

18.2.6 Evaluation of COL Information Item 18.2-1 (no comparable FSER section)

18.2.6.1 Summary of Technical Information

COL Information Item 18.2-1 states the following:

The COL applicant referencing the AP1000 certified design is responsible for the execution of a U.S. Nuclear Regulatory Commission (NRC)-approved HFE Program.

In DCD Revision 17, the applicant stated:

[The] AP1000 Human Factors Engineering Program Plan fully captures the information certified in Section 18.2 and provides execution guidance for the NRC-approved HFE Program. The ongoing confirmation that the AP1000 HFE Program Plan is being executed as required is demonstrated by fulfillment of the other COL Information Items in Chapter 18. The final confirmation that the HFE Program Plan has been executed will be demonstrated by completion of the ITAAC [Inspections, Tests, Analyses and Acceptance Criteria] (Tier 1 Material, Table 3.2-1, Items 1 to 13).

18.2.6.2 Evaluation

From a program overview perspective, the applicant used Revision 17 to document changes in the status of a number of COL information items and ITAAC. TRs provided for staff review contain the supporting documentation. When the TRs indicate that partial progress has been made and additional work to address information items is ongoing, the staff evaluated redundancy between the COL information item and the ITAAC. If the staff identified redundancy, then the COL action item was closed. In all cases, the review ensured that final design product completion was appropriately tracked. The staff identified all documents used to conclude that the NUREG-0711 criteria were satisfactorily implemented, and Westinghouse docketed the documents.

With respect to COL Information Item 18.2-1, the staff determined that the information item is closed based on the following:

- (1) The AP1000 HFE Program Plan is consistent with AP1000 DCD, Revision 15. It describes the scope of the HFE program in terms of each of the NUREG-0711 elements. It provides additional information on where and how the overall design process should use HFE guidance and, thus, provides reasonable assurance that the applicant will implement and undertake the required HFE activities for the AP1000 design at the most appropriate time in the project schedule. This program element requires no additional product development.
- (2) COL information items in other sections and the ITAAC listed in Table 3.2-1 address specific HFE design products that require completion. Retaining this generic information item is redundant with the remaining open information items and ITAAC.
- (3) The applicant must implement the HFE verification and validation (V&V) program in accordance with ITAAC Table 3.2-1, Item 1 (DCD Revision 17). This includes five specific tasks that validate and verify HFE program implementation and concludes with

an as-built inspection of the human-system interfaces (HSIs) as constructed at the time of plant startup. The combination of these actions provides better verification of field implementation than would be accomplished under this COL information item.

18.2.6.3 Conclusion

The staff concludes that COL Information Item 18.2-1 is redundant to existing ITAAC included in Tier 1, Table 3.2-1. Consequently this COL information item is closed. ITAAC Item 1 (DCD Revision 17) will verify the execution of the NRC-approved HFE program.

18.2.7 Evaluation of COL Information Item 18.2-2 (no comparable FSER section)

18.2.7.1 Summary of Technical Information

COL Information Item 18.2-2 states the following:

Specific information regarding the location of the emergency operations facility and emergency operations facility communications will be provided by the Combined Operating License applicant to address the Combined License information requested in this subsection.

18.2.7.2 Evaluation

The applicant stated in TR-134 (APP-GW-GLR-134, Revision 4, "AP1000 Standard COLA Technical Report," issued March 2008) that TR-136 (APP-GW-GLR-136, Revision 1, "AP1000 Human Factors Program Implementation for the Emergency Operations Facility and Technical Support Center," issued October 2007) partially addresses the information requested by this information item. In TR-136, the applicant described the method used to apply the AP1000 HFE Program Plan to technical support centers (TSCs) and emergency operations facilities (EOFs) used to support AP1000 plants and stated that the COL applicant has overall responsibility for the human factors adequacy of the TSC and EOF. In APP-OCS-GGR-110-P, Revision 1, "AP1000 Technical Support Center and Emergency Operations Facility Workshop," issued February 2008, the applicant described in detail how it developed the information in TR-136.

In TR-136 and subsequently in AP1000 DCD Amendment 17, the applicant made changes to this COL information item that deleted HFE design responsibilities that were included in the previously approved COL information item in the DCD, Revision 15. In response to RAI-SRP18-COLP-21 (Westinghouse letter DCP/NRC 002577; July 31, 2009), the applicant removed EOF and TSC location requirements and added responsibilities for EOF and TSC human factors attributes.

Deletion of location requirements is acceptable because the HFE design is not dependent on location. The location of the EOF and TSC is subject to regulatory guidance. This is addressed in Chapter 13.3, "Emergency Planning," of this SER.

The addition of COL responsibility for defining EOF and TSC human factors attributes is consistent with the intent of the original, approved COL information item and ensures that HFE design outside the scope of the AP1000 DCD is addressed. Inclusion of the RAI response into Revision 18 of the DCD is tracked as **Confirmatory Item CI-SRP18-COLP-21**.

From the program description provided in TR-136 and APP-OCS-GGR-110-P, the NRC staff noted a well-structured and disciplined assessment of the HFE requirements applicable to the TSC and EOF. The following examples demonstrate how the applicant used the AP1000 HFE Program Plan and appropriate regulations to identify the HFE design requirements of the TSC/EOF:

- Westinghouse and utility personnel worked together to identify the functional requirements for the TSC/EOF. The diverse experience in this group supported a thorough evaluation.
- Westinghouse extracted specific requirements from the AP1000 DCD; the AP1000 HFE Program Plan; NUREG -0711, Revision 2; NUREG-0696, "Functional Criteria for Emergency Response Facilities," issued February 1981; and NUREG-0654, Revision 1, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants," issued March 2002. These documents serve as the basis for identifying the TSC/EOF functional requirements. Identification of functional requirements is one of the basic steps required in the AP1000 HFE Program Plan and NUREG-0711. APP-OCS-GGR-110-P provides complete documentation of how Westinghouse identified applicable functions.
- Westinghouse and utility representatives conducted an operating experience review (OER). Application of lessons learned from operating experience is one of the basic steps required in the AP1000 HFE Program Plan and NUREG-0711.
- Westinghouse completed a task analysis incorporating OER results, observations from emergency plan drills at V.C. Summer and Harris nuclear sites, input from emergency procedures from four different utilities, and review comments from both Westinghouse and utility personnel. In TR-136, the applicant stated that it will capture the requirement for this task analysis in the Operational Sequence Analysis-2 (OSA-2) Implementation Plan. A task analysis is one of the basic steps required in the AP1000 HFE Program Plan and NUREG-0711, and OSA-2 incorporates accepted methods for performing task analyses.
- In accordance with TR-136, Section 2.4.4, Westinghouse has identified applicable HSI design guidelines from the AP1000 HSI design guidelines (APP-OCS-J1-002, Revision 0, "AP1000 Human System Interface Design Guidelines") to promote the human factors design adequacy of the TSC/EOF design. This ensures that standard HSI design requirements will be applied to the appropriate elements of HSI design.
- EOF/TSC HFE design elements outside the AP1000 scope are addressed via a COL information item. This provides reasonable assurance that a complete HFE design will be achieved for these emergency facilities.

Based on the activities outlined above, the applicant's use of a tailored approach in applying the AP1000 HFE program to the TSC and EOF is solidly based on NUREG-0711. The applicant has documented the TSC and EOF task analysis results in APP-OCS-JOA-001, "HFE Analysis to Support TSC and EOF Design." Open Item **OI-SRP18-COLP-18** tracked completion of the task analysis and documentation of the results. This Open Item has been addressed by

issuance of the report, which satisfactorily summarizes task analysis results associated with the EOF and TSC and is closed.

18.2.7.3 Conclusion

The applicant has developed a sufficient basis for applying a tailored HFE program to the TSC and EOF and has documented the TSC and EOF task analysis results in the APP-OCS-JOA-001 report. The revised COL Information Item 18.2-2 accurately communicates the COL applicant's responsibility for HFE design of the EOF and TSC. **Confirmatory Item CI-SRP18-COLP-21** tracks the revision of the DCD to reflect the revised COL information item.

18.2.8 Evaluation of Tier 1 Information—Design Commitment 3, ITAAC Table 3.2-1 (DCD Revision 15)

18.2.8.1 Summary of Technical Information

ITAAC Design Commitment 3 (DCD Revision 15) reads as follows:

Design Commitment: The HSI design is performed for the operation and control system (OCS) in accordance with the HSI design implementation plan.

Inspection, Tests, and Analyses: An evaluation of the implementation of the HSI design.

Acceptance Criteria: A report exists and concludes that the HSI design for the OCS was conducted in conformance with the implementation plan and includes the following documents:

- Operation and Control Centers System Specification Document
- Functional requirements and design basis documents for the alarm system, plant information system, wall panel information system, controls (soft and dedicated), and the qualified data processing subsystems
- Design guideline documents (based on accepted HFE guidelines, standards, and principles) for the alarm system, displays, controls, and Anthropometrics
- Design specifications for the alarm system, plant information system, wall panel information system, controls (soft and dedicated), and the qualified data processing subsystems
- Engineering test report document summarizing outcomes of each man-in-the loop engineering test iteration performed to support HSI design

In DCD Revision 17, the applicant deleted this ITAAC based on completion of the work it described.

18.2.8.2 Evaluation

The staff did not find a one-to-one correlation between the list of completed documents in TR-82 (APP-GW-GLR-082, Revision 0, "Execution and Documentation of the Human System Interface Design Implementation Plan," issued May 2007) and the AP1000 DCD, Tier 1, ITAAC Table 3.2, Design Commitment 3 (DCD Revision 15), acceptance criteria. Design documents were not identified for the following areas:

- functional requirements and design-basis documents for the plant information system
- functional requirements and design-basis documents for controls (soft and dedicated)
- functional requirements and design-basis documents for the qualified data processing subsystems

RAI-SRP18-COLP-05 requested clarification of the discrepancy. The applicant's response (Westinghouse letter DCP/NRC2141 of May 28, 2008) indicated that terminology changes resulted in the inclusion of the areas listed above in the "Distributed Control and Information System" (APP-OCS-J1-010, "AP1000 Display System Functional Requirements"). The staff found that this document contains the functional requirements and design-basis information for the systems listed above. The staff concluded that this change was limited to renaming and reorganizing information to improve clarity and did not affect the intent of the ITAAC.

Open Item **OI-SRP18-COLP-01A** identified that the applicant had not completed all the design specifications listed in the ITAAC. These design specifications were subsequently completed along with specifications for systems not listed.

The staff reviewed the completed documents referenced in TR-82, along with the information provided in the RAI, and concluded that these documents appropriately implement the HSI design implementation plan, as described in AP1000 DCD, Revision 17. This included the documents referenced in the ITAAC. Clarity was consistently good across the procedural hierarchy, and the specificity of design requirements had increased in the transition from the functional design level to design specifications. These procedures provide reasonable assurance that the design process will effectively implement standardized HFE design requirements. Based on these results, **OI-SRP18-COLP-01A** has been satisfactorily addressed and is closed. The staff evaluates the translation of these design documents to a physical design as part of ITAAC Table 3.2-1 Design Commitment 1b (DCD Revision 17).

18.2.8.3 Conclusion

The staff concludes that the proposed change to delete Design Commitment 3 of the ITAAC is supported by the quality of the design documents that have been produced. The design documents provide the level of detail needed to provide reasonable assurance that the Human Factors engineering design will be effectively implemented within the control room, remote shutdown station, and local control stations. Design Commitment 3 in ITAAC Table 3.2-1 (DCD Revision 15) is closed.

