US-APWR

Design Implementation Plan

December 2011

Prepared: Eisuke Noda — 12/14/2011
Eisuke Noda, Deputy Manager
Human Factor and Training Facility Engineering Section
Nuclear Electrical, Instrumentation & Control Engineering Department
Date

Prepared: Satoshi Hanada — 12/14/2011
Satoshi Hanada, Deputy Manager
Human Factor and Training Facility Engineering Section
Nuclear Electrical, Instrumentation & Control Engineering Department
Date

Prepared: Koji Ito — 12/14/2011
Koji Ito, Engineering Manager
Human Factor and Training Facility Engineering Section
Nuclear Electrical, Instrumentation & Control Engineering Department
Date

Reviewed: Hideaki Tokunaga — 12/15/2011
Hideaki Tokunaga, Deputy Manager
Human Factor and Training Facility Engineering Section
Nuclear Electrical, Instrumentation & Control Engineering Department
Date

Approved: Masanori Yokoyama — 12/15/2011
Masanori Yokoyama, Manager
Human Factor and Training Facility Engineering Section
Nuclear Electrical, Instrumentation & Control Engineering Department
Date

Approved: Yuzuru Yasui — 12/16/2011
Yuzuru Yasui, Director
Nuclear Electrical, Instrumentation & Control Engineering Department
Date

Signature History

	Rev. 0	Rev. 1		
Prepared	Satoshi Hanada	Eisuke Noda		
		Satoshi Hanada		
	Koji Ito			
		Koji Ito		
Reviewed	Hideaki Tokunaga	Hideaki Tokunaga		
Approved	Masanori Yokoyama	Masanori Yokoyama		
	Yoshinori Inazumi	Yuzuru Yasui		

Revision History

Revision	Date	Page (Section)	Description
0	April 2010	All	Original issued
1	December 2011	General	Revised “V&V’ed” to “V&V’d”.
		p.2 (Section 2.0)	Revised description of first sentence for response to RAI 755 (Question No. 18-115).
			Revised description of item 1.
			Revised description of item 3 for response to RAI 755 (Question No. 18-115).
		p.4 (Section 4.0)	Revised “the Waste Processing System” to “the HSI for the Radioactive Waste Disposal System”.
			Added a paragraph about objective for response to RAI 755 (Question No. 18-117).
			Added a paragraph about evaluation.
		p.5 (Section 4.1.2)	Added description about evaluation.
		p.5 (Section 4.1.3)	Added description about evaluation.
		p.5 (Section 4.1.4)	Added description about evaluation.
		pp.6-7 (Section 4.2.2)	Revised description about RSR software configuration check.
		p.7 (Section 4.2.3)	Revised description about RSR hardware configuration check.
		p.8 (Section 4.3.2)	Revised description about TSC software configuration check.

Revision	Date	Page (Section)	Description
		p.8 (Section 4.3.3)	Revised description about TSC hardware configuration check.
		p.8 (Section 4.4)	Revised “flux mapping system” to “Incore Nuclear Instrumentation System (for flux mapping)”.
			Revised “waste process system” to “Radioactive Waste Disposal System”.
		p.8 (Section 4.4.2)	Deleted “in-situ” for response to RAI 755 (Question No. 18-118).
			Added “Configuration and Suitability” to the section title for response to RAI 755 (Question No. 18-118).
		p.9 (Section 4.6.1)	Added “is”.
			Revised “see” to “confirm that”.
		pp.9-10 (Section 4.7)	Added the new section 4.7 (this new section is based on the previous section 4.1.5) and revised description for response to RAI 755 (Question No. 18-118).
			Revised the section title ”MCR In-Situ Check” to “HSI Regression Analysis” for response to RAI 755 (Question No. 18-118).
		p.10 (Section 4.8)	Added the new section 4.8 “Summary report” for response to RAI 755 (Question No. 18-119).
		p.11 (Section 5.0)	Revised description of references.

Mitsubishi Heavy Industries, Ltd.
16-5, Konan 2-chome, Minato-ku
Tokyo 108-8215 Japan

Abstract

This document presents the Implementation Plan for the HSI design implementation of safety significant HSI for a site specific US-APWR. Hereafter, the plan is referred to as the “HSI Design Implementation Plan.”

The plan addresses the task by first dividing the implemented HSI into categories and then defining a detailed HSI design implementation plan for each category.

