US-APWR

Human-System Interface Design Implementation Plan

Non-Proprietary Version

June 2013

Revision History

Revision	Date	Page (Section)	Description
0	April 2010	All pages	Original issued
1	November 2011	General	Revised capitalization of section and figure titles
			Revised “US Basic” to “US-Basic”
		p.vi (Abstract)	Revised “describe” to “describes”
			Revised “HEDs” to “Human Engineering Discrepancies (HEDs)”
		p.1 (Section 1.0)	Revised description
		p.2 (Section 2.0)	Added description to the end of third sentence in subsection 1
			Added description to the end of sixth sentence in subsection 2
			Added “or” in subsection 3
			Added description to the last sentence in subsection 3
		p.4 (Section 4.1)	Deleted “the”
			Revised “the” to “to”
			Revised “Stuffing” to “Staffing”
			Added “(TA for risk significant human actions, only)”
		pp.4–5 (Section 4.1, 1))	Added “HSI Design defines the HSI environment to meet the assumption…” for RAI Response No. 664 (Question No. 18-88)
		pp.5–6 (Section 4.1, 2))	Revised “function,” to “functions and”

Revision	Date	Page (Section)	Description
			Revised description of first bullet in subsection 2) 2) a. HSI
			Added “HSI”
			Revised description about regulatory requirements
			Revised description about other requirements
		pp.8–9 (Section 4.2)	Revised “Shift supervisor” to “Shift manager” for RAI Response No. 792 (Question No. 18-140)
			Revised description about overriding automatic systems
			Revised description about tagging
		p.11 (Section 4.4, 1))	Revised description of second paragraph
		pp.11–12 (Section 4.4, 2))	Added a sentence to last paragraph for RAI Response No. 797 (Question No. 18-180)
			Revised “will be” to “are” for RAI Response No. 797 (Question No. 18-180)
			Added “2 and 3” for RAI Response No. 797 (Question No. 18-180)
		p.12 (Section 4.4, 3))	Revised “will be” to “are” for RAI Response No. 797 (Question No. 18-180)
			Added “2 and 3” for RAI Response No. 797 (Question No. 18-180)
		p.12 (Section 4.4, 4))	Revised “will be” to “are” for RAI Response No. 797 (Question No. 18-180)
			Added “2 and 3” for RAI Response No. 797 (Question No. 18-180)
		pp.12–13 (Section 4.4, 5))	Revised “concept” to “design” for RAI Response No. 797 (Question No. 18-180)
			Added “as documented in Topical Report MUAP-07007,”

Revision	Date	Page (Section)	Description
			Revised “will be updated to reflect” to “reflects” for RAI Response No. 797 (Question No. 18-180)
			Revised “Phase 1 design related HEDs” to “the significant HEDs from Phase 1” for RAI Response No. 797 (Question No. 18-180)
			Added two sentences to last paragraph for RAI Response No. 797 (Question No. 18-180)
		p.14 (Section 4.5)	Revised “… size etc).” to “… size, etc.).”
		p.15 (Section 4.5, 2))	Revised “we conduct an … using…” to “an … is conducted using …”
		p.15 (Section 4.5, 3))	Revised “stuffing” to “staffing”
		pp.15–18 (Section 4.5, 8))	Added a sentence to the end of first paragraph
			Revised “in” to “for the”
			Added “operators”
			Added “the”
			Revised “is” to “are”
		p.19 (Section 4.5, 9))	Revised “was” to “is”
			Revised “were” to “are”
			Revised “conducted” to “conduct”
			Revised “allowed” to “allows”
		p.22 (Section 4.6)	Revised “design plan” to “designs”
			Revised “described” to “describe”
			Added “(Phase 3)”
		pp.22–23 (Section 4.7)	Added “and Monitoring Circuit Basic”
			Revised “(e.g. “to “(e.g., “
		p.23	Added new Section 4.8 about results summary

Revision	Date	Page (Section)	Description
		(Section 4.8) p.24 (Section 5.0)	report Added Reference 5-20 Revised description of references
2	October 2012	All pages	Revised to incorporate comments by the NRC in March 2012 to keep consistency in technical description with DCD Chapter 18, MUAP-09019, MUAP-10008, MUAP-10012, MUAP-10013, and MUAP-10014
3	June 2013	All pages	Complete rewrite. Revised to align closely with NUREG-0711 order and format.