18.5 Element 4: Task Analysis

18.5.5 Evaluation of Operational Sequence Analysis-2 Implementation Plan and Results Summary

18.5.5.1 Summary of Technical information

In AP1000 DCD, Revision 17, the discussion of OSA-2 deleted the description of a specific theoretical model for evaluating operator workload measures, but still committed to conducting an evaluation of the effect of the HSI design and the task demands on operator workload. In TR-81 (APP-GW-GLR-081, Revision 1, "Closure of COL Information Item 18.5-1, Task Analysis," issued May 2007) and in the RAI-TR81-COLP-01 response dated January 29, 2008 (Agency wide Documents Access and Management System (ADAMS) Accession Number ML080320212), Westinghouse indicated that APP-OCS-J1R-210, Revision 1 "AP1000 Operational Sequence Analysis (OSA-2) Implementation Plan," would identify the most appropriate task analysis methods to use.

18.5.5.2 Evaluation

The staff reviewed the OSA-2 Implementation Plan, which describes the applicant's methods for analyzing the collected task sequence information needed to satisfy the four issues addressed in the DCD: (1) completeness of available information, (2) time to perform tasks, (3) operator workload analysis, and (4) operational crew staffing. The staff concludes that it is acceptable to remove the prescriptive language from the DCD because the applicant provided a robust implementation plan containing detailed information describing how to conduct an OSA analysis, the tasks that should be part of the analysis, and the expected results from the analysis.

The staff also reviewed APP-OCS-J1R-220, Revision B, "AP1000 Operational Sequence Analysis (OSA-2) Summary Report," which describes the results of conducting the activities described in the implementation plan.

18.5.5.3 Conclusion

Based on its review of the implementation plan and the summary report, the staff has determined that sufficient information exists to address the NUREG-0711 review criteria as described in the COL closure section below.

18.5.6 Evaluation of COL Information Item 18.5-1 (FSER Item 18.5.3-3)

18.5.6.1 Summary of Technical Information

COL Information Item 18.5-1 states the following:

Combined License applicants referencing the AP1000 certified design will address the execution and documentation of the task analysis implementation plan presented in Section 18.5.

Appendix F of NUREG-1793 broke this COL information item into two pieces and reworded the information item so that it reads:

FSER Item 18.5.3-3: The staff reviewed the applicant's task analysis at an implementation plan level of detail; finished products to complete the element were not available for review, but the methodology for conducting a complete

task analysis was evaluated. The COL applicant will use this methodology to conduct a complete HFE task analysis after design certification.

FSER item 18.5.3-2: The COL applicant will utilize the information from the AP1000-specific task analysis in the development of its procedures and training programs.

This section addresses execution of the task analysis implementation plan which Westinghouse completed. TR-81 was submitted to document the task analysis results. The report recommends a revision to Tier 1 of the DCD ITAAC to reflect completion of the AP1000 function-based task analysis and provides a basis for closure of COL Information Item 18.5-1. The applicant also provided the OSA-2 Implementation Plan, which describes the methodology used to conduct the second round of OSA.

18.5.6.2 Evaluation

The staff evaluated the information provided by the applicant in the OSA-2 Implementation Plan and the OSA-2 Summary Report against acceptance criteria from NUREG-0711, Revision 2.

NUREG-0711, Section 5.4(1), states Criterion 1 as the following:

The scope of the task analysis should include the following:

- selected representative and important tasks from the areas of operations, maintenance, test, inspection, and surveillance
- a full range of plant operating modes, including startup, normal operations, abnormal and emergency operations, transient conditions, and low power and shutdown conditions
- Human Actions (HAs) that have been found to affect plant risk by means of PRA importance and sensitivity analyses should also be considered risk-important
- where critical functions are automated, all human tasks, including monitoring of the automated system and execution of backup actions if the system fails

Evaluation of Criterion 1

The staff reviewed OSA-2 Summary Report, which provides the results of the OSA-2 for the AP1000 design in accordance with the OSA-2 Implementation Plan. The OSA-2 Implementation Plan summarizes [] components and the corresponding [] maintenance, test, inspection, and surveillance (MTIS) tasks used for the task analysis. The inclusion of representative and important tasks from the areas of operations, maintenance, test, inspection, and surveillance during OSA-2 implementation satisfies the requirements in the first bullet of NUREG-0711 Criterion 1.

The OSA-2 Implementation Plan identified [] risk-important tasks, including tasks during normal operations, emergency and abnormal operations, and shutdown conditions. The

inclusion of these tasks within the scope of the task analysis implementation plan satisfies the requirements of the second bullet of NUREG-0711 Criterion 1.

As described in the AP1000 DCD, the applicant performed OSA-2 for a representative subset of tasks including risk-important human actions, risk-important tasks, and tasks that have human performance concerns. The applicant used human reliability analysis (HRA) to identify [] scenarios and associated tasks described in the implementation plan as risk-important tasks. This is an acceptable method for identifying risk-important tasks. The applicant used probabilistic risk assessment (PRA) to identify estimated timeframes for completing the tasks, as well as the beginning and ending steps. For example, the plan discusses tasks associated with [] an [], and a []. These events are considered to be within the design basis, and risk-important tasks are associated with them. The identification and inclusion of these risk-important tasks within the scope of the OSA-2 Implementation Plan satisfies the third bullet of NUREG-0711 Criterion 1.

The OSA-2 Implementation Plan discusses [] tasks identified during OSA-1 as having human performance concerns. These []

[]. The selection of tasks that have associated human factors concerns demonstrates that the applicant has chosen to analyze critical automated functions. The implementation plan describes the backup actions to be taken in case of a failure. Analysis of automated system failures and backup actions during OSA-2 satisfies the fourth bullet of NUREG-0711 Criterion 1.

The staff has determined that the scope of the task analysis is consistent with NUREG-0711 Criterion 1.

NUREG-0711, Section 5.4 (2), states Criterion 2 as the following:

Tasks should be linked using a technique such as operational sequence diagrams. Task analyses should begin on a gross level and involve the development of detailed narrative descriptions of what personnel have to do. The analyses should define the nature of the input, process, and output needed by and of personnel.

Evaluation of Criterion 2

Consistent with the NUREG-0711 criterion, the applicant used the [] methodology to conduct two rounds of analysis. The first analysis, OSA-1, identified risk-important tasks, []

[] for safe operation and safe shutdown for the AP1000 design. OSA-2 used the tasks identified from OSA-1 to estimate [].

The staff reviewed the OSA-1 report titled "AP1000 Operational Sequence Analysis (OSA) Summary Report," Revision 0, (APP-OCS-J1R-120) and the implementation plans for OSA-1 (APP-OCS-J1R-110) and OSA-2, (APP-OCS-J1R-210). These reports describe the applicant's methods for analyzing the collected sequence information needed to satisfy the four issues identified in the DCD:

- (1) Completeness of information: Establish the necessary information for successful task performance. The results of this analysis feed into the interface design process to ensure necessary information is available to the operator performing the task activities.
- (2) Time to perform tasks: Establish that the operators will be able to complete tasks within the time available. This information is based on assumptions about the time required to access displays, select and actuate controls, etc. The OSA-2 Summary Report discusses that the generally acceptable range of "good" or appropriate operator workload is between 50 and 80 percent. A workload greater than 80 percent indicates a potential overload, while a workload less than 50 percent indicates a potential underload.
- (3) Operator Workload: Establish the impact of task requirements and the HSI design on operator workload.
- (4) Operational crew staffing: Establish staffing requirements. The results of the operator workload assessment and the identification of time constraints are used to review the adequacy of staffing assumptions, HSI design, task allocation and work organization.

Since the OSA-1 analysis was more general than the OSA-2 analysis, and the information from OSA-1 was used as input into OSA-2, the applicant's task analysis is consistent with NUREG-0711 Criterion 2 that the analysis should begin on a gross level (OSA-1) and become more detailed as the analysis proceeds.

Because of the overlap between Criteria 2 and 3, the staff presents its evaluation of the applicant's task analysis with regard to development of detailed narrative descriptions under Criterion 3 below and addresses the input, process, and output needed by and from personnel.

Based on its evaluation, the staff concludes that the applicant has satisfactorily met NUREG-0711 Criterion 2.

NUREG-0711, Section 5.4(3), states Criterion 3 as the following:

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.

Evaluation of Criterion 3

Westinghouse conducted OSA-1 and OSA-2 and described these analyses in APP-OCS-J1R-120, Revision 0, and APP-OCS-J1R-220, Revision B, respectively. The staff evaluated these documents and found that OSA-1 focused on specifying the operational requirements for a set of selected tasks. OSA-1 also identified risk-important tasks and thoroughly described the [

]. An [] was developed to show

To illustrate this aspect of the task analysis data collection process, the applicant provided an example task analysis for [] in the OSA-2 Summary Report. For one risk-important task, “[]” the applicant identified (1) []

].

Based on its review of the process discussed in the applicant’s OSA-2 Implementation Plan and the example provided, the staff concludes that the task analyses conducted were 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.

Based on its evaluation, the staff concludes that the applicant has satisfactorily met NUREG-0711 Criterion 3.

NUREG-0711, Section 5.4(4), states Criterion 4 as the following:

The task analysis should address issues such as:

- the number of crew members
- crew member skills
- allocation of monitoring and control tasks to the (a) formation of a meaningful job, and (b) management of crew member’s physical and cognitive workload.

Evaluation of Criterion 4

Section 2.3.3 of the task analysis implementation plan describes operator workload analysis as an evaluation of the effect of the HSI design and the demands on operator workload. The methodology used for assessing []

].

Section 2.3.4 of the task analysis implementation plan discusses the analysis of operational crew staffing. When the OSA indicates []

[]]. The applicant uses the results from the OSA to []

[]]. The applicant provided an example of the []].

The staff has concluded that Westinghouse has conducted a thorough task analysis using both OSA-1 and OSA-2 and has described in detail the results from its analysis. The OSA-2 analysis was conducted in accordance with the implementation plan, which addresses issues such as the number of crew members, crew member skills, and allocation of monitoring and control tasks.

NUREG-0711, Section 5.4 (5), states Criterion 5 as the following:

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.

Evaluation of Criterion 5

The OSA-2 Implementation Plan, section 2.3.1, states that the [

]. The HSI design process uses the [

] of OSA-2. This approach is consistent with the information described in Revisions 15–17 of the DCD and satisfies NUREG-0711 Criterion 5.

NUREG-0711, Section 5.4 (6), states the following as Criterion 6:

The task analysis should provide input to the design of HSIs, procedures, and personnel training programs.

Evaluation of Criterion 6

The OSA-1 analysis identified inputs to the HSI design including display requirements, display design constraints, performance time constraints, inventory (alarms, controls, parameters), and display organization and navigation constraints. OSA-2 is performed as part of the design development process to understand the estimated operator workload, performance time estimates, staffing issues, and error potential associated with each task. The staff concludes that, as with OSA-1, the results of OSA-2 provide input to the design of HSIs by providing a set of requirements and constraints on operator task performance.

In NUREG-1793, Section 18.5.3, the staff identified COL Information Item 18.5-1 (FSER Item 18.5.3-2), which states, “The COL applicant will use the information from the AP1000-specific task analysis in the development of its procedures and training programs.” In response to RAI-SRP18.5-COLP-01 provided in a letter dated May 28, 2008, the applicant referred to Sections 5.6 and 5.7 of the AP1000 HFE Program Plan (APP-OCS-GBH-001), which describes two documents: APP-OCS-GER-031, “The Incorporation of Human Factors Engineering into the Development of the AP1000 Plant Procedures,” and APP-OCS-GER-041, “The Incorporation of Human Factors Engineering into the Development of the AP1000 Plant Training Program.” According to Westinghouse’s response to the RAI, the purpose of these documents is to capture the operator training and procedure information identified in the task analyses. These reports ensure that information related to training and procedures is identified, recorded, and communicated to those responsible for the development of the training programs.