Table of Contents

List of Acronyms vi

1.0 Purpose 1
2.0 Scope 2
3.0 Applicable Codes, Standards, and Regulatory Guidance 3
4.0 Implementation Plan 4
4.1 The Main Control Room 4
4.1.1 MCR Functional Check 4
4.1.2 MCR Software Configuration Check 4
4.1.3 MCR Hardware Configuration Check 5
4.1.4 MCR Dedicated Controls Check 5
4.2 Remote Shutdown Room (RSR) 6
4.2.1 RSR Functional Check 6
4.2.2 RSR Software Configuration Check 6
4.2.3 RSR Hardware Configuration Check 7
4.3 Technical Support Center (TSC) 7
4.3.1 TSC Functional Check 7
4.3.2 TSC Software Configuration Check 7
4.3.3 TSC Hardware Configuration Check 8
4.4 Single Purpose HSI 8
4.4.1 Inclusion in the HFE Process 8
4.4.2 Single Purpose Configuration and Suitability Check 9
4.5 Emergency Operations Facility (EOF) 9
4.6 QA Supervision 9
4.6.1 Human Engineering Discrepancies (HED) 9
4.6.2 Other Plant Organizations 9
4.7 HSI Regression Analysis 9
4.8 Summary report 10
5.0 References 11

List of Acronyms

AOO	anticipated operational occurrence
CFR	Code of Federal Regulations
COL	combined license
COLA	combined license application
DAS	diverse actuation system
DCD	design certification document
DHP	diverse HSI panel
EOF	emergency operations facility
EOP	emergency operating procedure
ERG	emergency response guidelines
GDC	general design criteria
HA	human action
HFE	human factors engineering
HSI	human-system interface
HSIS	human system interface system
HED	human engineering discrepancy
HFE	human factors engineering
HSI	human-system interface
HSIS	human system interface system
I&C	instrumentation and control
ITAAC	inspection, test, analysis, and acceptance criteria
ITV	industrial television
LCS	local control station
LDP	large display panel
MCR	main control room
NRC	Nuclear Regulatory Commission, U.S.
PA	postulated accidents
PAM	post-accident monitoring
QA	quality assurance
RG	Regulatory Guide

RO	reactor operator
RSC	remote shutdown console
RSR	remote shutdown room
SRO	senior reactor operator
TSC	technical support center
US-APWR	United States – Advanced Pressurized Water Reactor
V&V	verification and validation
VDU	visual display unit

1.0 Purpose

This document provides the implementation plan for the HSI design for a site specific US−APWR.

The implementation plan defines the set of activities that demonstrate that the implemented HSI (i.e., the “as-built” HSI) conforms to the HSI design that was created by the US-APWR HFE process.

2.0 Scope

This plan covers all the HSI within the scope of the US-APWR HFE program, as defined in DCD Section 18.1.1.2.

For a site specific US-APWR the implementation phase is well defined and carefully monitored to determine:

1. That the HSI design that is implemented, heretofore referred to as the as built HSI matches the HSI design that was verified and validated in the US-APWR HFE program, heretofore referred to as the V&V'd HSI, and that other aspects of the plant that would affect by the final V&V program results (e.g. lighting and noise) are consistent with the assumptions of the V&V program;
2. That HSI or plant changes that occur after final V&V, but prior to fuel load, are adequately evaluated and addressed from an HFE perspective;
3. That other HSI included in the US-APWR HFE program, which has not been encompassed by the HFE program HSI V&V activity (e.g. local controls, EOF) meets the previously established HFE requirements.

Any design modifications that may occur after completion of the V&V part of the HFE program shall be evaluated and managed in accordance with the design change process described in Reference 5-2 Section 5.11.

3.0 Applicable Codes, Standards, and Regulatory Guidance

The compliance to the applicable codes and standards for the US-APWR HSIS design is identified in section 3.0 of the topical report “HSI System Description and HFE Process”, MUAP-07007 (Reference 5-2). The topical report includes following standards and guidelines.

