MUAP-07007-P (R3) Section 5.6 Human Reliability Analysis MUAP-07007-P (R3) Section 5.7.3.3 HSI Tests and Evaluations MUAP-07007-P (R3) Section 5.10 Human Factors Verification and Validation MUAP-07007-P (R3) Section 5.11 Design Implementation Plan MUAP-07007-P (R3) 5.12 Human Performance Monitoring Plan MUAP-07007-P (R3) Appendix C Phased Implementation Plan MUAP-09019-P (R0) Part 1 Section 5.4 TA MUAP-09019-P (R0) Part 1 Section 5.5 HRA MUAP-09019-P (R0) Part 1 Section 5.6 SA MUAP-09019-P (R0) Part 1 6.2 HED Problem Statement MUAP-09019-P (R0) Part 1 6.4.2 NRC Priority		

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	MUAP-09019-P (R0) Part 1 9.2 HFE Guidance and Review MUAP-09019-P (R0) Part 1 Section 8.3.2 Phase 3b		
2.4.2 HFE Team and Organization (1) Responsibility - The team should be responsible (with respect to the scope of the HFE program) for (a) the development of all HFE plans and procedures; (b) the oversight and review of all HFE design, development, test, and evaluation activities; (c) the initiation, recommendation, and provision of solutions through designated channels for problems identified in the implementation of the HFE activities; (d) verification of implementation of team recommendations; (e) assurance that all HFE activities comply with the HFE plans and procedures; and (f) scheduling of activities and milestones.	DCD Ch.18 Section 18.1.2.1 HFE Responsibility MUAP-07007-P (R3) Section 5.1.2.2 Roles and Responsibilities MUAP-07007-P (R3) Section 5.5 Staffing and Qualification Requirements MUAP-09019-P (R0) Part 1 Section 2.3 Excluded HFE Elements MUAP-09019-P (R0) Part 1 Section 3 Multidiscipline Multiple Organization Team MUAP-09019-P (R0) Part 1 Section 3.2 Organization Roles and Responsibilities MUAP-09019-P (R0) Part 1 Section 3.3.2 HSIS V&V Manager (paragraph 5) MUAP-09019-P (R0) Part 1 Section 8.2.2.3 US-APWR HSIS (paragraph 3)		
2.4.2 HFE Team and Organization (2) Organizational Placement and Authority - The primary HFE organization(s) or function(s) within the organization of the total program should be identified, described, and illustrated (e.g., charts to show organizational and functional relationships, reporting relationships, and lines of communication). When more than one organization is responsible for HFE, the lead organizational unit responsible for the HFE program plan should be identified. The team should have the authority and organizational placement to provide reasonable assurance that all its areas of responsibility are accomplished and to identify problems in the implementation of the overall plant design. The team should have the authority to control further processing, delivery, 10 installation, or use of HFE products until the disposition of a nonconformance,	DCD Ch.18 Section 18.1.2 Team and Organization DCD Ch.18 Section 18.1.2.1 HFE Organizational Placement and Authority MUAP-07007-P (R3) Section 5.1.2.1 Organization MUAP-09019-P (R0) Part 1 Section 3.3 Team Management MUAP-09019-P (R0) Part 1 Section 3.3.2 HSIS V&V Manager (paragraph 5)		

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deficiency, or unsatisfactory condition has been achieved.			
2.4.2 HFE Team and Organization (3) Composition - The HFE design team should include the expertise described in the Appendix.	DCD Ch.18 Section 18.1.2.3 HFE Organization Composition MUAP-07007-P (R3) Section 5.1.2.2-2) Design Team Manager (DTM) (paragraph 2) MUAP-07007-P (R3) Section 5.1.2.2-3) HFE V&V Team Manager (HFEVTM) (paragraph 2) MUAP-09019-P (R0) Part 1 Section 3.1 HFE Team and Organization		
2.4.2 HFE Team and Organization (4) Team Staffing - Team staffing should be described in terms of job descriptions and assignments of team personnel.	DCD Ch.18 Section 18.1.2.4 HFE Organizational Staffing MUAP-07007-P (R3) Section 5.1.2.2-2) Design Team Manager (DTM) (paragraphs 1&3) MUAP-07007-P (R3) Section 5.1.2.2-3) HFE V&V Team Manager (HFEVTM) (paragraphs 1&3) MUAP-09019-P (R0) Part 1 Section 3.3.1 HSIS Design Manager MUAP-09019-P (R0) Part 1 Section 3.3.2 HSIS V&V Manager MUAP-09019-P (R0) Part 1 Section 3.3.3 HSIS Implementation Manager		
2.4.3 HFE Process and Procedures (1) General Process Procedures - The process through which the team will execute its responsibilities should be identified. The process should include procedures for: <ul style="list-style-type: none"> • assigning HFE activities to individual team members • governing the internal management of the team • making management decisions regarding HFE • making HFE design decisions • governing equipment design changes • design team review of HFE products 	DCD Ch.18 Tier 1 Figure 2.9-1 Overall HFE Design Process DCD Ch.18 Section 18.1.3 HFE Process and Procedures DCD Ch.18 Section Figure 18.1-4 Overall HFE Design Process DCD Ch.18 Section 18.1.3.1 General Procedures MUAP-07007-P (R3) Section 5.1.3-a. General Process Procedures MUAP-07007-P (R3) Figure 5.1-2 General Process Procedure of HFE Design MUAP-09019-P (R0) Part 1 Section 2.1 Work Procedures MUAP-09019-P (R0) Part 1 Section 5 Work Flow MUAP-09019-P (R0) Part 1 Section 8.1.1.2 Phase 1a Procedures		

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	MUAP-09019-P (R0) Part 1 Section 8.1.2.1 Phase 1b Procedures MUAP-09019-P (R0) Part 1 Section 8.2.1.1 Phase 2a Procedures MUAP-09019-P (R0) Part 1 Section 8.2.2.4 Phase 2b Procedures MUAP-09019-P (R0) Part 1 Section 8.3.3 Phase 3 Procedures		
2.4.3 HFE Process and Procedures (2) Process Management Tools - Tools and techniques (e.g., review forms) to be utilized by the team to verify they fulfill their responsibilities should be identified.	DCD Ch.18 Section 18.1.3.2 Process Management Tools MUAP-07007-P (R3) Section 5.1.3-b. Process Management Tools		
2.4.3 HFE Process and Procedures (3) Integration of HFE and Other Plant Design Activities - The integration of design activities should be identified, that is, the inputs from other plant design activities to the HFE program and the outputs from the HFE program to other plant design activities. The iterative nature of the HFE design process should be addressed.	DCD Ch.18 Section 18.1.3.3 Integration of HFE and other Plant Design Activities MUAP-07007-P (R3) Section 5.1.1.1 Human Factors Engineering Program Goals MUAP-07007-P (R3) Section 5.1.3-c. Integration of HFE and Other Plant Design Activities MUAP-07007-P (R3) Section 5.1.5 Human Factors Engineering Technical Program and Milestones MUAP-09019-P (R0) Part 1 Figure 4 HFE Work Flow MUAP-09019-P (R0) Part 1 Section 5.1 Role of the HFE Process in Nuclear Plant Design MUAP-09019-P (R0) Part 1 Section 5.3 FRA/FA MUAP-09019-P (R0) Part 1 Section 5.5.2 Integration Role of HRA MUAP-09019-P (R0) Part 1 Section 9.1 Inclusion in the HFE process		
2.4.3 HFE Process and Procedures (4) HFE Program Milestones - HFE milestones should be identified so that evaluations of the effectiveness of the HFE effort can be made at critical check points and the relationship to the	DCD Ch.18 Section 18.1.3.4 HFE Program Milestones MUAP-07007-P (R3) Section 5.1.3-d. HFE program Milestones MUAP-07007-P (R3) Figure 5.1-3 Overall Design Process MUAP-07007-P (R3) Section 5.1.5 Human Factors Engineering Technical Program and Milestones		

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integrated plant sequence of events is shown. A relative program schedule of HFE tasks showing relationships between HFE elements and activities, products, and reviews should be available for review.	MUAP-09019-P (R0) Part 1 Section 8 US-APWR MCR Development MUAP-09019-P (R0) Part 1 Figure 5 US-APWR MCR Development High Level Logic MUAP-09019-P (R0) Part 1 Figure 6 US-APWR MCR Development High Level Schedule MUAP-09019-P (R0) Part 1 Figure 7 Design and V&V Phases and Licensing Correlation		
2.4.3 HFE Process and Procedures (5) HFE Documentation - HFE documentation items should be identified and briefly described along with the procedures for retention and access.	DCD Ch.18 Section 18.1.3.5 HFE Documentation MUAP-07007-P (R3) Section 5.1.3 Human Factors Engineering Processes and Procedures - a. General Process Procedures MUAP-07007-P (R3) Section 5.1.3-e. HFE Documentation MUAP-07007-P (R3) Section 7.0 Future Licensing Submittals MUAP-09019-P (R0) Part 1 Section 8.1.4 US Basic HSI Design Documents MUAP-09019-P (R0) Part 1 Section 8.2.3 US-APWR Documents	HFE Documentation Retention and Access will be included in US-APWR documentation.	
2.4.3 HFE Process and Procedures (6) Subcontractor HFE Efforts - HFE requirements should be included in each subcontract and the subcontractor's compliance with HFE requirements should be periodically verified.	DCD Ch.18 Section 18.1.3.2 Subcontractor Efforts MUAP-07007-P (R3) Section 5.1.3-f. Subcontractor HFE Efforts MUAP-09019-P (R0) Part 1 Section 3.1 HFE Team and Organization MUAP-09019-P (R0) Part 1 Figure 1 HFE Project Organization MUAP-09019-P (R0) Part 1 Section 3.4 Quality Assurance		
2.4.4 HFE Issues Tracking (1) Availability - A tracking system should be available to address human factors issues that are (a) known to the industry (defined in the Operating Experience Review element, see Section 3) and (b) identified throughout the life cycle of the HFE aspects of design, development, and evaluation. Issues are those items that need to be addressed	DCD Ch.18 Section 18.1.4 HFE Issues Tracking MUAP-07007-P (R3) Section 5.1.2.2 Roles and Responsibilities 2) Design Team Manager (DTM) MUAP-07007-P (R3) Section 5.1.4 HFE Issues Tracking MUAP-09019-P (R0) Part 1 Section 6 HEDs		

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at some later date and thus need to be tracked to provide reasonable assurance that they are not overlooked. It is not necessary to establish a new system to track HFE issues that is independent from the rest of the design effort. An existing tracking system may be adapted to serve this purpose (such as a plant's corrective action program, CAP).			
2.4.4 HFE Issues Tracking (2) Method - The method should document and track HFE issues from identification until the potential for negative effects on human performance has been reduced to an acceptable level.	MUAP-07007-P (R3) Section 5.1.4 HFE Issues Tracking MUAP-07007-P (R3) Section 5.7.3.1 Input Information to HSI Design Process MUAP-09019-P (R0) Part 1 Section 6.1 HED Process MUAP-09019-P (R0) Part 1 Section 6.2 HED Problem Statement MUAP-09019-P (R0) Part 1 Section 6.3 HED Evaluation MUAP-09019-P (R0) Part 1 Section 6.4 HED Significance MUAP-09019-P (R0) Part 1 Section 6.6 HED Closure		
2.4.4 HFE Issues Tracking (3) Documentation - Each issue or concern that meets or exceeds the threshold established by the design team should be entered into the system when first identified, and each action taken to eliminate or reduce the issue or concern should be thoroughly documented. The final resolution of the issue should be documented in detail, along with information regarding design team acceptance.	MUAP-07007-P (R3) Section 5.1.4 HFE Issues Tracking MUAP-07007-P (R3) Section 5.11 Design Implementation Plan MUAP-09019-P (R0) Part 1 Section 6.6 HED Closure MUAP-09019-P (R0) Part 1 Section 7 HED Database	The Implementation Procedure will be revised to say that the Expert Panel HED Analysis shall be documented.	
2.4.4 HFE Issues Tracking (4) Responsibility - When an issue is identified, the tracking procedures should describe individual responsibilities for issue logging, tracking and resolution, and resolution acceptance.	MUAP-07007-P (R3) Section 5.1.2.2 Roles and Responsibilities 3) HFE V&V Team Manager (HFEVTM) MUAP-09019-P (R0) Part 1 Section 6.5 HED Resolution MUAP-09019-P (R0) Part 1 Section 6.6 HED Closure	The Implementation Procedure will be revised to say that the V&V Team is responsible for closing an HED.	
2.4.5 Technical Program (1) The general development of implementation plans, analyses, and evaluation of the following	DCD Ch.18 Section 18.1.5 Technical Program (paragraph 1) DCD Ch.18 Section Figure 18.1-4 Overall HFE Design		

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<p>should be identified and described:</p> <ul style="list-style-type: none"> • operating experience review • functional requirements analysis and function allocation • task analysis • staffing and qualifications • human reliability analysis • HSI design • procedure design • training design • human factors verification and validation • design implementation • human performance monitoring 	<p>Process MUAP-07007-P (R3) Section 5.1.5 HFE Technical Program and Milestones MUAP-07007-P (R3) Figure 5.1-3 Overall Design Process MUAP-09019-P (R0) Part 1 Section 5 Work Flow MUAP-09019-P (R0) Part 1 Section 8 US-APWR MCR Development MUAP-09019-P (R0) Part 1 Section 9 US-APWR Local Controls MUAP-09019-P (R0) Part 1 Section 10 US-APWR As-Built HSI</p>		
<p>2.4.5 Technical Program (2) The HFE requirements imposed on the design process should be identified and described. The standards and specifications that are sources of HFE requirements should be listed.</p>	<p>DCD Ch.18 Section 18.1.5 Technical Program (paragraphs 2&6) MUAP-07007-P (R3) Section 3.0 Applicable Codes, Standards and Regulatory Guidance MUAP-09019-P (R0) Part 1 Section 1.2 US Licensing Approach MUAP-09019-P (R0) Part 1 Section 8.2.2.3 US-APWR HSI (paragraph 4)</p>		
<p>2.4.5 Technical Program (3) HFE facilities, equipment, tools, and techniques (such as laboratories, simulators, rapid prototyping software) to be utilized in the HFE program should be specified.</p>	<p>DCD Ch.18 Section 18.1.5 Technical Program (paragraphs 3 & 4) DCD Ch.18) Figure 18.1-4 Overall HFE Design Process DCD Ch.18 Section 18.6.2 Methodology DCD Ch.18 Section 18.9.2.2 Organization of Training DCD Ch.18 Section 18.9.2.4 Content of Training Program DCD Ch.18 Section 18.10.2.3 Integrated System Validation DCD Ch.18 Section 18.11.2 Methodology MUAP-07007-P (R3) Section 5.1.4 HFE Technical Program and Milestones (paragraph 2) MUAP-07007-P (R3) Figure 4.0-1 HFE Design Process of Past Mitsubishi PWR HSI MUAP-07007-P (R3) Section 5.1.5 Human Factors Engineering Technical Program and Milestones</p>		

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	MUAP-07007-P (R3) Figure 5.4-1 Task Analysis in HFE Process Flow MUAP-07007-P (R3) Figure 5.6-1 HRA in HFE Process Flow MUAP-07007-P (R3) Section 5.9.2 Operator Training Simulator Fidelity MUAP-07007-P (R3) Section 5.10 Human Factors Verification and Validation MUAP-07007-P (R3) Appendix C Phased Implementation Plan MUAP-09019-P (R0) Part 1 Section 3.2 Organization Roles and Responsibilities MUAP-09019-P (R0) Part 1 Figure 4 HFE Work Flow MUAP-09019-P (R0) Part 1 Section 3.2 Organization Roles and Responsibilities (paragraph 3) MUAP-09019-P (R0) Part 1 Section 8.1.1 Phase 1a (paragraph 2) MUAP-09019-P (R0) Part 1 Section 8.2.2.3 US-APWR HSIS (paragraph 3) MUAP-09019-P (R0) Part 1 Section 8.3.2 Phase 3b		
<p>2.4.5 Technical Program</p> <p>(4) The applicant should provide assurance in the HFE plan that a plant modification meets current regulations, except where specific exemptions are requested under 10 CFR 50.12 or 10 CFR 2.802. An exemption might be granted under one or more of the following regulations: 10 CFR 20, 10 CFR 50 Appendix A, Criterion 19, and 10 CFR 50 Appendices C through R.</p>	DCD Ch.18 Section 18.1.5 Technical Program (paragraph 5) MUAP-07007-P (R3) Section 3.0 Applicable Codes, Standards and Regulatory Guidance - explains regulatory conformance		

2. HFE Program Management

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<p>2.4.5 Technical Program</p> <p>(5) The applicant should provide assurance in the HFE plan that a modification does not compromise defense-in-depth. Defense-in-depth is one of the fundamental principles upon which the plant was designed and built. Defense-in-depth uses multiple means to accomplish safety functions 12 and to prevent the release of radioactive materials. Defense-in-depth is important in accounting for uncertainties in equipment and human performance, and for ensuring some protection remains even in the face of significant breakdowns in particular areas. Defense-in-depth may be changed but should be maintained overall. Important aspects of defense-in-depth are identified in RG 1.174, and include:</p> <ul style="list-style-type: none"> • A reasonable balance is preserved among prevention of core damage, prevention of containment failure, and consequence mitigation. • There is no over-reliance on programmatic activities to compensate for weaknesses in plant design. This may be pertinent to changes in credited human actions (HAs). • System redundancy, independence, and diversity are preserved commensurate with the expected frequency, consequences of challenges to the system, and uncertainties (e.g., no risk outliers). 	<p>DCD Ch.18 Section 18.1.5 Technical Program (paragraph 6)</p> <p>DCD Ch.18 Section Table 18.2-1 Examples of Issues and Resolutions from US-APWR OER Report (No. 3)</p> <p>MUAP-07007-P (R3) Abstract (paragraphs 6&9)</p> <p>MUAP-07007-P (R3) Section 4.11.3 Loss of All Non-safety HSI</p> <p>MUAP-07007-P (R3) Section 4.11.4 Loss of All Digital Non-safety and Safety HSI (CCF)</p> <p>MUAP-07007-P (R3) Section 5.3.2.1 General Rules</p> <p>MUAP-09019-P (R0) Part 1 Section 8.1.1 Phase 1a (paragraph 3)</p> <p>MUAP-09019-P (R0) Part 1 Section 8.1.2 Phase 1b (paragraph 5)</p> <p>MUAP-09019-P (R0) Part 1 Section 8.2.2.3 US-APWR HSI (paragraph 4)</p>		

2. HFE Program Management

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<p>2.4.5 Technical Program (5) continued</p> <ul style="list-style-type: none"> • Defenses against human errors are preserved. For example, establish procedures for a second check or independent verification for risk-important HAs to determine that they have been performed correctly. • The intent of the General Design Criteria (GDC) in Appendix A to 10 CFR Part 50 is maintained. GDC that may be relevant are 3 - Fire Protection, 13 - Instrumentation and Control, 17 - Electric Power Systems, 19 - Control Room, 34 - Residual Heat Removal, 35 - Emergency Core Cooling System, 38 - Containment Heat Removal, and 44 - Cooling Water. • Safety margins often used in deterministic analyses to account for uncertainty and provide an added margin to provide adequate assurance that the various limits or criteria important to safety are not violated. Such safety margins are typically not related to HAs, but the reviewer should take note to see if there are any that may apply to the particular case under review. It is also possible to add a safety margin (if desired) to the HA by demonstrating that the action can be performed within some time interval (or margin) that is less than the time identified by the analysis. 			

3. Operating Experience Review

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<p>3.3 Applicant Submittals As per Section 1.2.1, item (3) Applicant Submittals, the applicant should provide for staff review an implementation plan for conducting a review of operating experience. Upon completion of the applicant's OER, a results summary report should be submitted so that the staff can review the identification and analysis of HFE-related problems and issues using the criteria provided in Section 3.4 below. In addition, the reviewer may also audit the issue tracking system for examination of OER issue treatment.</p>	<p>Section 18.2 of the DCD Ch.18 and Section 5.2 of the topical report MUAP-07007-P (R3) provide the methodology of the OER.</p> <p>Part 2 of the technical report MUAP-08014-P (R0) provides the result summary of the OER for US-APWR.</p>		
<p>3.4 Review Criteria 3.4.1 Scope (1) Predecessor/Related Plants and Systems - The review should include information pertaining to the human factors issues related to the predecessor plant(s) or highly similar plants and plant systems. For a review of plant modifications, the scope of the OER should be focused to provide information relevant to the plants' systems, HSIs, procedures, or training that are being modified. It should address the operating experience of the plant that will be modified, including experiences with the systems that will be modified and with technologies that are similar to those under consideration for it. Some useful information may be found in the plant's CAP. Also, when personnel are unfamiliar with the proposed technology, attention should be paid to the operating experience of other plants that already have the technology.</p>	<p>Part 2, Section 6 of the technical report MUAP-08014-P (R0) provides the OER Information Sources.</p>	<p>If upgrades to existing plant HSIs are planned based upon this Design Certification, a discussion as to how MHI plans to address OER will be provided.</p>	

3. Operating Experience Review

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<p>3.4.1 Scope (2) Recognized Industry HFE Issues - NUREG/CR-6400 (Higgins and Nasta, 1996) issues should be addressed. The issues are organized into the following categories:</p> <ul style="list-style-type: none"> • unresolved safety issues/generic safety issues • TMI issues • NRC generic letters and information notices • reports of the former NRC Office for Analysis and Evaluation of Operational Data • low power and shutdown operations • operating plant event reports 	<p>Section 18.2.1 “objective and scope” of the DCD Ch.18 addresses the NUREG/CR-6400 which contains;</p> <ul style="list-style-type: none"> • unresolved safety issues/generic safety issues • TMI issues • NRC generic letters and information notices • reports of the former NRC Office for Analysis and Evaluation of Operational Data • low power and shutdown operations • operating plant event reports <p>Section 5.2 of the Topical Report MUAP-07007-P (R3) contains NUREG/CR-6400.</p> <p>Part 2 of the technical report MUAP-08014-P (R0) addresses the HFE issues NUREG/CR-6400.</p>		
<p>3.4.1 Scope (3) Related HFE Technology - The OER should address related HFE technology. For example, if touch screen interfaces or computerized procedures are planned, HFE issues associated with their use should be reviewed.</p>	<p>Section 18.2.1 “objective and scope” of the DCD Ch.18 addresses the related HFE technology.</p> <p>The related HFE technology such as touch screen display, large-screen display and computer-based procedure are addressed and reviewed in Section 3.2 and 6 of the technical report MUAP-08014-P (R0).</p>		

3. Operating Experience Review

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<p>3.4.1 Scope</p> <p>(4) Issues Identified by Plant Personnel - Personnel interviews should be conducted to determine operating experience related to predecessor plants or systems. The following topics should be included in the interviews as a minimum:</p> <ul style="list-style-type: none"> • Plant Operations <ul style="list-style-type: none"> - normal plant evolutions (e.g., startup, full power, and shutdown) - instrument failures [e.g., safety-related system logic and control unit, fault tolerant controller (nuclear steam supply system), local "field unit" for multiplexer (MUX) system, MUX controller (balance of plant), break in MUX line] - HSI equipment and processing failure (e.g., loss of video display units, loss of data processing, loss of large overview display) - transients (e.g., turbine trip, loss of offsite power, station blackout, loss of all feedwater, loss of service water, loss of power to selected buses or control room (CR) power supplies, and safety/relief valve transients) - accidents (e.g., main steam line break, positive reactivity addition, control rod insertion at power, control rod ejection, anticipated transients without scram (ATWS), and various-sized loss-of-coolant accidents (LOCA)) - reactor shutdown and cooldown using remote shutdown system - procedures, training, staffing/qualifications, and job design 	<p>Section 18.2.2.6 identifies the interview which contains plant operation and HFE design topics.</p> <p>The interview was conducted during Phase 1a and 1b V&V.</p> <p>Part1 Appendix B Section 2.2 and 3.1 of the technical report MUAP-08014-P (R0) contain the verbal debriefs.</p> <p>Part 3 Section 4.2 of the technical report MUAP-08019-P (R0) contains the test method including verbal debrief.</p>		

3. Operating Experience Review

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(4) (Continued) • HFE Design Topics - alarm and annunciation - display - control and automation - information processing and job aids - real-time communications with plant personnel and other organizations	(Continued)		
3.4.1 Scope (5) Risk-Important Human Actions - The OER should identify risk-important HAs that have been identified as different or where errors have occurred. The human actions should be identified as requiring special attention during the design process to lessen their probability.	Section 18.2.2.3 of the DCD Ch.18 identifies the Risk-Important Human Actions. The HAs are entered into HED issue tracking system. Part 2 Section 6 Table 6 and 7 of the technical report MUAP-08014-P (R0) provide the result of the OER regarding Risk-Important Human Actions.		
3.4.2 Issue Analysis, Tracking, and Review (1) Analysis Content - The issues should be analyzed with regard to the identification of • human performance issues, problems, and sources of human error • design elements that support and enhance human performance	Section 18.2.2.7 and 18.2.3 of the DCD Ch.18 identify the issue analysis, tracking and review and the result. The result of the analysis is provided in Part 2 section 3.2 Table 6 through 10 of the technical report MUAP-08014-P (R0).		
3.4.2 Issue Analysis, Tracking, and Review (2) Documentation - The analysis of operating experience should be documented in an evaluation report.	Section 18.2.3 of the DCD Ch.18 addresses the record of the OER. The OER is documented as Part 2 of the technical report MUAP-08014-P (R0).		

3. Operating Experience Review

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3.4.2 Issue Analysis, Tracking, and Review (3) Incorporation Into the Tracking System - Each operating experience issue determined to be appropriate for incorporation in the design (but not already addressed in the design) should be documented in the issue tracking system.	Part 1 section 3.9 of the technical report MUAP-08014-P (R0) addresses the data collection approach. Part 1 section 7.2 of the technical report MUAP-09019-P (R0) addresses the HED database.		