Open Item **OI-SRP18-COLP-17** tracked completion of these documents. The staff has reviewed the completed documents and determined that information from OSA-1 and OSA-2 analyses useful to procedures and training program development has been identified, extracted, and compiled such that it can be used as direct input by procedure and training developers. Accordingly, the staff finds that Criterion 6 has been satisfactorily addressed and the open item is closed.

NUREG-0711, Section 5.4 (7), states Criterion 7 as 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.

Evaluation of Criterion 7

The applicant is not required to address the impact of plant modifications on risk-important HAs because Revision 17 of the AP1000 DCD applies to new plant construction.

18.5.6.3 Conclusion

In its evaluation of Revision 15 of the AP1000 DCD, the staff reviewed the function-based task analysis and OSA-1 results and concluded that the applicant had developed an acceptable task analysis implementation plan to satisfy the NUREG-0711 criteria for task analyses. The COL applicant was expected to use this methodology to conduct a complete task analysis after design certification (Reference COL Action Item 18.5.3-3). To close this action item, Revision 17 of the AP1000 DCD referenced additional task analysis documents, which describe an implementation plan for conducting a second operational sequence analysis (OSA-2) and provide a summary report of the OSA-2 results. The OSA-2 Implementation Plan and OSA-2 Summary Report focus on risk-important human actions, tasks with high human performance concerns, and on maintenance, testing, inspection, and surveillance activities. Based on its evaluation of Revision 17 of the DCD and the referenced reports, the staff concludes that the applicant's task analysis conforms to all applicable Criteria from NUREG-0711, Section 18.5.

18.5.7 Evaluation of COL Information Item 18.5-1 (FSER Item 18.5.3-2)

18.5.7.1 Summary of Technical Information

COL Information Item 18.5-1 from the DCD does not correlate well with its counterpart, FSER Item 18.5.3-2 which states:

The COL applicant will utilize the information from the AP1000-specific task analysis in the development of its procedures and training programs.

The DCD information item 18.5-1 (see previous section) focuses on documentation of task analysis results and the staff identified information item addresses application of that information.

18.5.7.2 Evaluation

In response to RAI-SRP18.5-COLP-01, the applicant referred to Sections 5.6 and 5.7 of the AP1000 HFE Program Plan, which describes two documents (APP-OCS-GER-031, "The

Incorporation of Human Factors Engineering into the Development of the AP1000 Plant Procedures,” and APP-OCS-GER-041, “The Incorporation of Human Factors Engineering into the Development of the AP1000 Plant Training Program”). These documents capture the operator training and procedure information identified in the task analyses. They provide an acceptable vehicle for communicating this information to those responsible for the development of the procedure and training programs. This directly addresses the DCD related action to document the task analysis results.

Using task analysis results to support procedure program development is satisfactorily addressed in the writer’s guides, which are discussed in section 18.9.5.2 of this report.

Using task results to support training program development is not directly addressed in the DCD. When the DCD Revision 15 SER was prepared, no action was taken to include an additional COL information item to reflect the conclusions in the SER. Addition of the action to DCD Revision 18 is considered unnecessary. The bases material has been made readily available. COL applicants can use this information as appropriate as they develop SAT based training programs in accordance with industry and regulatory guidance.

18.5.7.3 Conclusion

This COL information item is closed because APP-OCS-GER-031, “The Incorporation of Human Factors Engineering into the Development of the AP1000 Plant Procedures,” and APP-OCS-GER-041, “The Incorporation of Human Factors Engineering into the Development of the AP1000 Plant Training Program” adequately communicate the task analysis results applicable to procedure and training program development. As mentioned earlier, this work was being tracked by **OI-SRP18-COLP-17**, which has been closed.

18.5.8 Evaluation of COL Information Item 18.5-2 (FSER Item 18.5.3-1)

18.5.8.1 Summary of Technical Information

COL Information Item 18.5-2 (FSER Item 18.5.3-1) states the following:

[A] COL applicant referencing the AP1000 certified design will document the scope and responsibilities of each Main Control Room position, considering the assumptions and results of the task analysis.

The applicant submitted TR-52 (APP-GW-GLR-010, Revision 2, “AP1000 Main Control Room Staff Roles and Responsibilities,” issued June 2007) as a basis for closing COL Information Item 18.5-2 (FSER Item 18.5.3-1).

18.5.8.2 Evaluation

TR-52 states that the applicant has fully addressed the COL information item. Revision 18 of the DCD incorporates the applicable changes. As described in Section 4.5 of TR-52, the role of the shift technical advisor (STA) for the AP1000 design, including the role of assessing possible significant plant abnormalities observed during normal operations, is consistent with the typical responsibilities of the STA as listed in NUREG-0737, “Clarification of TMI Action Plan Requirements,” issued November 1980.

The staff issued RAI-TR52-COLP-12 asking Westinghouse to further clarify the duties and responsibilities in some key areas, including the RO and STA roles in communication and coordination. In response, Westinghouse submitted “AP1000 COL Responses to Requests for Additional Information,” dated November 16, 2007 (ADAMS Accession Number ML073240107), which clarifies the roles and responsibilities of the RO and STA. In its response, Westinghouse described the responsibilities for all MCR ROs to communicate with the MCR supervisor and local equipment operators (EOs) to ensure coordination of local unit evolutions with plant operations. The RAI response also describes the responsibilities of the MCR supervisor to maintain awareness of directions given to the EOs and to evaluate any abnormal conditions or operating concerns reported by either the ROs or the EOs. The OSA-2 Implementation Plan and the OSA-2 Summary Report also address MCR responsibilities. These responsibilities conform with the requirements in Title 10 of the *Code of Federal Regulations* (10 CFR) 50.54, “Conditions of Licenses.”

18.5.8.3 Conclusion

The staff finds that TR-52 adequately describes the MCR staff roles. The applicant’s response to RAI-TR52-COLP-12 addresses each section of the RAI not addressed in TR-52, including specifying how each STA responsibility matches with the list of 12 responsibilities in Appendix C to NUREG-0737. These documents in combination provide sufficient information to close COL Information Item 18.5-2 (FSER Item 18.5.3-1).

18.5.9 Evaluation of Tier 1 Information—Design Commitment 2, ITAAC Table 3.2-1 (DCD Revision 15)

18.5.9.1 Summary of Technical Information

ITAAC Design Commitment 2 reads as follows:

Design Commitment: The applicant performs a task analysis in accordance with the task analysis implementation plan.

Inspection, Tests, and Analyses: An evaluation of the implementation of the task analysis will be performed.

Acceptance Criteria: A report exists and concludes that function-based task analyses were conducted in conformance with the task analysis implementation plan and include the following functions:

- Control reactivity
- Control reactor coolant system (RCS) boron concentration
- Control fuel and cladding temperature
- Control RCS coolant temperature, pressure, and inventory
- Provide RCS flow
- Control main steam pressure
- Control steam generator inventory
- Control containment pressure and temperature
- Provide control of main turbine

A report exists and concludes that operational sequence analyses (OSAs) were conducted in conformance with the task analysis implementation plan. OSAs performed include the following:

- Plant heatup and startup from post-refueling to 100 percent power
- Reactor trip, turbine trip, and safety injection
- Natural circulation cooldown (startup feedwater with steam generator)
- Loss of reactor or secondary coolant
- Post-loss-of-coolant accident (LOCA) cooldown and depressurization
- Loss of RCS inventory during shutdown
- Loss of the normal residual heat removal system (RNS) during shutdown
- Manual automatic depressurization system (ADS) actuation
- Manual reactor trip via PMS, via diverse actuation system (DAS)
- ADS valve testing during mode 1

In DCD Revision 17, the applicant deleted this ITAAC because it had completed the work described.

18.5.9.2 Evaluation

The task analysis consists of a function-based task analysis and two OSA analyses (OSA-1 and OSA-2). As documented in its safety evaluation of the AP1000 DCD Revision 15, the staff reviewed the function-based task analysis and OSA-1 results and concluded that these task analyses are complete. As part of the DCD Revision 17 review, the staff reviewed the OSA-2 Implementation Plan and OSA-2 Summary Report. The reports describe the detailed methodology the applicant used to conduct OSA-2, as well as the results and impact on the four issues described in the OSA-2 Implementation Plan: 1) completeness of available information, 2) time to perform tasks, 3) operator workload analysis, and 4) operational crew staffing. As described, the task analysis was used in establishing the basis for the HFE design.

The staff reviewed the OSA-2 Summary Report (APP-OCS-J1R-220), Revision A, which provides the results of OSA-2 for the AP1000 design in accordance with the implementation plan. The implementation plan summarizes [] components and the corresponding [] MTIS tasks for analysis. The results summary report also describes [] scenarios and [] associated tasks that were described in the implementation plan and analyzed during OSA-2 implementation. Open Item **OI-SRP18-COLP-02A** documented that the task analysis had not been completed for all of the MTIS tasks. This work was subsequently completed and submitted for staff review in OSA-2 Summary Report (APP-OCS-J1R-220), Revision B. Revision B of the results summary report contains the following information:

- (1) The report summarizes the analysis of the [] risk-important MTIS tasks.

Westinghouse includes a description of the [] and the task analysis results for the MTIS in its results summary report. [] similar to OSA, which provides a []. This analysis uses “[]” logic, which enables the evaluator to determine [] for the MTIS tasks. This is consistent with the specification in Criterion 2 (in Section 5.4 of NUREG-0711) that the applicant uses a process like OSA. Appendix C to the summary report presents the results of the MTIS analyses.

(2) Section 2.1 of the summary report discusses the [] scenarios developed as a basis for the total of [] tasks to be analyzed using the OSA-2 methodology. (The [] tasks equate to [] scenarios because [].) For each scenario, the description in Appendix A to the summary report includes the [

]. Appendix B to the summary report discusses the results of the analyses.

The summary report briefly describes the OSA-2 analyses of these [] scenarios and [] tasks. The analyses identified [] risk-important tasks and the following [

].

The OSA-2 Summary Report contains tables giving detailed [], as well as the []. The descriptions include the [

]. For example, each scenario and its related tasks are labeled as “[

]. In the case of an [

], the first basic event is [

]. The beginning step or cue in this case

is the []. The second cue is that at [

]. Westinghouse continues to describe the next few events

including the []. This analysis continues until the [

].

Westinghouse’s OSA-2 for this particular task includes [

]. In this case, each task associated with the basic event [

].

The staff has concluded that the task analysis for Revision 17 of the AP1000 DCD is complete and has sufficient depth to support control room inventory identification and workload analysis. Open Item **OI-SRP18-COLP-02A** is closed and Design Commitment 2 in ITAAC Table 3.2-1 (DCD Revision 15) is complete and closed.

18.5.9.3 Conclusion

The staff has reviewed the OSA-2 Implementation Plan, Revision 1, and the OSA-2 Summary Report, Revision B, and has determined that the applicant has adequately addressed the criteria found in Section 5 of NUREG-0711. In addition, the staff’s review has determined that there is sufficient information to close COL Information Item 18.5-2 (FSER 18.5.3-1), COL Information Item 18.5-1 (FSER Item 18.5.3-2) and COL Information Item 18.5-1 (FSER Item 18.5.3-3). Design Commitment 2 in ITAAC Table 3.2-1 (DCD Revision 15) is complete and closed. The task analysis that was completed under this ITAAC provides reasonable assurance that a complete Control Room Inventory has been identified. The task analysis also demonstrates that the HFE design ensures an acceptable workload for the operators.

18.7 Element 6: Human Reliability Analysis

The applicant made no substantive changes to this section. However, Westinghouse submitted TR-59 (APP-GW-GLR-011, Revision 0, "AP1000 Standard Combined License Technical Report, Execution and Documentation of the Human Reliability Analysis/Human Factors Engineering Integration") to close COL Information Item 18.7-1.

18.7.5 Evaluation of COL Information Item 18.7-1

18.7.5.1 Summary of Technical Information

COL Information Item 18.7-1 states the following:

Combined license applicants referencing the AP1000 certified design will address the execution and documentation of the human reliability analysis/human factors engineering integration implementation plan that is presented in Section 18.7.

