# US-APWR

# Design Implementation Plan

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# Revision History

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| 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 |
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| | | 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. |
| 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-10009, MUAP-10012, MUAP-10013 and MUAP-10014. |

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# Abstract

This document presents the Implementation Plan for the Human System Interface (HSI) design implementation for a site-specific US-APWR. Hereafter, the plan is referred to as the "US-APWR HSI Design Implementation Plan." (Reference 5-5)

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

# Table of Contents

# List of Acronyms and Abbreviations

| | |
|---|---|
| DAS | diverse actuation system |
| DCD | design control document |
| DHP | diverse HSI panel |
| EOF | emergency operations facility |
| HED | human engineering discrepancy |
| HFE | human factors engineering |
| HSI | human-system interface |
| HSIS | human system interface system |
| ISV | integrated system validation |
| 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. |
| QA | quality assurance |
| RSC | remote shutdown console |
| RSR | remote shutdown room |
| TSC | technical support center |
| US-APWR | United States – Advanced Pressurized Water Reactor |
| V&V | verification and validation |
| V&V'd | verified and validated |
| VDU | visual display unit |

## 1.0 PURPOSE

This document provides the implementation plan for the human system interface (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 validated by the US-APWR verification and validation (V&V) process (Reference 5-6).

In addition, the design implementation plan identifies and evaluates aspects of the design that were not addressed in the V&V program element. These may be site-specific aspects that were not included in V&V or design changes that occur after V&V. It is noted that while successful integrated system validation (ISV) marks the end of the V&V program element, the HSI design will continue to be challenged during Phase 3 of the human factors engineering (HFE) program, which includes operator training. Any minor human engineering discrepancies (HEDs) generated during the V&V program that do not affect the ISV acceptance criteria or conclusions, and any HEDs generated after completion of the V&V program element, will be resolved through this Design Implementation program element.

## 2.0 SCOPE

This plan covers all the HSI within the scope of the US-APWR HFE program defined in design control document (DCD) Section 18.1.1.2. (Reference 5-1)

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, matches the HSI design that was verified and validated in the US-APWR HFE program;
2. That other aspects of the plant that would be affected by the final V&V program results (e.g. lighting and noise) are consistent with the assumptions of the V&V program;
3. 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;
4. 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.

AII HSI that is in the scope of the US-APWR HFE program, as described in DCD Section 18.1.1.2 (Reference 5-1), is within the scope of the V&V program. The V&V for the main control room (MCR) will utilize full scope dynamic simulation, including lighting conditions and simulation of the noise environment. The V&V for HSIS outside the MCR will utilize mockup and part task simulation methods. The same V&V methods, such as operational conditions, sampling, design verification, test design and data analysis, as applied to the MCR, will be adapted to thoroughly evaluate the HSI in all facilities. The process of capturing and resolving HEDs will be applied to all HSIS.

## 3.0 APPLICABLE CODES, STANDARDS, AND REGULATORY GUIDANCE

Compliance to the applicable codes and standards for the US-APWR HSIS design is the same as section 3.0 of the topical report “HSI System Description and HFE Process”, MUAP-07007 (Reference 5-2). :

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

## 4.0 IMPLEMENTATION PLAN

This plan addresses all the HSI that is within the scope of the US-APWR HFE program, by dividing it into three categories:

1. MCR
2. Derivatives of the MCR
3. Single purpose HSIS

Derivatives of the MCR are subsets of the MCR HSIS configured to provide the functionality needed for the purpose of the facility. The HSIS for the remote shutdown room (RSR) and the technical support center (TSC) are derivatives of the MCR.

Single purpose HSIS is an HSIS that is unique to a specific piece of plant or plant equipment type. Examples of single purpose HSIS are the HSIS for safety significant local controls, such as those within the Radioactive Waste Disposal System.

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 (V&V'd) 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 as-built HSIS, procedures, and training are compared with the detailed design description to verify that they conform to the design that has resulted from the HFE process and the V&V activities. The methodology of the verification is described in Reference 5-6.

The evaluation shall examine software, hardware and functionality. Differences in as-built software or hardware shall be evaluated to determine the impact on functionality.