- Code of Federal Regulations
- Staff Requirements Memoranda
- NRC Regulatory Guides
- NRC Branch Technical Positions
- NUREGs
- Other Reference Guidelines

4.0 Implementation Plan

This plan addresses all the safety significant US-APWR HSI by dividing them into three categories:

1. The main control room (MCR)
2. Derivatives of the main control room
3. Single purpose HSI

Derivatives of the main control room are subsets of the main control room HSI configured to provide the functionality needed for the purpose of the facility. The HSI for the remote shutdown room and the technical support center are derivatives of the main control room.

Single purpose HSI is an HSI interface that is unique to a specific piece of plant or plant equipment type. Examples of single purpose HSI are the HSI for the Radioactive Waste Disposal System and local controls.

The objective of the design implementation plan is to demonstrate that the design that is implemented (i.e., the "as-built" design) accurately reflects the verified and validated design. For aspects of the design that were not addressed in the V&V program, a regression analysis will determine what HFE program elements must be implemented or repeated.

The evaluation shall examine software, hardware and functionality. Differences in software or hardware implementation shall be evaluated to determine the impact on functionality; it is recognized that there will be hardware and software differences, because the V&V is conducted on a simulator, not the actual plant equipment.

4.1 The Main Control Room

The MCR is the place for process control and supervision in all plant situations. In addition, it provides the means for communication to others outside the plant. Finally, it is the center to initiate the maintenance of process-related equipment.

In general, the US-APWR main control room HSI has been verified and validated as a complete and integrated design. However, for practical reasons there may be differences between the verified and validated HSI design and an implemented site specific US-APWR main control room. The following specific checks shall be preformed.

4.1.1 MCR Functional Check

The as-built MCR shall be checked against the MCR functional specification to verify that all functions specified are provided by facilities within the room.

4.1.2 MCR Software Configuration Check

The MCR configuration check shall demonstrate the software configuration of the as-built design matches the V&V'd design. The assessment shall be accomplished by checking that the versions of the MCR HSI software data match the V&V'd design software data for:

1. Large display panel displays
2. Large display panel display logic
3. Visual display units operation displays
4. Visual display units operator control stations
5. Visual display units operation displays and operator control stations logic
6. Safety displays
7. Safety displays operator control stations
8. Safety displays and operator control stations logic
9. The alarm display logic
10. The alarm messages database
11. The operating procedures database for normal operations, anticipated operational occurrences, and emergency operations
12. The safety controls operating procedures off-line computer data files for paper procedures
13. The diverse actuation system operating procedures off-line computer data files for paper procedures

The MCR software configuration assessment shall check the versions of one hundred percent of the software data files that define the HSI operation of the main control room. Where the configuration control method shows a clear correlation between software implemented in the simulator for V&V and the as-built software, the two shall be considered matched. Other differences (e.g. differences in computer operating systems) shall be evaluated for their impact on HSI operation.

4.1.3 MCR Hardware Configuration Check

For the hardware configuration the assessment shall be accomplished by checking that the MCR HSI panels match the V&V'd HSI panels. Differences shall be evaluated for their impact on HSI operation. For example, differences such as panel color changes, material changes or minor dimensional differences are evaluated, but are likely to have no impact on HSI operation.

4.1.4 MCR Dedicated Controls Check

The MCR dedicated controls check shall demonstrate that the as-built dedicated controls match the V&V'd design. The assessment shall be accomplished by checking that the as−built physical implementation match the V&V'd design for:

- Safety switches
- Diverse HSI Panel (DHP) indicators
- Diverse HSI Panel (DHP) switches

Differences shall be evaluated for their impact on HSI operation. For example, variations in switch/indicator model numbers commonly occur with no change in functional performance.

4.2 Remote Shutdown Room (RSR)

The RSR is a derivative of the MCR.

The Remote Shutdown Room (RSR) is located in a different fire zone than the MCR. The Remote Shutdown Console (RSC), which is located in the RSR, has capabilities to achieve and maintain cold shutdown.

Operators can monitor and control the plant using the VDUs on the RSC to shutdown the plant, to maintain a hot shutdown condition and also transfer to maintain a cold shutdown condition.

VDUs on the RSC provide the same screens as that of the main control room, this reduces the need for additional training and minimizes the potential for human error.

4.2.1 RSR Functional Check

The as-built RSR shall be checked against the RSR functional specification to verify that all functions specified are provided by facilities within the room.