Westinghouse submitted TR-59 to close COL Information Item 18.7-1. This technical report summarizes the applicant's method for conducting the HRA/HFE evaluation for the AP1000 and unites the relevant HRA/HFE evaluation implementation plan with the results documentation.

The staff reviewed and approved Westinghouse Commercial Atomic Power (WCAP)-14651, Revision 2, "Integration of Human Reliability Analysis with Human Factors Engineering Design Implementation Plan," as a supporting document for DCD Revision 15. Sections 2 through 5 of WCAP-14651 describe the major aspects of the plan:

- Section 2 discusses the PRA/HRA identification of critical HAs and risk-important tasks.
- Section 3 describes the task analyses for critical HAs and risk-important tasks.
- Section 4 discusses the reexamination of critical HAs and risk-important tasks.
- Section 5 provides information on the validation of HRA performance assumptions.

The staff used this implementation plan (in addition to NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Chapter 18, "Human Factors Engineering," Revision 2, issued March 2007, and NUREG-0711, Revision 2) to review WCAP-16555, Revision 1, "AP1000 Identification of Critical Human Actions and Risk Important Tasks." In addition to TR-59, Westinghouse provided WCAP-16555 to the NRC to close COL Information Item 18.7-1. In WCAP-16555, the applicant provided the results of the evaluation of the AP1000 PRA/HRA that identifies the critical HAs and risk-important tasks for plant operation.

18.7.5.2 Evaluation

The staff determined that WCAP-16555 addresses Section 2 of the WCAP-14651 implementation plan. The applicant addressed Sections 3 through 5 of the implementation plan in Parts 1 and 2 of the OSA.

Section 2 of WCAP-14651 relates to Criterion 1 in Section 7.4 of NUREG-0711, which states the following:

Risk-important human actions should be identified from the PRA/HRA and used as input to the HFE design effort.

- 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.

Section 2 of WCAP-14651 discusses the PRA/HFE identification of critical HAs and risk-important tasks. Sections 2.1 and 2.2, respectively, describe the process used to identify critical HAs and risk-important tasks. Section 2.2 is divided into three subsections describing the process to identify the risk-important quantitative, qualitative, and qualitative MTIS criteria.

Evaluation Criterion 1—Critical Human Actions: Section 2.1 of WCAP-14651 states that the applicant will determine critical HAs using both deterministic and PRA criteria. In Section 3.1 of WCAP-16555, the applicant presented the results of the analyses, which determined that there were no critical actions for the AP1000. For the deterministic criterion, there were no Type A (as defined in Sections 7.5.2.1 and 7.5.3.1 of the DCD) post-accident instruments, and no HAs were required to mitigate any design-basis accident. For the PRA criteria, the analysis showed that no HA, when failed in the PRA, results in a core damage frequency (CDF) of 1×10^{-4} core damage events per reactor-year or greater. Further, no HA, when failed in the PRA, results in a large release frequency of 1×10^{-5} events per reactor-year. Thus, there are no critical actions for the AP1000 plant. This is in accordance with the design objectives of the AP1000.

Evaluation Criterion 2—Quantitative and Qualitative Risk-Importance Criteria: Section 2.2 of WCAP-14651 states that the applicant will use both quantitative and qualitative criteria to identify the risk-important tasks of the AP1000 design. The quantitative criteria are a risk achievement worth (RAW) of 3.0 and a risk reduction worth (RRW) of 1.1. The RAW is a value that examines the increase in risk that would result if a single HA were to fail. The RRW value examines the decrease in risk that would result if an HA were made perfectly reliable for a given process or parameter. The focused PRA reduced these values to an RAW of 2.0 and an RRW of 1.05.

Section 3.2 of WCAP-16555 and related tables provide the results of the evaluation using the RAW and RRW measures. The applicant performed evaluations for both the CDF and the large early release frequency and considered the internal events, flooding, fire, and shutdown PRAs. The applicant identified about 20 risk-important tasks, summarized in Table 3.2-2. The staff also compared the HAs in the dominant sequences with the top operator actions determined by the risk-importance measures. The dominant sequences and the operator actions were consistent. The staff finds that the applicant's use of quantitative risk-importance criteria meets the objective of the implementation plan.

Section 2.2 of WCAP-14651 includes five qualitative criteria for identifying additional risk-important tasks in conjunction with an expert panel. The applicant used the criteria listed in WCAP-16555, Section 2.2.1, to identify the qualitative risk-important HAs. These criteria are consistent with those in the implementation plan. The applicant also provided the results of this evaluation in Sections 2.2.1 and 3.2.1 of WCAP-16555. The expert panel identified three HAs that were added to the list of risk-important tasks. This approach to identifying the qualitative

risk-important HAs is consistent with that given in the implementation plan. The staff finds this to be acceptable.

Evaluation Criterion 3—MTIS Risk-Importance Qualitative Criteria: Section 2.2 of WCAP-14651 provides qualitative criteria for identifying risk-important MTISs.

In Section 3.3 of WCAP-16555, the applicant gives the methodology used to identify the MTIS activities for the risk-important structures, systems, and components (SSCs). A group of engineers representing various disciplines and backgrounds, including HFE, HRA, and PRA, reviewed the results produced by this methodology. The applicant also provided Tables 3.3-1 and 3.3-2, which present the results of the MTIS evaluation. Table 3.3-1 includes the initial list of SSCs considered for MTIS activities, along with any other components that may be risk-important and have interfaces with the control room but may not have been included in the initial list. Lastly, Table 3.3-2 lists the representative MTIS activities that will receive the HFE review. In cases where the same MTIS activity was repeated for different SSCs, one of those MTIS activities from that list was chosen to represent (or selected as a “representative” of) that group.

The staff requested clarification in RAI TR-59-11 about the activities outside of the control room and whether they were included in the set of MTIS tasks identified through the expert panel. The staff noted that the Davis-Besse reactor vessel incident is an example of the need for proper MTIS task identification. The reactor vessel is a risk important SSC, and inspection of the vessel exterior would be an MTIS activity that seems worthy of appropriate planning at the design stage to address human factors issues associated with this activity. Thus, by including activities outside of the control room, accessibility can be assured and procedures and training provided to avoid the kinds of problems that occurred with reactor vessel leakage and corrosion. In their response dated July 27, 2007, Westinghouse provided information clarifying that operator actions outside of the control room were considered and noted that two of the actions considered were outside of the control room. Further, the passive nature of the plant design limits the use of manual control valves, and the manual control valves that are risk-important have main control room position indication.

The staff finds that the applicant has acceptably implemented the process specified in WCAP-14651 to identify the MTIS risk-important tasks.

Criterion 2 in Section 7.4 of NUREG-0711 states the following:

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).

Criterion 2 Evaluation

WCAP-14651, Section 3, describes the process for including the HRA risk-important activities in the task analysis. Westinghouse’s OSA documents (for OSA-1 and OSA-2) summarize how the applicant input the HRA risk-important tasks into the task analysis. The OSA-1 Summary Report, Table 3-1, specifically addresses the risk-important tasks. The OSA also detailed task sequences and performance requirements. The applicant gave details of its methodology for task identification with regard to emergency operating procedures, system operating procedures, and general operating procedures. Section 4.2.4 of the OSA-1 Summary Report

presents recommendations for the risk-important actions. Finally, in Section 1 of the OSA-1 Summary Report, Westinghouse stated that the results of the OSA are a set of requirements and constraints on operator task performance and that these are fed into the HSI design. The staff finds that the applicant has acceptably implemented the process described in the implementation plan.

Criterion 3 in Section 7.4 of NUREG-0711 states the following:

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.

The applicant submitted the implementation methodology for OSA-2 to address part of Sections 3 and 4 in WCAP-14651. The applicant also provided the OSA-2 Summary Report for review. These documents meet the objectives of Sections 3 and 4 of WCAP-14651, by assigning focus areas for operators, by including MTIS activities in OSA-2, and by using operating procedures during the process. The staff finds that the applicant acceptably implemented the process described in the implementation plan.

Criterion 4 in Section 7.4 of NUREG-0711 states the following:

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.

WCAP-14651 describes the process for the validation of the HRA performance assumptions. The applicant is implementing this process as part of its integrated system validation for the AP1000. Section 10.0 of this report details the review of the process used to integrate the HRA risk-important HAs.

18.7.5.3 Conclusion

The staff concludes that TR-59 (APP-GW-GLR-011), WCAP-16555, and the related RAI response (RAI TR59-11) describe an acceptable approach to implementing WCAP-14651 and to meeting the criteria in Section A.6 of NUREG-0800 and Section 7.4 of NUREG-0711. Based on this material COL Information Item 18.7-1 is closed.

18.7.6 Evaluation of Tier 1 Information—Design Commitment 1, ITAAC Table 3.2-1, Tier 1, Section 3.2 (DCD Revision 15)

18.7.6.1 Summary of Technical Information

ITAAC Design Commitment 1 reads as follows:

Design Commitment: The integration of HRA with HFE design is performed in accordance with the implementation plan.

Inspection, Tests, and Analyses: The applicant will perform an evaluation of the implementation for the integration of HRA with HFE design.

Acceptance Criteria: A report exists and concludes that critical human actions (if any) and risk important tasks were identified and examined by task analysis, and used as input to the HSI design, procedure development, staffing, and training.

In DCD Revision 17, the applicant deleted this ITAAC based on completion of the work it described.

18.7.6.2 Evaluation

This ITAAC was deleted in Revision 16 of the AP1000 DCD (but the number was kept as a place holder), then subsequently removed entirely from Revision 17. For Revision 17 to the DCD, the applicant has provided the methodology and summary reports that show the risk-important tasks were examined and would have input into the other HFE elements listed in the acceptance criteria. Also, the work products provided by the applicant demonstrate the following:

- There are no “critical human actions” because of the AP1000 passive design.
- “Risk-important actions” as well as “significant” actions are identified and included in the HFE design process in accordance with NUREG-0711 guidance.
- The OSA-1 analysis included all identified actions from the HRA. OSA-2 is a reiterative analysis (see Section 18.5 of this report) that also includes input from the HRA.

18.7.6.3 Conclusion

The staff concludes that Design Commitment 1 in ITAAC Table 3.2-1 (DCD Revision 15) is complete and closed and the COL information item 18.7-1 is complete and closed because risk-important HAs have been identified in accordance with the implementation plan and these HAs have been appropriately implemented in the HFE design via the task analysis in OSA-2.

18.8 Element 7: Human-System Interface Design

18.8.3 General Human System Interface Design Feature Selection

18.8.3.1 Summary of Technical Information

In DCD Section 18.8.1.8, the applicant deleted reference to the use of computer-based models of cognitive response to control room events as an analytic method supporting workload analysis. The applicant substituted the term “task analysis”: the sentence now reads, “Analytic methods include the use of task analysis.”

18.8.3.2 Evaluation

FSER Section 18.8.1.3 discusses task analysis only from a generic perspective as one of the NUREG-0711 elements. FSER Section 18.8 does not include specific methods for evaluating workload. In both cases, the change described above does not affect the evaluation or

conclusions from this section of the safety evaluation. Section 18.5, "Task Analysis," provides an evaluation of the impact of the change on task analysis.

18.8.3.3 Conclusion

The staff concludes that this change does not affect the evaluation or results documented in FSER Section 18.8.1.3.

18.8.4 Evaluation of COL Information Item 18.8-1

18.8.4.1 Summary of Technical Information

COL Information Item 18.8-1 states the following:

The COL applicant referencing the AP1000 certified design is responsible for the execution and documentation of the HSI design implementation plan.

The applicant issued TR-82 to address this COL information item. In this document, the applicant stated that the COL item has been fully addressed and no additional work is required by the COL applicant.