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Abstract

This document describes the human-system interface (HSI) design (HD) implementation plan (IP) of the US Advanced Pressurized Water Reactor (US-APWR) human factors engineering (HFE) process. This document encompasses the design process for the US-APWR human-system interface system (HSIS) and the US-APWR Local HSIs and the facilities in which these reside.

The US-APWR HSIS is based on the US-Basic HSIS, which has been separately approved by the U.S. Nuclear Regulatory Commission (NRC). The US-Basic HSIS encompasses the generic design elements for alarms, displays, controls, computer-based procedures (CBPs), and other physical aspects of the HSI that are pertinent to supporting the operating crew. The US-APWR HSIS is the result of combining the generic design elements of the US-Basic HSIS with the US-APWR HSI inventory. The US-APWR HSI inventory is the specific set of alarms, displays, controls, and CBPs that are developed for the US-APWR through various US-APWR HFE program elements, including this one. The US-APWR HSIS is employed in the main control room (MCR) of the US-APWR. A subset of the US-APWR HSIS is also employed in the remote shutdown room (RSR) and in the technical support center (TSC). A subset of the US-APWR HSIS data is transmitted for display in the emergency operations facility (EOF).

The US-APWR Local HSIs are unique to a specific piece of plant equipment (e.g., pump, valve, radiation monitor) or a specific plant function whose primary control is from a location outside the MCR (e.g., waste management). The US-APWR Local HSIs are limited to the local controls used by plant operations personnel.

This HD IP describes four key activities: (1) design activities to resolve human engineering discrepancies (HED) from the development of the US-Basic HSIS; (2) design activities to create the US-APWR HSI inventory, including the safety parameter display system requirements for the EOF; (3) design activities to create the US-APWR Local HSIs; and (4) design activities to create the complete HSI facilities for the US-APWR (i.e., MCR, RSR, TSC, and Local HSIs). The EOF itself is outside the scope of the US-APWR HFE program.

For each of these activities this IP describes the personnel qualifications of the HFE design team, the output products created by that team, and the processes used to create and approve those products. This program element uses input from functional requirements analysis and function allocation, human reliability analysis, task analysis, and staffing and qualifications elements to create its outputs. The end product of this program element is the complete and final US-APWR HSIS, which is verified and validated in the human factors V&V program element.

This IP also describes the requirements for documenting the completion of the HD program element in the HD results summary report (ReSR). The ReSR is used to demonstrate that the HSI for the US-APWR was designed in accordance with this IP. Design documentation through the ReSR is a requirement for inspection, test, analysis, and acceptance criteria (ITAAC) closure.

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Acronyms

BISI	bypassed and inoperable status indication
CAS	central alarm station
CBP	computer-based procedure
COL	combined license
CRDM-CS	control rod drive mechanism – control system
CSF	critical safety function
D3CA	defense-in-depth and diversity coping analysis
DAS	diverse actuation system
DCA	design change analysis
DCD	Design Control Document
D-EOP	EOP for DHP
DHP	diverse human-system interface panel
DIHA	deterministically important human action
EOF	emergency operations facility
EOP	emergency operating procedure
FA	function allocation
FRA	functional requirements analysis
HD	HSI design (HFE)
HED	human engineering discrepancy
HFE	human factors engineering
HRA	human reliability analysis
HSI	human-system interface
HSIS	human-system interface system
HVAC	heating, ventilation, and air conditioning
I&C	instrumentation and control
ID	identifier
IHA	important human action
IP	implementation plan
ISV	integrated system validation
ITAAC	inspection, test, analysis, and acceptance criteria
LCS	local control station
LDP	large display panel
MCR	main control room
MHI	Mitsubishi Heavy Industries
NRC	Nuclear Regulatory Commission, U.S.
OER	operating experience review
O-VDU	operational VDU
P&ID	piping and instrumentation diagram
PAM	post-accident monitoring
PBP	paper-based procedure
PCMS	plant control and monitoring system
PMP	program management plan