4.2.2 RSR Software Configuration Check

The RSR configuration check shall demonstrate the software configuration of the as-built design matches the V&V'd design. The assessment shall be accomplished by checking that the versions of the RSR HSI software data match the MCR V&V'd design software data for:

1. Visual display units operation displays
2. Visual display units operator control stations
3. Visual display units operation displays and operator control stations logic
4. Safety displays
5. Safety displays operator control stations
6. Safety displays and operator control stations logic
7. The alarm display logic
8. The alarm messages database
9. The operating procedures database for normal operations, anticipated operational occurrences, and emergency operations
10. The safety controls operating procedures off-line computer data files for paper procedures

The RSR software configuration assessment shall check the versions of one hundred percent of the software data files that define the HSI operation of the remote shutdown room. Where the configuration control method shows a clear correlation between software implemented in the simulator for V&V and the as-built software, the two shall be considered matched. Other differences (e.g. differences in computer operating systems) shall be evaluated for their impact on HSI operation.

This check is performed against the MCR V&V'd software because the RSR is a derivative of the MCR; therefore, the final validation implements the RSR only on a part task basis.

4.2.3 RSR Hardware Configuration Check

For the hardware configuration the assessment shall be accomplished by checking that the RSR console is equivalent to the V&V'd console. Differences are expected because the RSR is a derivative of the MCR. Therefore, the final validation of the RSR console is conducted by part task simulation; there will not be an exact layout or configuration match to the previously verified HSI console design documentation or the as-built RSR console. Differences shall be evaluated for their impact on HSI operation and compliance with NUREG 0700.

4.3 Technical Support Center (TSC)

The TSC is a derivative of the MCR.

The TSC has facilities to support the plant management and technical personnel who will be assigned there during an emergency and will be the primary onsite communications center for the plant during the emergency.

The facility consists of a plant data display system using VDUs (only for monitoring functions) and a LDP, data communication system, tele-communication system of telephones and facsimiles by multiple methods of transmission including private and public lines, satellite communications and adequate working area.

The TSC working space is sized for a minimum of 25 persons, including 20 persons designated by the licensee and five NRC personnel. The minimum size of the working space provided is approximately 75 sq ft/person.

4.3.1 TSC Functional Check

The as-built TSC shall be checked against the TSC functional specification to verify that all functions specified are provided by facilities within the room.

4.3.2 TSC Software Configuration Check

The TSC configuration check shall demonstrate the software configuration of the as-built design matches the V&V'd design.

For the software the assessment will be accomplished by checking that the versions of the TSC HSI software data match the MCR V&V'd design software data for:

1. Large display panel displays
2. Large display panel display logic
3. Visual display units operation displays
4. Visual display units operation displays logic
5. The alarm display logic

6. The alarm messages database
7. The operating procedures database for normal operations, anticipated operational occurrences, and emergency operations

The TSC software configuration assessment shall check the versions of one hundred percent of the software data files that define the HSI operation of the technical support center. Where the configuration control method shows a clear correlation between software implemented in the simulator for V&V and the as-built software, the two shall be considered matched. Other differences (e.g. differences in computer operating systems) shall be evaluated for their impact on HSI operation.

This check is performed against the MCR V&V'd software because the TSC is a derivative of the MCR; therefore, the final validation implements the TSC only on a part task basis.

4.3.3 TSC Hardware Configuration Check

For the hardware configuration the assessment shall be accomplished by checking that the TSC HSI configuration is equivalent to the V&V'd HSI configuration. Differences are expected because the TSC is a derivative of the MCR. Therefore, the final validation of the TSC is conducted by part task simulation; there will not be an exact layout or configuration match to the verified TSC design documentation or the as-built TSC HSI. Differences shall be evaluated for their impact on HSI operation and compliance with NUREG 0700.

4.4 Single Purpose HSI

Other departments and groups provide plant design outputs with HSI, such as local controls on motor control centers and skid mounted equipment.

Single purpose HSI also includes HSI for plant supporting processes such as the Incore Nuclear Instrumentation System (for flux mapping) and the Radioactive Waste Disposal System.

4.4.1 Inclusion in the HFE Process

HSI design outputs that have HSI safety significance are included in the US-APWR HFE Process. In order to assure HSI across the nuclear plant systems and components conform to industry accepted HFE practices and do not represent conflicts with the V&V'd US-APWR HSI or with one another, the HFE team interacts with the rest of the plant design teams to review and control design products that contain information related to safety significant HSI. This HFE review and control of the HSI applies to both internal and external suppliers of unique systems or systems with local controls. For example, HFE review and control shall apply to local skid mounted HSI and local controls that may be supplied as part of a pump or valve.