18.8.4.2 Evaluation

The applicant has satisfactorily completed documentation of the HSI design implementation plan. The staff reviewed the completed documents referenced in TR-82 and concluded that they appropriately execute the HSI design implementation plan, as described in the AP1000 DCD, Revision 15. The specificity of design requirements clearly increased in the transition from the functional design level to design specifications. The documents were consistently clear across this procedural hierarchy. The scope of and specificity in the design documents provide reasonable assurance that the design process will effectively produce the design document needed to support procurement, construction and inspection activities.

This COL information item is redundant to Design Commitment 3 from ITAAC Table 3.2-1 (DCD Revision 16), which states that the HSI design is performed for the OCS [Operation and Control System] in accordance with the HSI design implementation plan. Based on this redundancy, the COL information item is closed.

18.8.4.3 Conclusion

The applicant is completing design documents in accordance with the HSI design implementation plan. While the applicant has not completed execution of the HSI design implementation plan, the COL information item is being closed because it is redundant to an existing ITAAC.

18.8.5 Review of Human Factors Evaluation Style Guide (APP-OCS-J1-002) against NUREG-0711 Criteria

18.8.5.1 Summary of Technical Information

The applicant submitted AP1000 HSI Design Guidelines (APP-OCS-J1-002, Revision 0). This document implements several NUREG-0711 criteria that have not been previously reviewed at

the implementation plan level. The evaluation below verifies that the AP1000 HSI Design Guidelines effectively address applicable NUREG-0711 criteria.

18.8.5.2 Evaluation

Criterion 1—Style Guide

NUREG-0711, Section 8.4.5, “HSI Detailed Design and Integration Criteria,” Criterion 1 states the following:

Design-specific HFE design guidance (style guide) should be developed. The design of the HSI features, layout, and environment should incorporate HFE guidelines.

In APP-OCS-J1-002, the applicant provided a detailed set of HFE requirements for all HSIs similar to the level of detail in NUREG-0700, Revision 2, “Human-System Interface Design Review Guidelines,” issued May 2002. The goal of the document is to ensure that the AP1000 designs comply with applicable HFE design principles.

The staff concludes that this document meets this criterion for design-specific HFE guidance.

Subcriterion—Style Guide Content

NUREG-0711, Section 8.4.5, Criterion 1, states the following:

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. The applicant may justify guidelines that are not derived from generic HFE guidelines 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 reflect the applicant’s design decisions that address the specific goals and needs of the HSI design.

In APP-OCS-J1-002, the applicant included a list of technical references used to develop specific HFE guidance for the AP1000 design. The applicant used NUREG-0700 as a major source. The following references also support the AP1000 HFE design guidance:

- []
- []
- []
- []

- []
- []
- []

The staff concludes that these technical references represent a diverse and thorough set of inputs for the AP1000 guidance. The AP1000 design guidance contains design principles and specific design criteria for all of the AP1000 HSIs.

Subcriterion—Scope and Level of Detail

NUREG-0711, Section 8.4.5, Criterion 1, states the following:

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.

In APP-OCS-J1-002, Section 3, the applicant described the scope of the design guidelines. This includes the MCR, remote shutdown station, and TSC. Specific HSI interfaces include the plant information system, alarm system, computerized procedures, safety systems, soft controls, dedicated controls, diverse actuation system, and large screen displays. The scope addresses all areas described by the previously reviewed program-level documents. APP-OCS-J1-002, Section 26, contains environment-related criteria.

The staff concludes that the design guideline addresses the HSI scope satisfactorily. The level of detail is consistent with that found in NUREG-0700, an accepted program for HFE design criteria.

Subcriterion—Guideline Specificity

NUREG-0711, Section 8.4.5, Criterion 1, states the following:

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 level of detail provided in individual guidelines is consistent with the specificity in NUREG-0700. In general, the guidelines provide quantifiable direction. For many of the guidelines, and particularly for those cases in which more general direction is given, the basis

for the guideline is included. This reference provides direction on guideline implementation. The guidance is divided into required and optional categories, which provides additional support to the designers and evaluators.

The staff concludes that the direction provided in the design guidance document is of sufficient detail that design personnel will be able to achieve a consistent and verifiable design.

Subcriterion—Style Guide Ease of Use

NUREG-0711, Section 8.4.5, Criterion 1, states the following:

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 that designers can readily understand it. The style guide should support the interpretation and comprehension of design guidance by supplementing text with graphical examples, figures, and tables.

APP-OCS-J1-002 provides generic direction stating that the design guidance will be used during the design process and to facilitate design verification. Implementation plans for both of these activities refer to the use of the []. The plans cross-reference between [] and the applicable sections of APP-OCS-J1-002, which will likely facilitate the use of the [], as indicated in the criterion, [], and the [] is provided to answer questions that might arise as to the applicability of the design guidance.

The staff concludes that the design guidance in APP-OCS-J1-002 is presented in a manner likely to facilitate its use by designers and evaluators. The applicant has provided sufficient cross-referencing in procedures to ensure their appropriate use.

Subcriterion—Usability

NUREG-0711, Section 8.4.5, Criterion 1, states the following:

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 applicant maintains APP-OCS-J1-002 on its electronic document tracking system as a controlled document. This ensures document accessibility and facilitates usability by virtue of word search capability. The document itself is [

]. The applicant has demonstrated the ability to keep the document updated by incorporating more detail on []. Each guideline contains a reference to source material; this should also aid the designer in determining how best to implement the requirements and to facilitate the evaluation of tradeoffs.

18.8.5.3 Conclusion

The staff concludes that APP-OCS-J1-002 provides specific HFE design guidance that satisfactorily implements NUREG-0711 criteria. The document provides sufficient detail to ensure that the process is consistently followed and provides reasonable assurance that design requirements are properly factored into the HSIs.

18.9 Element 8: Procedure Development

The applicant made no substantive changes to this section. However, Westinghouse submitted TR-70 (APP-GW-GLR-040, Revision 1, "Plant Operations, Surveillance, and Maintenance Procedures") to close COL Information Item 18.9-1.

18.9.5 Evaluation of COL Information Item 18.9-1

18.9.5.1 Summary of Technical Information

COL Information Item 18.9-1 was identified in NUREG-1793 (AP1000 SER for DCD Revision 15) and does not have a counterpart in the DCD. This COL action item is divided into two parts. The COL action item states the following:

With regard to procedure development, the COL applicant will (1) address the procedure development considerations in NUREG-0711, and (2) identify the minimum documentation that the COL applicant will provide to the staff to complete its review.

Westinghouse submitted TR-70 for staff review. This report documents the methodology, criteria, and schedules for procedure development. The document addresses the information needed to close COL Information Item 18.9-1. The applicant made the TR-70 supporting documents available to the staff for the purpose of closing COL Information Item 18.9-1. Two of these documents were the writer's guides for normal operating procedures and two-column operating procedures (APP-GW-GJP-100, Revision G, "AP1000 Normal Operating Procedures (NOPs) Writer's Guideline," and APP-GW-GJP-200, Revision D, "Writer's Guideline for Two Column Procedures," respectively). The writer's guidelines explain the programmatic process that controls the preparation of the normal operating procedures and two column procedures.

The goal of the staff's review was to address each part of the action item. Consequently, the evaluation is described in two parts. Part 1 details how the applicant addressed the procedure development considerations in NUREG-0711. Part 2 describes the documents that were submitted to the staff for review.

18.9.5.2 Part 1—Evaluation

The staff reviewed TR-70 in combination with the writer's guides. The staff verified that the applicant had implemented the guidelines specified in WCAP-14690, "Designer's Input to Procedure Development for the AP600." WCAP-14690 is the staff-approved document that describes the methodology the COL applicant should use to develop procedures. In NUREG-1793 (the AP1000 FSER), the staff approved the use of this document as a guide for procedures development and an acceptable guideline for creation of an implementation plan for the AP1000. In its review, the staff found that the writer's guides meet the criteria in

NUREG-0711, Section 9.4, for the basis, development, and content of the AP1000 two column and normal operating procedures. The staff found that the information in TR-70 is consistent with the guidelines in WCAP-14690. Section 2.0 of WCAP-14690 details the general criteria that an applicant should implement to develop procedures. TR-70 addresses all of the guidance criteria in Section 2.0 of WCAP-14690. Section 4.0 of WCAP-14690 provides guidance on the process that should be used to write the plant-specific emergency operating procedures. Sections 3.0 and 5.0 of the WCAP describe the guidance for creation of the implementation plan with regard to computer-based procedures (CBPs). The following section documents the CBP evaluation as a subpart to addressing Part 1 of COL Information Item 18.9-1.

Human Factors Engineering Aspects of Computer-Based Procedures

The applicant did not address the impact of computerized procedures and accessibility in the original design certification application. In the staff's evaluation of the AP1000 DCD, the FSER states the following:

Evaluation of the applicant's computerized procedure system was not included in the design certification for the AP1000. WCAP-14690, Revision 1, provides information on the computer-based procedure system which will serve as the interface to the plant procedures.

NUREG-0700, Section 8; Interim Staff Guidance (ISG)-05 ("Task Working Group #5: Highly-Integrated Control Room—Human Factors Issues"); and NUREG-0711, Section 9.4, Criteria 7 and 9, are used to evaluate the methodology used to design the CBP system and the interaction between the operator and that system. ISG-05 is used as complementary review guidance for Criterion 9.

Criterion 7 states the following:

An analysis should be conducted to determine the impact of providing 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.

In TR-70 or in the supporting referenced documentation, the applicant addressed the impact and utilization of CBPs not addressed in the original design certification application. In Section 2.7 of TR-70, Revision 1, the applicant stated that comments from operations personnel involved in the human factors testing of the AP1000 control room design, and specifically the computerized procedure system, have been generally favorable. The applicant also documented the results of the analysis of the impact of providing CBPs in the referenced report WCAP-14645-NP, Revision 3, "Human Factors Engineering Operating Experience Review Report for the AP1000 Nuclear Power Plant." The staff reviewed WCAP-14645-NP, Revision 3. The applicant identified multiple human performance issues with the CBPs and then noted the solution, or proposed solution, for each issue.

The staff issued RAI-SRP18-COLP-14 to the applicant requesting the analysis of alternatives to CBPs, in the event that a loss of CBPs occurs. In the RAI-SRP18-COLP-14 response dated August 4, 2008 (ADAMS Accession Number ML082200546), Westinghouse stated that it would conduct this analysis as part of the second OSA, described in Section 2.1 of APP-OCS-J1R-210.

Subsequent to this RAI, the staff reviewed APP-OCS-J1R-220, Revision B, OSA-2 Summary Report. The OSA-2 Summary Report identifies the [], This task, [], has [] that are described in Scenario 16. Also, in this section of the summary report, Westinghouse described how the []. Appendix B, Section B.22, to the report gives details of the [] steps described in Scenario 16.

Open Item **OI-SRP-COLP-19** was established to track an RAI clarifying how a loss of CBPs is managed. In RAI-SRP18-COLP-19 response dated September 1, 2009 (ADAMS Accession Number ML092670162) the applicant provided the staff with this clarification:

- []
- []
- []

].

Based on this information the open item was closed.

The staff conducted an audit of the CBP interface at the Westinghouse Energy Center in Monroeville, Pennsylvania in September, 2009 (Audit summary - ADAMS Accession Number ML093070733). During the audit the staff reviewed the AP1000 Computerized Procedure System (CPS) design process, including supporting documentation, as well as the characteristics and functions of the current system as implemented in the AP1000 engineering test simulator. The CPS characteristics and functions included []

].

Based on the audit the staff concluded that the Westinghouse AP1000 CPS system was designed in accordance with the NRC certified HSI Design Implementation Plan and that all supporting documentation was acceptable and consistent with the NRC design review guidance including the guidance specific to computer-based procedure systems. The design as currently implemented is consistent with Westinghouse's design procedures and documentation.