PSMS	protection and safety monitoring system
ReSR	results summary report
RIHA	risk-important human action
RO	reactor operator
RSC	remote shutdown console
RSR	remote shutdown room
S&Q	staffing and qualifications
SAS	secondary alarm station
SDCV	spatially dedicated continuously visible
S-EOP	S-VDU EOP
SME	subject-matter expert
SPDS	safety parameter display system
SRO	senior reactor operator
STA	shift technical advisor
S-VDU	safety VDU
TA	task analysis
TBVCS	turbine bypass valve control system
TCS	turbine control system
TSC	technical support center
US, U.S.	United States
US-APWR	US Advanced Pressurized Water Reactor
V&V	verification and validation
VDU	visual display unit
3D	three dimensional

1.0 PURPOSE

This document provides the human-system interface (HSI) design (HD) implementation plan (IP) for the US Advanced Pressurized Water Reactor (US-APWR). This IP describes the process for translating functional and task requirements into the detailed HSI for the US-APWR, which encompasses the indications, alarms, controls, and procedures used by plant personnel to operate the plant.

This human factors engineering (HFE) program element conforms to the guidance and satisfies the acceptance criteria of NUREG-0711, Revision 2, “Human Factors Engineering Program Review Model,” Section 8 (Reference 8-1).

This IP also describes the requirements for documenting the completion of the HD program element in the HD results summary report (ReSR). The ReSR is used to demonstrate that the HSI for the US-APWR was designed in accordance with this IP. Design documentation through the ReSR is a requirement for Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) closure. The completion of this program element, including resolution of all human engineering discrepancies (HEDs), is a prerequisite for the verification and validation (V&V) program element.

2.0 SCOPE

This plan addresses the HSIs within the scope of the US-APWR HFE program by dividing that scope into four categories:

- US-APWR HSI system (HSIS)
- Derivatives of the US-APWR HSIS
- US-APWR Local HSIs
- HSI facilities

The main control room (MCR) employs the US-APWR HSIS. The US-APWR HSIS employs the generic design elements (i.e., alarms, indications, controls, and computer-based procedures (CBPs)) defined by the US-Basic HSIS. These HSI design elements are used to implement the US-APWR HSI inventory of alarms, indications, controls, and procedures, which is developed through other US-APWR HFE program elements. The US-APWR HSIS also includes the HSI used by the operators to communicate to other personnel within the plant, with the emergency operations facility (EOF), and with the central alarm station (CAS) and secondary alarm station (SAS).

Although the US-APWR plant design defined by the Design Control Document (DCD) (Reference 8-9) is limited, the US-APWR HSIS encompasses a complete plant through site-specific assumptions that address the portions of the plant not included in the DCD. A US-APWR site-specific HSIS will confirm those assumptions or change them for an actual site-specific location; this design change activity to convert the US-APWR HSIS to a US-APWR site-specific HSIS is conducted through the Design Implementation program element.

Derivatives of the US-APWR HSIS are configured to provide the functionality needed for the purpose of a specific facility. The HSIS for the remote shutdown room (RSR) and the technical support center (TSC) are derivatives of the US-APWR HSIS. A portion of the HSI for the EOF is also a derivative of the US-APWR HSIS. This portion is limited to the safety parameter display system (SPDS). Therefore, the EOF scope encompassed by the US-APWR HFE program and included in this HD program element is limited to the information requirements (i.e., HSI inventory) for the EOF's SPDS.

Local control stations (LCSs) are unique to a specific piece of plant equipment (e.g., pump, valve, and radiation monitor) or a specific plant function whose primary control is from a location outside the MCR (e.g., waste management). The LCS scope encompassed by the US-APWR HFE program and included in this HD program element is that used by plant operations personnel. These LCSs are referred to as US-APWR Local HSIs.

The HSI scope of the HD program element includes the CBPs and paper-based procedures (PBPs) that are used for the scenarios conducted during integrated system validation (ISV). Other procedures that are unrelated to the V&V scenarios are not in the scope of the HD program element because they have their own development and verification program.