4. Functional Requirements Analysis and Function Allocation

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<p>4.3 Applicant Submittals As per Section 1.2.1, item (3) Applicant Submittals, the applicant should provide for staff review an implementation plan for conducting functional requirements analysis and functional allocation. Upon completion of the applicant's efforts, a results summary report should be submitted so that the staff can review the applicant's definition of the plant's functions and the allocation of functions to human and system resources using the criteria provided in Section 4.4 below.</p>	<p>A commitment to perform a functional requirements analysis and function allocation (FRA/FA) and a description of the scope of the FRA/FA is provided in Section 2.9.1.2.2 of the Design Control Document for the US-APWR – DCD Tier 1 .</p> <p>Acceptance criteria are specified in Table 2.9-1, item 4 of the Design Control Document for the US-APWR - Tier 1 (DCD – Tier 1 MUAP-DC020).</p> <p>Section 18.3.2 of the DCD provides a high level overview of the MHI FRA/FA methodology.</p> <p>US-APWR HSI Design Technical report (MUAP-09019), Part 2 “HFE analysis”, Section 1 (Functional Requirements Analysis and Function Allocation) contains the FRA/FA implementation procedure and a summary report of the results of the FRA/FA.</p>		
<p>4.4 Review Criteria (1) Functional requirements analysis and function allocation should be performed using a structured, documented methodology reflecting HFE principles. An example functional allocation process and considerations is shown in Figure 4.1. The functional requirements analysis and function allocation may be graded based on:</p> <ul style="list-style-type: none"> • the degree to which the functions of the new design differ from those of the predecessor • the extent to which difficulties related to plant functions were identified in the plant's operating experience and will be addressed in the new design. 	<p>Section 18.3.2 of the DCD Ch.18 provides a high level overview of the FRA/FA methodology.</p> <p>It specifies that the functional requirements analysis and function allocation is conducted based on the degree to which the functions of the new design differ from those of the predecessor design (Section 18.3.2.1, paragraph 3, page 18.3-2).</p> <p>The major FA changes for the US-APWR as compared to standard Japanese PWR plants (and PWR plants generally) are spelled out in Section 18.3.3, of the DCD, bottom of page 18.3-4 and top of page 18.3-5).</p> <p>Section 5.3 of the US-APWR Topical Report HSI System Description and HFE Process (MUAP-07007-P) provides an overview of the range of rules, considerations and HFE principles that MHI has used to guide FRA/FA.</p> <p>MUAP-09019-P (R0) Part 2 Section 1.4.1 details the structured</p>		

4. Functional Requirements Analysis and Function Allocation

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	<p>documented MHI methodology for Functional Requirement Analysis.</p> <p>MUAP-09019-P (R0) Part 2 Section 1.4.2 details the structured documented MHI methodology for Function Allocation.</p>		
<p>4.4 Review Criteria</p> <p>(2) The functional requirements analysis and function allocation should be kept current over the life cycle of design development and held until decommissioning so that it can be used as a design basis when modifications are considered. Control functions should be re-allocated in an iterative manner, in response to developing design specifics, operating experience, and the outcomes of ongoing analyses and trade studies.</p>	<p>18.3.2.1 of the DCD Ch.18 explicitly specifies that the FRA/FA are kept current over the life cycle of design development and are maintained until decommissioning; and are reallocated in an iterative manner in response to developing design specifics and operating experience (bottom of page 18.3-2, top of page 18.3-3)MUAP-09019-P (R0) Part 2 Section 1.6.2 specifies that the HSI system design team manager is responsible for insuring that the FRA/FA is kept current over the life cycle of design development (bottom of page 40).</p>	<p>Changes on FA/FRA such as automation will be included in revision of technical report MUAP-09009-P (R0), if changes in FA are made.</p>	
<p>4.4 Review Criteria</p> <p>(3) A description of the functions and systems should be provided along with a comparison to the reference plants/systems, i.e., the previous plants or plant systems on which the new system is based. This description should identify differences that exist between the proposed and reference plants/systems. Safety functions (e.g., reactivity control) include functions needed to prevent or mitigate the consequences of postulated accidents that could cause undue risk to the health and safety of the public. For each safety function, the set of plant system configurations or success paths that are responsible for or capable of carrying out the function should be clearly defined. Function decomposition should start at</p>	<p>MUAP-09019-P (R0) Part 2 Section 1.4.1 Functional Requirement Analysis documents the structured method that is used for identifying and decomposing plant functions. The MHI functional requirements hierarchical structure is presented in Figure 1.4-2.</p> <p>The detailed results of the functional requirements analysis are presented in Appendix 1.8.1.</p> <p>FRA/FA summary report identifies the difference that exist between the proposed and reference plants/systems (MUAP-09019-P, page 33). Safety functions include six critical functions which credit for prevention and mitigation of the consequences of postulated accidents.</p> <p>The set of plant system configurations or success paths that are responsible for or capable of carrying out the function are clearly defined in the summary report.</p> <p>In the report, the plant functions are decomposed from top-level function through specific component level (MUAP-09019-P,</p>		

4. Functional Requirements Analysis and Function Allocation

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<p>“top-level” functions where a very general picture of major functions is described, and continue to lower levels until a specific critical end-item requirement emerges (e.g., a piece of equipment, software, or HA). The functional decomposition should address the following levels</p> <ul style="list-style-type: none"> • high-level functions [e.g., maintain reactor coolant system (RCS) integrity] and critical safety functions (e.g., maintain RCS pressure control) • specific plant systems and components 	Figure 1.42, page 39).		
<p>4.4 Review Criteria (4) A description should be provided for each high-level function which includes:</p> <ul style="list-style-type: none"> • purpose of the high-level function • conditions that indicate that the high-level function is needed • parameters that indicate that the high-level function is available • parameters that indicate the high-level function is operating (e.g., flow indication) • parameters that indicate the high-level function is achieving its purpose (e.g., reactor vessel level returning to normal) • parameters that indicate that operation of the high-level function can or should be terminated <p>Note that parameters may be described qualitatively (e.g., high or low). Specific data values or setpoints are not necessary at this stage.</p>	<p>MUAP-09019-P (R0) Part 2 Section 1.4.1 Functional Requirement Analysis specifies the information provided for each high level function as part of the function requirements analysis (pages 33 and 34). This includes all the information specified in NUREG 0711, review criteria 4.4 (4). The results of the functional requirements analysis for each function are documented in Appendix 1.8.1</p>	<p>The result of function-based task analysis will be included in revision of technical report MUAP-09009-P (R0).</p>	
<p>4.4 Review Criteria (5) The technical basis for modifications to high-level functions in the new design (compared to the predecessor design)</p>	<p>The high level functions for the US-APWR remain the same as for predecessor PWRs.</p>		

4. Functional Requirements Analysis and Function Allocation

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should be documented.			
<p>4.4 Review Criteria (6) The technical basis for all function allocations should be documented; including the allocation criteria, rationale, and analyses method. The technical basis for functional allocation can be any one or combination of the evaluation factors (see Fig 4.1). For example, the performance demands to successfully achieve the function, such as degree of sensitivity needed, precision, time, or frequency of response, may be so stringent that it would be difficult or error prone for personnel to accomplish. This would establish a basis for automation (assuming acceptability of other factors, such as technical feasibility or cost).</p>	<p>MUAP-09019-P (R0) Part 2 Section 1.4.2 Function Allocation documents the specific technical basis for all function allocations. The specific criteria for function assignment are provided on pages 36-38. The results of the function allocation and detailed basis for each function assignment are documented in Appendix 1.8.4</p>		
<p>4.4 Review Criteria (7) The OER should be used to identify modifications to function allocations, if necessary. If problematic OER issues are identified, then an analysis should be performed to (a) justify the original analysis of the function, (b) justify the original human-machine allocation, and (c) identify solutions such as training, personnel selection, and procedure design that will be implemented to address the OER issues.</p>	<p>MUAP-09019-P (R0) Part 2 Section 1.4.2 Function Allocation (page 38, middle of page) specifies that the OER is used to identify modifications to function allocation if necessary.</p> <p>The results of the OER are documented in MUAP-08014-P, Part 2, Operating Experience Review. Problematic OED issues identified are documented as Human Engineering Discrepancies (HEDs). New HEDs generated through the Operating Experience Review are documented in Table 2 in MUAP-08014-P.</p> <p>The process for evaluating, tracking, and resolving HEDs is documented in MUAP-09019-P, Part 1, Section 6.</p>	<p>The FRA/FA results documentation will be updated, if changes in FA are made based on evaluation of HEDs, including HEDs identified based on OER.</p>	
<p>4.4 Review Criteria (8) The allocation analysis should consider not only the primary allocations to personnel, but also their responsibilities to monitor automatic functions and to assume manual control in the event of an automatic</p>	<p>MUAP-09019-P (R0) Part 2 Section 1.4.2 Function Allocation specifies that the function allocation analysis considers not only the primary allocations to personnel, but also their responsibilities to monitor automatic functions and to assume manual control in the event of an automatic system failure</p>	<p>The process of the FA analysis will be included in revision of the technical report MUAP-09009-P</p>	

4. Functional Requirements Analysis and Function Allocation

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system failure.	(page 35).	(R0).	
4.4 Review Criteria (9) A description of the integrated personnel role across functions and systems should be provided in terms of personnel responsibility and level of automation.	MUAP-09019-P (R0) Part 2 Section 1.4.3 Function Allocation specifies that the integrated personnel role across functions and systems is provided in terms of personnel responsibility and level of automation (top of page 40).		
4.4 Review Criteria (10) The functional requirements analysis and function allocation should be verified: <ul style="list-style-type: none"> • all the high-level functions necessary for the achievement of safe operation are identified. • all requirements of each high-level function are identified. • the allocations of functions result in a coherent role for plant personnel 		The process on verification of the FA/FRA will be included in revision of the technical report MUAP-09009-P (R0).	
4.4 Review Criteria (11) When the analyses address plant modifications, the following considerations should also be addressed: <ul style="list-style-type: none"> • Functional requirements analyses for modifications that are likely to change existing safety functions, introduce new functions for systems supporting safety functions, or involve unclear functional requirements that may be important to safety. The functional requirements analysis should address new functions resulting from changes in the degree of integration between plant systems. For example, installing higher-level automation may bring systems that were formerly controlled separately under a single controller. Also, the modifications may change the degree to which different plant systems share common resources (e.g., power sources, 	N/A	If upgrades to existing plant HSIs are planned based upon this Design Certification, a discussion as to how MHI plans to address FRA/FA will be provided.	

4. Functional Requirements Analysis and Function Allocation

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<p>cooling water, and data-transmission buses). These may be important in diagnosing malfunctions or planning responses. The functional requirements analyses should be revised and updated to reflect the modification; the scope of the analyses may be restricted to functions related to the modification.</p> <ul style="list-style-type: none"> • Function allocation analyses for modifications that are likely to change the allocation between personnel and plant systems of functions important to safety. The analyses should be revised and updated to reflect the modification; their scope may be restricted to functions involving the modification. • A change in an operator's role due to a modification should be examined within the context of its effects on the operator's overall responsibilities. Increases in certain task demands may affect the ability of the operator to carry out others that are risk-important. 			

5. Task Analysis

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<p>5.3 Applicant Submittals As per Section 1.2.1, item (3) Applicant Submittals, the applicant should provide for staff review an implementation plan for conducting task analysis. Upon completion of the applicant's efforts, a results summary report should be submitted so that the staff can review the applicant's identification of tasks that are needed for function accomplishment and the information, control and task-support requirements using the criteria provided in Section 5.4 below.</p>	<p>A commitment to perform a task analysis and description of the scope is provided in Section 2.9.1.2.3 of the Design Control Document for the US-APWR - Tier 1 (DCD – Tier 1 MUAP-DC020).</p> <p>Acceptance criteria are specified in Table 2.9-1, item 5 of the Design Control Document for the US-APWR - Tier 1 (DCD – Tier 1 MUAP-DC020).</p> <p>US-APWR, HSI Design MUAP-09019-P (R0), Part 2, Section 3 contains the task analysis implementation procedure and results for Phase 2a. It reports results of task analysis of risk important human actions. TA for the full range of operating tasks will be conducted in conjunction with operating procedure development in Phase 2b and will be documented.</p> <ul style="list-style-type: none"> • MUAP-09019-P (R0), Part 1, Section 8.2.1.2 (bullet 2) • MUAP-09019-P (R0), Part 2, Section 3 • MUAP-09019-P (R0), Part 2, Section 3, Appendix 3.9.1 • MUAP-09019-P (R0), Part 2, Section 3, Table 3.2-1 	<p>Table 2.9-1, item 5 and item 8-2 of the Design Control Document for the US-APWR - Tier 1 (DCD – Tier 1 MUAP-DC020) indicates that a function-based task analysis will be performed. The process of function-based task analysis will be included in Phase 2b task analysis implementation procedure.</p>	

5. Task Analysis

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<p>5.4 Review Criteria</p> <p>(1) The scope of the task analysis should include:</p> <ul style="list-style-type: none"> • selected representative and important tasks from the areas of operations, maintenance, test, inspection, and surveillance • full range of plant operating modes, including startup, normal operations, abnormal and emergency operations, transient conditions, and low-power and shutdown conditions • HAs that have been found to affect plant risk by means of PRA importance and sensitivity analyses should also be considered risk-important. Internal and external initiating events and actions affecting the PRA Level I and II analyses should be considered when identifying risk-important actions • where critical functions are automated, the analyses should consider all human tasks including monitoring of the automated system and execution of backup actions if the system fails. 	<p>The complete planned scope of the task analysis is provided in:</p> <ul style="list-style-type: none"> • Section 2.9.1.2.3 and Table 2.9-1, item 5 of the Design Control Document for the US-APWR - Tier 1 (DCD – Tier 1 MUAP-DC020). • Section 18.4.1 of the Design Control Document for the US-APWR (DCD) • Section 5.4.2 of the US-APWR, Topical Report HSI System Description And HFE Process (MUAP-07007-P (R3)) <p>MUAP-09019-P (R0), Part 2, Section 3 provides the methods and results for risk important human actions</p> <p>MUAP-09019-P (R0), Part 2, Section 3.4 (second to last paragraph) specifies the planned scope of task analysis to be performed in Phase 2B</p>	<p>The Phase 2b Task Analysis implementation procedure will specify the task selection process and set of specific tasks that will be included in the Phase 2b task analysis.</p> <p>The Phase 2b task analysis will cover a broader range of representative and important tasks from the areas of operations, maintenance, test, inspection and surveillance and a broader range of operating modes so as to meet all 5.4 (1) review criteria.</p>	

5. Task Analysis

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(Continued)	(Continued)	(Continued) Phase 2b task analyses will also specifically address the supervisory role of MCR operators with respect to critical functions that are automated. This includes monitoring of the automated systems and execution of backup actions if the system fails.	

5. Task Analysis

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<p>5.4 Review Criteria</p> <p>(2) Tasks should be linked using a technique such as operational sequence diagrams.</p> <p>Task analyses should begin on a gross level and involve the development of detailed narrative descriptions of what personnel have to do.</p> <p>The analyses should define the nature of the input, process, and output needed by and of personnel. Detailed task descriptions should address (as appropriate) the topics listed in Table 5.1</p>	<p>Section 18.4.2.1 of the Design Control Document for the US-APWR (DCD) specifies the methods to be used for task analysis. This includes a commitment to use operational sequence diagrams.</p> <p>Section 18.4.2 of the Design Control Document for the US-APWR (DCD) specifies that the detailed task descriptions will cover the topics listed in Table 5.1 as appropriate.</p> <p>Section 5.4.3.1 of the US-APWR, Topical Report HSI System Description And HFE Process (MUAP-07007-P (R3)) specifies the methods to be used for task analysis. This includes a commitment to use operational sequence diagrams.</p> <p>Section 5.4.3 of the US-APWR, Topical Report HSI System Description And HFE Process (MUAP-07007-P (R3)) specifies that the detailed task descriptions will cover the topics listed in Table 5.1 as appropriate (See Table 5.4-1).</p> <p>MUAP-09019-P (R0), Part 2, Section 3.4 provides a detailed description of the task analysis method that was used in Phase 2a. This includes a specification of how the topics listed in Table 5.1 were met (See Table 3.4-1) as well as a description of how the operational sequence diagrams were developed and used in the task analysis.</p>	<p>The Phase 2b Task Analysis implementation procedure will specify the more detailed task analysis process that will be used in Phase 2B so as to provide the needed detail to support HSI design and HSI task support verification.</p>	

5. Task Analysis

NUREG 0711 Revision 2 Review Criteria	Compliance Road Map		
	Current Documentation	Planned Documentation	Gap
<p>5.4 Review Criteria (3) The task analysis should be iterative and become progressively more detailed over the design cycle. It should be detailed enough to identify information and control requirements to enable specification of detailed requirements for alarms, displays, data processing, and controls for human task accomplishment.</p>	<p>Section 18.4.2. paragraph 4 of the Design Control Document for the US-APWR (DCD) specifies that is iterative and becomes progressively more detailed over the design cycle.</p> <p>Section 18.4.2, paragraph 4 of the Design Control Document for the US-APWR (DCD) specifies that the task analysis will be detailed enough to identify detailed requirements for alarms, displays, data processing and controls.</p> <p>Section 5.4.2 paragraph 2 and Section 5.4.2 last paragraph of the US-APWR, Topical Report HSI System Description And HFE Process (MUAP-07007-P (R3)) specifies that the task analysis will be iterative and detailed enough to identify detailed requirements for alarms, displays, data processing and controls.</p> <p>MUAP-09019-P (R0), Part 2, Section 3.4, last paragraph specifies that the task analysis process is iterative and that the Phase 2B task analysis method will be adapted to support the more detailed TA that is required to support HSI design, HSI task support verification and procedure development.</p>	<p>The Phase 2b Task Analysis implementation procedure will specify the more detailed task analysis process that will be used in Phase 2B so as to provide the needed detail to identify information and control requirements to enable specification of detailed requirements for alarms, displays, data processing, and controls for human task accomplishment.</p>	

5. Task Analysis

NUREG 0711 Revision 2 Review Criteria	Compliance Road Map		
	Current Documentation	Planned Documentation	Gap
<p>5.4 Review Criteria (4) The task analysis should address issues such as:</p> <ul style="list-style-type: none"> • the number of crew members • crew member skills • allocation of monitoring and control tasks to the <p>(a) formation of a meaningful job and (b) management of crew member's physical and cognitive workload.</p>	<p>Section 18.4.1, last paragraph of the Design Control Document for the US-APWR (DCD) specifies that the task analysis addresses these criteria.</p> <p>Section 5.4.2 paragraph 2 of the US-APWR, Topical Report HSI System Description And HFE Process (MUAP-07007-P (R3)) specifies that the task analysis addresses these criteria.</p> <p>MUAP-09019-P (R0), Part 2, Section 3.4 specifies the TA methodology including consideration of number of crew members, allocation of monitoring and control tasks, and physical and cognitive workload.</p> <p>MUAP-09019-P (R0), Part 2, Section 3.7 present a results table (Table 3.2) that includes the factors specified in criteria 5.4 (4).</p>		

5. Task Analysis

NUREG 0711 Revision 2 Review Criteria	Compliance Road Map		
	Current Documentation	Planned Documentation	Gap
<p>5.4 Review Criteria (5) The task analysis results should be used to define a minimum inventory of alarms, displays, and controls necessary to perform crew tasks based on both task and instrumentation and control requirements.</p>	<p>Section 18.4.2, paragraph 4 of the Design Control Document for the US-APWR (DCD) specifies that the task analysis will be detailed enough to identify detailed requirements for alarms, displays, data processing and controls.</p> <p>Section 5.4.2 paragraph 2 and Section 5.4.2 last paragraph of the US-APWR, Topical Report HSI System Description And HFE Process (MUAP-07007-P (R3)) specifies that the task analysis will be iterative and detailed enough to identify detailed requirements for alarms, displays, data processing and controls.</p> <p>MUAP-09019-P (R0), Part 2, Section 3.7 present a results table (Table 3.2) that includes the factors specified in criteria 5.4 (5).</p>	<p>The Phase 2b Task Analysis implementation procedure will specify the more detailed task analysis process that will be used in Phase 2B so as to provide the needed detail to identify a minimum inventory of alarms, displays, and controls necessary to perform crew tasks based on both task and instrumentation and control requirements.</p>	

5. Task Analysis

NUREG 0711 Revision 2 Review Criteria	Compliance Road Map		
	Current Documentation	Planned Documentation	Gap
<p>5.4 Review Criteria (6) The task analysis results should provide input to the design of HSIs, procedures, and personnel training programs</p>	<p>A commitment use task analysis as input to design of HSIs, procedures and personnel training programs is provided in Section 2.9.1.2.3 of the Design Control Document for the US-APWR - Tier 1 (DCD – Tier 1 MUAP-DC020).</p> <p>Section 18.4.3 of the Design Control Document for the US-APWR (DCD) specifies that the task analysis will provide input to design of HSIs, procedures, and personnel training programs.</p> <p>Section 5.4.1, Section 5.4.2, last paragraph, and Figure 5.4-1 of the US-APWR, Topical Report HSI System Description and HFE Process (MUAP-07007-P (R3)) specifies the HFE activities that the task analysis will provide inputs to.</p>		

5. Task Analysis

NUREG 0711 Revision 2 Review Criteria	Compliance Road Map		
	Current Documentation	Planned Documentation	Gap
<p>5.4 Review Criteria</p> <p>(7) The following considerations should be addressed for plant modifications that are likely to affect HAs previously identified as risk-important, cause existing HAs to become risk-important, or create new actions that are risk-important.</p> <ul style="list-style-type: none"> The tasks analyses should be revised and updated to reflect requirements of the modification; the scope should include tasks involving the modification and its interactions with the rest of the plant, including those resulting from functions addressed in the analyses of functional requirements and function allocation. For maintenance, tests, inspections, and surveillances, attention should be given to risk-important actions that are new or supported by new technologies (e.g., new capabilities for on-line maintenance). 	N/A	If upgrades to existing plant HSIs are planned based upon this Design Certification, a discussion as to how MHI plans to address task analysis will be provided.	

5. Task Analysis

NUREG 0711 Revision 2 Review Criteria	Compliance Road Map		
	Current Documentation	Planned Documentation	Gap
<p>(Continued)</p> <ul style="list-style-type: none"> The task analysis should identify the design characteristics of the existing HSIs that support the performance of experienced personnel (e.g., support high levels of performance during demanding situations). They may include the spatial arrangement of control- and display-devices and the ability to adjust controls and displays to deal with special tasks. These design characteristics should be considered in developing new design requirements. That is, the new design should have features performing similar functions, or should eliminate the need for them by performing these functions differently. In addition, the task analysis should identify and examine adjustments made to the HSIs by users, such as notes and external memory-aids, which suggest that the users' needs may not be fully met by its current design. All task demands should be adequately addressed by the new design requirements. Design features identified during OERs should be considered in these analyses. 	(Continued)	(Continued)	

6. Staffing and Qualifications

US-APWR HFE Program NUREG-0711 Compliance Roadmap MUAP-09024 (R0)

NUREG 0711 Revision 2 Review Criteria	Compliance Road Map		
	Current Document	Planned Documentation	GAP
<p>6.3 Applicant Submittals As per Section 1.2.1, item (3) Applicant Submittals, the applicant should provide for staff review an implementation plan for staffing and qualifications analysis. Upon completion of the applicant's efforts, a results summary report should be submitted so that the staff can review the applicant's evaluation of the requirements for the number and qualifications of personnel using the criteria provided in Section 6.4 below.</p>	MUAP-07007-P (R3) Figure 4.0-2 Submittal and Audit Plan for the US-APWR Design Certification and 7.0 Future Licensing Submittals shows a overview for the document submittals		
<p>6.4 Review Criteria (1) Staffing and qualifications should address applicable guidance in NUREG-0800 Section 13.1 and 10 CFR 50.54.</p>	DCD Ch.18 Section 18.5.2 Methodology refers 10 CFR 50.54 and NUREG-0800, Subsections 13.1 as necessary to ensure that personnel staffing in number and qualifications		
<p>6.4 Review Criteria (2) The staffing analysis should determine the number and background of personnel for the full range of plant conditions and tasks including operational tasks (normal, abnormal, and emergency), plant maintenance, and plant surveillance and testing. The scope of personnel that should be considered is identified in the HFE Program Management element (see Section 2.4.1, Criterion 5).</p>	<p>DCD Ch.18 Section 18.5.2 Methodology specifies the staffing analysis.</p> <p>MUAP-07007-P (R3) Section 4.1 Design Basis identifies plant conditions.</p>	<p>The US-APWR Staffing and Qualification Analysis report will be included in the Phase 2b V&V report as described in the MUAP-09019 (R0) Part1 section 8.2.2.5.</p> <p>It is verified during Tier 1 ITAAC phase as Tale 2.9-1 item 6.</p>	

6. Staffing and Qualifications

NUREG 0711 Revision 2 Review Criteria	Compliance Road Map		
	Current Document	Planned Documentation	GAP
<p>6.4 Review Criteria (3) The staffing analysis should be iterative; that is, initial staffing goals should be reviewed and modified as the analyses associated with other elements are completed.</p>	<p>DCD Ch.18 Section 18.1.1.1 Assumption and Constraints Identification</p> <p>MUAP-07007-P (R3) Section 4.1 Design Basis indicates Main Control Room Staff is a key feature of the HFE design.</p> <p>MUAP-07007-P (R3) Section 5.1.1.2 Assumptions and Constraints describes that the HFE program should meet the requirements of utility operators.</p> <p>MUAP-09019-P (R0) Part 1 5.6 SA describes staffing/qualification analysis.</p>	<p>The US-APWR Staffing and Qualification Analysis report will be included in the Phase 2b V&V report as described in the MUAP-09019 (R0) Part1 section 8.2.2.5.</p> <p>It is verified during Tier 1 ITAAC phase as Tale 2.9-1 item 6.</p>	