Criterion 9 states the following:

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.

The staff used ISG-05 as the complementing review guidance for NUREG-0711, Section 9.4, Criterion 9. ISG-05 provides review criteria for how the user will interface with the CBP system. The applicant provided the documentation to satisfy the ISG-05 criteria in APP-OCS-J1-020,

Revision A, "Computerized Procedures System Functional Requirements." APP-OCS-J1-020 documents how the operator physically interfaces with the computer procedure system. The technical information in APP-OCS-J1-020 is consistent in addressing the criteria in ISG-05. CBPs are designed to be the primary procedure interface and access is gained via the video display units. Audit observations confirmed that the CBP system is easily accessed from VDU menus. Navigation to a specific procedure is via a procedure menu. Navigation between procedures is typically driven by embedded links but the operator can also return to the main menu to select the desired procedure. Navigation was found to be simple and straightforward. Use of the hardcopy procedures, which are available in the control room as a backup to the CBPs, followed conventional practices. The staff submitted RAI-SRP18-COLP-11 to Westinghouse requesting clarification of the CBP automation and whether the AP1000 computer procedure system would be computer-paced or user-paced. In the RAI-SRP18-COLP-11 response dated August 4, 2008 (ADAMS Accession Number ML082200546), Westinghouse stated that this issue would not be of any consequence because the computer-paced function would be removed. The staff found this response acceptable.

18.9.5.3 Part 1—Conclusion

The staff determined that TR-70 and the writer's guides for normal and two column procedures together constitute an acceptable implementation plan for procedure development. This is because (1) the documents address the criteria in the staff-approved WCAP-14690, which explains the process the procedure writer should take to develop an implementation plan, and (2) the documents also address the applicable criterion in the procedures development chapter in NUREG-0711.

The staff concludes that Westinghouse has designed a system that ensures the usability and usefulness of CBPs. Specifically, loss of the CBP HSI is appropriately addressed in procedures and training. Support provided for the transition to paper based procedures provides reasonable assurance that such a failure would not significantly impact the operator's ability to implement the appropriate accident response procedures. Further, the staff concluded that Westinghouse's approach for implementing a new technology into the control room and operating practices was acceptably conservative and should provide for a smooth transition to computerized operation of important procedures, such as EOPs. This approach will minimize any safety concerns associated with the loss of the Computerized Procedure System.

Based on the preceding information, the staff concludes that COL Information Item 18.9-1 part 1 is complete and closed.

18.9.5.4 Part 2—Evaluation

To address the second part of COL Information Item 18.9-1, in addition to submitting TR-70, the applicant stated in Revision 17 of the AP1000 DCD that the COL applicant will be responsible for addressing the operational and programmatic issues and training to complete the AP1000 COL licensing process. Westinghouse would be responsible for managing the development, review, and approval of the AP1000 normal operating, abnormal operating, emergency operating, refueling and outage planning, alarm response, administrative, and MTIS procedures, as well as the procedures that address the operation of post-72-hour equipment.

18.9.5.5 Part 2—Conclusion

In DCD Tier 2, Revision 17, responsibility for completing this COL action was assumed by Westinghouse. As described above, sufficient documentation has been submitted to satisfy the criteria in NUREG-0711, Section 9.4. COL applicants have continuing responsibilities related to training and procedures but these are evaluated as part of operating program inspections. This Westinghouse response satisfies Part 2 of COL Information Item 18.9-1 (FSER Item 18.9.3-1).

The staff concludes that the applicant's procedure development program provides reasonable assurance that procedures will support and guide human interaction with plant systems, as well as control plant-related events and activities. Human engineering principles and criteria are applied, along with all of the other design requirements, to develop procedures that are technically accurate, comprehensive, explicit, easy to use, validated, and in conformance with 10 CFR 50.34(f)(2)(ii). In addition, this closes **OI-SRP18-COLP-19**.

The staff concludes that COL Information Item 18.9-1 part 2 is complete and closed. COL information. Item 13.5-1 covers the remainder of the procedures development.

18.11 Element 10: Human Factors Verification and Validation

Westinghouse submitted the following implementation plans to address COL Information Item 18.11-1 and ITAAC Design Commitment 4, Tier 1, Table 3.2-1 (DCD Revision 15):

- APP-OCS-GEH-120, "AP1000 Human Factors Engineering Design Verification Plan," Revision B
- APP-OCS-GEH-220, "AP1000 Human Factors Engineering Task Support Verification Plan," Revision B
- APP-OCS-GEH-320, "AP1000 Human Factors Engineering Integrated System Validation Plan," Revision D
- APP-OCS-GEH-321, "AP1000 Human Factors Engineering Integrated System Validation Scenario Information," Revision B
- APP-OCS-GEH-420, "Human Factors Engineering Discrepancy Resolution Process," Revision B
- APP-OCS-GEH-520, "AP1000 Plant Startup HFE Design Verification Plan," Revision B

NUREG-0711 states the following:

"An implementation plan gives the applicant's proposed methodology for meeting the acceptance criteria of the element. An implementation plan review gives the applicant the opportunity to obtain staff review of and concurrence in the applicant's approach before conducting the activities associated with the element. Such a review is desirable from the staff's perspective because it provides the opportunity to resolve methodological issues and provide input early in the analysis or design process when staff concerns can more easily be addressed than when the effort is completed."

The staff will verify the final results of the design analyses to ensure that the design is completed in accordance with the process specified in the implementation plans in accordance with the design acceptance criteria (DAC) approach. This may occur via a design certification (DC) amendment, the COL application review, or through the ITAAC closure process.

When conducting an implementation plan review, the staff needs to:

- understand how the detailed methodology will be implemented
- determine that the methodology can be reliably conducted by design personnel
- be confident that the methodology will provide results that will be acceptable as evaluated by the relevant NUREG-0711 review criteria

18.11.5 Evaluation of COL Information Item 18.11-1

18.11.5.1 Summary of Technical Information

COL Information Item 18.11-1 states the following:

Combined License applicants referencing the AP1000 certified design will address the development, execution and documentation of an implementation plan for the verification and validation of the AP1000 Human Factors Engineering Program. The programmatic level description of the AP1000 verification and validation program presented and referenced by Section 18.11 will be used by the Combined License applicant to develop the implementation plan.

18.11.5.2 Evaluation

COL Information Item 18.11-1 contains two distinct activities related to the AP1000 HFE program V&V. The first activity addresses development of an implementation plan. Design Commitment 4, Tier 1, Chapter 3, ITAAC Table 3.2-1, of the AP1000 DCD, Revision 15, also addresses this commitment. The second activity is to execute and document the execution of the implementation plan. Design Commitment 5, Tier 1, Chapter 3, ITAAC Table 3.2-1, of the AP1000 DCD, Revision 15, addresses this commitment.

18.11.5.3 Conclusion

The NRC staff notes that COL Information Item 18.11-1 is similar to existing Design Commitments 4 and 5, ITAAC Table 3.2-1 (DCD Revision 15). The development of the implementation plans has been completed and these implementation plans are evaluated below under Evaluation of Tier 1 Information Design Commitment 4 below. The execution and documentation of the implementation plans will be addressed in Design Commitment 5, ITAAC Table 3.2-1. Thus, COL Information Item 18.11-1 is no longer needed since the work has either been completed by Westinghouse or will be completed under the DCD ITAAC 5.

18.11.6 Evaluation of Tier 1 Information—Design Commitment 4, ITAAC Table 3.2-1, Tier 1, Section 3.2 (DCD Revision 15), Part 1 of 5, HSI Task Support Verification

18.11.6.1 Summary of Technical Information

ITAAC Design Commitment 4 reads as follows:

Design Commitment: An HFE program verification and validation implementation plan is develop[ed] in accordance with the programmatic level description of the AP1000 human factors verification and validation plan.

Inspection, Test, and Analysis: An inspection of the HFE verification and validation implementation plan will be performed.

Acceptance criteria (part 1): A report exists and concludes that the HFE verification and validation implementation plan was developed in accordance with the programmatic level description of the AP1000 human factors verification and validation plan and includes the ...HSI task support verification activity.

In DCD Revision 17, the applicant deleted this ITAAC based on completion of the work it described.

18.11.6.2 Evaluation

NUREG-0711, Section 11.4.2.2, Criterion 1, states the following:

The criteria for task support verification come from task analyses of HSI requirements for performance of personnel tasks.

Evaluation of Criterion 1

In APP-OCS-GEH-220, the applicant provided a specific verification plan for each of the task analysis inputs as outlined below:

- Section 2.2 is the verification plan for the function-based task analysis. APP-OCS-J1A-030, Revision A, "FBTA Summary Report," provides []. The []. If the final design does not implement the recommendations, [].
- Section 2.3 is the verification plan for OSA-1. These tasks are derived from []. A database is used to maintain the tasks identified by this analysis. Before final task verification, the plan requires the database to be []. The independent verifier ensures that for each unique operator action, [].
- Section 2.4 is the verification plan for OSA-2 []. If a new task is identified, then the OCS product manager ensures that disposition of the task is addressed. For each task identified in OSA-2, a list of []

]. The independent verifier then confirms that the HSI resource is available, the HSI display information is appropriate, the communication facility is available and located appropriately, and the labeling is correct.

- Section 2.5 is the verification plan for the OSA-2 tasks specific to []. Verification follows the same process as that used for OSA-1.
- Section 2.6 is the verification plan for the OSA-2 tasks specific to []. Verification follows the same process as that used for OSA-1.

The staff concludes that APP-OCS-GEH-220 provides clear, specific direction on how the results of each specific task analysis are verified. Acceptance criteria are stated within the procedure and, when combined with the use of an independent verifier, provide reasonable assurance that the HSI requirements properly incorporate the task analysis results.

NUREG-0711, Section 11.4.2.2, Criterion 2, "General Methodology," states the following:

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.

Evaluation of Criterion 2

The implementation plan for task support verification, as outlined above, provides clear direction that the final HFE design is to be compared to personnel task requirements. Direction is provided to document and justify or resolve all deviations. The direction is structured so that each task is specifically addressed. This supports a clear communication of source documents and acceptance criteria to be used in the verification.

The staff concludes that APP-OCS-GEH-220 provides sufficient details to satisfactorily demonstrate implementation of this NUREG criterion for the general methodology of task verification.

NUREG-0711, Section 11.4.2.2, Criterion 3, states the following:

Human engineering discrepancies (HEDs) should be identified when an HSI needed for task performance is not available or when HSI characteristics do not match personnel task requirements.

Evaluation of Criterion 3

In APP-OCS-GEH-220, the applicant stated that any time an HSI resource or an appropriate display is not available, a discrepancy worksheet is filled out. The procedure specifically states the following verification points:

- [].
- [].
- [].
- [].
- [].

When the V&V evaluation is complete, the OCS product manager assesses each work discrepancy worksheet. Discrepancies that are directly justified as exceptions are not considered HEDs. The applicant documents justified discrepancies as part of future report APP-OCS-GER-120, "AP1000 HFE Task Support Verification Report," along with a list of HEDs identified by discrepancy reports. APP-OCS-GEH-420 provides an implementation plan for resolving the discrepancy worksheets that are not justified by the product manager.

The staff concludes that APP-OCS-GEH-220 provides sufficient details of the implementation plan to satisfactorily demonstrate implementation of this NUREG criterion for identifying task requirement deficiencies during task verification.

NUREG-0711, Section 11.4.2.2, Criterion 4, states the following:

An HED should be identified for HSIs that are available in the HSI, but are not needed for any task....

Evaluation of Criterion 4

In APP-OCS-GEH-220, Sections 2.3.2 (OSA-1) and 2.4.2 (OSA-2), the applicant stated that the independent verifier will check each display for information and/or controls that are not associated with task requirements. Deviations must be documented on a discrepancy worksheet.