The US-APWR HSIS, derivatives of the US-APWR HSIS, and US-APWR Local HSIs reside in facilities that also require design of aspects that are pertinent to HFE, such as environmental characteristics, meeting facilities, storage facilities, and so forth. The facilities encompassed by the US-APWR HFE program and included in this HD program element are the MCR, RSR, TSC, and LCSs. The EOF facility is in the scope of the combined license (COL) applicant; therefore, the EOF is outside the scope of the US-APWR HD program element (except for the HSI inventory for the SPDS).

3.0 METHODOLOGY OVERVIEW

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4.6.9 S-VDU SDCV Screen

4.6.10 S-VDU Task Monitoring and Control Screen

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4.6.13 Data Management Console Screen

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4.6.16 Technical Support Center Facility

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4.6.18 Other Local HSI

5.0 IMPLEMENTATION TEAM

The SMEs who conduct the HD program element are described in Section 4.6 above, and summarized in Table 5-1.

Table 5-1 HSI Design Implementation Summary

Implementation Activity	Section	Subject Matter Experts
MCR Facility	4.6.1	
US-APWR MCR 3D model	4.6.1	HSI/I&C Engineering, Plant Operations, Human Factors Engineering, Architect Engineering, Maintainability/Inspectability Engineering, Computer/Simulator Engineering
Drawings for US-APWR MCR consoles and physical arrangement	4.6.1	
Lighting specification	4.6.1	
Communications specification	4.6.1	
Architect engineering specifications to minimize background noise	4.6.1	
US-APWR MCR facility specification for ISV simulator	4.6.1	
Visibility and traffic flow report	4.6.1	
US-APWR nomenclature guide	4.6.2	Human Factors Engineering, Plant Operations
US-APWR functional specification of LDP	4.6.3	HSI/I&C Engineering, Plant Operations, Human Factors Engineering
US-APWR safety switch panel specification	4.6.4	HSI/I&C Engineering, Plant Operations, Human Factors Engineering
Alarms	4.6.5	
US-APWR alarm data base	4.6.5	HSI/I&C Engineering, Plant Operations
Test report	4.6.5	
US-APWR functional specification of O-VDU system displays	4.6.6	HSI/I&C Engineering, Human Factors Engineering, Systems Engineering
O-VDU Task Displays	4.6.7	
US-APWR functional specification of O-VDU task displays	4.6.7	HSI/I&C Engineering, Human Factors Engineering, Systems Engineering
Test report	4.6.7	
US-APWR functional specification of S-VDU system displays	4.6.8	HSI/I&C Engineering, Human Factors Engineering, Systems Engineering
US-APWR functional specification of S-VDU SDCV display	4.6.9	Human Factors Engineering, HSI/I&C Engineering
S-VDU task monitoring and control screens	4.6.10	
US-APWR functional specification of S-VDU task monitoring displays	4.6.10	Human Factors Engineering, HSI/I&C Engineering, Plant Operations
US-APWR functional specification of S-VDU task control displays	4.6.10	
Test report	4.6.10	
US-APWR control pop-up database	4.6.11	Human Factors Engineering,

Implementation Activity	Section	Subject Matter Experts
		HSI/I&C Engineering
CBP screens	4.6.12	
Written procedures with hyperlink screen ID tags	4.6.12	Human Factors Engineering, HSI/I&C Engineering, Plant Operations
CBP corresponding to each PBP used by operators in the MCR	4.6.12	
Test report	4.6.12	
DMC screens	4.6.13	
US-APWR functional specification of DMC displays	4.6.13	Human Factors Engineering, HSI/I&C Engineering, Plant Operations
Test report	4.6.13	
DAS HSI panel	4.6.14	
US-APWR DHP specification	4.6.14	Human Factors Engineering, HSI/I&C Engineering, Plant Operations
Test report	4.6.14	
RSR facility	4.6.15	
US-APWR MCR 3D model	4.6.15	HSI/I&C Engineering, Plant Operations, Human Factors Engineering, Architect Engineering, Maintainability/Inspectability Engineering
Drawings for US-APWR RSR consoles and physical arrangement	4.6.15	
Lighting specification	4.6.15	
Communications specification	4.6.15	
Architect Engineering specifications to minimize background noise	4.6.15	
Visibility and traffic flow report	4.6.15	
TSC facility	4.6.16	
Detailed drawings for US-APWR RSR physical arrangement	4.6.16	HSI/I&C Engineering, Plant Operations, Human Factors Engineering, Architect Engineering, Maintainability/Inspectability Engineering
Lighting specification	4.6.16	
Communications specification	4.6.16	
Architect engineering specifications to minimize background noise	4.6.16	
Visibility and traffic flow report	4.6.16	
Local HSI for abnormal and emergency conditions	4.6.17	
US-APWR Local HSIs specification	4.6.17	HSI/I&C Engineering, System Engineers, Plant Operations, Human Factors Engineering
Specifications for each LCS – these are the responsibility of plant system designers	4.6.17	
Tabletop analysis report	4.6.17	
Specifications for other local HSIs used by operations personnel	4.6.18	System Engineers, Plant Operation, Human Factors Engineering