6. Staffing and Qualifications

NUREG 0711 Revision 2 Review Criteria	Compliance Road Map		
	Current Document	Planned Documentation	GAP
<p>6.4 Review Criteria</p> <p>(4) The basis for staffing and qualifications should be modified to address these issues:</p> <ul style="list-style-type: none"> • Operating Experience Review <ul style="list-style-type: none"> - operational problems and strengths that resulted from staffing levels in predecessor systems - initial staffing goals and their bases including staffing levels of predecessor systems and a description of significant similarities and differences between predecessor and current systems - staffing considerations described in NRC Information Notice 95-48, "Results of Shift Staffing Study" - staffing considerations described in NRC Information Notice 97-78, "Crediting of Operator Actions in Place of Automatic Actions and Modifications of Operator Actions, Including Response Times" • Functional Requirements Analysis and Function Allocation <ul style="list-style-type: none"> - mismatches between functions allocated to personnel and their qualifications - changes the roles of personnel due to plant system and HFE modifications 	<p>DCD Ch.18 Section 18.5.2 Methodology describes that the staffing analysis is to be addressed OER, FRA/FA, Task Analysis, HRA,.</p> <p>DCD Ch.18 Section 18.2.2.6 Issues Identified by Plant Personnel describes operating experience related to predecessor plants or systems for plant operation.</p> <p>DCD Ch.18 Section 18.3.2.2 Methodology for Function Allocation Analysis describes allocation analysis to plant personnel.</p> <p>Table 1 the Technical Report MUAP-08014-P (R0) Part 3 identifies that the staffing is considered as HED design topics for the OER.</p> <p>Section 5.3 of the Topical Report MUAP-07007-P (R3) describes that the FA of the US-APWR is based on reduced operator staffing.</p>	<p>The US-APWR Staffing and Qualification Analysis report will be included in the Phase 2b V&V report as described in the MUAP-09019 (R0) Part1 section 8.2.2.5. It is verified during Tier 1 ITAAC phase as Tale 2.9-1 item 6.</p> <p>In addition, IN 95-48 and IN 97-78 will be added to MUAP-07007 and MUAP-08014 as references.</p>	

6. Staffing and Qualifications

NUREG 0711 Revision 2 Review Criteria	Compliance Road Map		
	Current Document	Planned Documentation	GAP
<p>6.4 Review Criteria (4) continued</p> <ul style="list-style-type: none"> • Task Analysis <ul style="list-style-type: none"> - the knowledge, skills, and abilities needed for personnel tasks addressed by the task analysis - personnel response time and workload - personnel communication and coordination, including interactions between them for diagnosis, planning, and control activities, and interactions between personnel for administrative, communications, and reporting activities - the job requirements that result from the sum of all tasks allocated to each individual both inside and outside the control room - decreases in the ability of personnel to coordinate their work due to plant and HFE modifications - availability of personnel considering other activities that may be ongoing and for which operators may take on responsibilities outside the control room (e.g., fire brigade) - actions identified in 10 CFR 50.47, NUREG-0654, and procedures to meet an initial accident response in key functional areas as identified in the emergency plan - staffing considerations described by the application of ANSI/ANS 58.8-1994, "Time Response Design Criteria for Safety-Related Operator Actions" • Human Reliability Analysis <ul style="list-style-type: none"> - the effect of overall staffing levels on plant safety and reliability - the effect of overall staffing levels and crew coordination for risk-important HAs - the effect of overall staffing levels and the coordination of personnel on human errors associated with the use of advanced technology 	<p>DCD Ch.18 Section 18.4.1 Objectives and Scope identifies that the TASK Analysis includes Operating personnel skill requirements.</p> <p>Section 5.4.1 Objective of Task Analysis of the Topical Report MUAP-07007-P (R3) identifies staffing, qualifications, job design, and training as a basis.</p> <p>Section 5.5.1 Operator Staffing Level of the Topical Report MUAP-07007-P (R3) identifies Task Analysis and Human Reliability are basis for staff's qualification.</p>	<p>The US-APWR Staffing and Qualification Analysis report will be included in the Phase 2b V&V report as described in the MUAP-09019 (R0) Part1 section 8.2.2.5. It is verified during Tier 1 ITAAC phase as Tale 2.9-1 item 6.</p> <p>In addition, ANSI/ANS 58.8 will be added to the Topical Report MUAP-07007 as references.</p>	

6. Staffing and Qualifications

US-APWR HFE Program NUREG-0711 Compliance Roadmap MUAP-09024 (R0)

NUREG 0711 Revision 2 Review Criteria	Compliance Road Map		
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<p>6.4 Review Criteria (4) continued</p> <ul style="list-style-type: none"> • HSI Design - staffing demands resulting from the locations and use (especially concurrent use) of controls and displays - coordinated actions between individuals - decreases the availability or accessibility of information needed by personnel due to plant system and HFE modifications - the physical configuration of the control room and control consoles - the availability of plant information from individual workstations and group-view interfaces • Procedure Development - staffing demands resulting from requirements for concurrent use of multiple procedures - personnel skills, knowledge, abilities, and authority identified in procedures • Training Program Development - crew coordination concerns that are identified during the development of training 	<p>DCD Ch.18 Section 18.7.2.1 HSI Design Inputs. DCD Ch.18 Section 18.7.2.5 HSI Detailed Design and Integration, 18.8 Procedure Development and Section 18.9 Training Program Development describes that the staffing analysis is to be HSI Design Procedure Development and Training Program Development.</p> <p>Section 5.7.1 Scope of HSI Design, 5.7.3.1 Input Information to HSI Design Process, and 5.7.3.2 HSI Detailed Design and Integration of the Topical Report MUAP-07007-P (R3) describes that the HSI Design id based on the staffing/qualifications and job analyses.</p> <p>Section 5.8.2 Procedures Development Process of the Topical Report MUAP-07007-P (R3) describes that Plant operators is to be included in the procedures development team to reflect provide knowledge of operational tasks, and the Task Analysis, which is based on the staffing/qualification analysis, is used to develop procedures.</p> <p>Section 5.9.1 Training Program of the Topical Report MUAP-07007-P (R3) describes that the Task Analysis, which is based on the staffing/qualification analysis, is used to develop training program.</p>	<p>The US-APWR Staffing and Qualification Analysis report will be included in the Phase 2b V&V report as described in the MUAP-09019 (R0) Part1 section 8.2.2.5.</p> <p>It is verified during Tier 1 ITAAC phase as Tale 2.9-1 item 6.</p> <p>In addition, the Section 5.9.1 Topical Report MUAP-07007 will be revised will be revised to include the SA as explicitly.</p>	

7. Human Reliability Analysis

NUREG 0711 Revision 2 Review Criteria	Compliance Road Map		
	Current Documentation	Planned Documentation	Gap
<p>7.3 Applicant Submittals As per Section 1.2.1, item (3) Applicant Submittals, the applicant should provide for staff review an implementation plan for human reliability analysis. Upon completion of the applicant's efforts, a results summary report should be submitted so that the staff can review the applicant's evaluation of human-error mechanisms in the design of the HFE aspects of the plant and their integration of the HFE program and PRA and risk analysis using the criteria provided in Section 7.4 below.</p>	<p>DCD Ch.19 discusses the PRA/HRA and its uses in the design of the US-APWR. Parts 19.1.1.1, 19.1.1.2, 19.1.2.1 and 19.1.3.4 describe respectively the uses of the PRA and in turn the HRA in the design process and in the HFE of the US-APWR. Table 19.1-1 shows the use of the PRA results in the design process. Section 19.1.7 introduces the integration of the PRA and the HRA into other elements of the HFE program. Section 19.1.3.4 introduces the use of PRA / HRA in the design process. Section 19.1.2.3 discusses the quality level of the PRA and HRA.</p> <p>DCD Ch.18, section 18.6 discusses the US-APWR HRA Completeness and use throughout the design process.</p> <p>DCD Tier1 section 2.9.1.2.5 discusses the integration of the HRA into the design process applying an iterative process.</p> <p>MUAP-07007 R3, section 5.1.1.1 continues the discussion of the application of the HRA in the design process. MHI commits, in section 5.6.1 and 5.6.2, to apply a fully integrated process that integrates the results of the HRA with other elements of the HFE program.</p> <p>MUAP 09019 R0 Part 1, sections 5.5.1, 5.5.2 describes the integrating roll of PRA and HRA. Section 8.2.1.1 commits MHI to preparing an implementation procedure for HRA. Figure 4 displays the HFE work flow process and the integration of the HRA and figure shows the design process. Figure 5 shows how HRA is an input to the HSI design process. Part 2, page 91 begins the specific discussion of the HRA process, its use in design and results from the analysis.</p> <p>MUAP-09019 R0 part 1 section 8.2.2.3 describes the phase</p>	<p>MHI has committed to prepare an implementation procedure for the HRA process that meets NUREG 0711 R2.</p> <p>DCD Tier1 table 2.9-1 displays the HFE ITAACs</p>	

7. Human Reliability Analysis

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	<p>2 V&V testing. Part 3, section 2.4 page 217 describes the use and future planned application of the Risk Significant Human Errors results contained in the above MHI internal report in the V&V program. Appendix 2.9.1 of Part 2 describes the method used to determine Risk Important Human Actions and Appendix 2.9.1 shows the use of an integration table.</p> <p>6*DS-1E-UAP-080002, an internal MHI report, presents the Risk Significant Human Actions for the US-APWR resulting from the PRA/HRA analysis, the Importance analysis and the sensitivity study.</p>		
<p>7.4 Review Criteria</p> <p>(1) Risk-important human actions should be identified from the PRA/HRA and used as input to the HFE design effort.</p> <ul style="list-style-type: none"> • These actions should be developed from the Level 1 (core damage) PRA and Level 2 (release from containment) PRA including both internal and external events. They should be developed using selected (more than one) importance measures and HRA sensitivity analyses to provide reasonable assurance that an important action is not overlooked because of the selection of the measure or the use of a particular assumption in the analysis. • When upgrading plant systems, HSIs, procedures, and training the scope of the analysis should address personnel actions resulting from the modification and its 	<p>Risk Important Human Actions, including Level 1 and Level 2 internal and external events are discussed in detail in DCD Ch.19 . The actual list of Risk Important Human Actions is presented in 6*DS-1E-UAP-080002. The application of the RAW and FV importance measures are displayed, for example, in Tables 19.1-31 and 19.1-32 for Level 1 at power events and tables 19.1-45 and 19.1-46 for level 2 at power. Additionally DCD Ch.19 contains an example of the use of sensitivity studies on page 19.1-124. Page 19.1-36 in general and for the HRA page 19.1-38 discusses, as an example, the use of the Fussell Vesely and the risk achievement worth importance measures.</p> <p>DCD Ch.18 section 18.6 continues the discussion of the PRA inclusion of Level 1 and 2 at power internal and external events as well as low power and shutdown events. Page 18.6-1 discusses risk important HAs.</p> <p>DCD Tier1 section 2.9.1.2.5 discusses the iterative nature of the use of risk important HAs in the design process.</p>	<p>If upgrades to existing plant HSIs are planned based upon this Design Certification, a discussion as to how MHI plans to address HRA and Risk Significant Human Errors will be provided.</p>	

7. Human Reliability Analysis

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<p>interactions with the rest of the plant. Consideration should be given to the following effects of these modifications on the existing HRA:</p> <ul style="list-style-type: none"> - whether the original HRA assumptions are valid for the modified design - whether the human errors analyzed in the existing HRA are still relevant - whether the probability of errors by operators and maintenance personnel may change - whether errors may be introduced that are not modeled by the existing HRA and PRA - whether the consequences of errors, established in the existing HRA, may change 	<p>Section 5.6.3 of MUAP-07007 R3 describes the industry accepted methodology used for the HRA. Section 5.8 describes the development process for procedures including the integration of HRA staff and HRA results.</p> <p>MUAP-09019 R0 Part 2 discusses the development and use of Risk Important Human Actions in sections: 2.3, 2.4, 2.7.1, 3.7 and appendix 2.9.1 and 2.9-2</p> <p>Part 3 sections 1 and 2.4 describe the use of Risk Important Human Actions in the Phase 1b V&V testing. Appendix 8.1 presents the HEDs from tests 1a used to develop scenarios in 1b, including the determination of risk importance.</p>		
<p>7.4 Review Criteria</p> <p>(2) Risk-important HAs and their associated tasks and scenarios should be specifically addressed during function allocation analyses, task analyses, HSI design, procedure development, and training. This will help verify that these tasks are well supported by the design and within acceptable human performance capabilities (e.g. within time and workload requirements).</p>	<p>Descriptions of the integration between the Risk Important Human Actions and the function allocation analysis the task analysis and the work load requirements is described in: DCD Ch.18; Fig 18.1-4, section 18.4.1 and 18.6.2. Figure 18.1-4 shows the integration with the function allocation and task analysis. Pages 18.2-3, 18.4-1, and 18.5-3 discuss the HRA s relation to the OER, TA and staffing analysis respectively.</p> <p>MUAP-07007 R3; section 5.4.2 and figure 5.4-1. Section 5.4.2 page 112 discusses the relationship of the risk important HAs to the task analysis and the roll of system automation. Section 5.6.5 page 130 further address integration.</p> <p>MUAP-09019 R0; Part 1 section 5.5 and 8.2.1, Part 2 section 2.2, 3.1 and 3.6.1. Part 2 section 2.2 discusses the iterative nature of the scope, and 2.4 states that the methodology embodies each organizations review of the results of the HRA for impact on their responsible HFE</p>		

7. Human Reliability Analysis

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	element.		
<p>7.4 Review Criteria (3) The use of PRA/HRA results by the HFE design team should be specifically addressed; that is, how are risk-important HAs addressed (through HSI design, procedural development, and training) under the HFE program to minimize the likelihood of operator error and provide for error detection and recovery capability.</p>	<p>Application of PRA/ HRA results and Risk Important Human Actions by the HFE team in the US-APWR HSI design, procedure development and training program development is discussed in: DCD Ch.19: page 19.0-1, sections 19.1.3.4 and 19.1.7. DCD Ch.18: sections 18.2.2.3 ,18.8.2.1, 18.9. Section 18.7 page 18.7-2 and 7-6 discuss the design process's considerations to minimize risk important HAs. MUAP-07007 R3: Sections 5.8.2, 5.9.5 MUAP-09019 R0: Part 1 fig 4 and 5, sections 8.2.1.1, 8.2.1.2, Part 2 section 2.4.2 states that all organizations with responsibilities for HFE elements will review the HRA results for impact.</p>		
<p>7.4 Review Criteria (4) HRA assumptions such as decision-making and diagnosis strategies for dominant sequences should be validated by walkthrough analyses with personnel with operational experience using a plant-specific control room mockup or simulator. Reviews should be conducted before the final quantification stage of the PRA.</p>	<p>DCD Ch.18 section 18.4.1 describes the original bases for the HSI. Page 18.1-8 introduces the V&V activity in the design and page 18.1_10 discusses the use of the HFE tracking system. MUAP-09019 discusses the retention of HFE data for application in the design process. Limited assessment of HRA assumptions was conducted during the phase 1b V&V testing program scenarios, MUAP-09019 R0, part 3 page 217, 218 and 219, and appendix 8.1</p>	<p>The V&V procedure will clearly describe the use of the US-APWR simulator to validate the HRA assumptions through US operator reviews and walkthroughs. Results of this assessment will be published in the Phase 2b test report.</p>	

8. Human-System Interface Design

US-APWR HFE Program NUREG-0711 Compliance Roadmap MUAP-09024 (R0)

NUREG 0711 Revision 2 Review Criteria	Compliance Road Map		
	Current Documentation	Planned Documentation	Gap
<p>8.3 Applicant Submittals As per Section 1.2.1, item (3) Applicant Submittals, the applicant should provide for staff review an implementation plan for human-system interface design process. Upon completion of the applicant's efforts, a results summary report should be submitted so that the staff can review the applicant's development of design requirements and the HSI design using the criteria provided in Section 8.4 below.</p>	<p>Section 18.7 of the DCD Ch.18 addresses the HSI design process. Section 5.0 of the topical report MUAP-07007-P (R3) contains the HSI design process. The basic HSI design is provided in section 4.0 of the topical report.</p>		

8. Human-System Interface Design

NUREG 0711 Revision 2 Review Criteria	Compliance Road Map		
	Current Documentation	Planned Documentation	Gap
<p>8.4 Review Criteria 8.4.1 HSI Design Inputs The following sources of information should provide input to the HSI design process: (1) Analysis of Personnel Task Requirements - The analyses performed in earlier stages of the design process should be used to identify requirements for the HSIs. These analyses include: • Operational experience review - Lessons learned from other complex human-machine systems, especially predecessor designs and designs involving similar HSI technology should be used as an input to HSI design. • Functional requirement analysis and function allocation - The HSIs should support the operator's role in the plant, e.g., appropriate levels of automation and manual control.</p>	<p>Section 18.7.2.1 of the DCD Ch.18 addresses the HSI design inputs. Section 18.7 of the DCD refers the topical report MUAP-07007-P (R3) which contains the process of OER, FA/FRA, TA, and Stuffing. (The process of the OER is discussed in section 3 of the NUREG compliance roadmap.)</p> <p>The result summary report for OER, FA/FRA and TA is provided in technical report MUAP-09014-P Part 2 and (R0) MUAP-09019-P (R0) Part 2.</p>	<p>The US-APWR Staffing and Qualification Analysis report will be included in the Phase 2b V&V report as described in the MUAP-09019 (R0) Part1 section 8.2.2.5.</p>	

8. Human-System Interface Design

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<p>(Continued)</p> <ul style="list-style-type: none"> • Task analysis - The set of requirements to support the role of personnel is provided by task analysis. The task analysis should identify: <ul style="list-style-type: none"> - tasks that are necessary to control the plant in a range of operating conditions for normal through accident conditions; - detailed information and control requirements (e.g., requirements for display range, precision, accuracy, and units of measurement); - task support requirements (e.g., special lighting and ventilation requirements); and - risk-important HAs and their associated performance shaping factors, as identified through HRA should be given special attention in the HSI design process. • Staffing/qualifications and job analyses - The results of staffing/qualifications analyses should provide input for the layout of the overall control room and the allocation of controls and displays to individual consoles, panels, and workstations. They establish the basis for the minimum and maximum number of personnel to be accommodated and requirements for coordinating activities between personnel. 	(Continued)	(Continued)	

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8.4.1 HSI Design Inputs (2) System Requirements - Constraints imposed by the overall instrumentation and control (I&C) system should be considered throughout the HSI design process.	The system requirement regarding overall I&C system is provided in Section 18.7.2.1 The design of the overall I&C system is provided in DCD chapter 7.		
8.4.1 HSI Design Inputs (3) Regulatory Requirements - Applicable regulatory requirements should be identified as inputs to the HSI design process.	The regulatory requirements are provided in section 1.9 of the DCD Ch.1 and section 3.0 of the HFE topical report MUAP-07007-P (R3).		
8.4.1 HSI Design Inputs (4) Other Requirements - The applicant should identify other requirements that are inputs to the HSI design.	Other requirements are provided in section 18.7.2.2 and section 3.0 of the HFE topical report MUAP-07007-P (R3).		

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<p>8.4.2 Concept of Operations (1) A concept of operations should be developed indicating crew composition and the roles and responsibilities of individual crew members based on anticipated staffing levels. The concept of operations should:</p> <ul style="list-style-type: none"> • Identify the relationship between personnel and plant automation by specifying the responsibilities of the crew for monitoring, interacting, and overriding automatic systems and for interacting with computerized procedures systems and other computerized operator support systems. • Provide a high-level description of how personnel will work with HSI resources. Examples of the types of information that should be identified is the allocation of task to the main control room or local control stations, whether personnel will work at a single large workstation or individual workstations, what types of information each crew member will have access to, and what types of information should be displayed to the entire crew. • Address the coordination of crew member activities, such as the interaction with auxiliary operators and coordination of maintenance and operations should be addressed. 	<p>The concept of operation is provided in section 18.7.2.2 of the DCD Ch.18 and that refers section 4.1 of the topical report MUAP-07007-P (R3). The section 4.1 includes;</p> <ul style="list-style-type: none"> -Crew composition -Roles and responsibilities of individual crewmembers. -Personnel interaction with plant automation. -Use of control room recourses by crewmembers. -Method used to ensure good coordination of crewmember activities. 	<p>The US-APWR Staffing and Qualification Analysis report will be included in the Phase 2b V&V report as described in the MUAP-09019 (R0) Part1 section 8.2.2.5.</p>	

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8.4.3 Functional Requirement Specification (1) Functional requirements for the HSIs should be developed to address: <ul style="list-style-type: none"> • the concept of operations • personnel functions and tasks that support their role in the plant as derived from function, task, and staffing/qualifications analyses • personnel requirements for a safe, comfortable working environment 	The functional requirement specification is provided in section 18.7.2.3 of DCD Ch.18. The functional requirements are included in section 5.7.2 and 5.7.3 of the topical report MUAP-07007-P (R3) and the results of the Functional Requirement Analysis are provided in the technical report MUAP-09019-P (R0).		
8.4.3 Functional Requirement Specification (2) Requirements should be established for various types of HSIs, e.g., alarms, displays, and controls.	See 8.4.3 (1)		
8.4.4 HSI Concept Design (1) The functional requirement specification should serve as the initial source of input to the HSI design effort. If the design is a direct evolution from a predecessor, rather than a new design concept, the criteria in this section should be considered relative to operating experience of the predecessor and the design features (e.g., aspects of the process, equipment, or operations) of the new design that may be different from the predecessor. Human performance issues identified from operating experience with the predecessor design should be resolved.	The functional requirement specification of Japanese APWR HSI is served as the initial source of input as described in the section 18.7.2.4.		

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<p>8.4.4 HSI Concept Design (2) Alternative approaches for addressing HSI functional requirements should be considered. A survey of the state-of-the-art in HSI technologies should be conducted to:</p> <ul style="list-style-type: none"> • support the development of concept designs that incorporate advanced HSI technologies • provide assurance that proposed designs are technically feasible • support the identification of human performance concerns and tradeoffs associated with various HSI technologies 	<p>Section 5.1 of the topical report MUAP-07007-P (R3) and section 18.7.2.4 of the DCD Ch.18 addresses the alternative approach for state-of-the-art HSI technologies.</p> <p>A survey of the state-of-art in HSI technologies are provided in part1 section 6 and part 3 section 2 of the technical report MUAP-09019-P (R0).</p>		
<p>8.4.4 HSI Concept Design (3) Alternative approaches for addressing HSI functional requirements should be considered. Evaluation methods can include operating experience and literature analyses, tradeoff studies, engineering evaluations and experiments.</p>	<p>The overall process of the HSI design and HED includes the operating experience and literature analyses, tradeoff studies, engineering evaluations and experiments as shown in section 5.7.3.3 of the topical report MUAP-07007-P (R3) and section 18.7.2.4 of the DCD Ch.18.</p> <p>These considerations are included in part1 section 6 and part 3 section 2 of the technical report MUAP-09019-P (R0).</p>		
<p>8.4.4 HSI Concept Design (4) Alternative concept designs should be evaluated so that one can be selected for further development. The evaluation should provide reasonable assurance that the selection process is based on a thorough review of design characteristics and a systematic application of selection criteria. Tradeoff analyses, based on the selection criteria, should provide a rational basis for the selection of concept designs.</p>	<p>The alternative concept design is addressed in section 18.7.2.4 of the DCD Ch.18.</p> <p>These considerations are included in part1 section 6 and part 3 section 2 of the technical report MUAP-09019-P (R0).</p>		

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<p>8.4.4 HSI Concept Design (5) HSI design performance requirements should be identified for components of the selected HSI concept design. These requirements should be based on the functional requirement specifications but should be refined to reflect HSI technology considerations identified in the survey of the state of the art in HSI technologies and human performance considerations identified in the human performance research.</p>	<p>The HSI design performance requirements are addressed in section 18.7.2.4 of the DCD Ch.18. These considerations are included in part1 section 6 and part 3 section 2 of the technical report MUAP-09019-P (R0).</p>		

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<p>8.4.5 HSI Detailed Design and Integration</p> <p>(1) Design-specific HFE design guidance (style guide) should be developed. HFE Guidelines should be utilized in the design of the HSI features, layout, and environment.</p> <ul style="list-style-type: none"> The content of the Style Guide should be derived from (1) the application of generic HFE guidance to the specific application, and (2) the development of the applicant's own guidelines based upon design-related analyses and experience. Guidelines that are not derived from generic HFE guidelines may be justified by the applicant based on an analysis of recent literature, analysis of current industry practices and operational experience, tradeoff studies and analyses, and the results of design engineering experiments and evaluations. The guidance should be tailored to reflect design decisions by the applicant to address specific goals and needs of the HSI design. The topics in the Style Guide should address the scope of HSIs included in the design and address the form, function, and operation of the HSIs as well as environmental characteristics relevant to human performance. 	<p>Section 18.7.2.5 of the DCD addresses the style guide.</p> <p>The basic design of the display and the style guide is provided in Section 5.7.3.2 of the topical report MUAP-07007-P.</p> <p>Section 4.4 through 4.9 of the topical report MUAP-07007-P contain the basic display design.</p>		

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<p>(Continued)</p> <ul style="list-style-type: none"> The individual guidelines should be expressed in concrete, easily observable terms. In general, generic HFE guidelines should not be used in their abstract form. Such generic guidance should be translated into more specific design guidelines that can, as much as possible, provide unambiguous guidance to designers and evaluators. They should be detailed enough to permit their use by design personnel to achieve a consistent and verifiable design that meets the applicant's guideline. The Style Guide should provide procedures for determining where and how HFE guidance is to be used in the overall design process. The Style Guide should be written so it can be readily understood by designers. The Style Guide should support the interpretation and comprehension of design guidance by supplementing text with graphical examples, figures, and tables. 	(Continued)		

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8.4.5 HSI Detailed Design and Integration (1) continued • The guidance should be maintained in a form that is readily accessible and usable by designers and that facilitates modification when the contents require updating as the design matures. Each guideline included in the guidance documentation should include a reference to the source upon which it is based. • The Style Guide should address HSI modifications. This guidance should specifically address consistency in design across the HSIs.	(Continued)	If upgrades to existing plant HSIs are planned based upon this Design Certification, a discussion as to how MHI plans to address detailed design and integration will be provided.	
8.4.5 HSI Detailed Design and Integration (2) The HSI detailed design should support personnel in their primary role of monitoring and controlling the plant while minimizing personnel demands associated with use of the HSIs (e.g., window manipulation, display selection, display system navigation). NUREG-0700 describes high-level HSI design review principles that the detailed design should reflect.	See 8.4.5 (1)		
8.4.5 HSI Detailed Design and Integration (3) For risk-important HAs, the design should seek to minimize the probability that errors will occur and maximize the probability that an error will be detected if one should be made.	Section 18.7.2.5 of the DCD Ch.18 addresses risk-important HAs. The design process is provided in section 5.7.3.2 of the topical report MUAP-07007-P (R3).		