The staff concludes that APP-OCS-GEH-220 provides sufficient details to satisfactorily demonstrate implementation of this NUREG criterion for identifying unnecessary HSI components during task verification.

18.11.6.3 Conclusion

The staff concludes that APP-OCS-GEH-220 provides an implementation plan that satisfactorily implements the guidance contained in NUREG-0711 relative to task support verification. The level of detail provided and the use of an independent verifier provides reasonable assurance that the HSI requirements properly incorporate the results from all task analyses performed. This element of ITAAC Design Commitment 4 (DCD Revision 15), as described above, is complete and closed.

18.11.7 Evaluation of Tier 1 Information—Design Commitment 4, ITAAC Table 3.2-1, Tier 1, Section 3.2 (DCD Revision 15), Part 2 of 5, HFE Design Verification

18.11.7.1 Summary of Technical Information

ITAAC Design Commitment 4 reads as follows:

Design Commitment: An HFE program verification and validation implementation plan is develop[ed] in accordance with the programmatic level description of the AP1000 human factors verification and validation plan.

Inspection, Test, and Analysis: An inspection of the HFE verification and validation implementation plan will be performed.

Acceptance criteria (Part 2): A report exists and concludes that the HFE verification and validation implementation plan was developed in accordance with the programmatic level description of the AP1000 human factors verification and validation plan and includes the ...HFE Design Verification activity.

In DCD Revision 17, the applicant deleted this ITAAC based on completion of the work it described.

18.11.7.2 Evaluation

NUREG-0711, Section 11.4.2.3, Criterion 1, states the following:

The HFE guidelines serve as review criteria. Selection of specific guidelines depends on the characteristics of the HSI components included in the scope of review and whether the applicant has developed a design-specific guideline document. NUREG-0700 may be used for HFE design verification.

Evaluation of Criterion 1

In APP-OCS-GEH-120, the applicant stated that HSI resources and operation and control centers are verified against APP-OCS-J1-002. APP-OCS-J1-002 satisfactorily implements NUREG-0711, Section 8.4.5(1), as described in Section 18.8. It includes guidance from NUREG-0700, Revision 2, and CEI/IEC 964, which program-level documents specifically cite. The report also includes results from operating experience review, function-based task analysis, and other industry guidance.

The staff concludes that APP-OCS-GEH-120 provides sufficient direction to ensure that the HFE guidelines serve as review criteria and have an appropriate level of detail. The report is also consistent with the program description.

NUREG-0711, Section 11.4.2.3, Criterion 2, states the following:

The applicant should compare the characteristics of the HSI components with the HFE guidelines to determine whether the HSI is acceptable or discrepant (i.e., an HED).

The applicant should evaluate discrepancies as potential indicators of additional issues.

Evaluation of Criterion 2

In APP-OCS-GEH-120 the applicant provided a complete list of [](Section 1.2.2). The general process description in Section 2.1 specifies that each [] APP-OCS-J1-002. Appendices B and C provide []. APP-OCS-J1-002 provides pass/fail criteria. A discrepancy worksheet documents all discrepancies. Disposition of discrepancies can be handled immediately by the OCS product manager or submitted to the AP1000 HFE engineering discrepancy resolution process described in APP-OCS-GEH-420. A future report, APP-OCS-GER-120, will describe all discrepancies and their justification or resolution.

The staff concludes that the implementation plan provides a disciplined process for verifying that the HSI design effectively implements design acceptance criteria. Discrepancies are documented and subjected to a corrective action process that evaluates the potential for additional issues. The staff concludes that APP-OCS-GEH-120 provides sufficient detail to satisfactorily demonstrate implementation of this NUREG criterion for design verification methodology.

NUREG-0711, Section 11.4.2.3, Criterion 3, states the following:

The applicant should document HEDs in terms of the HSI component involved and explain how the characteristics depart from a particular guideline.

The evaluation of this criterion is contained in the evaluation of Criterion 2, directly above.

18.11.7.3 Conclusion

The staff concludes that APP-OCS-GEH-120 provides an implementation plan that satisfactorily implements the NUREG-0711 criteria associated with design verification. The document provides reasonable assurance that the HSI designs reflect the design requirements. This element of ITAAC Design Commitment 4 (DCD Revision 15), as described above, is complete and closed.

18.11.8 Evaluation of Tier 1 Information—Design Commitment 4, ITAAC Table 3.2-1, Tier 1, Section 3.2 (DCD Revision 15), Part 3 of 5, Integrated System Validation

18.11.8.1 Summary of Technical Information

At the time of the Westinghouse AP1000 design certification, based on Rev 15 of the DCD, human factors engineering (HFE) verification and validation (V&V) was reviewed and found acceptable at a programmatic level. The Westinghouse V&V program was described in a document entitled *Programmatic Level Description of the AP1000 Human Factors Verification and Validation Plan* (WCAP-15860), Revision 2, dated October, 2003. Per Section 18.11.1 of the AP1000 DCD, a COL applicant referencing the AP1000 is committed to developing an implementation plan for V&V consistent with the NRC approved programmatic description contained in WCAP-15860. ITAAC Design Commitment 4 (Tier 1 Section 3.2, Human Factors Engineering, Table 3.2-1) states:

Design Commitment: An HFE program verification and validation implementation plan is develop[ed] in accordance with the programmatic level description of the AP1000 human factors verification and validation plan.

Inspection, Test, and Analysis: An inspection of the HFE verification and validation implementation plan will be performed.

Acceptance criteria (part 3): A report exists and concludes that the HFE verification and validation implementation plan was developed in accordance with the programmatic level description of the AP1000 human factors verification and validation plan and includes the ...Integrated System Validation activity.

To fulfill this commitment, Westinghouse has submitted AP1000 Human Factors Engineering Verification and Validation (WCAP-16769-P) and two implementation plans:

- APP-OCS-GEH-320, Rev. D, AP1000 Human Factors Engineering Integrated System Validation Plan, May 2010, (ISV Plan)
- APP-OCS-GEH-321, Revision B, AP1000 Human Factors Engineering Integrated System Validation Scenario Information, May 2010, (ISV Scenario Plan)

OI-SRP18-COLP-03A was created by the staff to track the review of these documents.

18.11.8.2 Evaluation

The purpose of this review is to determine whether the applicant's ISV Plan and its companion document, the ISV Scenario Plan, provide an acceptable implementation plan in accordance with NUREG-0711. These documents are evaluated using WCAP-15860 and the NUREG-0711 review criteria for operational condition sampling and ISV.

18.11.8.2.1 Applicable Review Criteria

When the staff has an NRC-certified, programmatic-level description of an HFE activity, the review criteria used to evaluate an implementation plan come from two sources: the certified, programmatic description and NUREG-0711. The programmatic description, WCAP-15860, identifies the general ISV approaches and constraints. The staff's review of the ISV Plan's compliance with WCAP-15860 is discussed in Section 2 below.

NUREG-0711 criteria were used to evaluate the detailed methodology (taking into account the approved approach described in the WCAP). The ISV review criteria used were from the following sections of NUREG-0711:

- Section 11.4.1 - Operation Condition Sampling
 - Sampling Dimensions (3 review criteria)
 - Identification of Scenarios (2 review criteria)
- Section 11.4.3 - Integrated System Validation
 - Test Objectives (1 review criteria)
 - Validation Test Beds (9 review criteria)
 - Plant Personnel (4 review criteria)
 - Scenario Definition (3 review criteria)
 - Performance Measurement (5 review criteria)
 - Test Design (9 review criteria)
 - Data Analysis and Interpretation (5 review criteria)
 - Validation Conclusions (2 review criteria)

In this document, the NUREG-0711 criteria are used to assess the completeness of the ISV Plan and its acceptability as an implementation plan. The results of the staff's evaluation of the ISV Plan with respect to the NUREG-0711 criteria are provided in Sections 3 and 4 for operational condition sampling and ISV methodology respectively.

18.11.8.2.2 Compliance with the WCAP-15860

The staff evaluated whether the ISV Plan was developed in accordance with the commitments made in WCAP-15860 and whether the ISV Plan satisfies the NRC review criteria of NUREG-

0711, Section 11. In general, the ISV Plan follows the commitments made in WCAP-15860. Inconsistencies noted in earlier revisions of the ISV Plan were documented in RAI-22 and the specific details have now been acceptably addressed in Revision D of the ISV Plan.

Additionally, Section 1.5 of the ISV Plan now states that the ISV Plan conforms to the commitments, scope, purpose, and issues as stated in WCAP-15860 with the exception of two areas where exceptions have been taken. The staff has reviewed these two exceptions and found them acceptable for the reasons stated below.

Exception 1: WCAP-15860 states that ISV will utilize currently qualified operating crews as the participants. However, as AP1000 is a new plant design, the ISV participants will not be fully qualified and experienced AP1000 operators. The ISV subjects will not have the same task performance proficiency as that of fully qualified AP1000 operators.

Evaluation: The staff finds this exception acceptable because the ISV Plan continues to include operating experience specifications that are sufficient to ensure valid testing. The ISV will be relatively more demanding and thus a more conservative test of the HFE design. Section 4.3, "Plant Personnel," of this appendix provides additional detail.

Exception 2: WCAP-15860 states that ISV will address all of the EOPs. However, the ISV Plan states that the ISV scenarios will include a representative subset of the EOPs. ... The ISV scenarios will ensure that all functional operator knowledge, skills, and abilities addressed in the EOPs are assessed.

Evaluation: The staff finds this exception acceptable because:

- The applicable NUREG-0711 review criteria do not call for 100 percent coverage of procedures during ISV. Section 3, "Operational Conditions Sampling," of this appendix provides additional detail.
- Westinghouse verified the following:

"The ISV scenarios will ensure that all functional operator knowledge, skills and abilities addressed in the AP1000 EOPs are examined and validated in ISV. While the ISV scenarios may not explicitly cause the operators to enter each of functional recovery procedures, the demand to perform similar EOP steps will be represented []

Additionally, prior to the ISV, [

]. It also ensures a thorough ISV process. Thus, this exception is acceptable.

18.11.8.2.3 Compliance with NUREG-0711 - Operational Conditions Sampling (OCS)

NUREG-0711, Section 11.4.1, states, "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.”

The objective of reviewing operational condition sampling is to 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 staff reviewed the defined scenarios in the ISV Plan and the ISV Scenario Plan to determine whether the OCS dimensions were addressed. The aspects of the specified OCS, both from WCAP-15860 and from NUREG-0711 have been addressed by the ISV Plan and the ISV Scenario Plan.

18.11.8.2.3.1 Sampling Dimensions

The sampling dimensions addressed in NUREG-0711, Section 11.4.1.2, include plant conditions, personnel tasks, and situational factors known to challenge personnel performance.

(1) The following plant conditions should be included:

- normal operational events including plant startup, plant shutdown or refueling, and significant changes in operating power
- failure events, e.g.,
 - 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.,
 - 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 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 cool down using the remote shutdown system
- 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.

Evaluation of Criterion (1)

WCAP-15860, Section 4.6 contains an extensive and multi-dimensional set of criteria that address this particular criterion. The ISV Plan was developed based on this criterion and includes [] separate scenarios, which are detailed in the ISV Scenario Plan. ISV Plan, Section 5.1.1, "Events," lists the various [] scenarios. Also, the ISV Scenario Plan has an Appendix A titled, "Scenario Specifications" that provides the [] scenarios. The scenarios themselves follow in the rest of Appendix A. Additionally, the ISV Scenario Plan, Appendix E, "Tasks of Special Interest," lists each [] and in which scenario(s) it is addressed. Appendix E also provides a cross reference between scenarios and the []. This scenario information was compared with the commitments of WCAP-15860 and with the NUREG-0711 criteria. The ISV Plan and ISV Scenario Plan together were found to satisfy both the programmatic plan and NUREG-0711 and meet the criterion on plant conditions.