If those components are safety related and the local HSI will be used to support safety significant testing or maintenance activities, as follows:

- On-line testing, radiological protection activities, and required chemical monitoring supporting technical specifications
- Maintenance required by technical specifications

- Emergency and abnormal conditions response

Then the HSI shall be included in the US-APWR HFE process.

4.4.2 Single Purpose Configuration and Suitability Check

The single purpose HSI assessment shall be accomplished by checking the single purpose HSI implementation against the documented HFE requirements.

If there are no specific HFE requirements, suitability shall be checked with respect to the intended function in accordance with NUREG-0700.

4.5 Emergency Operations Facility (EOF)

The emergency response facility (EOF) may be either a derivative of the MCR HSI design or a single purpose HSI or combination of both. Whichever is the case, the EOF HSI design implementation shall follow the relevant method(s) defined in this implementation plan.

4.6 QA Supervision

In addition to the normal QA supervision associated with a nuclear power plant project, there is unique QA supervision associated with HSI design implementation.

4.6.1 Human Engineering Discrepancies (HED)

Any HFE issue arising during the HSI design implementation phase shall documented as a human engineering discrepancy (HED). These HEDs shall follow the same process to closure as all other HEDs. That is, they shall be captured and tracked to close using the HED database. It is the responsibility of the HSI Design Team to develop the solution. And it is the responsibility of the V&V team to confirm that the closure requirements are met.

4.6.2 Other Plant Organizations

The interaction between the HFE Design/V&V Teams and other plant organizations shall be included in the QA procedures governing plant implementation activities for safety significant HSI. HFE comments that cannot be resolved through mutual agreement between the HFE organization and the plant organizations shall be brought to management attention for resolution.

4.7 HSI Regression Analysis

For aspects of the HSI that differ from the V&V'd design a regression analysis shall be performed.

A regression analysis shall be conducted for HSI equipment or interfaces, which were part of the V&V'd HSI design, but differ from the V&V'd HSI design. The regression analysis shall

determine the significance of the change and the extent of HFE re-analysis and retesting that is needed.

As a minimum, HSI equipment or interfaces that were not included in the V&V'd design (i.e., ITV, temporary HSI for testing and maintenance) shall be checked to assure they do not interfere with accomplishing the V&V'd HSI functions. In addition, HSI equipment that was not included in the V&V'd design shall be checked for conformance to the documented HFE requirements. If there are no specific HFE requirements, suitability shall be checked with respect to the intended function in accordance with NUREG-0700.

4.8 Summary report

All HFE program check results which are described in Section 4.1 through 4.5 are summarized in a Design Implementation result summary report. This report will be made available for NRC for review. This report is intended to fulfill the reporting requirements of the Inspections, Tests, Analyses, and Acceptance Criteria defined in Tier 1 of the DCD.

The result summary report shall include the following:

- The configuration control identification of the V&V'd HSI (either directly or by reference)
- The configuration control identification of the as-built HSI (either directly or by reference)
- A listing of the operational differences identified and the results of the regression analysis of those differences
- Where the regression analysis leads to implementing or repeating HFE program elements, references to the HFE documentation for those program elements, and a summary of compliance to the program element acceptance criteria
- A conclusion that the Design Implementation Program Element has been conducted in accordance with the HSI Design Implementation Plan, that the as-built HSI is the same as the V&V'd HSI or that any changes from the V&V'd HSI have been confirmed using supplemental HFE methods.

5.0 References

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

5-2 HSI System Description and HFE Process, MUAP-07007, Revision 4, MHI, July 2011

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

5-4 US-APWR HSI Design, MUAP-09019, Revision 0, MHI, June 2009

5-5 US-APWR HSI Design Implementation Plan, MUAP-10009, Revision 0, MHI, April 2010

5-6 US-APWR Procedure Development Implementation Plan, MUAP-10010, Revision 0, MHI, April 2010

5-7 US-APWR Training Program Development Implementation Plan, MUAP-10011, Revision 0, MHI, April 2010

5-8 US-APWR Verification and Validation Implementation Plan, MUAP-10012, Revision 0, MHI, April 2010