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8.4.5 HSI Detailed Design and Integration (4) When developing functional requirements for monitoring and control capabilities that may be provided either in the control room or locally in the plant, the following factors should be considered: <ul style="list-style-type: none"> • communication, coordination, and workload • feedback • local environment • inspection, test, and maintenance • importance to safety 	The functional requirement for monitoring and control is addressed in section 18.7.2.5 of the DCD Ch.18. The design process is provided in section 5.7.3.2 of the topical report MUAP-07007-P (R3).		
8.4.5 HSI Detailed Design and Integration (5) The layout of HSIs within consoles, panels, and workstations should be based upon (1) analyses of operator roles (job analysis) and (2) systematic strategies for organization such as arrangement by importance, frequency of use, and sequence of use.	The layout of the HSIs is addressed in section 18.7.2.5 of the DCD Ch.18. The design process is provided in section 5.7.3.2 of the topical report MUAP-07007-P (R3).		
8.4.5 HSI Detailed Design and Integration (6) Personnel and task performance should be supported during minimal, nominal, and high-level staffing.	The personnel and task performance are addressed in section 18.7.2.5 of the DCD Ch.18. The design process is provided in section 5.7.3.2 of the topical report MUAP-07007-P (R3).		
8.4.5 HSI Detailed Design and Integration (7) The design process should take into account the use of the HSIs over the duration of a shift where decrements in performance due to fatigue may be a concern.	The use of the HSIs over the duration of a shift where decrements in performance are addressed in section 18.7.2.5 of the DCD Ch.18. The design process is provided in section 5.7.3.2 of the topical report MUAP-07007-P (R3).		

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<p>8.4.5 HSI Detailed Design and Integration (8) HSI characteristics should support human performance under the full range of environmental conditions, e.g., normal as well as credible extreme conditions. For the main control room requirements should address conditions such as loss of lighting, loss of ventilation, and main control room evacuation. For the remote shutdown facility and local control stations, requirements should address constraints imposed by the ambient environment (e.g., noise, temperature, contamination) and by protective clothing (if necessary).</p>	<p>The human performance under the full range of environmental conditions is addressed in section 18.7.2.5 of the DCD Ch.18. The environmental conditions are discussed in Section 6.4, 9.4 and 9.5 of the DCD. Section 4.11 of the topical report "HSI system description and HFE process" MUAP-07007-P" addresses the loss of Main Control Room.</p>		
<p>8.4.5 HSI Detailed Design and Integration (9) The HSIs should be designed to support inspection, maintenance, test, and repair of (1) plant equipment and (2) the HSIs. The HSIs should be designed so that inspection, maintenance, test, and repair of the HSIs do not interfere with other plant control activities (e.g., maintenance tags should not block the operators' views of plant indications).</p>	<p>The inspection, maintenance, test, and repair of plant equipment and the HSIs are addressed in section 18.7.2.5 of the DCD Ch.18. Section 4.11 of the topical report MUAP-07007-P discusses the response to HSI equipment failures.</p>		

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<p>8.4.5 HSI Detailed Design and Integration (10) The following considerations should be addressed in the review of design modifications:</p> <ul style="list-style-type: none"> • HSI modifications should be designed, to the extent possible, to be consistent with users' existing strategies for gathering and processing information and executing actions, identified in the task analysis. Consistency with existing strategies can reduce the learning personnel need to become proficient in using the modification. • Design requirements for computer-based HSI modifications should include requirements for crew coordination and define design characteristics for supporting it. Design characteristics that may limit crew coordination include features that limit the ability of personnel to have a shared view of plant information (e.g., decision-aids and display devices that can only be accessed by one individual), maintain an awareness of others' actions, and communicate effectively with others from anticipated work locations. • If the degree of integration between plant systems is changed, then design requirements should be developed to verify that the HSIs support personnel in controlling these systems. The design requirements of the HSIs should provide reasonable assurance that the relationships between plant systems are clearly and accurately depicted. 	N.A.	If upgrades to existing plant HSIs are planned based upon this Design Certification, a discussion as to how MHI plans to address detailed design and integration will be provided.	

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<p>8.4.6 HSI Tests and Evaluations Testing and evaluation of HSI designs should be conducted throughout the HSI development process and evaluations should be performed iteratively. The methodology used for testing should be reviewed using the appropriate criteria provided below. Note the types of tests and evaluations performed will vary depending on the specific applicant's design process.</p>	<p>Testing and evaluation of HSI designs are addressed in section 18.7.2.5 of the DCD Ch.18. These methodologies are provided in Section 18.10 of DCD Ch.18.</p>	<p>A detailed description of the design features or characteristic to be used for US-APWR V&V will be included in the Phase 2b verification and validation procedure.</p>	
<p>8.4.6.1 Trade-Off Evaluations (1) Aspects of human performance that are important to task performance should be carefully selected and defined so that the differential effects of design options on human performance can be adequately considered in the selection of design approaches. The following factors should be considered when developing selection criteria:</p> <ul style="list-style-type: none"> • personnel task requirements • human performance capabilities and limitations • HSI system performance requirements • inspection and testing requirements • maintenance requirements • use of proven technology and the operating experience of predecessor designs. 	<p>The trade-off evaluations and performance-based test are contained in the appendix A and B of the topical report MUAP-07007-P (R3). The additional tests and evaluations are contained in Section 18.10 of DCD Ch.18.</p>		
<p>8.4.6.1 Trade-Off Evaluations (2) The selection process should make explicit the relative benefits of design alternatives and the basis for their selection.</p>	<p>The trade-off evaluations and performance-based test are contained in the appendix A and B of the topical report MUAP-07007-P (R3). The additional tests and evaluations are contained in Section 18.10 of DCD Ch.18.</p>		

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8.4.6.2 Performance-Based Tests (1) Performance-based tests can have many different purposes, therefore, the hypotheses should be structured to address the specific questions being addressed.	The performance-based test is discussed in Section 11 Human Factors V&V of the NUREG 0711 compliance roadmap.		
8.4.6.2 Performance-Based Tests (2) The general approach to testing should be based on the test objective. The design of performance-based tests should be driven by the purpose of the evaluation and the maturity of the design.	The performance-based test is discussed in Section 11 Human Factors V&V of the NUREG 0711 compliance roadmap.		
8.4.6.2 Performance-Based Tests (3) The specific design features or characteristics of design features should be carefully defined. If the characteristics are to be manipulated in the test, i.e., systematically varied, the differences between test conditions should be specified in detail.	The performance-based test is discussed in Section 11 Human Factors V&V of the NUREG 0711 compliance roadmap.		
8.4.6.2 Performance-Based Tests (4) The selection of testbeds for the conduct of performance-based tests should be based upon the requirements imposed by the test hypotheses and the maturity of the design.	The performance-based test is discussed in Section 11 Human Factors V&V of the NUREG 0711 compliance roadmap.		
8.4.6.2 Performance-Based Tests (5) The selection of performance measures should be based on a consideration of: <ul style="list-style-type: none"> • measurement characteristics • identification and selection of variables to represent measures of the aspects of performance under investigation • development of performance criteria. 	The performance-based test is discussed in Section 11 Human Factors V&V of the NUREG 0711 compliance roadmap.		

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8.4.6.2 Performance-Based Tests (6) The selection of participants for HSI design tests should be based on the nature of the questions being addressed in test objectives and the level of design maturity.	The performance-based test is discussed in Section 11 Human Factors V&V of the NUREG 0711 compliance roadmap.		
8.4.6.2 Performance-Based Tests (7) The test design should permit the observation of performance in a manner that avoids or minimizes bias, confounds, and error variance (noise).	The performance-based test is discussed in Section 11 Human Factors V&V of the NUREG 0711 compliance roadmap.		
8.4.6.2 Performance-Based Tests (8) Test data should be analyzed using established analysis techniques.	The performance-based test is discussed in Section 11 Human Factors V&V of the NUREG 0711 compliance roadmap.		
8.4.6.2 Performance-Based Tests (9) Design solutions, such as modifications of the HSIs or user training requirements, should be developed to address problems that are identified during the testing and evaluation of the HSI detailed design.	The performance-based test is discussed in Section 11 Human Factors V&V of the NUREG 0711 compliance roadmap.		
8.4.7 HSI Design Documentation (1) The HSI design should be documented to include: <ul style="list-style-type: none"> • the detailed HSI description including its form, function and performance characteristics • the basis for the HSI requirements and design characteristics with respect to operating experience and literature analyses, tradeoff studies, engineering evaluations and experiments, and benchmark evaluations • records of the basis of the design changes 	The HSI design results are documented as described in section 18.7.3 of the DCD Ch.18. The HSI documentation is contained in section 5.7.3.4 of the topical report MUAP-07007-P (R3).	A detailed design for US-APWR will be included in the standard HFE design documentation.	

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8.4.7 HSI Design Documentation (2) The outcomes of tests and evaluations performed in support of HSI design should be documented.	The result summary report is provided in technical report MUAP-09014-P (R0) and MUAP-09019-P (R0). The performance-based test is discussed in Section 11 Human Factors V&V of the NUREG 0711 compliance roadmap.		

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<p>9.3 Applicant Submittals As per Section 1.2.1, item (3) Applicant Submittals, the applicant should provide for staff review an implementation plan for procedure development. Upon completion of the applicant's efforts, a results summary report should be submitted so that the staff can review the applicant's efforts to develop procedures that are technically accurate, comprehensive, explicit, easy to use, and validated using the criteria provided in Section 9.4 below. In addition, GTG and sample procedures should be available for review. The scope of the procedures covered in the element are:</p> <ul style="list-style-type: none"> • GTG for emergency operating procedures (EOPs) • plant and system operations (including startup, power, and shutdown operations) • maintenance • abnormal and emergency operations • alarm response 	<p>The Operating Procedure Development Plan is described in MUAP-07007-P (R3) Section 5.8 for plant and system operations, maintenance, alarm response, and emergency operating procedures.</p> <p>Generic Technical Guidelines are the basis for EOP development as described in DCD Section 18.8.2.1.</p> <p>HSI Design Technical Report MUAP-09019-P (R0) Part 1, Section 8.2.5 describes the Phased approach for procedure development.</p> <p>DCD Section 18.8.2.2 describes the development of a procedure writers guide used in the process for developing technical procedures that are complete, accurate, consistent, and easy to understand and follow.</p> <p>HSI Design Technical Report MUAP-09019 (R0) Part 1, Section 8.2.5, "Development of Operating Procedures" states that ERGs/EOPs are being developed in two Phases, Phase 1 and Phase 2, while System Operating, Integrated Plant Operating, Abnormal and Alarm Response Procedures are to be developed in Phase 2.</p> <p>DCD Tier 1 Section 2.9.1.3.2 discusses the verification and validation of all procedures. Table 2.9-1 Design Commitments 7 and 7m with supporting ITAAC.</p>		

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<p>9.4 Review Criteria (1) Procedures should address applicable requirements of NUREG-0800, Section 13.5.</p>	<p>The US-APWR Procedures Program addresses the applicable requirements of NUREG-0800, Section 13.5 as described in DCD Section 18.8.2.</p>		
<p>9.4 Review Criteria (2) The basis for procedure development should include:</p> <ul style="list-style-type: none"> • plant design bases • system-based technical requirements and specifications • task analyses results • risk-important human actions identified in the HRA/PRA • initiating events to be considered in the EOPs, including those events in the design bases • GTG for EOPs 	<p>The basis for procedure development is defined in DCD Section 18.8.2.1.</p> <p>MUAP-07007-P (R3), HSI System Description and HFE Process Section 5.8.2, includes a description of the basis for procedure development (page 145).</p>		
<p>9.4 Review Criteria (3) A writers guide should be developed to establish the process for developing technical procedures that are complete, accurate, consistent, and easy to understand and follow. The guide should contain objective criteria so that procedures developed in accordance with it are consistent in organization, style, and content. The guide should be used for all procedures within the scope of this element. It should provide instructions for procedure content and format including the writing of action steps and the specification of acceptable acronym lists and acceptable terms to be used.</p>	<p>DCD Section 18.8.2.2 describes the development of the US-APWR procedure writer's guide.</p> <p>MUAP-07007-P (R3) Section 5.8.2 identifies that a style guide is developed to establish the process for developing technical procedures. Section 5.8.2 also affirms that the V&V team shall ensure that features, such as consistency in format and numbering, facilitate easy access to correct procedures.</p>		

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<p>9.4 Review Criteria (4) The content of the procedures should incorporate the following elements:</p> <ul style="list-style-type: none"> • title and identifying information, such as number, revision, and date • statement of applicability and purpose • prerequisites • precautions (including warnings, cautions, and notes) • important human actions • limitations and actions • acceptance criteria • checkoff lists • reference material 	<p>DCD Section 18.8.2.3 describes that all nine elements are incorporated in the US-APWR procedure writers' guide for operating procedures.</p> <p>MUAP-07007-P (R3) Section 5.8.2 re-affirms the development of a style guide for technical procedures encompassing all nine elements.</p>		
<p>9.4 Review Criteria (5) GTGs and EOPs should be symptom-based with clearly specified entry conditions.</p>	<p>DCD Section 18.8.2.3 establishes that Generic Technical Guidelines and EOPs are symptom-based with clearly specified entry and exit conditions.</p> <p>MUAP-07007-P (R3) Section 5.8.1 acknowledges that event-base procedures are provided for transients and design-basis accidents.</p>		

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<p>9.4 Review Criteria (6) All procedures should be verified and validated, including:</p> <ul style="list-style-type: none"> • A review should be conducted to verify they are correct and can be carried out. • Their final validation should be performed in a simulation of the integrated system as part of the verification and validation activities described in the Human Factors Verification and Validation element, see Section 11. • When procedures are modified, they should be verified to verify their adequate content, format, and integration. The procedures also should be assessed through validation if a modification substantially changes personnel tasks that are significant to plant safety. The validation should verify that the procedures correctly reflect the characteristics of the modified plant and can be carried out effectively to restore the plant. 	<p>DCD Section 18.8.2.3 states that all procedures are verified and validated for all three criteria.</p> <p>HSI Design Technical Report MUAP-09019-P (R0) Part 1, Section 8.2.2.3 describes both the Phase 2b static verification analysis and dynamic validation tests for operating procedures.</p> <p>Part 1, Section 8.2.5 describes the process for Verification and Validation of procedure development.</p> <p>MUAP-07007-P (R3) Section 5.8.2 specifies that preliminary procedures are provided before the activity of HSI V&V. The procedures are verified first by analytical validation, such as task analysis and HRA. They are validated and finalized in the integrated system validation described in section 5.10.</p>		

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<p>9.4 Review Criteria (7) An analysis should be conducted to determine the impact of providing computer-based procedures (CBPs) and to specify where such an approach would improve procedure utilization and reduce operating crew errors related to procedure use. The justifiable use of CBPs over paper procedures should be documented. An analysis of alternatives in the event of loss of CBPs should be performed and documented.</p>	<p>DCD Section 18.8.2.4 identifies that for the standard Japanese APWR HSI design, which is applicable to the US-APWR, analysis was conducted to determine the impact of CBP usage, where such an approach improved procedure utilization, and the reduction procedure related operator errors. This evaluation included operator performance during degraded HSI conditions, including the loss of CBPs.</p> <p>The justifiable use of CBPs over paper procedures, and in conjunction with paper procedures, was documented. Feedback from operating crews was incorporated into the CBP and paper procedure designs. Since the US-APWR CBP design and paper procedures are based on the Japanese CBP design and paper procedures, with changes primarily for plant process systems, this evaluation is applicable to the US-APWR. "The Development and Validation of Standardized Main Control Boards for full digital PWR I & C system", Trans. At. Energy Soc. Japan, Vol.2, No.3, pp. 307 ~ 35. (2003)</p> <p>The V&V program evaluates the performance of operating crews utilizing CBPs under normal and abnormal operating conditions, and using paper procedures under degraded HSI conditions as stated in DCD Section 18.8.2.4. In addition, MUAP-07007 (R3) Section 5.10.2.1 "Operational Conditions Sampling" identifies the range of operational conditions to guide V&V activities.</p>		

9. Procedure Development

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<p>9.4 Review Criteria (8) A plan for procedure maintenance and control of updates should be developed. Procedure modifications should be integrated across the full set of procedures; alterations in particular parts of the procedures should not conflict nor be inconsistent with other parts.</p>	<p>MUAP-07007-P (R3), HSI System Description and HFE Process, Section 4.8 currently outlines the procedure development process. Backup Procedures Review Criteria 11 identifies that computer-based procedures and backup paper procedures are generated from the same source file, to ensure the contents are the same.</p>		

9. Procedure Development

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<p>9.4 Review Criteria (9) The physical means by which operators access and use procedures, especially during operational events, should be evaluated as part of the HFE design process. This criterion generally applies to both hard-copy and computer-based procedures, although the nature of the issues differs somewhat depending on the implementation. For example, the process should address the storage of procedures, ease of operator access to the correct procedures, and laydown of hard-copy procedures for use in the control room, remote shutdown facility, and local control stations.</p>	<p>The physical means by which operators access and use hard copy and CBPs especially during operational events is contained in MUAP-07007-P (R3), HSI System Description and HFE Process Section 4.8.</p> <p>The storage, ease of operator access, and lay-down of hard copy procedures in the control room and RSR, are discussed under Backup Procedures Review Criteria 6 and 7.</p> <p>V&V activities ensure that the computer-based procedure system always displays the selected procedure. Failure to display a procedure is easily recognized and prompts the operator to utilize backup HSI, as stated in MUAP-07007 (R3) Section 4.8, General Review Criteria #4.</p> <p>The ability for operators to quickly, easily and effectively transition to backup procedures is confirmed through formal V&V activities, which include tests of the fully integrated HSI using dynamic high fidelity full scope simulation as stated in MUAP-07007 (R3) Section 4.8, Backup Procedures Review Criteria #9.</p>		

10. Training Program Development

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<p>10.3 Applicant Submittals As per Section 1.2.1, item (3) Applicant Submittals, the applicant should provide for staff review an implementation plan for training program development.</p> <p>Upon completion of the applicant's efforts, a results summary report should be submitted so that the staff can review the applicant's training program using the criteria provided in Section 10.4 below.</p>	<p>DCD Ch. 18.9 pgs 18.9-1 through 18.9-6</p> <p>DCD Ch. 13.2 Pgs. 13.2-1 through 13.2-2</p> <p>“DCD Tier 1 2.9.1.3.3 Training Program Development” Identifies a “training program report” (Future Document) that will document the detailed training program development process.</p>	<p>The training program for the US-APWR is verified during Tier 1 ITAAC phase.</p>	
<p>10.4 Review Criteria The review criteria are organized into the following sections: General Approach, Organization of Training, Learning Objectives, Content of Training Program, Evaluation of Training, and Periodic Re-training.</p>	<p>See 10.4.1 through 10.4.6 on this document below.</p>	<p>See 10.3 on this document above.</p>	
<p>10.4.1 General Approach (1) A systems approach to the training of plant personnel should be developed that address applicable guidance in NUREG-0800 Section 13.2 ("Training"), as defined in 10 CFR 55.4, and as required by 10 CFR 52.78 and 50.120.</p>	<p>Systems approach to the training of plant personnel are described in the DCD Ch. 18 section 18.9.2.1 Pg. 18.9-2 through 18.9-3</p>	<p>See 10.3 on this document above.</p>	

10. Training Program Development

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<p>10.4.1 General Approach (2) The overall scope of training should be defined including the following:</p> <ul style="list-style-type: none"> • categories of personnel (e.g., senior reactor operator) to be trained • specific plant conditions (normal, upset, and emergency) • specific operational activities (e.g., operations, maintenance, testing and surveillance) • HSIs (e.g., in the main control room, emergency operations facility, remote shutdown panel, local control stations) 	<p>The overall scope of training is defined in the DCD Ch. 18 section 18.9.2.1 Pg. 18.9-2 through 18.9-3</p>	<p>See 10.3 on this document above.</p>	

10. Training Program Development

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	Current Documentation	Planned Documentation	Gap
<p>10.4.1 General Approach</p> <p>(3) The training program should provide reasonable assurance that personnel have the qualifications commensurate with the performance requirements of their jobs. Training should address:</p> <ul style="list-style-type: none"> • the full range of positions of operational personnel including licensed and nonlicensed personnel whose actions may affect plant safety • the full range of plant functions and systems including those that may be different from those in predecessor plants (e.g., passive systems and functions) • the full range of relevant HSIs (e.g., main control room, remote shutdown panel, local control stations) including characteristics that may be different from those in predecessor plants (e.g., display space navigation, operation of "soft" controls) • the full range of plant conditions 	<p>The overall training program is described in the DCD Ch. 18 section 18.9.2.1 Pg. 18.9-2 through 18.9-3</p>	<p>See 10.3 on this document above.</p>	

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<p>10.4.2 Organization of Training (1) The roles of all organizations, especially the applicant and vendors, should be specifically defined for the development of training requirements, development of training information sources, development of training materials, and implementation of the training program. For example, the role of the vendor may range from merely providing input materials (e.g., EPG) to conducting portions of specific training programs.</p>	<p>The roles of all organization of training for the US-APWR is described in the DCD Ch. 13 section 13.2 Pgs 13.2-1 through 13.2-2 and DCD Ch. 18 section 18.9.2.2, Pg. 18.9-3</p>	<p>See 10.3 on this document above.</p>	
<p>10.4.2 Organization of Training (2) The qualifications of organizations and personnel involved in the development and conduct of training should be defined.</p>	<p>The roles of organizations of training for the US-APWR are described in followings: DCD Ch. 18 Section 18.9.2.2 Pg. 18.9-3 Topical Report MUAP-07007-P (R3) - 5.9.4 Pg. 148</p>	<p>See 10.3 on this document above.</p>	
<p>10.4.2 Organization of Training (3) Facilities and resources such as plant-referenced simulator and part-task training simulators needed to satisfy training design requirements and the guidance contained in ANSI 3.5 and Regulatory Guide 1.149 should be defined.</p>	<p>The facilities and resources of training for the US-APWR are described in followings: Topical Report MUAP-07007-P (R3) section 5.9.2, Pg. 146-147 DCD Ch. 18 18.9.2.2, Pg. 18.9-3</p>	<p>See 10.3 on this document above.</p>	

10. Training Program Development

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<p>10.4.3 Learning Objectives</p> <p>(1) Learning objectives should be derived from the analysis that describes desired performance after training. This analysis should include but not be limited to training needs identified in the following:</p> <ul style="list-style-type: none"> • Licensing Basis - Final Safety Analysis Report, system description manuals and operating procedures, facility license and license amendments, licensee event reports, and other documents identified by the staff as being important to training • Operating Experience Review - previous training deficiencies and operational problems that may be corrected through additional and enhanced training, and positive characteristics of previous training programs • Function Analysis and Allocation - functions identified as new or modified • Task Analysis - tasks identified during task analysis as posing unusual demands including new or different tasks, and tasks requiring a high degree of coordination, high workload, or special skills • Human Reliability Analysis - coordinating individual roles to reduce the likelihood and/or consequences of human error associated with risk-important HAs and the use of advanced technology • HSI Design - design features whose purpose or operation may be different from the past experience or expectations of personnel • Plant Procedures - tasks that have been identified during procedure development as being problematic (e.g., procedure steps that have undergone extensive revision as a result of plant safety concerns) • Verification and Validation (V&V) - training concerns identified during V&V, including HSI usability concerns identified during validation or suitability verification and operator performance concerns (e.g., misdiagnoses of plant event) identified during validation trials 	<p>The learning objectives for the US-APWR are described in the DCD Ch. 18 section 18.9.2.3, Pgs. 18.9-2 through 18.9-3</p>	<p>See 10.3 on this document above.</p>	

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<p>10.4.3 Learning Objectives (2) Learning objectives for personnel training should address the knowledge and skill attributes associated with all relevant dimensions of the trainee's job, such as interactions with the plant, the HSIs, and other personnel. Table 10.1, below, shows these dimensions. Table 10.1 Some knowledge and skill dimensions for learning objectives identification Topic Knowledge Skill Plant Interactions Understanding of plant processes, systems, operational constraints, and failure modes. Skills associated with monitoring and detection, situation awareness, response planning and implementation. HSI and Procedure Interactions Understanding of procedures and HSI structure, functions, failure modes, and interface management tasks (actions, errors, and recovery strategies). Skills associated with interface management tasks. Personnel Interactions (In the CR and in the plant) Understanding information requirements of others, how actions should be coordinated with others, policies and constraints on crews' interaction. Skills associated with crew's interactions (i.e., teamwork)</p>	Refer to 10.4.3 (1).	See 10.3 on this document above.	

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<p>10.4.4 Content of Training Program (1) The design of the training program should be defined to specify how learning objectives will be conveyed to the trainee. The definition should include:</p> <ul style="list-style-type: none"> • The use of lecture, simulator, and on-the-job training to convey particular categories of learning objectives should be defined. • Specific plant conditions and scenarios to be used in training programs should be defined. • Training implementation considerations such as the temporal order and schedule of training segments should be defined. 	<p>The content of Training Program is described in the DCD Ch. 18 18.9.2.4, Pg. 18.9-4</p>	<p>See 10.3 on this document above.</p>	
<p>10.4.4 Content of Training Program (2) Factual knowledge should be taught within the context of actual tasks so that personnel learn to apply it in the work environment. The context of the job should be defined, and it should be represented meaningfully to help trainees to link the knowledge to the job's requirements. Training that addresses theory should be integrated with training in using procedures.</p>	<p>Refer to 10.4.4 (1)</p>	<p>See 10.3 on this document above.</p>	

10. Training Program Development

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<p>10.4.4 Content of Training Program (3) Training programs for developing skills should be structured so that the training environment is consistent with the level of skill being taught. It should support skill acquisition by allowing trainees to manage cognitive demands. For example, trainees should not be placed in environments teaching high-level skills, such as coordinating control actions among crew members, before they have mastered requisite, low-level skills, such as how to manipulate control devices.</p>	Refer to 10.4.4 (1)	See 10.3 on this document above.	
<p>10.4.4 Content of Training Program (4) Training should address rules for decision-making related to plant systems, HSIs, and procedures. It should include rules for accessing and interpreting information and rules for interpreting symptoms of failures of systems, HSIs, and procedures. This training should cover acquiring new decision-making rules and eliminating existing ones that are not appropriate to the design.</p>	Refer to 10.4.4 (1)	See 10.3 on this document above.	