### 4.1 The Main Control Room (MCR)

The MCR is the central location for all process control and plant management. The MCR provides communication with emergency response facilities, the central alarm station and secondary alarm station, and communication with personnel who maintain plant process equipment.

In general, the US-APWR MCR HSIS has been verified and validated as a complete and integrated design. However, for practical reasons there may be differences between the V&V'd HSI design and an implemented site-specific US-APWR MCR. The following subsections address specific verifications that shall be performed.

#### 4.1.1 MCR Functional Verification

The as-built MCR shall be verified against the MCR functional specifications to confirm that all functions specified are provided by facilities within the room. This shall include communications with on-site and off-site emergency facilities, the central alarm station, secondary alarm station and local control stations (LCS's).

#### 4.1.2 MCR Software Configuration Verification

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

1. Large display panel (LDP) displays
2. LDP display logic
3. Operational visual display units (VDU) displays
4. Operational VDU controls
5. Operational VDU displays and controls logic
6. Safety VDU displays
7. Safety VDU controls
8. Safety VDU control logic
9. Alarm VDU displays
10. Alarm VDU display logic
11. Alarm messages database
12. Operating procedures database for normal operations, abnormal operations and emergency operations (computer-based procedures and paper procedures)
13. Safety controls operating procedures(paper procedures)
14. Diverse actuation system (DAS) operating procedures(paper procedures)

The MCR software configuration assessment shall verify all versions of the software data files that define the HSIS in the MCR. When the configuration assessment identifies 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 the HSI operation.

### 4.1.3 MCR Hardware Configuration Verification

For the hardware configuration, the assessment shall be accomplished by verifying the MCR HSIS panels match the V&V'd HSIS panels. Differences shall be evaluated for their impact on HSI operation. For example, differences in such as panel color, material or minor dimensional differences might be evaluated that they would not impact on HSIS operation.

### 4.1.4 MCR Dedicated Controls Verification

The MCR dedicated controls verification shall demonstrate that the as-built dedicated controls match the V&V'd design. The assessment shall be accomplished by verifying that the as−built physical configuration of the MCR dedicated controls match with the V&V'd design for the following:

- Safety switches
- Diverse HSI Panel (DHP) indicators

- DHP switches

For the cases variations in switch/indicator model numbers are identified, the differences shall be evaluated for their impact on operation of the HSIS, focusing changes in functional performance.

### 4.2 Remote Shutdown Room (RSR)

The RSR is a derivative of the MCR.

The RSR is located in a different fire zone with 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, maintain hot shutdown condition, and transfer to maintain cold shutdown.

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

#### 4.2.1 RSR Functional Verification

The as-built RSR shall be verified against RSR functional specifications to confirm that all functions specified are provided by facilities within the room. This shall include communications with on-site and off-site emergency facilities, the central alarm station, secondary alarm station and LCSs.

#### 4.2.2 RSR Software Configuration Verification

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

1. Operational VDU displays
2. Operational VDU controls
3. Operational VDU control logic
4. Safety VDU displays
5. Safety VDU controls
6. Safety VDU control logic
7. Alarm VDU logic
8. Alarm messages database
9. Operating procedures for normal operations, abnormal operations, and emergency operations(paper procedures)
10. Safety controls operating procedures(paper procedures)

The RSR software configuration assessment shall verify all versions of the software data files that define the HSIS in the RSR. Where the configuration verification identifies 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 the HSIS operation.

This verification 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 for only a portion of the task basis.

### 4.2.3 RSR Hardware Configuration Verification

For the hardware configuration, the assessment shall be accomplished by verifying 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 accommodates facilities to support plant management and technical personnel assigned during emergency, and will be the primary onsite plant emergency communications center.

The facility consists of a plant data display system using VDUs (monitoring functions only) and a LDP, data communication system, telecommunication system of telephones and facsimiles by multiple methods of transmission, including private and public lines, satellite, as well as adequate work 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 Verification

As-built TSC shall be verified against the TSC functional specification to verify that all functions specified are provided by facilities within the room. This shall include communications with on-site and off-site emergency facilities and the MCR.