The SME qualifications are defined in HFE PMP (Reference 8-8).

6.0 RESULTS SUMMARY REPORT CONTENT

Results of the HD program element are compiled in an ReSR. This report is used to demonstrate that the US-APWR functional and task requirements have been translated into the detailed HSI design for the US-APWR in accordance with this IP. Demonstrating conformance to this IP, as documented through this ReSR, is a requirement of the ITAAC closure defined in the US-APWR DCD Tier 1 (Reference 8-9).

The HD ReSR includes the following:

- Each implementation team member's name and SME position he or she fulfills
- Each HD output reviewer's name and SME position he or she fulfills
- The HD results overview, which includes the principal findings of the HFE program element
- The HD execution results, which include all details that demonstrate compliance with the methodology section of this IP, using the output format defined in Section 4. This includes the following:
  - Specifications for each HSI element within the US-APWR HSIS
  - Specifications for each facility within the US-APWR HSIS
  - Databases for alarms and control pop-ups
  - Reports that document the evaluations of facility traffic flow and visibility for each facility
  - Reports that document performance-based testing for functions where the US-APWR HSI inventory was not sufficiently represented during Phase 1 testing of the US-Basic HSIS
  - Reports that document tabletop analysis for local HSIs used for abnormal and emergency conditions for beyond-design-basis events
- A conclusion that the HD program element has been conducted in accordance with the HD IP and that functional and task requirements of the US-APWR have been completely and correctly implemented in the detailed HSI design for the US-APWR, which encompasses the indications, alarms, controls, and procedures used by plant personnel to operate the plant

7.0 COMPLIANCE WITH NUREG-0711 FOR DESIGN IMPLEMENTATION PLAN

Table 7-1 shows the compliance of the HD IP with the criteria of the NUREG-0711 HD element (Reference 8-1).

Table 7-1 Compliance with NUREG-0711

Review Criteria Stated in NUREG-0711, Rev. 2	HD IP Section No. and paragraph
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:	Section 3.3, paragraph 1
• 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.	Section 3.3.1, paragraph 1
• 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.	Section 3.3.1, paragraph 1
• Task analysis - The set of requirements to support the role of personnel is provided by task analysis. The task analysis should identify: - 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.	Section 3.3.1, paragraph 1
• 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.	Section 3.3.1, paragraph 1
(2) System Requirements - Constraints imposed by the overall instrumentation and control (I&C) system should be considered throughout the HSI design process.	Section 3.3.2, paragraph 1
(3) Regulatory Requirements - Applicable regulatory requirements should be identified as inputs to the HSI design process.	Section 3.3.3, paragraphs 1–2
(4) Other Requirements - The applicant should identify other requirements that are inputs to the HSI design	Section 3.3.4, paragraph 1
8.4.2 Concept of Operations (1) A concept of operations should be developed indicating crew composition	Section 4.1, paragraphs 1–2

Review Criteria Stated in NUREG-0711, Rev. 2	HD IP Section No. and paragraph
and the roles and responsibilities of individual crew members based on anticipated staffing levels. The concept of operations should:	
-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.	Section 4.1, paragraphs 1–2
- 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.	Section 4.1, paragraphs 1–2
- Address the coordination of crew member activities, such as the interaction with auxiliary operators and coordination of maintenance and operations should be addressed.	Section 4.1, paragraphs 1–2
8.4.3 Functional Requirement Specification (1) Functional requirements for the HSIs should be developed to address: • 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	Section 4.2, paragraph 1
(2) Requirements should be established for various types of HSIs, e.g., alarms, displays, and controls.	Section 4.2, paragraphs 2–6
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	Section 4.3, paragraphs 1–3
(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: • 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	Section 4.3, paragraphs 1–3
(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.	Section 4.3, paragraphs 1–3
(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.	Section 4.3, paragraphs 1–3
(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	Section 4.3, paragraphs 2–4