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<p>10.4.5 Evaluation and Modification of Training (1) Methods for evaluating the overall effectiveness of the training programs and trainee mastery of training objectives should be defined, including written and oral tests and review of personnel performance during walkthrough, simulator exercises, and on-the-job. Evaluation criteria for training objectives should be defined for individual training modules. Methods for assessing overall proficiency should be defined and coordinated with regulations, where applicable.</p>	<p>The evaluation and modification of training for the US-APWR is described in followings: DCD Ch. 18 section 18.9.2.5, Pg 18.9-5</p> <p>Topical Report MUAP-07007-P (R3) – Section 5.9.6, Pg. 149</p>	<p>See 10.3 on this document above.</p>	
<p>10.4.5 Evaluation and Modification of Training (2) Methods for verifying the accuracy and completeness of training course materials should be defined.</p>	<p>Refer to 10.4.6 (1).</p>	<p>See 10.3 on this document above.</p>	
<p>10.4.5 Evaluation and Modification of Training (3) Procedures for refining and updating the content and conduct of training should be established, including procedures for tracking training course modifications.</p>	<p>Refer to 10.4.6 (1).</p>	<p>See 10.3 on this document above.</p>	
<p>10.4.6 Periodic Retraining (1) Personnel should undergo periodic retraining.</p>	<p>The periodic retraining for the US-APWR is described in followings: DCD Ch. 18 section 18.9.2.6, Pg. 18.9-5</p> <p>Topical Report MUAP-07007-P (R3) – Section 5.9.7, Pg. 149</p>	<p>See 10.3 on this document above.</p>	
<p>10.4.6 Periodic Retraining (2) The applicant should evaluate whether any changes or increases in retraining are warranted following plant modernization programs.</p>	<p>Refer to 10.4.6 (1).</p>	<p>See 10.3 on this document above.</p>	

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<p>11.3 Applicant Submittals As per Section 1.2.1, item (3) Applicant Submittals, the applicant should provide for staff review an implementation plan for HFE V&V. Upon completion of the applicant's efforts, a results summary report should be submitted so that the staff can review the applicant's V&V evaluations using the criteria provided in Section 11.4 below. In addition to the review of the applicant's documentation, the NRC staff may also verify a sample of V&V activities to confirm the results and observe the integrated system validation trials as part of the review.</p>	<p>MHI has a comprehensive V&V program. Sections 18.10 of the DCD introduce the implementation plan for HFE V&V. The DCD Ch. 18, 18.10.2.1 identifies the topical report MUAP-07007-P (R3) as containing the V&V implementation plan A commitment to perform the steps and meet the criteria specified in NUREG-0711, Rev. 2, Element 11 is provided in Section 18.10 of the DCD Ch. 18 and Section 5.10 of the topical report MUAP-07007-P (R3). A more detailed description of the MHI V&V program is provided in:</p> <ul style="list-style-type: none"> • MUAP-07007-P (R3), Page 150, 161 and page 133 and App C describes the phased approach to design and the roll of V&V testing. The former describes how the ongoing V&V testing program has support the modification of the Japanese basic design to the current design. Page 138 describes the MHI integrated design approach. • MUAP-09019-P (R0). Part 1, Section 8.1, paragraph 2. • MUAP-09019-P (R0) PART 1, Section 8.1.1 paragraph 2 and 3 • MUAP-09019-P (R0) PART 1, Section 8.1.2, 8.1.3 • MUAP-09019-P (R0) PART 1, Section 8.2.2.3, 8.2.4 • MUAP-09019-P (R0) PART 1, Section 8.3 • MUAP-09019-P (R0) PART 1, Section 10 <p>A high level description the US-APWR plant-specific V&V plan is provided in MUAP-09019-P (R0) PART 1, Section 8.2.2.3</p> <ul style="list-style-type: none"> • MUAP-09019-P (R0) PART 1, Section 8.2.2.4, paragraph 1: <p>The MHI V&V program specifies that there will be a site-specific V&V implementation procedure developed, if required. MUAP-09019-P (R0) Part 1, Section 8.3.3</p>	<p>The US-APWR V&V procedure will be included in the Phase 2b verification and validation procedure.</p>	

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<p>11.3 Applicant Submittals (continued)</p>	<p>MHI has provided a commitment to prepare a plant specific V&V implementation procedure for the US-APWR plant in the Phase 2b verification and validation procedure.</p> <ul style="list-style-type: none"> MUAP-09019-P (R0) PART 1, Section 8.2.2.4, paragraph 1: <p>The MHI V&V program specifies that there will be a site-specific V&V implementation procedure developed, if required.</p> <ul style="list-style-type: none"> MUAP-09019-P (R0) Part 1, Section 8.3.3 <p>MHI has provided procedures and results for Phase 1a and Phase 1b test activities that are being conducted as part of our complete V&V program. These test procedures provide a model for the test procedure that will be employed in the US-APWR V&V. A results summary report of Phase 1a testing is provided in MUAP-08014-P (R0), Part 1.</p> <p>A results summary report of Phase 1b testing is provided in MUAP-09019-P (R0) Part 3, HSI System Verification and Validation (Phase 1b)</p> <p>A report, which provides a complete description of Phase 1b test methods and results, will be completed and available for audit by the NRC.</p>	<p>MHI has committed to produce a V&V procedure for the Phase 2b V&V program</p>	
<p>11.4 Review Criteria 11.4.1 Operational Conditions Sampling</p> <p>The sampling methodology will identify a range of operational conditions to guide V&V activities. The review of operational conditions sampling considers the dimensions to be used to identify and select conditions and their integration into scenarios.</p>	<p>The DCD Ch. 18 18.10.2.1 introduces the application of condition sampling the phase 1 and 2 of the V&V program.</p> <p>Section 5.10.2.1 of the topical report MUAP-07007-P (R3) provides a commitment to meet the requirements specified in NUREG 0711 Rev 2, Section 11.4.1</p> <p>The Phase 1a and 1b test result summary reports illustrate the MHI approach to operational conditions sampling. While the Phase 1a and Phase 1b did not attempt to cover all the operational conditions specified in NUREG-0711, they sampled many of the operational</p>	<p>A detailed description of the operational conditions sampling (OCS) methodology to be used for US-APWR V&V will be included in the Phase 2b verification and validation</p>	

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	conditions including normal operational events, transients and accidents, HSI failures, and risk significant events. <ul style="list-style-type: none"> • MUAP-08014-P (R0), Part 1, Section 3.4 • MUAP-08014-P (R0), Part 1, Section 3.12.2 • MUAP-09019-P (R0) Part 3, Section 2.4 • MUAP-09019-P (R0) Part 3, Appendix 8.1 • MUAP-09019-P (R0) Part 3, Appendix 8.3 	procedure.	
11.4.1.1 Operational Conditions Sampling Review Objectives The review should verify that the applicant has identified a sample of operational conditions that (1) includes conditions that are representative of the range of events that could be encountered during operation of the plant, (2) reflects the characteristics that are expected to contribute to system performance variation, and (3) considers the safety significance of HSI components. These sample characteristics are best identified through the use of a multidimensional sampling strategy to provide reasonable assurance that variation along important dimensions is included in the V&V evaluations. The review criteria, therefore, address the sampling dimensions used and the identification of scenarios based on those dimensions. In addition, special considerations for plant modernization and modification programs are identified.	Refer to item 11.4.1, above		
11.4.1.2 Operational Conditions Sampling Review Criteria 11.4.1.2.1 Sampling Dimensions The following sampling dimensions are	As specified in Section 5.10.2.1 of the topical report MUAP-07007-P	The operational	

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<p>addressed below: plant conditions, personnel tasks, and situational factors known to challenge personnel performance.</p> <p>(1) The following plant conditions should be included:</p> <ul style="list-style-type: none"> • normal operational events including plant startup, plant shutdown or refueling, and significant changes in operating power • failure events, e.g., <ul style="list-style-type: none"> - instrument failures [e.g., safety-related system logic and control unit, fault tolerant controller, local "field unit" for multiplexer (MUX) system, MUX controller, and break in MUX line] including I&C failures that exceed the design basis, such as a common mode I&C failure during an accident - HSI failures (e.g., loss of processing and/or display capabilities for alarms, displays, controls, and computer-based procedures) • transients and accidents, e.g., <ul style="list-style-type: none"> - transients (e.g., turbine trip, loss of off-site power, station blackout, loss of all feedwater, loss of service water, loss of power to selected buses or main control room (MCR) power supplies, and safety and relief valve transients) - accidents (e.g., main steam line break, positive reactivity addition, control rod insertion at power, anticipated transient without scram, and various-sized loss-of-coolant accidents) - reactor shutdown and cooldown using 	<p>(R3), a comprehensive set of test scenarios will be developed for the US-APWR plant-specific and site specific HSI V&V that meet all NUREG 0711 rev 2 section 11.4.1 operational sampling criteria.</p> <p>The sampling dimensions for plant conditions that are planned to be included are listed in section 5.10.2.1(a) of the topical report MUAP-07007-P (R3).</p> <p>The sampling strategy used in Phase 1a and Phase 1b testing included scenarios that sampled from all of these operational conditions – including normal operational events, instrument failures, HSI failures, transients and accidents, and risk-significant events:</p> <ul style="list-style-type: none"> • MUAP-08014-P (R0), Part 1, Section 3.4 • MUAP-08014-P (R0), Part 1, Section 3.12.2 • MUAP-09019-P (R0) Part 3, Section 2.4 • MUAP-09019-P (R0) Part 3, Appendix 8.1 • MUAP-09019-P (R0) Part 3, Appendix 8.3 	<p>conditions sampling dimensions and scenario identification process for the US-APWR V&V will be included in the Phase 2b verification and validation procedure.</p>	

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<p>the remote shutdown system</p> <ul style="list-style-type: none"> reasonable, risk-significant, beyond-design-basis events, which should be determined from the plant specific PRA consideration of the role of the equipment in achieving plant safety functions [as described in the plant safety analysis report (SAR)] and the degree of interconnection with other plant systems. A system that is interconnected with other systems could cause the failure of other systems because the initial failure could propagate over the connections. This consideration is especially important when assessing non-class 1E electrical systems. 			
<p>11.4.1.2.1 Sampling Dimensions</p> <p>(2) The following types of personnel tasks should be included:</p> <ul style="list-style-type: none"> Risk-significant HAs, systems, and accident sequences - All risk-important HAs should be included in the sample. These include identified in the PRA and those identified as risk-important in the SAR and NRC's safety evaluation report (SER) should be included. Situations where human monitoring of an automatic system is risk-important should be considered. Additional factors should be sampled that contribute highly to risk, as defined by the PRA, including: <ul style="list-style-type: none"> - dominant human actions (selected via sensitivity analyses) - dominant accident sequences - dominant systems (selected via PRA 	<p>The DCD Ch.18, 18.10.2.1 introduces the application of risk importance in the selection of scenarios, events, transients and accidents used in the V&V program.</p> <p>Phase 1a and Phase 1b tests included a wide range of personnel tasks including a partial sampling of risk significant human actions, and a range of procedure guided tasks including normal, abnormal, emergency, and alarm response procedures.</p> <ul style="list-style-type: none"> MUAP-08014-P (R0), Part 1, Section 3.4 MUAP-08014-P (R0), Part 1, Section 3.12.2 MUAP-09019-P (R0) Part 3, Section 2.4 MUAP-09019-P (R0) Part 3, Appendix 8.1 MUAP-09019-P (R0) Part 3, Appendix 8.3 <p>The US-APWR plant specific V&V will include all the types of personnel tasks specified in NUREG-0711, Rev 2, Section 11.4.1.2.1. The sampling dimensions for personnel tasks that are planned to be included are listed in Section 5.10.2.1 (b) of the Topical Report MUAP-07007-P (R3). See also MUAP-09019-P (R0) Part 1, Section 8.2.3, paragraph 4.</p>		

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<p>importance measures such as Risk Achievement Worth or Risk Reduction Worth)</p> <ul style="list-style-type: none"> • OER-identified difficult tasks - The sample should include all personnel tasks identified as problematic during the applicant's review of operating experience. • Range of procedure guided tasks - These are tasks that are well defined by normal, abnormal, emergency, alarm response, and test procedures. The operator should be able to, as part of rule-based decision-making, understand and execute the specified steps. Regulatory Guide 1.33, Appendix A, contains several categories of "typical safety-related activities that should be covered by written procedures." The sample should include appropriate procedures in each relevant category: <ul style="list-style-type: none"> - administrative procedures - general plant operating procedures - procedures for startup, operation, and shutdown of safety-related systems - procedures for abnormal, off normal, and alarm conditions - procedures for combating emergencies and other significant events - procedures for control of radioactivity - procedures for control of measuring and test equipment and for surveillance tests, procedures, and calibration - procedures for performing maintenance - chemistry and radiochemical control procedures 			

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<p>11.4.1.2.1 Sampling Dimensions (2) continued</p> <ul style="list-style-type: none"> • Range of knowledge-based tasks - these are tasks that are not as well defined by detailed procedures. Knowledge-based decision-making involves greater reasoning about safety and operating goals and the various means of achieving them. A situation may require knowledge-based decision-making if the rules do not fully address the problem, or the selection of appropriate rule is not clear. An example in a pressurized water reactor plant may be the difficulty in diagnosing a steam generator tube rupture (SGTR) with a failure of radiation monitors on the secondary side of the plant because (1) there is no main indication of the rupture (the presence of radiation in secondary side), and (2) the other effects of the rupture (i.e., slight changes in pressures and levels on the primary and secondary sides) may be attributed to other causes. While the operators may use procedures to treat the symptoms of the event, the determination that the cause is a SGTR may require situation assessment based on an understanding of the plant's design and the possible combinations of failures that could result in the observed symptoms. Errors in rule-based decision-making result from selecting the wrong rule or incorrectly applying a rule. Errors in knowledge-based decision-making result 	<p>Phase 1a and 1b testing included failures in sensors and failures in automation that required operators to utilize knowledge-based decision-making. Specifically Phase 1a included a SGTR with a loss of radiation monitor. Phase 1b included a failure in automation that resulted in unexpected increase in SG level that operators needed to detect and respond to – without explicit procedural guidance.</p> <ul style="list-style-type: none"> • MUAP-08014-P (R0), Part 1, Section 3.4 • MUAP-08014-P (R0), Part 1, Section 3.12.2 • MUAP-09019-P (R0) Part 3, Section 2.4 • MUAP-09019-P (R0) Part 3, Appendix 8.1 • MUAP-09019-P (R0) Part 3, Appendix 8.3 		

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from mistakes in higher-level cognitive functions such as judgment, planning, and analysis. The latter are more likely to occur in complex failure events where the symptoms do not resemble the typical case, and thus, are not amenable to pre-established rules.			
<p>11.4.1.2.1 Sampling Dimensions (2) continued</p> <ul style="list-style-type: none"> • Range of human cognitive activities -The sample should include the range of cognitive activities performed by personnel, including: <ul style="list-style-type: none"> - detection and monitoring (e.g., of critical safety-function threats) - situation assessment (e.g., interpretation of alarms and displays for diagnosis of faults in plant processes and automated control and safety systems) - response planning (e.g., evaluating alternatives for recovery from plant failures) - response implementation (e.g., in-the-loop control of plant systems, assuming manual control from automatic control systems, and carrying out complicated control actions) - obtaining feedback (e.g., of the success of actions taken) • Range of human interactions - The sample should reflect the range of interactions among plant personnel, including tasks that are performed independently by individual crew members 	<p>Phase 1a and 1b testing included scenarios that required a range of cognitive and collaborative activities. This included instance of critical safety function threats and automation failures that exercised detection and monitoring, and instances where automation failures required manual take-over.</p> <ul style="list-style-type: none"> • MUAP-08014-P (R0), Part 1, Section 3.4 • MUAP-08014-P (R0), Part 1, Section 3.12.2 • MUAP-09019-P (R0) Part 3, Section 2.4 • MUAP-09019-P (R0) Part 3, Appendix 8.1 • MUAP-09019-P (R0) Part 3, Appendix 8.3 		

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<p>and tasks that are performed by crew members acting as a team. These interactions among plant personnel should include interactions between:</p> <ul style="list-style-type: none"> - main control room operators (e.g., operations, shift turnover walkdowns) - main control room operators and auxiliary operators - main control room operators and support centers (e.g., the technical support center and the emergency offsite facility) - main control room operators with plant management, NRC, and other outside organizations <ul style="list-style-type: none"> • Tasks that are performed with high frequency. 			
<p>11.4.1.2.1 Sampling Dimensions (3) The sample should reflect a range of situational factors that are known to challenge human performance, such as:</p> <ul style="list-style-type: none"> • Operationally difficult tasks - The sample should address tasks that have been found to be problematic in the operation of NPPs, e.g., procedure versus situation assessment conflicts. The specific tasks selected should reflect the operating history of the type of plant being validated (or the plant's predecessor). • Error-forcing contexts - Situations specifically designed to create human errors should be included to assess the error tolerance of the system and the capability of operators to recover from errors should they occur. • High-workload conditions - The sample 	<p>Phase 1a and 1b testing included a range of tasks that varied in cognitive complexity and mental and physical workload demands. For example, in the Phase 1b test, the Small break LOCA with violation of two critical safety functions stressed situation assessment processes; whereas the SGTR imposed time pressure and cognitive workload.</p> <ul style="list-style-type: none"> • MUAP-09019-P (R0) Part 3, Section 2.4 • MUAP-09019-P (R0) Part 3, Appendix 8.3 		

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<p>should include situations where human performance variation due to high workload and multitasking situations can be assessed.</p> <ul style="list-style-type: none"> • Varying-workload situations - The sample should include situations where human performance variation due to workload transitions can be assessed. These include conditions that exhibit (1) a sudden increase in the number of signals that must be detected and processed following a period in which signals were infrequent and (2) a rapid reduction in signal detection and processing demands following a period of sustained high task demand. • Fatigue and circadian factors - The sample should include situations where human performance variation due to personnel fatigue and circadian factors can be assessed. • Environmental factors - The sample should include situations where human performance variation due to environmental conditions such as poor lighting, extreme temperatures, high noise, and simulated radiological contamination can be assessed. 			

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<p>11.4.1.2.2 Identification of Scenarios (1) The results of the sampling should be combined to identify a set of scenarios to guide subsequent analyses. A given scenario may combine many of the characteristics identified by the operational event sampling.</p>	<p>An elaborate conditions sampling methodology was used in the Phase 1 B test to create a set of scenarios that simultaneously could be used to evaluate design changes that were made in response to Phase 1a and also expand the set of operational conditions sampled to include more cognitively complex scenarios. A similar, multi-dimensional sampling strategy will be used for the plant specific US-APWR V&V. A description of the multi-dimensional sampling strategy and methodology that was used to create the Phase 1b test scenarios is provided in:</p> <ul style="list-style-type: none"> • MUAP-09019-P (R0) Part 3, Section 2.4 • MUAP-09019-P (R0) Part 3, Section 4.1 • MUAP-09019-P (R0) Part 3, Appendix 8.1 • MUAP-09019-P (R0) Part 3, Appendix 8.3 		
<p>11.4.1.2.2 Identification of Scenarios (2) The scenarios should not be biased in the direction of over representation of the following:</p> <ul style="list-style-type: none"> • scenarios for which only positive outcomes can be expected • scenarios that for integrated system validation are relatively easy to conduct administratively (scenarios that place high demands, data collection or analysis are avoided) • scenarios that for integrated system validation are familiar and well structured (e.g., which address familiar systems and failure modes that are highly compatible with plant procedures such as “textbook” design-basis accidents) 	<p>The elaborate conditions sampling methodology that was used in the Phase 1B test illustrates the systematic approach that MHI uses to create scenarios that are explicitly designed to stress the HSI and broadly sample a range of operating conditions and cognitive demands -- thus avoiding the pitfall of using only straightforward scenarios that do not stress the HSI. A description of the multi-dimensional sampling strategy and methodology that was used to create the Phase 1b test scenarios is provided in:</p> <ul style="list-style-type: none"> • MUAP-09019-P (R0) Part 3, Section 2.4 • MUAP-09019-P (R0) Part 3, Section 4.1 • MUAP-09019-P (R0) Part 3, Appendix 8.1 • MUAP-09019-P (R0) Part 3, Appendix 8.3 		
<p>11.4.1.2.3 Special Considerations for Plant Modernization Programs</p>	<p>Topical Report MUAP-07007-P (R3), section 5.11 page 161,</p>	<p>If upgrades to existing plant HSIs</p>	

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When evaluating plant modifications, the following factors should be addressed when identifying operational conditions: (1) The operational conditions should reflect tasks that involve the modification, rather than the entire range of topics discussed above for Personnel Tasks.	Paragraph 4 discusses plant modernizations.	are planned based upon this Design Certification, a discussion as to how MHI plans to address Operational Condition Sampling (OCS) will be provided.	
11.4.1.2.3 Special Considerations for Plant Modernization Programs (2) For integrated system validation, the operational conditions should address the transfer of learning effects on personnel performance when a modification replaces an old HSI or procedure. (Negative transfer of learning effects may occur when the new and old components are different and impose different demands on personnel.)	Refer to item 11.4.1.2.3 (1).		
11.4.1.2.3 Special Considerations for Plant Modernization Programs (3) For integrated system validation, when both old and new versions of the same HSI components with different means of presentation and methods of operation are permanently present in the HSI, evaluations should provide reasonable assurance that personnel can alternate their use of these HSI components without degrading their performance.	Refer to item 11.4.1.2.3 (1).		
11.4.1.2.3 Special Considerations for Plant Modernization Programs (4) Where old HSI components that are to be deactivated and left in place in the HSI,	Refer to item 11.4.1.2.3 (1).		

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conditions should be identified for integrated system validation that would test the potential for task interference. For example, the presence of deactivated HSI components may cause visual clutter that interferes with the ability of operators to locate and use other HSI components.			
<p>11.4.2 Design Verification</p> <p>11.4.2.1 Inventory and Characterization</p> <p>11.4.2.1.1 Inventory and Characterization Review Objectives</p> <p>The objective of this review is to verify that the applicant's HSI inventory and characterization accurately describes all HSI displays, controls, and related equipment that are within the defined scope of the HSI design review.</p>	<p>Section 18.10.2.2 of the DCD Ch.18 introduces a discussion of inventory and HSI characteristics. Section 5.10.2.2.1 of the Topical Report MUAP-07007-P (R3) provides a commitment to perform the steps and meet the criteria specified in NUREG-0711, Rev. 2, Element 11.</p> <p>Additional details are provided in MUAP-09019-P (R0) Part 1, Section 8.2.2.3, paragraph 2</p> <p>MHI has provided procedures and results for Phase 1a verification in MUAP-08014-P (RO), Part 1, Section 2. The Phase 1a verification focused on design verification and compared the MHI HSI design to NUREG 0700.</p>	<p>A detailed description of the verification methodology to be used for US-APWR V&V including acceptance criteria will be included in the Phase 2b verification and validation procedure.</p> <p>This includes a description of the task support verification and design verification.</p>	
<p>11.4.2.1.2 Inventory and Characterization Review Criteria</p> <p>(1) Scope - The applicant should develop an inventory of all HSI components associated with the personnel tasks based on the identified operational conditions. The inventory should include aspects of the HSI that are used for interface management such as navigation and display retrieval in addition to those that</p>		<p>The HSI Inventory and Characterization process for the US-APWR V&V will be included in the Phase 2b verification and validation procedure.</p>	

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control the plant.		The Phase 2b verification and validation procedure will include an inventory of all HSI components associated with the personnel tasks based on the identified operational conditions.	
<p>11.4.2.1.2 Inventory and Characterization Review Criteria</p> <p>(2) HSI Characterization - The inventory should describe the characteristics of each HSI component within the scope of the review. The following is a minimal set of information for the characterization:</p> <ul style="list-style-type: none"> • a unique identification code number or name • associated plant system and subsystem • associated personnel functions/subfunction • type of HSI component <ul style="list-style-type: none"> - computer-based control (e.g., touch screen or cursor-operated button and keyboard input) - hardwired control (e.g., J-handle controller, button, and automatic controller) - computer-based display (e.g., digital value and analog representation) - hardwired display (e.g., dial, gauge, and 		Refer to item 11.4.2.1.2 (1).	

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strip chart recorder) • display characteristics and functionality [e.g., plant variables/parameters, units of measure, accuracy of variable/parameter, precision of display, dynamic response, and display format (bar chart, and trend plot)] • control characteristics and functionality [e.g., continuous versus discrete settings, number and type of control modes, accuracy, precision, dynamic response, and control format (method of input)] • user-system interaction and dialog types (e.g., navigation aids and menus) • location in data management system (e.g., identification code for information display screen) • physical location in the HSI (e.g., control panel section), if applicable Photographs, copies of VDU screens, and similar samples of HSI components should be included in the HSI inventory and characterization.			
11.4.2.1.2 Inventory and Characterization Review Criteria (3) Information Sources - The inventory should be based on the best available information sources. Equipment lists, design specifications, and drawings describe HSI components. These descriptions should be compared by directly observing the components, both hardwired and computer-generated, to verify that the inventory accurately reflects their current state.		Refer to item 11.4.2.1.2 (1).	