### 4.3.2 TSC Software Configuration Verification

The TSC configuration verification 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 verifying that the versions of the TSC HSI software data match the MCR V&V'd design software data for the following:

1. LDP displays

2. LDP display logic
3. Operational VDU displays
4. Operational VDU displays logic
5. Alarm VDU display logic
6. Alarm messages database
7. Operating procedures for normal operations, abnormal operations and emergency operations(paper procedures)

The TSC software configuration assessment shall verify all versions the software data files that define the HSI operation of the TSC. 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 verification 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 for only a portion of the task basis.

### 4.3.3 TSC Hardware Configuration Verification

For the hardware configuration, the assessment shall be accomplished by verifying 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. The as-built TSC HSIS may not exactly match the layout or configuration of the verified TSC design documentation. Differences shall be evaluated for their impact on HSI operation and compliance with NUREG-0700.

## 4.4 Single Purpose HSIS

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

Single purpose HSIS also includes HSI for plant support systems 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 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 HSIS and local controls that may be supplied as part of a pump or a valve.

Those components that are safety-related and the local HSI will be used to support safety-significant testing or maintenance activities are:

- Technical specification activities for surveillance testing, radiological protection and required chemical monitoring
- Maintenance required by the plant technical specifications
- Emergency and abnormal conditions response

The results of this HSI shall be included in the US-APWR HFE process.

### 4.4.2 Single Purpose Configuration and Suitability Verification

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

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

## 4.5 Emergency Operations Facility (EOF)

The 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 Quality Assurance (QA) Supervision

The QA supervision associated with a nuclear power plant project including HSI design implementation is applied.

### 4.6.1 Human Engineering Discrepancies (HEDs)

Any HFE issue arising during the HSI design implementation phase shall be documented as a HED. HEDs shall be processed in the same method as all other HEDs generated in other HFE program element. (See Reference 5-4, Part 1, Section 6) All HEDs generated shall be captured and tracked using the HED database.

### 4.6.2 Other Organizations

The interaction between the HFE Design/V&V Teams and other 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. The regression analysis shall determine the significance of the change and what aspects of prior HFE program elements must be repeated.

As a minimum, HSI equipment or interfaces that were not included in the V&V'd design (i.e., industrial television (ITV), temporary HSI for testing and maintenance) shall be verified to ensure that they do not interfere with V&V'd HSI functions.

For HSI features that have been included within each HFE program element but were not evaluated in the V&V program element, a specific method of V&V will be determined. V&V methods include the use of table-top walkthroughs, mock-ups, part task simulators and plant walk-downs. This is expected to apply to HSI features that (1) are outside the scope of a typical MCR simulator (e.g. HSI for local equipment testing) or whose detailed implementation was not available in time to support ISV, and (2) are evaluated to have no impact on the ISV.

Completely-new HSI features will be evaluated in accordance with each HFE program element. If the evaluation concludes the HSIS has no impact on the ISV, then a specific V&V method will be determined as explained above. Otherwise, the aspects of ISV that are impacted by the new HSI feature will be repeated.

### 4.8 Summary Report

All results of the V&V Program will be compiled in the form of a results summary report. This report is also intended to fulfill the requirements of the Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) defined in DCD Tier 1.

The results summary report shall include:

- The configuration control identification of the V&V'd HSIS (either directly or by reference)
- The configuration control identification of the as-built HSIS (either directly or by reference)
- A listing of the operational differences identified and the results of the regression analysis of those differences
- References to the HFE documentation for the program elements and a summary of compliance to each program element acceptance criteria, for the cases where the regression analysis leads to implementing or repeating HFE program elements
- A conclusion that the Design Implementation Program Element has been conducted in accordance with the HSI Design Implementation Plan; that the as-built HSIS is the same as the V&V'd; or that no impact on the HSIS operation has been identified in any changes from the V&V'd HSIS by 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 5, MHI, November 2011

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

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

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

5-6 US-APWR Verification and Validation Implementation Plan, MUAP-10012, Revision 2, MHI, October 2012