Review Criteria Stated in NUREG-0711, Rev. 2	HD IP Section No. and paragraph
the art in HSI technologies and human performance considerations identified in the human performance research.	
8.4.5 HSI Detailed Design and Integration 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. • 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. • 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. • 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.	Section 4.4, paragraph 1
(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.	Section 4.4.1
(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 4.4.3
(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: • communication, coordination, and workload • feedback • local environment • inspection, test, and maintenance • importance to safety	Sections 4.4.2 and 4.4.4
(5) The layout of HSIs within consoles, panels, and workstations should be based upon (1) analyses of operator roles (job analysis) and (2) systematic	Section 4.4.5

Review Criteria Stated in NUREG-0711, Rev. 2	HD IP Section No. and paragraph
strategies for organization such as arrangement by importance, frequency of use, and sequence of use	
(6) Personnel and task performance should be supported during minimal, nominal, and high-level staffing.	Section 4.4.6
(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.	Section 4.4.7
(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).	Section 4.4.8
(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).	Section 4.4.9
(10) The following considerations should be addressed in the review of design modifications: • 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 (see Section 6.4 of HFE PMP, Reference 8-8)
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.	Section 4.5, including all of its subsections
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: • personnel task requirements • human performance capabilities and limitations • HSI system performance requirements • inspection and testing requirements • maintenance requirements	Section 4.5.1, paragraph 1

Review Criteria Stated in NUREG-0711, Rev. 2	HD IP Section No. and paragraph
• use of proven technology and the operating experience of predecessor designs. (2) The selection process should make explicit the relative benefits of design alternatives and the basis for their selection.	
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.	Section 4.5.2, paragraphs 1–3
(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.	Section 4.5.2, paragraphs 1–3
(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.	Section 4.5.2, paragraphs 1–3
(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.	Section 4.5.2, paragraphs 1–3
(5) The selection of performance measures should be based on a consideration of: • measurement characteristics • identification and selection of variables to represent measures of the aspects of performance under investigation • development of performance criteria.	Section 4.5.2, paragraphs 1–3
(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.	Section 4.5.2, paragraphs 1–-3
(7) The test design should permit the observation of performance in a manner that avoids or minimizes bias, confounds, and error variance (noise).	Section 4.5.2, paragraphs 1–3
(8) Test data should be analyzed using established analysis techniques.	Section 4.5.2, paragraphs 1–3
(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.	Section 4.5.2, paragraphs 1–3
8.4.7 HSI Design Documentation (1) The HSI design should be documented to include: • 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	Section 4.6, paragraphs 1–3
(2) The outcomes of tests and evaluations performed in support of HSI design should be documented.	Section 4.6, paragraphs 1–3

8.0 REFERENCES

8-1 Human Factors Engineering Program Review Model, NUREG-0711, Revision 2, U.S. Nuclear Regulatory Commission, February 2004

8-2 HSI System Description and HFE Process, MUAP-07007, Revision 5, MHI, November 2011

8-3 US−APWR HSI Design Style Guide, JEJC-1763-1001, Revision 2, MHI, May 14, 2008

8-4 Design Implementation Plan, MUAP-10013, Revision 3, MHI, June 2013

8-5 Human-System Interface Design Review Guidelines, NUREG-0700, Revision 2, U.S. Nuclear Regulatory Commission, May 2002

8-6 US-Basic Human-System Interface Verification and Validation (Phase 1), MUAP-08014, Revision 2, MHI, 2013

8-7 US-APWR Safety I&C System Description and Design Process, MUAP-07004, Revision 7, MHI, May 2011

8-8 Human Factors Engineering Program Management Plan, MUAP-09019, Revision 3, MHI, June 2013

8-9 Design Control Document for the US-APWR, Revision 3, MHI, March 2011