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<p>11.4.2.2 HSI Task Support Verification 11.4.2.2.1 HSI Task Support Verification Review Objectives The objective of this review is to verify that the applicant has verified that the HSI provides all alarms, information, and control capabilities required for personnel tasks.</p>	<p>Section 18.4.3 of the DCD Ch.18 introduces the use of task analysis results in the development of the HSI procedures and personnel training. Section 5.10.2.2.2, of the topical report MUAP-07007-P (R3) provides a commitment to meet the requirements specified in NUREG 0711 Rev 2, Section 11.4.2.2. Section 3, page 154, of MUAP-09019 R0 describes the development of the Task Analysis that will be used in the Task Support verification.</p>	<p>The Phase 2b verification and validation procedure will include the methodology that will be used for the Task Support Verification.</p>	
<p>11.4.2.2.2 HSI Task Support Verification Review Criteria (1) Criteria Identification - The criteria for Task Support Verification come from task analyses of HSI requirements for performance of personnel tasks that are selected operational conditions should be defined.</p>	<p>MHI commits to performing Task Support verification in Phase 2b in DCD Ch.18 section 18.10.2.2. MUAP-07007 (R3) section 5.4.1 commits to use the results from the Task Analysis in the Task support verification. The process is described in MUAP-07007 (R3) section 5.10.2.2.2 and in Figure 5.4-1</p>	<p>The HSI Task Support Verification process for the US-APWR V&V will be included in the Phase 2b verification and validation procedure.</p>	
<p>11.4.2.2.2 HSI Task Support Verification Review Criteria (2) General Methodology - The HSIs and their characteristics (as defined in the HSI inventory and characterization) should be compared to the personnel task requirements identified in the task analysis.</p>	<p>Refer to item 11.4.2.2.2.</p>		

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<p>11.4.2.2.2 HSI Task Support Verification Review Criteria (3) Task Requirements Deficiencies - HEDs should be identified when:</p> <ul style="list-style-type: none"> • an HSI needed for task performance (e.g., a required control or display) is not available • HSI characteristics do not match the personnel task requirements, e.g., a display shows the necessary plant parameter but not the range or precision needed for the task 	Refer to item 11.4.2.2.2.		
<p>11.4.2.2.2 HSI Task Support Verification Review Criteria (4) Unnecessary HSI Components - An HED should be identified for HSIs that are available in the HSI but are not needed for any task. Unnecessary HSIs introduce clutter and can distract personnel for the selection of appropriate HSIs. It is important to verify that the HSI is actually unnecessary. Appropriate HSI components may not appear to be associated with personnel tasks for the following reasons:</p> <ul style="list-style-type: none"> • The HSI component is needed for a task that was not addressed by the task analysis (e.g., it was not within the scope of the design review). • The task analysis was incomplete, and thus overlooked the need for the HSI component. • The HSI component only partially meets the personnel task requirements that were established. 	Refer to item 11.4.2.2.2.		

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If an HSI component has no associated personnel tasks because the function and task analysis was incomplete, then the applicant should identify and resolve any shortcomings in that analysis.			
<p>11.4.2.2.2 HSI Task Support Verification Review Criteria</p> <p>(5) Additional Methodology Considerations for Plant Modifications - the following considerations should be addressed:</p> <ul style="list-style-type: none"> • HSI Task Support Verification should address all aspects of HSIs described above that are relevant to the modification. For modifications to plant systems that do not include modifications of the HSIs, task-support verification should identify any new demands for monitoring and control, and determine whether they are adequately addressed by the existing HSI design. • HSI Task Support Verification should address modification configurations in which old HSIs are permanently deactivated, but not removed (e.g., abandoned in place). Criterion 4, above, states that the HSIs should not contain any information, displays, or controls that do not support personnel tasks. This verification should identify deactivated HSIs that may have potentially negative effects on personnel performance, such as obstructing the view of important information or adding visual clutter which may interfere with monitoring. Deactivated HSIs requiring further evaluation through 	N.A.	If upgrades to existing plant HSIs are planned based upon this Design Certification, a discussion as to how MHI plans to address HSI Task Support Verification will be provided.	

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<p>HFE design verification or integrated system validation should be identified.</p> <ul style="list-style-type: none"> • HSI Task Support Verification should address temporary configurations of the HSIs and plant systems that may be created during implementation of the modification, and used by operations and maintenance personnel when the plant is not shutdown. These configurations may include: <ul style="list-style-type: none"> - the use of HSIs that differ from the intended final design - combinations of HSIs and system configurations that differ from both the original and the intended final designs. <p>For each temporary HSI configuration, the task requirements of personnel should be identified and compared to the information and control capabilities provided. For example, if a temporary configuration of plant systems introduces special monitoring requirements, then the HSIs should provide the necessary information.</p>			
<p>11.4.2.2.2 HSI Task Support Verification Review Criteria</p> <p>(6) HED Documentation - HEDs should be documented to identify the HSI, the relevant task criterion, and basis for the deficiency (what aspect of the HSI has been identified as not meeting task requirements).</p>	The HED process is described in section 1 of MUAP-09019-P (R0)		

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<p>11.4.2.3 HFE Design Verification 11.4.2.3.1 HFE Design Verification Review Objective The objective of this review is to verify that the applicant has verified that the characteristics of the HSI and the environment in which it is used conform to HFE guidelines. The aspects of the applicant's HFE Design Verification that are addressed in the staff's evaluation are discussed below.</p>	<p>These criteria are committed to in section 5.10.2.2.3 of the Topical report MUAP-07007-P (R3). In addition MHI has provided procedures and results for Phase 1a verification in MUAP-08014-P (RO), Part 1, Section 2. The Phase 1a verification focused on design verification and compared the MHI HSI design to NUREG-0700. As specified in MUAP-09019-P (R0) Part 1, Section 8.2.2.3, paragraph 2, as part of the US-APWR plant specific V&V MHI will perform a complete design verification review including comparing the display details against the MHI Design Style Guide, JEJC-1763-1001 R2, which, in turn will be verified against NUREG-0700</p>	<p>The Phase 2b verification and validation procedure will include a detailed description of how the MHI style guide will be verified against the NUREG-0700 criteria, and how the HSI will be verified against the style guide, is needed.</p>	
<p>11.4.2.3.2 HFE Design Verification Review Criteria (1) Criteria Identification - The criteria for this verification are the HFE guidelines. The selection of guidelines used in the review depends upon the characteristics of the HSI components included in the scope of the review, as defined in the HSI characterization. It also depends upon whether the applicant has developed a style guide (design-specific HFE guideline document). When a style guide is used by the applicant, its acceptability should be reviewed by the staff. The procedures involved are described in Section 8.4.5. The HFE guidelines contained in NUREG-0700 may be used to support the staff's review of the guidance contained in an applicant's style guide. When an NRC reviewed style guide has been used, it can provide the criteria for HFE design</p>	<p>A commitment to meet these criteria is provided in Section 5.10.2.2.3, paragraph 2 of the Topical Report MUAP-07007-P (R3). A draft Design Style Guide has been used in the design process and design verification. This Guide is a living document anchored to the Phase 1 testing. One example of a design change from the Japanese design is represented in MUAP-07007-P (R3) Figure 4.5-3. Also refer to Page 103 of MUAP-07007-P (R3) which discusses the design process that builds on past HSI design. Page 104 describes the application of the Design Style guide to subcontractor work.</p>	<p>The HFE Design Verification process for the US-APWR V&V will be included in the Phase 2b verification and validation procedure. A final HFE Design Style Guide, based on the Japanese design as modified by design changes for US operations resulting from the Phase 1 V&V testing, will be used for the phase 2b design</p>	

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<p>verification. When no style guide is available, the guidelines in NUREG-0700 can be used for the HFE design verification. However, since not all of these guidelines will be applicable to each review, the selection of guidelines should be based on the characteristics of the HSI components being evaluated. A subset of guidelines appropriate to the specific design implementation should be identified based on the HSI characterization.</p>		<p>verification and will be available for NRC review.</p>	
<p>11.4.2.3.2 HFE Design Verification Review Criteria (2) General Methodology - The characteristics of the HSI components should be compared with HFE guidelines. These guidelines are applicable to different aspects of the design: task-independent features (e.g., font size), task-specific features (e.g., scale units), and task-integration features (e.g., proximity of control-display). A single guideline may apply to many identical HSI components, especially in the case of significant HSI modifications and HSIs for new plants. In addition, some environmental considerations (e.g., lighting) may be applicable. To simplify the application of guidelines and reduce redundancy when reporting findings, the guidelines may be applied to features of the HSI as follows: • Global features - global HSI features are those relating to the configurational and</p>			

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<p>environmental aspects of the HSI, such as MCR layout, general workstation configuration, lighting, noise, heating, and ventilation. These aspects of the review, e.g., MCR lighting, tend to be evaluated only once.</p> <ul style="list-style-type: none"> Standardized features - standardized features are those that were designed using HFE guidelines applied across individual controls and displays (e.g., display screen organization, display format conventions, and coding conventions). Therefore, their implementation should be more consistent across the interface than features that were not designed with guidelines. Thus, for example, if display labeling is standardized by the applicant's HFE guidelines (style guide), which have been accepted by the NRC, then display labels can be spot-checked rather than being verified individually. Detailed features - detailed features are the aspects of individual HSIs that are not addressed by general HFE guidelines. The latter can be expected to be more variable than the standardized design features. 			
<p>11.4.2.3.2 HFE Design Verification Review Criteria (2) continued For each guideline, it should be determined whether the HSI is "acceptable" or "discrepant" from the guideline (therefore, potentially</p>	<p>A description of the Human Engineering Discrepancy Process is provided in MUAP-09019-P (R0) Part 1, Sections 6 and 7.</p>		

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<p>unacceptable), an HED. "Acceptable" should be indicated only if there is total compliance, i.e., only if every instance of the item is fully consistent with the criteria established by the HFE guidelines. If there is any instance of noncompliance, full or partial, then an evaluation of discrepant should be given, and a notation made as to where noncompliance occurs.</p> <p>Discrepancies should be evaluated as potential indicators of additional issues. For example, identifying an inappropriate format for presenting data on an individual display should be considered a potential sign that other display formats could be incorrectly used or that the observed format is inappropriately used elsewhere. As a result, the sampling strategy could be modified to encompass other display formats. In some cases, discovering these discrepancies could warrant further review in the identified areas of concern.</p>			
<p>11.4.2.3.2 HFE Design Verification Review Criteria</p> <p>(3) Additional Methodology Considerations for Plant Modifications - the following considerations should be addressed:</p> <ul style="list-style-type: none"> • The scope of HFE design verification may be restricted to the modified HSIs and their interactions with the rest of the HSIs. • When both old and new versions of similar HSIs are permanently present in design, this verification should provide reasonable assurance that their means of presentation and methods of operation are 		<p>If upgrades to existing plant HSIs are planned based upon this Design Certification, a discussion as to how MHI plans to address HFE Design Verification will be provided.</p>	

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<p>compatible, such that personnel performance will not be impaired when the use of old and new components is alternated.</p> <ul style="list-style-type: none"> • HEDs should be identified for the following: <ul style="list-style-type: none"> - failure to meet "crew-identified" functionality in addition to that specified by system designers. When a digital system replaces an existing system, it is important to make sure that all operational uses of the former system have been addressed, even those that were not intended in the original design. The replacement system's design should consider the actual usage of the former system - poor integration with the rest of the HSI - poor integration with procedures and training. • Temporary configurations of the HSIs and plant systems, which may be used by operations and maintenance personnel when the plant is not shutdown, should be reviewed to verify that their design is consistent with the principles of good HFE design, including consistency with the rest of the HSIs. 			
<p>11.4.2.3.2 HFE Design Verification Review Criteria (4) HED Documentation - HEDs, should be documented by the applicant in terms of the HSI component involved and how its characteristics depart from a particular guideline.</p>	<p>Section 18.10.2.4 of the DCD Ch.18 introduces the application of HEDs resulting from the V&V program. MHI has developed an HED documentation and analysis process. This process is documented in MUAP-09019-P (R0) Part 1, Section 6.1 – 6.6, and Section 7.</p>		
<p>11.4.3 Integrated System Validation</p>	<p>Section 18.10.2.3 of the DCD Ch.18 introduces the NUREG 0711</p>		

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<p>11.4.3.1 Integrated System Validation Review Objective</p> <p>Integrated system validation is the process by which an integrated system design (i.e., hardware, software, and personnel elements) is evaluated using performance-based tests to determine whether it acceptably supports safe operation of the plant. It is intended to evaluate the acceptability of those aspects of the design that cannot be determined through such analytical means as HSI task-support verification and HFE design verification.</p> <p>Plant personnel should perform operational events using a simulator or other suitable representation of the system to determine its adequacy to support safety operations. This should be undertaken after significant HEDs that were identified in verification reviews have been resolved, since these will negatively affect performance and, therefore, the results of validation. (See O'Hara, et al., 1997 for a more detailed discussion of integrated system validation methodology.)</p> <p>For the case of plant modifications, the applicability and scope of integrated system validation may vary. An integrated system validation should be reviewed for all modifications that may (1) change personnel tasks; (2) change task demands, such as changing task dynamics, complexity, or workload; or (3)</p>	<p>validation process.</p> <p>A commitment to meet these criteria is provided in Section 5.10.2.2.4 of the Topical Report, MUAP-07007-P (R3). Section 5.10.2.2.4 describes the Validation process used to date and proposed for future validation tests. Pages 155 and 156 describes the methods of data collection.</p> <p>Additional details are provided in MUAP-09019-P (R0) PART 1, Section 8.2.2.3</p> <p>MHI has provided procedures and results for Phase 1a and Phase 1b integrated system testing that are being conducted as part of our complete V&V program. These integrated system test procedures provide a model for the integrated system validation procedure that will be employed in the US-APWR V&V.</p> <p>A results summary report of Phase 1a testing is provided in MUAP-08014-P (R0), Part 1.</p> <p>A summary of the results of Phase 1b tests is provided in MUAP-09019-P (R0) Part 3, HSI System Verification and Validation (Phase 1b)</p>		

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interact with or affect HSIs and procedures in ways that may degrade performance. Integrated system validation may not be needed when a modification results in minor changes to personnel tasks such that they may reasonably be expected to have little or no overall effect on workload and the likelihood of error. The aspects of the validation that are addressed in the staff's evaluation are discussed below.			
<p>11.4.3.2 Integrated System Validation Review Criteria</p> <p>11.4.3.2.1 Test Objectives</p> <p>(1) Detailed objectives should be developed to provide evidence that the integrated system adequately supports plant personnel in the safe operation of the plant. The test objectives and scenarios should be developed to address aspects of performance that are affected by the modification design, including personnel functions and tasks affected by the modification. The objectives should be to:</p> <ul style="list-style-type: none"> • Validate the role of plant personnel. • Validate that the shift staffing, assignment of tasks to crew members, and crew coordination (both within the control room as well as between the control room and local control stations and support centers) is acceptable. This should include validation of the nominal shift levels, minimal shift levels, and shift turnover. • Validate that for each human function, the design provides adequate alerting, 	<p>[The following is a map between sections of current documents and the review criteria that are related to Integrated System Validation. The discussion in these documents shows the approach that is planned by MHI and will be applied to the US-APWR V&V testing. The documented application is limited at this time due to the ongoing design process, but MHI believes the approach addresses the intent of the review criteria.]</p> <p>A commitment to meet these criteria is provided in Section 5.10.2.2.4(a) of MUAP-07007-P (R3). This report also discusses the HSI design goals on pages 91 and 92</p> <p>The Phase 1 a and Phase 1b test result summary reports illustrate the MHI methodology for establishing test objectives and developing test scenarios and test instruments to address these objectives. Phase 1 test objectives are consistent with 11.4.3.2 objectives, including assessing:</p> <ul style="list-style-type: none"> • shift staffing, assignment of tasks to crew members, and crew coordination. • whether the design provides adequate alerting, information, control, and feedback capability for human functions to be performed under normal plant evolutions, transients, design-basis accidents, and selected, risk-significant events. • Whether personnel tasks can be accomplished within time and performance criteria, with a high degree of operating crew 	<p>The Integrated System Validation process for the US-APWR V&V will be included in the Phase 2b verification and validation procedure.</p> <p>[MHI commits to developing a US-APWR V&V Procedure, prior to the execution of the US-APWR V&V Test program that follows the approach in developing the Procedure with respect to Integrated System Validation that is found in the documentation cited in the column to the</p>	

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<p>information, control, and feedback capability for human functions to be performed under normal plant evolutions, transients, design-basis accidents, and selected, risk-significant events that are beyond-design basis.</p> <ul style="list-style-type: none"> • Validate that specific personnel tasks can be accomplished within time and performance criteria, with a high degree of operating crew situation awareness, and with acceptable workload levels that provide a balance between a minimum level of vigilance and operator burden. Validate that the operator interfaces minimize operator error and provide for error detection and recovery capability when errors occur. • Validate that the crew can make effective transitions between the HSIs and procedures in the accomplishment of their tasks and that interface management tasks such as display configuration and navigation are not a distraction or undue burden. • Validate that the integrated system performance is tolerant of failures of individual HSI features. • Identify aspects of the integrated system that may negatively affect integrated system performance. 	<p>situation awareness, and with acceptable workload levels.</p> <ul style="list-style-type: none"> • Whether the crew can make effective transitions between the HSIs and procedures in the accomplishment of their tasks and that interface management tasks such as display configuration and navigation are not a distraction or undue burden. • That the integrated system performance is tolerant of failures of individual HSI features. • and Identify aspects of the integrated system that may negatively affect integrated system performance (i.e., HEDs). <p>Test objectives for Phase 1a are provided in MUAP-08014-P (R0), Part 1, Section 3.2. Additional test objectives for Phase 1b are provided in MUAP-09019-P (R0) Part 3, Section 4.1.</p>	<p>immediate left. The procedure will, however, be more robust and thorough in its description of the methods employed for addressing these review criteria.]</p>	
<p>11.4.3.2.1 Test Objectives (1) continued</p> <ul style="list-style-type: none"> • For modifications that change plant systems but do not modify the HSI, validation can provide evidence about the 		<p>If upgrades to existing plant HSIs are planned based upon this Design Certification, a</p>	

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adequacy of the existing HSIs, procedures, and training for supporting personnel performance. The staff should verify that the applicant validates that the functions and tasks allocated to plant personnel can be accomplished effectively when the integrated design is implemented.		discussion as to how MHI plans to address Integrated System Validation including existing HSi, procedures, and training will be provided.	
<p>11.4.3.2.2 Validation Testbeds A testbed is the HSI representation used to perform validation evaluations. One approach to identifying a validation testbed that is consistent with the following review criteria, is to use the American National Standard "Nuclear power plant simulators for use in operator training," (ANSI/ANS 3.5-1998) as a guide. (1) Interface Completeness - The testbed should completely represent the integrated system. This should include HSIs and procedures not specifically required in the test scenarios. For example, adjacent controls and displays may affect the ways in which personnel use those that are addressed by a particular validation scenario.</p>	<p>Section 18.10.2.3 of the DCD Ch.18 introduces the need for testbed validation and commits to apply ANS ANSI 3.5. A commitment to meet these criteria is provided in Section 5.10.2.2.4(b) of the Topical Report, MUAP-07007-P (R3). Page 100 commits MHI to use of a simulator as the focal point for collecting US operator feedback through the design process. Additional details are provided in MUAP-09019-P (R0) Part 1, Section 8.2.2.3, paragraph 2 Use of a Main Control Room dynamic simulator as a validation test bed is demonstrated, by example, in sect 3 of MUAP-09019 R0. Limitations of this current test bed for Phase 1, based on criteria from NUREG 0711 R2 11.4.3.2.2, testing is also described</p>	<p>A description of the US-APWR validation test bed and how it meets the criterion specified in 11.4.3.2.2 will be included in the Phase 2b verification and validation procedure.</p>	
<p>11.4.3.2.2 Validation Testbeds (2) Interface Physical Fidelity - A high degree of physical fidelity in the HSIs and procedures should be represented, including presentation of alarms, displays, controls, job aids, procedures, communications, interface management tools, layout and spatial relationships.</p>	Refer to item 11.4.3.2.2 (1).		

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<p>11.4.3.2.2 Validation Testbeds (3) Interface Functional Fidelity - A high degree of functional fidelity in the HSIs and procedures should be represented. All HSI functions should be available. High functional fidelity includes HSI component modes of operation, i.e., the changes in functionality that can be invoked on the basis of personnel selection and/or plant states.</p>	Refer to item 11.4.3.2.2 (1).		
<p>11.4.3.2.2 Validation Testbeds (4) Environment Fidelity - A high degree of environment fidelity should be represented. The lighting, noise, temperature, and humidity characteristics should reasonably reflect that expected. Thus, noise contributed by equipment, such as air handling units and computers, should be represented in validation tests.</p>	Refer to item 11.4.3.2.2 (1).		
<p>11.4.3.2.2 Validation Testbeds (5) Data Completeness Fidelity - Information and data provided to personnel should completely represent the plant systems monitored and controlled from that facility.</p>	Refer to item 11.4.3.2.2 (1).		
<p>11.4.3.2.2 Validation Testbeds (6) Data Content Fidelity - A high degree of data content fidelity should be represented. The information and controls presented should be based on an underlying model that accurately reflects the reference plant. The model should provide input to the HSI in a manner such that information accurately matches that which will actually be presented.</p>	Refer to item 11.4.3.2.2 (1).		

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<p>11.4.3.2.2 Validation Testbeds (7) Data Dynamics Fidelity - A high degree of data dynamics fidelity should be represented. The process model should be capable of providing input to the HSI in a manner such that information flow and control responses occur accurately and in a correct response time; e.g., information should be provided to personnel with the same delays as would occur in the plant.</p>	Refer to item 11.4.3.2.2 (1).		
<p>11.4.3.2.2 Validation Testbeds (8) For important actions at complex HSIs remote from the main control room, where timely and precise human actions are required, the use of a simulation or mockup should be considered to verify that human performance requirements can be achieved. (For less risk-important HAs or where the HSIs are not complex, human performance may be assessed based on analysis such as task analysis rather than simulation.)</p>	Refer to item 11.4.3.2.2 (1).	The Phase 2b verification and validation procedure will specify how complex HSIs remote from the main control room as well as risk important scenarios that are beyond what the simulator can support (e.g., mid loop operations) will be evaluated.	
<p>11.4.3.2.2 Validation Testbeds (9) The testbeds should be verified for conformance to the testbed characteristics identified above before validations are conducted.</p>	Refer to item 11.4.3.2.2 (1).		

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<p>11.4.3.2.3 Plant Personnel (1) Participants in the validation tests should be representative of actual plant personnel who will interact with the HSI, e.g., licensed operators rather than training or engineering personnel.</p>	<p>DCD Ch.18 Section 18.10.2.3 introduces the use of plant personnel. A commitment to meet these criteria is provided in Section 5.10.2.2.4(c), paragraph 1, of the Topical Report MUAP-07007-P (R3) and also specified in MUAP-09019-P (R0) Part 1, Section 8.2.2.3, paragraph 4.</p> <p>Phase 1 a and Phase 1b testing utilized currently licensed and practicing ROs and SROs from Comanche Peak as test participants, that represented a range of ages and experience levels.</p> <p>A description of Phase 1a test participants is provided in MUAP-08014-P (R0), Part 1, Section 3.5.1</p> <p>A description of Phase 1b test participants in provided in MUAP-09019-P (R0) Part 3, Section 4.2.3</p>		
<p>11.4.3.2.3 Plant Personnel (2) To properly account for human variability, a sample of participants should be used. The sample should reflect the characteristics of the population from which the sample is drawn. Those characteristics that are expected to contribute to system performance variation should be specifically identified and the sampling process should provide reasonable assurance that variation along that dimension is included in the validation. Several factors that should be considered in determining representativeness include: license and qualifications, skill/experience, age, and general demographics.</p>	<p>A commitment to meet these criteria is provided in Section 5.10.2.2.4(c), paragraph 2, of the Topical Report MUAP-07007-P (R3).</p> <p>Phase 1 a and Phase 1b testing utilized currently licensed and practicing ROs and SROs from Comanche Peak as test participants, that represented a range of ages and experience levels.</p> <p>A description of Phase 1a test participants is provided in MUAP-08014-P (R0), Part 1, Section 3.5.1</p> <p>A description of Phase 1b test participants in provided in MUAP-09019-P (R0) Part 3, Section 4.2.3</p>		

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<p>11.4.3.2.3 Plant Personnel (3) In selection of personnel, consideration should be given to the assembly of minimum and normal crew configurations, including shift supervisors, reactor operators, shift technical advisors, etc., that will participate in the tests.</p>	<p>A commitment to meet these criteria is provided in Section 5.10.2.2.4(c), paragraph 3, of the Topical Report MUAP-07007-P (R3).</p> <p>Phase 1 a testing utilized 6 minimum (one RO and one SRO crews) and 2 currently standard (two ROs and one SRO crews) crew configurations.</p> <p>A specification of Phase 1a crew configurations is provided in MUAP-09019-P (R0) Part 1, Section 8.1.1, paragraph 3.</p>		
<p>11.4.3.2.3 Plant Personnel (4) To prevent bias in the sample, the following participant characteristics and selection practices should be avoided:</p> <ul style="list-style-type: none"> • participants who are part of the design organization • participants in prior evaluations • participants who are selected for some specific characteristic, such as using crews that are identified as good or experienced. 	<p>A commitment to meet these criteria is provided in Section 5.10.2.2.4(c), last paragraph, of the Topical Report MUAP-07007-P (R3).</p> <p>Phase 1 a and Phase 1b testing utilized currently licensed and practicing ROs and SROs from Comanche Peak as test participants these participants were not part of the design organization, or selected for some specific characteristic. In Phase 1b, 3 of the five test crews had participated in the prior evaluation. This was done intentionally so as to maximize the amount of training and experience that the test participants had with the HSI.</p> <p>A description of Phase 1a test participants is provided in MUAP-08014-P (R0), Part 1, Section 3.5.1</p> <p>A description of Phase 1b test participants in provided in MUAP-09019-P (R0) Part 3, Section 4.2.3</p>		
<p>11.4.3.2.4 Scenario Definition (1) The operational conditions selected for inclusion in the validation tests should be developed in detail so they can be performed on a simulator. The following information should be defined to provide reasonable assurance that important performance dimensions are addressed and to allow scenarios to be accurately</p>	<p>A commitment to meet these criteria is provided in Section 5.10.2.2.4(d) paragraphs 1 and 2 of the Topical Report MUAP-07007-P (R3).</p> <p>The Phase 1a and Phase 1b summary results report provide an illustration of the level of detail that is developed and documented for test scenario definitions. The same scenario definition approach will be used for the US-APWR test scenarios.</p>		

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<p>and consistently presented for repeated trials:</p> <ul style="list-style-type: none"> • description of the scenario and any pertinent "prior history" necessary for personnel to understand the state of the plant upon scenario start-up • specific initial conditions (precise definition provided for plant functions, processes, systems, component conditions and performance parameters, e.g., similar to plant shift turnover) • events (e.g., failures) to occur and their initiating conditions, e.g., time, parameter values, or events • precise definition of workplace factors, such as environmental conditions • task support needs (e.g., procedures and technical specifications) • staffing objectives • communication requirements with remote personnel (e.g., load dispatcher via telephone) • the precise specification of what, when and how data are to be collected and stored (including videotaping requirements, questionnaire and rating scale administrations) • specific criteria for terminating the scenario. 	<ul style="list-style-type: none"> • MUAP-08014-P (R0), Part 1, Section 3.4 • MUAP-08014-P (R0), Part 1, Section 3.12.2 • MUAP-09019-P (R0) Part 3, Section 2.4 • MUAP-09019-P (R0) Part 3, Appendix 8.1 • MUAP-09019-P (R0) Part 3, Appendix 8.3 		
<p>11.4.3.2.4 Scenario Definition (2) Scenarios should have appropriate task fidelity so that realistic task performance will be observed in the tests and so that test results can be generalized to actual operation of the real plant.</p>			

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<p>11.4.3.2.4 Scenario Definition (3) When evaluating performance associated with operations remote from the main control room, the effects on crew performance due to potentially harsh environments (i.e., high radiation) should be realistically simulated (i.e., additional time to don protective clothing and access radiologically controlled areas).</p>	<p>A commitment to meet these criteria is provided in Section 5.10.2.2.4(d) last paragraph of the Topical Report MUAP-07007 (R3).</p>		
<p>11.4.3.2.5 Performance Measurement The review criteria for performance measurement are divided into three sections. Section 11.4.3.2.5.1 addresses the measurement characteristics that effect the quality of the performance measures, Section 11.4.3.2.5.2 addresses the identification and selection of variables to represent measures of performance, and Section 11.4.3.2.5.3 addresses the development of performance criteria.</p>	<p>A commitment to meet these criteria is provided in Section 5.10.2.2.4(e) of the Topical Report MUAP-07007-P (R3).</p> <p>The Phase 1a and Phase 1b test procedures provide a model for the test measures that will be employed in the US-APWR V&V.</p> <p>A results summary report of Phase 1a testing is provided in MUAP-08014-P (R0), Part 1.</p> <p>A results summary report of Phase 1b testing is provided in MUAP-09019-P (R0) Part 3, HSI System Verification and Validation (Phase 1b)</p>		
<p>11.4.3.2.5.1 Measurement Characteristics (1) Performance Measurement Characteristics - Performance measures should acceptably exhibit the following measurement characteristics to provide reasonable assurance that the measures are of good quality (it should be noted that some of the characteristics identified below may not apply to every performance measure):</p> <ul style="list-style-type: none"> • Construct Validity - A measure should 	<p>MUAP-07007-P (R3), section 5.10.2.2.4, page 155, describes the test measures applied to the ongoing Phase 1 V&V testing and that will be used in the Phase 2b V&V.</p> <p>As explained in MUAP-08014-P (R0), Part 1, Section 3.2 MHI uses converging measures logic to assure that multiple, objective and subjective performance measures collected, are, in combination, providing valid results – i.e., are satisfying the performance measures criteria specified in NUREG 0711, Section 11.4.3.2.5.1.</p> <p>MHI will use the same set of performance measures in the US-APWR integrated validation as has been used in Phase 1a and Phase 1b</p>		

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<p>accurately represent the aspect of performance to be measured.</p> <ul style="list-style-type: none"> • Diagnosticity - A measure should provide information that can be used to identify the cause of acceptable or unacceptable performance. • Impartiality - A measure should be equally capable of reflecting good as well as bad performance. • Objectivity - A measure should be based on phenomena that are easily observed. • Reliability - A measure should be repeatable; i.e., if the same behavior is measured in exactly the same way under identical circumstances, the same measurement result should be obtained. • Resolution - A measure should reflect the performance at an appropriate level of resolution, i.e., with sufficient detail to permit a meaningful analysis. • Sensitivity - A measure's range (scale) and the frequency of measurement (how often data are collected) should be appropriate to the aspect of performance being assessed. • Simplicity - A measure should be simple both from the standpoint of executing the tests and from the standpoint of communicating and comprehending the meaning of the measures. • Unintrusiveness - A measure should not significantly alter the psychological or physical processes that are being investigated. 	<p>testing. The results of the Phase 1a and Phase 1b tests, illustrate that the measures have construct validity (surface validity and convergence), are diagnostic, objective, reliable, simple, unintrusive, and with enough resolution and sensitivity to be diagnostic – particularly when used in combination following the convergent measures logic.</p> <p>A description and rationale of the performance measures is provided in MUAP-08014-P (R0), Part 1, Section 3.9.</p> <p>Copies of the actual forms used in the Phase 1a test are provided in MUAP-08014-P (R0), Part 1, Section 7, appendix A and B. These forms provide a concrete illustration of the performance measures that will be used in the US-APWR integrated validation test.</p>		

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<p>11.4.3.2.5.2 Performance Measure Selection (1) A hierarchal set of performance measures should be used which includes measures of the performance of the plant and personnel (i.e., personnel tasks, situation awareness, cognitive workload, and anthropometric/physiological factors). Some of these measures could be used as "pass/fail" criteria for validation and the others to better understand personnel performance and to facilitate the analysis of performance errors. The applicant should identify which are in each category.</p>	<p>A commitment to meet these criteria is provided in Section 5.10.2.2.4(e) first paragraph of the Topical Report MUAP-07007-P (R3). Phase 1a and Phase 1b included measures of performance of the plant and personnel, including measures of objective personnel performance, situation awareness, mental workload, and anthropometric/physiological factors. A description and rationale of the performance measures is provided in MUAP-08014-P (R0), Part 1, Section 3.9. Copies of the actual forms used in the Phase 1a test are provided in MUAP-08014-P (R0), Part 1, Section 7, appendix A and B. These forms provide a concrete illustration of the performance measures that will be used in the US-APWR integrated validation test.</p>		
<p>11.4.3.2.5.2 Performance Measure Selection (2) Plant Performance Measurement - Plant performance measures representing functions, systems, components, and HSI use should be obtained.</p>	<p>A commitment to meet these criteria is provided in section 5.10.2.2.4(e) of the Topical Report MUAP-07007-P (R3). Phase 1a and Phase 1b tests included objective plant performance measures. A description of the objective plant performance measures collected is provided in MUAP-08014-P (R0), Part 1, Section 7, appendix C.</p>		
<p>11.4.3.2.5.2 Performance Measure Selection (3) Personnel Task Measurement - For each specific scenario, the tasks that personnel are required to perform should be identified and assessed. Two types of personnel tasks should be measured: primary (e.g., start a pump), and secondary (e.g., access the pump status display). Primary tasks are those involved in performing the functional role of the operator to supervise the plant; i.e., monitoring, detection, situation</p>	<p>A commitment to meet these criteria is provided in section 5.10.2.2.4(e) of the Topical report MUAP-07007-P (R3). Phase 1a and Phase 1b tests collected personnel task measures that were specific to each scenario. Two converging measures were used: recordings of operator performance made by expert observers during the scenarios and measures extracted from the plant simulator. A description of the expert observer forms and how they were used is provided in MUAP-08014-P (R0), Part 1, Section 3.9.6.7 A description of the objective plant performance measures collected is provided in MUAP-08014-P (R0), Part 1, Section 7, appendix C.</p>		

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<p>assessment, response planning, and response implementation. Secondary tasks are those personnel must perform when interfacing with the plant, but which are not directed to the primary task, such as navigation and HSI configuration. This analysis should be used for the identification of potential errors of omission.</p> <ul style="list-style-type: none"> • Primary tasks should be assessed at a level of detail appropriate to the task demands. For example, for some simple scenarios, measuring the time to complete a task may be sufficient. For more complicated tasks, especially those that may be described as knowledge-based, it may be appropriate to perform a more fine-grained analysis such as identifying task components: seeking specific data, making decisions, taking actions, and obtaining feedback. Tasks that are important to successful integrated system performance and are knowledge-based should be measured in a more fine-grained approach. • The measurement of secondary tasks should reflect the demands of the detailed HSI implementation, e.g., time to configure a workstation, navigate between displays, and manipulate displays (e.g., changing display type and setting scale). • The tasks that are actually performed by personnel during simulated scenarios should be identified and quantified. (Note that the actual tasks may be somewhat 			

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different from those that should be performed). Analysis of tasks performed should be used for the identification of errors of commission.			
<p>11.4.3.2.5.2 Performance Measure Selection (3) continued</p> <ul style="list-style-type: none"> • The measures used to quantify tasks should be chosen to reflect the important aspects of the task with respect to system performance, such as: - time - accuracy - frequency - errors (omission and commission) - amount achieved or accomplished - consumption or quantity used - subjective reports of participants - behavior categorization by observers 	<p>A commitment to meet these criteria is provided in Section 5.10.2.2.4(e) second bullet of the Topical Report MUAP-07007-P (R3).</p> <p>The performance measures used in Phase 1a and Phase 1b included time, accuracy, errors (omission and commission), subjective reports of participants and behavior categorization by observers.</p> <p>A description and rationale of the performance measures is provided in MUAP-08014-P (R0), Part 1, Section 3.9.</p> <p>Copies of the actual forms used in the Phase 1a test are provided in MUAP-08014-P (R0), Part 1, Section 7, appendix A and B. These forms provide a concrete illustration of the performance measures that will be used in the US-APWR integrated validation test.</p>		
<p>11.4.3.2.5.2 Performance Measure Selection (4) Situation Awareness - Personnel situation awareness should be assessed. The approach to situation awareness measurement should reflect the current state-of-the-art.</p>	<p>A commitment to meet these criteria is provided in section 5.10.2.2.4(e) of the Topical report, MUAP-07007-P (R3). Refer to page 159 for a detailed discussion of Situation Awareness testing.</p> <p>Phase 1a and Phase 1b used multiple, converging measures of situation awareness including objective and operator subjective measures of situation awareness. Objective measures of situation awareness were obtained by inserting specific events into simulator scenarios (e.g., equipment malfunctions, systems placed in manual that should be in automatic) and recording whether operators were able to detect them. This was recorded by the expert observers on the expert observer forms.</p> <p>Operator subjective measures of situation awareness were obtained via Likert rating scale questions that were included in questionnaires that operators were asked to fill out, following each simulator scenario.</p>		

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	<p>A description of the likert rating scale subjective measure of operator situation awareness is provided in MUAP-08014-P (R0), Part 1, Section 3.9.6.3.</p> <p>A description of the post scenario observer form that was used to document objective measures of problems in situation awareness is provided in MUAP-08014-P (R0), Part 1, Section 3.9.6.9.</p> <p>Copies of the actual forms used in the Phase 1a test are provided in MUAP-08014-P (R0), Part 1, Section 7, appendix A and B. These forms provide a concrete illustration of the performance measures that will be used in the US-APWR integrated validation test.</p>		
<p>11.4.3.2.5.2 Performance Measure Selection (5) Cognitive Workload - Personnel workload should be assessed. The approach to workload measurement should reflect the current state-of-the-art.</p>	<p>A commitment to meet these criteria is provided in section 5.10.2.2.4(e) forth bullet of the Topical report MUAP-07007-P (R3). Phase 1a and Phase 1b used multiple, converging measures of cognitive workload including operator subjective measures of their mental and physical workload, and expert observer assessment of operator workload.</p> <p>Operator subjective measures of workload were obtained via Likert rating scale questions that were included in questionnaires that operators were asked to fill out, following each simulator scenario. A description the likert rating scale subjective measure of workload is provided in MUAP-08014-P (R0), Part 1, Section 3.9.6.3.</p> <p>A description of the post scenario observer form that was used to document expert observer assessment of excessive workload is provided in MUAP-08014-P (R0), Part 1, Section 3.9.6.9.</p> <p>Copies of the actual forms used in the Phase 1a test are provided in MUAP-08014-P (R0), Part 1, Section 7, appendix A and B. These forms provide a concrete illustration of the performance measures that will be used in the US-APWR integrated validation test.</p>		

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<p>11.4.3.2.5.2 Performance Measure Selection (6) Anthropometric and Physiological Factors - Anthropometric and physiological factors include such concerns as visibility of indications, accessibility of control devices, and ease of control device manipulation that should be measured where appropriate. Attention should be focused on those aspects of the design that can only be addressed during testing of the integrated system, e.g., the ability of personnel to effectively use the various controls, displays, workstations, or consoles in an integrated manner.</p>	<p>Anthropometric and physiological factors such as visibility of indication, accessibility of control devices, and ease of control device manipulation were assessed during Phase 1a and 1b testing in multiple ways. This included likert rating scale questions provided on the final operator feedback form, blank space provided on the final operator feedback form for entering anthropometric HEDs, and an explicitly question soliciting any anthropometric concerns during the final verbal debrief.</p> <p>A description the final operator feedback form is provided in MUAP-08014-P (R0), Part 1, Section 3.9.6.4.</p> <p>A description the final verbal debrief checklist provided in MUAP-08014-P (R0), Part 1, Section 3.9.6.6.</p> <p>Copies of the actual forms used in the Phase 1a test are provided in MUAP-08014-P (R0), Part 1, Section 7, appendix A and B. These forms provide a concrete illustration of the performance measures that will be used in the US-APWR integrated validation test.</p>		
<p>11.4.3.2.5.3 Performance Criteria (1) Criteria should be established for the performance measures used in the evaluations. The specific criteria that are used for decisions as to whether the design is validated or not should be specified and distinguished from those being used to better understand the results.</p>	<p>The Phase 1a and Phase 1b summary results report provide an illustration of development of acceptance criteria. Two types of acceptance criteria were developed: acceptance criteria for operator subjective feedback provided via likert-rating scale questions and acceptance criteria for objective operator performance. The same approach to acceptance criteria definition will be used for the US-APWR integrated validation.</p> <ul style="list-style-type: none"> • MUAP-08014-P (R0), Part 1, Section 3.11.1 • MUAP-08014-P (R0), Part 1, Section 3.13.2.2, par. 1 • MUAP-08014-P (R0), Part 1, Section 3.13.2.2, appendix C • MUAP-09019-P (R0) Part 3, Appendix 8.4 		

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<p>11.4.3.2.5.3 Performance Criteria (2) The basis for criteria should be defined, e.g., requirement-referenced, benchmark referenced, normative referenced, and expert-judgment referenced.</p>		A description of the performance criteria and their basis will be included in the Phase 2b verification and validation procedure.	
<p>11.4.3.2.6 Test Design The review criteria for test design are divided into five sections. Section 11.4.3.2.6.1 addresses coupling crews and scenarios, Section 11.4.3.2.6.2 addresses test procedures, Section 11.4.3.2.6.3 addresses the training of test conductors, Section 11.4.3.2.6.4 addresses the training of test participants, and Section 11.4.3.2.6.5 addresses the conduct of pilot studies.</p>	<p>MUAP-07007-P (R3) section 5.10.2.2.4 describes the test design used in Phase 1. A commitment to meet the criteria specified in NUREG-0711, Rev. 2, 11.4.3.2.6 is provided Section 5.10.2.2.4(f) of the Topical Report MUAP-07007-P (R3).</p>		
<p>11.4.3.2.6.1 Coupling Crews and Scenarios (1) Scenario Assignment - Important characteristics of scenarios should be balanced across crews. Random assignment of scenarios to crews is not recommended. The value of using random assignment to control bias is only effective when the number of crews is quite large. Instead, the validation team should attempt to provide each crew with a similar and representative range of scenarios.</p>	<p>A commitment to meet the criteria specified in NUREG-0711, Rev. 2, 11.4.3.2.6.1 is provided in Section 5.10.2.2.4(f), first paragraph of the topical report MUAP-07007-P (R3). In the Phase 1a and 1b tests this criterion was met by presenting all of the scenarios to all of the crews.</p> <ul style="list-style-type: none"> • MUAP-08014-P (R0), Part 1, Section 3.12 • MUAP-09019-P (R0) Part 3, Section 4.2 <p>In the final, plant-specific US-APWR integrated validation it may be necessary to meet the 11.4.3.2.6.1 criteria using a different approach.</p>	<p>A description of crews to scenario coupling and scenario sequencing will be included in the Phase 2b verification and validation procedure.</p>	

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<p>11.4.3.2.6.1 Coupling Crews and Scenarios (2) Scenario Sequencing - The order of presentation of scenario types to crews should be carefully balanced to provide reasonable assurance that the same types of scenarios are not always being presented in the same linear position, e.g., the easy scenarios are not always presented first.</p>	<p>A commitment to meet the criteria is provided in Section 5.10.2.2.4(f), second paragraph of the topical report MUAP-07007-P (R3).</p> <p>In the Phase 1a and 1b tests the order of scenarios was the same for all crews.</p> <ul style="list-style-type: none"> • MUAP-08014-P (R0), Part 1, Section 3.12. • MUAP-09019-P (R0) Part 3, Section 4.2 <p>In the final, plant-specific US-APWR integrated validation the order of presentation of scenarios will be varied across crews so as to meet 11.4.3.2.6.1 criteria.</p>		
<p>11.4.3.2.6.2 Test Procedures (1) Detailed, clear, and objective procedures should be available to govern the conduct of the tests. These procedures should include:</p> <ul style="list-style-type: none"> • The identification of which crews receive which scenarios and the order that the scenarios should be presented. • Detailed and standardized instructions for briefing the participants. The type of instructions given to participants can affect their performance on a task. This source of bias can be minimized by developing standard instructions. • Specific criteria for the conduct of specific scenarios, such as when to start and stop scenarios, when events such as faults are introduced, and other information discussed in Section 11.4.3.2.4, Scenario Definition. • Scripted responses for test personnel who will be acting as plant personnel during test scenarios. To the greatest extent possible, responses to communications from operator 	<p>A commitment to meet this criterion is provided in Section 5.10.2.2.4(f), paragraph 3 of the topical report MUAP-07007-P (R3).</p> <p>In the Phase 1a and 1b testing detailed, clear, and objective procedures were available to govern the conduct of the tests. This was accomplished via a detailed test schedule description, detailed scenario descriptions, detailed data collection forms and detailed written guidelines for conducting debriefings.</p> <ul style="list-style-type: none"> • MUAP-08014-P (R0), Part 1, Section 3.12.1 • MUAP-09019-P (R0) Part 3, Section 4.2 		

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<p>participants to test personnel (serving as surrogate for personnel outside the control room personnel) should be prepared. There are limits to the ability to preplan communications since personnel may ask questions or make requests that were not anticipated. However, efforts should be made to detail what information personnel outside the control room can provide, and script the responses to likely questions.</p> <ul style="list-style-type: none"> • Guidance on when and how to interact with participants when simulator or testing difficulties occur. Even when a high-fidelity simulator is used, the participants may encounter artifacts of the test environment that detract from the performance for tasks that are the focus of the evaluation. Guidance should be available to the test conductors to help resolve such conditions. 			
<p>11.4.3.2.6.2 Test Procedures (1) continued</p> <ul style="list-style-type: none"> • Instructions regarding when and how to collect and store data. These instructions should identify which data are to be recorded by: <ul style="list-style-type: none"> - simulation computers - special purpose data collection devices (such as situation awareness data collection, workload measurement, or physiological measures) - video recorders (locations and views) - test personnel (such as observation checklists) - subjective rating scales and 	<p>A commitment to meet this criterion is provided in Section 5.10.2.2.4(f), paragraph 3 of the topical report MUAP-07007-P (R3).</p> <p>In the Phase 1a and 1b testing detailed, clear, and objective procedures were available to govern the conduct of the tests. This was accomplished via a detailed test schedule description, detailed scenario descriptions, detailed data collection forms and detailed written guidelines for conducting debriefings.</p> <ul style="list-style-type: none"> • MUAP-08014-P (R0), Part 1, Section 3.12.1 • MUAP-09019-P (R0) Part 3, Section 4.2 		

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<p>questionnaires.</p> <ul style="list-style-type: none"> Procedures for documentation, i.e., identifying and maintaining test record files including crew and scenario details, data collected, and test conductor logs. These instructions should detail the types of information that should be logged (e.g., when tests were performed, deviations from test procedures, and any unusual events that may be of importance to understanding how a test was run or interpreting test results) and when it should be recorded. 			
<p>11.4.3.2.6.2 Test Procedures (2) Where possible, test procedures should minimize the opportunity of tester expectancy bias or participant response bias.</p>	<p>A commitment to meet this criterion is provided in Section 5.10.2.2.4(f), paragraph 3 of the topical report MUAP-07007-P (R3).</p>		
<p>11.4.3.2.6.3 Test Personnel Training (1) Test administration personnel should receive training on:</p> <ul style="list-style-type: none"> the use and importance of test procedures experimenter bias and the types of errors that may be introduced into test data through the failure of test conductors to accurately follow test procedures or interact properly with participants the importance of accurately documenting problems that arise in the course of testing, even if due to test conductor oversight or error. 	<p>A commitment to meet this criterion is provided in Section 5.10.2.2.4(f), paragraph 4 of the topical report, MUAP-07007-P (R3). Refer to pages 94 and 95 for a description of the V&V team and its training as applied to Phase 1 V&V testing.</p> <p>In Phase 1a and Phase 1b test administration personnel underwent training in the test procedure and test data collection forms and their use.</p> <ul style="list-style-type: none"> MUAP-08014-P (R0), Part 1, Section 3.8 		

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<p>11.4.3.2.6.4 Participant Training (1) Participant training should be of high fidelity; i.e., highly similar to that which plant personnel will receive in an actual plant. The participants should be trained to provide reasonable assurance that their knowledge of plant design, plant operations, and use of the HSIs and procedures is representative of experienced plant personnel. Participants should not be trained specifically to perform the validation scenarios.</p>	<p>Section 18.10.2.3 of the DCD introduces test personnel training. A commitment to meet this criterion is provided in Section 5.10.2.2.4(f), paragraph 5 of the topical report MUAP-07007-P (R3).</p> <p>In the Phase 1a and Phase 1b testing, the operator crews received in-depth training on the plant simulation and HSI that was not specifically limited to the requirements validation scenarios.</p> <ul style="list-style-type: none"> • MUAP-08014-P (R0), Part 1, Section 3.6 • MUAP-09019-P (R0) Part 3, Section 4.2.3, paragraph. 2 and 3 		
<p>11.4.3.2.6.4 Participant Training (2) Participants should be trained to near asymptotic performance (i.e., stable, not significantly changing from trial to trial) and tested prior to conducting actual validation trials. Performance criteria should be similar to that which will be applied to actual plant personnel.</p>	<p>A commitment to meet this criterion is provided in Section 5.10.2.2.4(f), paragraph 6 of the topical report MUAP-07007-P (R3).</p>	<p>A description for participant training for the US-APWR V&V will be included in the Phase 2b verification and validation procedure.</p>	
<p>11.4.3.2.6.5 Pilot Testing (1) A pilot study should be conducted prior to conducting the integrated validation tests to provide an opportunity to assess the adequacy of the test design, performance measures, and data collection methods.</p>	<p>There is no documentation of a commitment to meet this criterion in the Topical Report MUAP-07007-P (R3).</p> <p>A pilot study was conducted prior to Phase 1b testing but is not documented in MUAP-09019-P (R0) Part 3</p>	<p>Pilot testing for the US-APWR V&V will be included in the Phase 2b verification and validation procedure.</p>	

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<p>11.4.3.2.6.5 Pilot Testing (2) If possible, participants who will operate the integrated system in the validation tests should not be used in the pilot study. If the pilot study must be conducted using the validation test participants, then:</p> <ul style="list-style-type: none"> • the scenarios used for the pilot study should be different from those used in the validation tests, and • care should be given to provide reasonable assurance that the participants do not become so familiar with the data collection process that it may result in response bias. 			
<p>11.4.3.2.7 Data Analysis and Interpretation (1) Validation test data should be analyzed through a combination of quantitative and qualitative methods. The relationship between observed performance data and the established performance criteria should be clearly established and justified based upon the analyses performed.</p>	<p>A commitment to meet this criterion is provided in Section 5.10.2.2.4(g), first paragraph of the topical report MUAP-07007-P (R3). The Phase 1a and Phase 1b summary results reports illustrate the MHI approach to data analysis and interpretation that combines quantitative and qualitative methods.</p> <ul style="list-style-type: none"> • MUAP-08014-P (R0), Part 1, Section 3.10 • MUAP-08014-P (R0), Part 1, Section 3.13 • MUAP-09019-P (R0) Part 3, Section 5 	<p>The full Phase 1 test report will describe in detail the qualitative and quantitative data analysis applied in the testing to date. This approach will be also applied in the Phase 2b V&V program.</p>	
<p>11.4.3.2.7 Data Analysis and Interpretation (2) For performance measures used as pass/fail indicators, failed indicators must be resolved before the design can be validated. Where performance does not meet criteria for the other performance measures, the results should be evaluated using the HED evaluation process.</p>	<p>A commitment to meet this criterion is provided in Section 5.10.2.2.4(g), paragraph 2 of the topical report MUAP-07007-P (R3). A description of the Human Engineering Discrepancy Process is provided in MUAP-09019-P (R0) Part 1, Sections 6 and 7.</p>		

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<p>11.4.3.2.7 Data Analysis and Interpretation (3) The degree of convergent validity should be evaluated, i.e., the convergence or consistency of the measures of performance.</p>	<p>A commitment to meet this criterion is provided in Section 5.10.2.2.4(g), paragraph 3 of the topical report MUAP-07007-P (R3). The Phase 1a and Phase 1b summary results reports illustrate the MHI approach to applying converging methods logic.</p> <ul style="list-style-type: none"> • MUAP-08014-P (R0), Part 1, Section 3.2 • MUAP-08014-P (R0), Part 1, Section 3.10.6 • MUAP-09019-P (R0) Part 3, Section 4.2.5 • MUAP-09019-P (R0) Part 3, Section 5.1 		
<p>11.4.3.2.7 Data Analysis and Interpretation (4) The data analyses should be independently verified for correctness of analysis.</p>	<p>A commitment to meet this criterion is provided in Section 5.10.2.2.4(g), paragraph 4 of the topical report MUAP-07007-P (R3).</p>	<p>The process by which the data analysis will be independently verified for correctness of analysis for the US-APWR V&V will be included in the Phase 2b verification and validation procedure.</p>	

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<p>11.4.3.2.7 Data Analysis and Interpretation (5) The inference from observed performance to estimated real-world performance should allow for margin of error; i.e., some allowance should be made to reflect the fact that actual performance may be slightly more variable than observed validation test performance.</p>	<p>A commitment to meet this criterion is provided in Section 5.10.2.2.4(g), paragraph 5 of the topical report MUAP-07007-P (R3).</p>	<p>The process by which the inference from observed performance to estimated real-world performance will allow for margin of error will be included in the Phase 2b verification and validation procedure.</p>	
<p>11.4.3.2.8 Validation Conclusions (1) The statistical and logical bases for determining that performance of the integrated system is and will be acceptable should be clearly documented.</p>	<p>A commitment to meet this criterion is provided in Section 5.10.2.2.4(h), paragraph 1 of the topical report MUAP-07007-P (R3).</p>	<p>The logic and statistical basis we will use to establish that performance of the integrated system is acceptable for the US-APWR V&V will be included in the Phase 2b verification and validation procedure.</p>	

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<p>11.4.3.2.8 Validation Conclusions (2) Validation limitations should be considered in terms of identifying their possible effects on validation conclusions and impact on design implementation. These include:</p> <ul style="list-style-type: none"> • aspects of the tests that were not well controlled • potential differences between the test situation and actual operations, such as absence of productivity-safety conflicts • potential differences between the validated design and plant as built (if validation is directed to an actual plant under construction where such information is available or a new design using validation results of a predecessor) 	<p>A commitment to meet this criterion is provided in Section 5.10.2.2.4(h), paragraph 2 of the topical report MUAP-07007-P (R3).</p>	<p>The reasoning or bases that justify the results, analyses, and conclusion that will explicitly consider the validation test limitations and their possible effects on validation conclusions will be included in the US-APWR V&V will be included in the Phase 2b verification and validation procedure.</p>	
<p>11.4.4 Human Engineering Discrepancy Resolution HED Resolution is an activity that can be performed iteratively with V&V. That is, the applicant may integrate these activities so that issues identified during a V&V activity are addressed and resolved prior to conducting other V&V activities. The purpose of the staff's review of the HED Resolution is to verify that the applicant has adequately completed the following tasks:</p> <ul style="list-style-type: none"> • evaluated HEDs to determine the need for their correction • identified design solutions to address significant HEDs 	<p>Section 18.10.2.3 of the DCD Ch.18 introduces the HED resolution process.</p> <p>A commitment to meet this criterion is provided in Section 5.10.2.2.5 of the topical report MUAP-07007-P (R3).</p> <p>A description of the Human Engineering Discrepancy Process is provided in MUAP-09019-P (R0) Part 1, Sections 6 and 7.</p> <p>A description of the process for HED resolution and HED closure is provided in MUAP-09019-P (R0) Part 1, Section 6.5 and 6.6.</p>		

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<p>• verified the implementation of the design solutions resolving HEDs. HEDs should not be considered in isolation and, to the extent possible, their potential interactions should be considered when developing and implementing solutions. For example, if the HSI for a single plant system is associated with many HEDs, then the set of design solutions should be coordinated to enhance overall performance and avoid incompatibilities between individual solutions. Approaches that develop design solutions to some HEDs before all have been identified from a particular verification or validation activity are acceptable provided that the potential interactions between HEDs are specifically considered prior to implementing the design solutions.</p>			

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<p>11.4.4.1 Human Engineering Discrepancy Resolution Review Objective</p> <p>The objectives of the review are to verify that:</p> <ul style="list-style-type: none"> • The applicant's HED evaluation acceptably prioritizes HEDs in terms of their need for improvement. (An HED evaluation is required only if the applicant does not plan to correct all HEDs. If all HEDs are to be corrected, design improvements should be identified, see Review Criteria 4 to 6 below). • The applicant develops design solutions and a realistic schedule for implementation to address those HEDs selected for correction. 	<p>A description of the process for HED evaluation is provided in MUAP-09019-P (R0) Part 1, Section 6.3.</p> <p>A description of the process for HED significance categories is provided in MUAP-09019-P (R0) Part 1, Section 6.4</p>		
<p>11.4.4.2 Human Engineering Discrepancy Resolution Review Criteria</p> <p>(1) HED Justification - Discrepancies could be acceptable within the context of the fully integrated design. If sufficient justification exists, a deviation from the guidelines may not constitute an HED. The technical basis for such a determination could include an analysis of recent literature or current practices, tradeoff studies, or design engineering evaluations and data. Unjustified discrepancies should be identified as HEDs to be addressed by the HED resolution.</p>	<p>A description of the process for HED Resolution is provided in MUAP-09019-P (R0) Part 1, Section 6.5.</p> <p>Closure criteria 8, which reads, "HED requires no corrective action. The HED can be closed immediately. The HED record shall include the basis for this determination", meets this criterion.</p>		
<p>11.4.4.2 Human Engineering Discrepancy Resolution Review</p>			

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<p>Criteria</p> <p>(2) HED Analysis - The following should be included in the HED evaluations:</p> <ul style="list-style-type: none"> • Plant system - the potential effects of all HEDs relevant to a single plant system should be evaluated. The potential effects of these HEDs on plant safety and personnel performance should be determined, in part, by the safety significance of the plant system(s), their effect on SAR accident analyses, and their relationship to risk significant sequences in the plant PRA. • HED scope <ul style="list-style-type: none"> - Global features HEDs - these are HEDs that relate to configurational and environmental aspects of the design such as lighting, ventilation, and traffic flow. They relate to general human performance issues. - Standardized features HEDs - these are HEDs that relate to design features that are governed by the applicant's design guidelines used across various controls and displays of the HSI (e.g., display screen organization and conventions for format, coding, and labeling). Because a single guideline may be used across many aspects of the design, a single HED could be applicable to many personnel tasks and plant systems. - Detailed features HEDs - these are HEDs that relate to design features that are not standardized, thus their generality has to be assessed. 	<p>A description of the Human Engineering Discrepancy Process is provided in MUAP-09019-P (R0) Part 1, Sections 6 and 7.</p>		

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<p>- Other - this subcategory specifically pertains to HEDs identified from integrated system validation that cannot be easily assigned to any of the three preceding categories.</p> <ul style="list-style-type: none"> • Individual HSI or procedure - HEDs should be analyzed with respect to individual HSIs and procedures. The potential effects of these HEDs on plant safety and personnel performance are determined, in part, by the safety significance of the plant system(s) that are related to the particular component. 			
<p>11.4.4.2 Human Engineering Discrepancy Resolution Review Criteria (2) continued</p> <ul style="list-style-type: none"> • Personnel function - HEDs should be analyzed with respect to individual personnel functions. The potential effects of these HEDs is determined, in part, by the importance of the personnel function to plant safety (e.g., consequences of failure) and their cumulative effect on personnel performance (e.g., degree of impairment and types of potential errors). HEDs should also be analyzed with respect to the cumulative effects of multiple HEDs on plant safety and personnel performance. While an individual HED might not be considered sufficiently severe to require correction, the combined effect of several HEDs upon the single aspect of the design could have significant consequences to plant safety 			

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<p>and, therefore, necessitate corrective action. Likewise, when a single plant system is associated with multiple HEDs that affect a number of HSI components, then their possible combined effect on the operation of that plant system should be considered</p> <p>In addition to addressing the specific HEDs, the analysis should treat the HEDs as indications of potentially broader problems. For example, identifying multiple HEDs associated with one particular aspect of the HSI design, such as the remote shutdown panel, could also indicate that there are other problems with that aspect of the design, such as inconsistent use of procedures and standards. In some cases, the evaluation of HEDs could warrant further review in the identified areas of concern.</p>			
<p>11.4.4.2 Human Engineering Discrepancy Resolution Review Criteria</p> <p>(3) HED Prioritization - Identification of HEDs for correction should be based upon a systematic evaluation, such as that illustrated in Figure 11.2. Priority 1 HEDs should be those with direct safety consequences and those with indirect or potential safety consequences. HEDs with significant safety consequences are those that affect personnel performance where the consequences of error could reduce the margin of plant safety below an acceptable level, as indicated by such</p>	<p>A description of the HED significance categories used by MHI and how they relate to the NRC three-level HED prioritization is provided in MUAP-09019-P (R0) Part 1, Section 6.4.</p>		

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<p>conditions as violations of Technical Specification safety limits, operating limits, or limiting conditions for operations. They include deviations from personnel information requirements or HFE guidelines for personnel tasks that are related to plant safety. These could include the following:</p> <ul style="list-style-type: none"> • are required by personnel tasks but are not provided by the HSI • do not satisfy all personnel information needs (e.g., information not presented with the proper range or precision) • contain deviations from HFE guidelines that are likely to lead to errors that would prevent personnel from performing the task. <p>HEDs with indirect safety consequences include deviations from HFE guidelines that would seriously affect the ability of personnel to perform the task. The severity of an HFE guideline deviation should be assessed in terms of the degree to which it contributes to human performance problems, such as workload and information overload.</p> <p>Priority 2 HEDs should be those that do not have significant safety consequences, but do have potential consequences to plant performance/operability, non-safety-related personnel performance/efficiency, or other factors affecting overall plant operability. These include deviations from personnel information requirements and HFE</p>			

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guidelines for tasks associated with plant productivity, availability, and protection of investment. These HEDs should be considered for correction.			
<p>11.4.4.2 Human Engineering Discrepancy Resolution Review Criteria (3) continued The remaining HEDs are those that do not satisfy the criteria associated with the first and second priorities. Resolution of these HEDs is not an NRC safety concern but may be resolved at the discretion of the applicant.</p>			
<p>11.4.4.2 Human Engineering Discrepancy Resolution Review Criteria (4) HED Evaluation Documentation - Each HED should be fully documented including assessment category (priority for correction), associated plant system, associated personnel function, and associated HSI or procedure. The documentation should clearly show whether the HED was dismissed or identified as needing design modification, and the basis for this determination in terms of consequence to plant safety or operation should be clearly described.</p>	HEDs and HED evaluations are documented and stored in an HED database. A description of the HED database and the work flow process for entering HEDs, and documenting the results of HED evaluation, resolution, and closure is provided in MUAP-09019-P (R0) Part 1, Section 7		
<p>11.4.4.2 Human Engineering Discrepancy Resolution Review Criteria (5) Development of Design Solutions - Design solutions to correct HEDs should be identified. The design solutions should</p>	A description of the Human Engineering Discrepancy Process is provided in MUAP-09019-P (R0) Part 1, Sections 6 and 7. This includes a request for design changes. The design changes are then subjected to additional V&V activities.		

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<p>be consistent with system and personnel requirements identified in the Preparatory Analysis (i.e., Operating Experience Review, Function and Task Analysis, and HSI Characterization). Inter-relationships of individual HEDs should be evaluated. For example, if a single HSI component is associated with multiple HEDs, then design solutions should be considered to address these HEDs together. If a single plant system is associated with multiple HSI components that are associated with HEDs, then the design of the individual solutions should be coordinated so that their combined effect enhances rather than detracts from that system's operation.</p>			

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<p>11.4.4.2 Human Engineering Discrepancy Resolution Review Criteria (6) Design Solution Evaluation - Designs should be evaluated by repeating the appropriate analyses of the verification and validation. For example, the HSI Task Support Verification should be conducted to provide reasonable assurance that the design satisfies personnel task requirements. Portions of the HFE design verification analysis should be conducted to provide reasonable assurance that the design is consistent with HFE guidelines, and integrated system validation could be conducted to evaluate its usability. When the problems identified by an HED cannot be fully corrected, justification should be given.</p>			
<p>11.4.4.2 Human Engineering Discrepancy Resolution Review Criteria (7) Design Modification - There should be an implementation schedule for activities associated with installing, testing, and HFE evaluation of the design solutions. All design solutions for Priority 1 HEDs should be scheduled for prompt implementation. The schedule should be developed to minimize demands and disruptions for personnel. For operating plants, the schedule should distinguish between solutions that can be implemented without interfering with the operation of the plant, and improvements</p>			

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that can only be made when the plant is not operating. Installing large groups of design solutions at discrete intervals should be considered to avoid subjecting operating crews to a continually changing HSI. Procedures should be established to provide reasonable assurance that information related to the design of the HSI such as plant procedures, drawings, and training programs is updated to reflect the changes.			

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<p>12.3 Applicant Submittals As per Section 1.2.1, item (3) Applicant Submittals, the applicant should provide for staff review an implementation plan for design implementation. Upon completion of the applicant's efforts, a results summary report should be submitted so that the staff can review the applicant's design implementation using the criteria provided in Section 12.4 below.</p>	<p>Section 18.11 of the DCD Ch.18 and Section 5.11 of the topical report MUAP-07007-P (R3) provide the design implementation plan. Part1 of the technical report MUAP-09019-P (R0) provides the HFE implementation overall procedure.</p>		
<p>12.4 Review Criteria The first five sections of review criteria are for the review of plant modifications only. Section 12.4.6, Final Plant HFE Design Verification, applies to both new and modified plant designs.</p>	<p>Only 12.4.6 is applied in this compliance Road map.</p>		
<p>12.4.1 General Criteria (1) The applicant should provide reasonable assurance that the reactor fuel is safely monitored during the shutdown time period while the physical modifications are being implemented in the control room.</p>	<p>N.A.</p>	<p>If upgrades to existing plant HSIs are planned based upon this Design Certification, a discussion as to how MHI plans to address the criteria will be provided.</p>	
<p>12.4.1 General Criteria (2) Operations and maintenance crews should be fully trained and qualified to operate and maintain the plant with respect to all modifications prior to starting-up with the new systems and HSIs in place.</p>	<p>N.A.</p>	<p>See 12.4.1(1)</p>	
<p>12.4.1 General Criteria (3) Modifications in plant procedures and training should reflect changes in plant systems, crew roles and responsibilities, HSIs, and procedures resulting from the new systems and HSIs should be in place prior to startup.</p>	<p>N.A.</p>	<p>See 12.4.1(1)</p>	

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<p>12.4.1 General Criteria (4) The applicant should have a plan in place to monitor the initial phase of startup to provide reasonable assurance that:</p> <ul style="list-style-type: none"> • operational and maintenance problems that arise with personnel interactions with the new systems, HSIs, and procedures are identified and addressed • personnel are sufficiently familiar with the new systems, HSIs, and procedures to support safe operations and maintenance • any negative transfer of training from the old removed HSIs to the corresponding new HSIs is identified and corrected • no new problems are created based on coordination of tasks between remaining old HSIs and new HSIs • no unanticipated negative effects on crew interaction and teamwork arise 	N.A.	See 12.4.1(1)	
<p>12.4.2 Modernization Programs Consisting of Many Small Modifications (1) Each modification should follow a HFE program that provides reasonable assurance of standardization and consistency (1) between old and new equipment, and (2) across the new systems being implemented.</p>	N.A.	See 12.4.1(1)	
<p>12.4.2 Modernization Programs Consisting of Many Small Modifications (2) The applicant should verify that new modifications fulfill a clear operational need and do not interfere with existing systems. For example, the auditory alerts in a new HSI should not distract operators from addressing more important alarms in the main system.</p>	N.A.	See 12.4.1(1)	

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12.4.3 Modernization Programs Consisting of Large Modifications During Multiple Outages (1) The interim configurations should be carefully defined and evaluated to verify that they are acceptable both from an engineering and operations perspective and meet regulatory requirements. Evaluations should include: • PRA • SAR • Technical specifications • Defense-in-depth	N.A.	See 12.4.1(1)	
12.4.3 Modernization Programs Consisting of Large Modifications During Multiple Outages (2) Task analysis should be performed for each interim configuration to verify that the task demands the are unique to interim configurations are known.	N.A.	See 12.4.1(1)	
12.4.3 Modernization Programs Consisting of Large Modifications During Multiple Outages (3) HRA should address any unique tasks that may impact risk or any changes to existing tasks due to the interim configuration.	N.A.	See 12.4.1(1)	
12.4.3 Modernization Programs Consisting of Large Modifications During Multiple Outages (4) The HSIs needed to perform important tasks should be consistent and standardized. Task performance should not require personnel to use both old and new HSIs for different aspects of the same task. If the underlying I&C modifications necessitate this situation, consideration should be given to creating temporary HSIs specifically designed for such tasks.	N.A.	See 12.4.1(1)	
12.4.3 Modernization Programs Consisting of Large Modifications During Multiple Outages (5) Procedures should be developed for temporary configurations of systems and HSIs that are used by personnel when the plant is not shutdown.	N.A.	See 12.4.1(1)	

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12.4.3 Modernization Programs Consisting of Large Modifications During Multiple Outages (6) Training should be developed for temporary configurations of systems, HSIs, and procedures that are used by personnel when the plant is not shutdown.	N.A.	See 12.4.1(1)	
12.4.3 Modernization Programs Consisting of Large Modifications During Multiple Outages (7) Verification and Validation • HFE Design Verification - Temporary configurations of the systems, HSIs, and procedures, which may be used by operations and maintenance personnel when the plant is not shutdown, should be reviewed to verify that their design is consistent with the principles of good HFE design. • HSI Task-Support Verification - Temporary configurations of the systems, HSIs, and procedures, which may be used by operations and maintenance personnel when the plant is not shutdown, should be reviewed to verify that their design supports the tasks that will be performed. For example, if a temporary configuration of plant systems introduces special monitoring requirements, then the HSIs should provide the necessary information. • Validation should be performed on interim configurations if warranted by the risk-significance of the crew tasks affected by the temporary configuration.	N.A.	See 12.4.1(1)	
12.4.4 Modernization Programs Where Both Old and New Equipment are Left in Place (1) The potential for negative effects on personnel performance due to control room or HSI clutter arising from having both old and new HSIs available in parallel should be evaluated. Where safety concerns are identified, appropriate measures should be taken to improve the HSIs.	N.A.	See 12.4.1(1)	

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<p>12.4.4 Modernization Programs Where Both Old and New Equipment are Left in Place (2) The potential for negative effects on personnel performance due to the simultaneous presence of parallel alarm systems should be evaluated. Where safety concerns are identified, appropriate measures should be taken to improve the HSIs.</p>	N.A.	See 12.4.1(1)	
<p>12.4.4 Modernization Programs Where Both Old and New Equipment are Left in Place (3) The potential should be evaluated for negative effects on personnel performance due to the differences between information from old and new systems for the same parameter or equipment. Where safety concerns are identified, appropriate measures should be taken to improve the HSIs.</p>	N.A.	See 12.4.1(1)	
<p>12.4.4 Modernization Programs Where Both Old and New Equipment are Left in Place (4) An evaluation should be performed to identify any safety concerns from providing controls from two different HSIs. Where a concern is identified, appropriate measures should be developed to prevent the concern. For example, a switch may be added to select which HSI controls the equipment thus preventing simultaneous control inputs.</p>	N.A.	See 12.4.1(1)	
<p>12.4.5 Modernization Programs Where New Non-Functional HSIs are in Place in Parallel with Old Functional HSIs (1) The potential for negative effects on personnel performance due to control room or HSI clutter arising from having both old and new HSIs available in parallel should be evaluated. Where safety concerns are identified, appropriate measures should be taken to improve the HSIs.</p>	N.A.	See 12.4.1(1)	

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<p>12.4.5 Modernization Programs Where New Non-Functional HSIs are in Place in Parallel with Old Functional HSIs (2) The non-functional state of the HSIs should be clearly indicated.</p>	N.A.	See 12.4.1(1)	
<p>12.4.6 Final Plant HFE Design Verification (1) Aspects of the design that were not addressed in V&V should be evaluated using an appropriate V&V method. Aspects of the design addressed by this criterion may include design characteristics such as new or modified displays for plant-specific design features and features that cannot be evaluated in a simulator such as CR lighting and noise.</p>	<p>DCD Ch.18 Section 18.11.2 addresses that design implementation evaluated using an appropriate V&V method.</p> <p>MUAP-07007-P (R3) Section 5.11 second paragraph ensures that Facility design changes are documented and analyzed for their potential impact on HSIs. Those design implementation issues that negatively impact human performance are identified as HEDs and are tracked and dispositioned. HFE design modifications are documented in a periodic status report.</p>	The plant-specific design is verified during Tier 1 ITAAC phase as described in Tale 2.9-1 item 11 of the DCD Tier 1.	
<p>12.4.6 Final Plant HFE Design Verification (2) The final (as-built in the plant) HSIs, procedures, and training should be compared with the detailed design description to verify that they conform to the design that resulted from the HFE design process and V&V activities. Any identified discrepancies should be corrected or justified.</p>	<p>DCD Ch.18 Section 18.11.2 addresses that design implementation evaluated using an appropriate V&V method.</p> <p>MUAP-07007-P (R3) Section 5.11 ensures that Facility design changes are documented and analyzed for their potential impact on HSIs. Those design implementation issues that negatively impact human performance are identified as HEDs and are tracked and dispositioned. HFE design modifications are documented in a periodic status report.</p>	The plant-specific design is verified during Tier 1 ITAAC phase as described in Tale 2.9-1 item 11 of the DCD Tier 1	

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<p>12.4.6 Final Plant HFE Design Verification (3) All HFE-related issues documented in the issue tracking system should be verified as adequately addressed.</p>	<p>DCD Ch.18 Section 18.11.2 addresses that design implementation evaluated using an appropriate V&V method.</p> <p>MUAP-07007-P (R3) Section 5.11 ensures that Facility design changes are documented and analyzed for their potential impact on HSIs. Those design implementation issues that negatively impact human performance are identified as HEDs and are tracked and dispositioned. HFE design modifications are documented in a periodic status report.</p>	<p>The plant-specific design is verified during Tier 1 ITAAC phase as described in Tale 2.9-1 item 11 of the DCD Tier 1</p>	

13. Human Performance Monitoring

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<p>13.3 Applicant Submittals Submittals for the staff's review of an applicant's human performance monitoring program should be made on a case-by-case basis.</p>	<p>DCD Ch.18 Section 18.12.2 Methodology describes that a human performance monitoring strategy is developed and documented</p> <p>MUAP-07007-P (R3) Figure 4.0-2 Submittal and Audit Plan for the US-APWR Design Certification and 7.0 Future Licensing Submittals shows a overview for the document submittals</p>		
<p>13.4 Review Criteria (1) The scope of the performance monitoring strategy should provide reasonable assurance that:</p> <ul style="list-style-type: none"> • The design can be effectively used by personnel, including within the control room and between the control room and local control stations and support centers. • Changes made to the HSIs, procedures, and training do not have adverse effects on personnel performance, e.g., a change interferes with previously trained skills. • Human actions can be accomplished within time and performance criteria. • The acceptable level of performance established during the integrated system validation is maintained. 	<p>DCD Ch.18 Section 18.12.2 Methodology describes that a human performance monitoring strategy is developed and documented</p> <p>MUAP-07007-P (R3) Section 5.12 second paragraph ensures that no significant safety degradation occurs because of any changes that are made in the plant, including changes to HSI designs, procedures and training, and the third paragraph describes that the plan requires periodic monitoring and documentation of human performance in actual or simulated plant conditions.</p>	<p>The human performance monitoring procedure is verified during Tier 1 ITAAC phase as Tale 2.9-1 item 12.</p>	

13. Human Performance Monitoring

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<p>13.4 Review Criteria</p> <p>(2) A human performance monitoring strategy should be developed and documented. The strategy should be capable of trending human performance after the changes have been implemented to demonstrate that performance is consistent with that assumed in the various analyses that were conducted to justify the change. Applicants may integrate, or coordinate, their performance monitoring for risk-informed changes with existing programs for monitoring personnel performance, such as the licensed operator training program and the corrective action program. If a plant change requires monitoring of actions that are not included in existing training programs, it may be advantageous to adjust the existing training program rather than to develop additional monitoring programs for risk-informed purposes.</p>	<p>DCD Ch.18 Section 18.12.2 Methodology describes that a human performance monitoring strategy is developed and documented and the human performance monitoring procedure is applicable after the completion of integrated HSI validation and operator training.</p> <p>MUAP-07007-P (R3) Section 5.12 third paragraph describes that the plan requires periodic monitoring and documentation of human performance in actual or simulated plant conditions.</p>	<p>The human performance monitoring procedure is verified during Tier 1 ITAAC phase as Tale 2.9-1 item 12.</p>	
<p>13.4 Review Criteria</p> <p>(3) The program should be structured such that</p> <ul style="list-style-type: none"> • human actions are monitored commensurate with their safety importance • feedback of information and corrective actions are accomplished in a timely manner • degradation in performance can be detected and corrected before plant safety is compromised (e.g., by use of the plant simulator during periodic training exercises) 	<p>DCD Ch.18 Section 18.12.2 Methodology describes that a human performance monitoring strategy is developed and documented and the human performance monitoring procedure is applicable after the completion of integrated HSI validation and operator training.</p> <p>MUAP-07007-P (R3) Section 5.12 second paragraph ensures that no significant safety degradation occurs because of any changes that are made in the plant, including changes to HSI designs, procedures and training.</p>	<p>The human performance monitoring procedure is verified during Tier 1 ITAAC phase as Tale 2.9-1 item 12.</p>	

13. Human Performance Monitoring

NUREG 0711 Revision 2 Review Criteria	Compliance Road Map		
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<p>13.4 Review Criteria (4) Plant or personnel performance under actual design conditions may not be readily measurable. When actual conditions cannot be simulated, monitored, or measured, the available information that most closely approximates performance data in actual conditions should be used.</p>	<p>DCD Ch.18 Section 18.12.2 Methodology describes that a human performance monitoring strategy is developed and documented and the human performance monitoring procedure is applicable after the completion of integrated HSI validation and operator training.</p> <p>MUAP-07007-P (R3) Section 5.12 third paragraph describes that the plan requires periodic monitoring and documentation of human performance in actual or simulated plant conditions.</p>	<p>The human performance monitoring procedure is verified during Tier 1 ITAAC phase as Tale 2.9-1 item 12.</p>	
<p>13.4 Review Criteria (5) As part of the monitoring program, it is important that provisions for specific cause determination, trending of performance degradation and failures, and corrective actions be included. The cause determination should identify the cause of the failure or degraded performance to the extent that corrective action can be identified that would preclude the problem or provide adequate assurance that it is anticipated prior to becoming a safety concern. The program should address failure significance, the circumstances surrounding the failure or degraded performance, the characteristics of the failure, and whether the failure is isolated or has generic or common cause implications. The monitoring program should identify and establish any corrective actions necessary to preclude the recurrence of unacceptable failures or degraded performance.</p>	<p>DCD Ch.18 Section 18.12.2 Methodology describes that a human performance monitoring strategy is developed and documented and the human performance monitoring procedure is applicable after the completion of integrated HSI validation and operator training.</p> <p>MUAP-07007-P (R3) Section 5.12 third paragraph describes that the plan requires periodic monitoring and documentation of human performance in actual or simulated plant conditions.</p>	<p>The human performance monitoring procedure is verified during Tier 1 ITAAC phase as Tale 2.9-1 item 12.</p>	