(2) The following types of personnel tasks should be included:

- Risk-significant HAs, systems, and accident sequences - All risk-important HAs should be included in the sample. These include [those] identified in the PRA and those identified as risk-important in the SAR and NRC's SER. 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:
 - dominant human actions (selected via sensitivity analyses)
 - dominant accident sequences
 - dominant systems (selected via PRA importance measures such as Risk Achievement Worth or Risk Reduction Worth)
- 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. RG 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:
 - 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

- 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 call for knowledge-based decision-making if the rules do not fully address the problem, or the selection of an 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 an SGTR may warrant 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 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.
- Range of human cognitive activities—The sample should include the range of cognitive activities performed by personnel, including:
 - 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 and tasks that are performed by crew members acting as a team. These interactions among plant personnel should include interactions between:
 - 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
- Tasks that are performed with high frequency.

Evaluation of Criterion (2)

As stated in the evaluation of Criterion (1) above, ISV Plan, Section 5.1.1, and ISV Scenario Plan, Appendix E, list the various evolutions (both high frequency and less common tasks), transients, accidents, and risk-important HAs that are included in the [] scenarios. The ISV

Scenario Plan, Appendix A, provides the [] actual scenarios. This scenario information was compared with the commitments of WCAP-15860 and with the NUREG-0711 criteria. The ISV documents satisfy both documents.

The risk-important HAs and tasks are identified in TR-59/WCAP-16555. WCAP-16555, Section 3.2, identifies [] post-accident risk-important HAs in Table 3.2-2. The ISV Plan draft included essentially all of these [] risk-important HAs in scenarios. However, the risk-important HA to [] was excluded in the ISV scenario Plan. An RAI-SRP18-COLP-53 was written. In the ISV Scenario Plan, this risk-important HA is now included as part of Scenario 18, "Loss of RNS during Mid-Loop Operation." Thus, all risk-important HAs are now addressed in at least one ISV scenario (a few are included in two scenarios). This risk-important HA also has local aspects that cannot be adequately simulated as part of ISV. Thus, the actual verification of acceptability of planned local actions associated with the [] will need to be deferred until the plant is built. Therefore the RAI response proposes adding this to the HFE Design Verification at Plant Startup, APP-OCS-GEH-520. The staff reviewed APP-OCS-GEH-520, Revision B, submitted in a letter dated August 2, 2010, and found that verification of local control action has been added to the document.

The ISV Scenario Plan, Appendix F, previously listed the PRA risk-dominant systems for AP1000. This Appendix was deleted from Revision B but is still available in the AP1000 PRA. These systems were verified to all be addressed in the scenarios. []].

The following important tasks identified from OSA analyses were included in the ISV, as shown in the ISV Scenario Plan, Appendix E, Table E-1: Loss of DDS; []. The following OER important tasks were also identified and included in the ISV Table E-1 and the ISV scenarios: []].

The scenarios presented in WCAP-15860 and the ISV Scenario Plan were also found to adequately address a broad range of: procedure-guided tasks, human cognitive activities, and human interactions. Thus, the ISV Scenarios were found to adequately address the types of personnel tasks specified in the NUREG-0711 Criterion 2 pending confirmation of RAI-SRP18-COLP-53.

- (3) The sample should reflect a range of situational factors that are known to challenge human performance, such as:
- 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 should include situations where human performance variation due to high workload and multitasking situations can be assessed.
 - 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.

Evaluation of Criterion (3)

The ISV Plan, and ISV Scenario Plan address operationally difficult tasks as identified via the OSA analyses and through the OER. These are summarized in the ISV Scenario Plan, Appendix F, and are discussed in the review of Criterion (2) above. The scenarios have []. This is described in the ISV Plan, Section 5.1.3, “Complications.” These complications also are added to the transient or accident scenarios to [].

The applicant took exception to addressing fatigue and circadian factors, relying on APP-OCS-GEH-320, Section 5.1.3, which states that the ISV does not address fatigue and circadian factors since it is considered to be impractical to attempt to mimic the conditions that are typical on the operating site. The staff agrees with this position and notes that 10 CFR Part 26 Subpart I addresses managing fatigue.

[]. For example, []. Other environmental factors are addressed as part of APP-OCS-GEH-520, “AP1000 Human Factors Engineering Design Verification at Plant Startup.”

Thus, the ISV plans acceptably address Criterion 3.

18.11.8.2.4.2 Identification of Scenarios

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.

Evaluation of Criterion (1)

The [] scenarios have been developed for use in ISV. The scenarios are quite varied and they do combine the various characteristics outlined in the operational event sampling. Detailed scenario descriptions are provided in the ISV Scenario Plan. The documents reviewed satisfy this criterion.

The scenarios should not be biased in the direction of over representation of the following:

- 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)

Evaluation of Criterion (2)

As noted above under Criterion 1, a robust set of [] scenarios has been developed and they are described in the ISV Scenario Plan. These scenarios have many failure events both as the key item of the scenario and as peripheral issues. They are not limited to familiar, typical, or easy-to-conduct scenarios or those with only positive outcomes. The documents reviewed satisfy this criterion.

18.11.8.2.4 Integrated System Validation

The objective of reviewing integrated system validation methodology is to verify that the applicant’s methodology will validate the integrated system design (i.e., hardware, software, and personnel elements) using performance-based tests that will determine whether it acceptably supports safe operation of the plant.

18.11.8.2.4.1 Test Objectives

- (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 [of the] design, including personnel functions and tasks affected by the modification. The objectives should be to:
 - 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, 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.
 - 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.

Evaluation of Criterion (1)

The objectives of the AP1000 ISV are identified in Section 4.2 of WCAP-15860, which has been approved by NRC as part of the original AP1000 design certification. They included:

1. Establish the adequacy of the integrated HSI for achieving HFE program goals
2. Confirm allocation of function and the structure of tasks assigned to personnel
3. Validate the EOPs and associated HSI
4. Confirm the dynamic aspects of the HSI for task accomplishment
5. Evaluate and demonstrate error tolerance to human and system failures
6. Establish the adequacy of staffing and of the HSI to support staff to accomplish their tasks

These objectives have been included in Section 1.2 of the ISV Plan. This approach acceptably meets the staff's review criterion.

18.11.8.2.4.2 Validation Testbeds

- (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.

Evaluation of Criterion (1)

ISV Plan, Section 2, indicates that the ISV will be performed at a dedicated, purpose-built facility. The facility will employ a high fidelity, near full-scope simulator to represent the AP1000 systems and the MCR. This simulator will satisfy the general requirements of Sections 3 and 4 of ANSI/ANS-3.5-1998, "Nuclear Power Plant Simulators for Use in Operator Training and Examination."

NUREG-0711 indicates the use of ANSI/ANS-3.5-1998 is an acceptable acceptable testbed. This satisfies Criterion 1.

- (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.

Evaluation of Criterion (2)

The AP1000 testbed will acceptably meet this criterion (see the evaluation of Criterion 1). In addition, in the ISV Plan, Section 5.1.2, "Procedures," the applicant states that the following types of procedures for AP1000 are incorporated into ISV Scenario Plan, and will be used:

- Optimal Recovery
- Functional Recovery
- Shutdown Procedures
- Normal Operating Procedures (NOPs)
- Abnormal Operating Procedures (AOPs)
- Refueling and Outage Procedures
- Alarm Response Procedures (ARPs)
- Maintenance and Surveillance Guidelines
- []
- []
- []

This approach acceptably meets the staff's review criterion.

- (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.

Evaluation of Criterion (3)

The AP1000 testbed will acceptably meet this criterion (see the evaluation of Criterion 1).

- (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.

Evaluation of Criterion (4)

Due to the constraints of the building, the simulator does not include the passive cooling fins; instead, there is a conventional office building tiled ceiling. This results in the lighting system being somewhat different, although it is still representative of the final lighting system design. In addition, the heating and ventilation is provided by a conventional office building system, and is therefore not representative of the final as-built MCR. Also, the acoustic properties cannot be completely replicated, although they will be similar (i.e., painted walls, hard ceiling tiles). The simulator will be as representative as possible of the final MCR design, so that the design can be assessed. The applicant believes the differences will have minimal or no impact on ISV crew performance. [

] Also, WEC noted in the response to RAI-SRP18-COLP-49 received in a letter dated February 2, 2010, that the environmental conditions will be fully assessed in APP-OCS-GEH-520, "AP1000 Plant Startup Human Factors Engineering Verification Plan." This approach provides sufficient environmental fidelity for ISV and acceptably meets Criterion 4.

- (5) Data Completeness Fidelity—Information and data provided to personnel should completely represent the plant systems monitored and controlled from that facility.

Evaluation of Criterion (5)

The AP1000 testbed will acceptably meet this criterion (see the evaluation of Criterion 1).

- (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.

Evaluation of Criterion (6)

The AP1000 testbed will acceptably meet this criterion (see the evaluation of Criterion 1).

- (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.

Evaluation of Criterion (7)

The AP1000 testbed will acceptably meet this criterion (see the evaluation of Criterion 1).

- (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.)

Evaluation of Criterion (8)

The use of local control stations (LCSs) and the Remote Shutdown Workstation (RSW) are included in the ISV scenarios. Scenario 7 for [] is included in the ISV Scenario Plan. The RSW will be validated using []. Operators will be able to []. ISV Plan, Section 2.1, “Physical Scope and Fidelity”, describes the details of the simulated RSW panel. Other LCSs are also included in the ISV scenario Plan. The one local action that is risk important relates to []

[]. The actual verification of acceptability of planned local actions [] will need to be deferred until the plant is built. The staff reviewed APP-OCS-GEH-520, Revision B, “HFE Design Verification at Plant Startup”, dated July 2010 against the response to RAI-SRP18-COLP-53 R1 received in a letter dated May 21, 2010. The staff confirmed the document conforms to the RAI response.

- (9) The testbeds should be verified for conformance to the testbed characteristics identified above before validations are conducted.

Evaluation of Criterion (9)

ISV Plan, Section 2.3, describes the simulator testing to be performed prior to ISV evaluations. The ISV Plan references the ISV Scenario Plan for detail concerning how the testing will be performed. That information is provided in ISV Scenario Plan, Appendix C, "Simulator Testing". The objective of this simulator testing in preparation for ISV is to demonstrate that the simulator responds in a manner similar to the reference unit while utilizing the operating procedures and that it meets ANSI/ANS 3.5-1998. The testing will be carried out [

]. This includes an estimated [] of testing. In addition, the ISV Plan, Section 3.3 describes Pilot Testing of each ISV scenario to ensure simulator readiness, and to confirm effective functioning of test protocols and data collection. This will be done by personnel different from the test subjects.

This provides an acceptable and comprehensive approach to testbed verification. This approach acceptably meets the staff's review criterion.

18.11.8.2.4.3 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.

Evaluation of Criterion (1)

ISV Plan, Section 4.9, indicates that validation crews will consist of currently qualified operating crews. WEC takes partial exception to this item from the program plan, as described in the ISV Plan, Section 1.5, Item 1. Since the AP1000 is a new plant design, the ISV participants will not be fully qualified and experienced AP1000 operators. The ISV subjects will not have the same task performance proficiency as that of fully qualified AP1000 operators. This is reasonable for ISV, and it does make the ISV somewhat more demanding. Per the ISV Plan, Section 4.1, "Subjects," the ISV subjects will be comprised of the following:

1. A group that has completed the []].
2. A group that has partially completed the []]. These subjects will have undertaken [] training program. Subjects will comprise []]. They will have completed [] of AP1000 systems training and [] of procedure/simulator based training.
3. A limited group of []].

Thus, The ISV crews are samples taken from the crews of the AP1000 customer utilities, as described above. This approach acceptably meets the staff's review criterion.

- (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.

Evaluation of Criterion (2)

The ISV Plan, Section 4.1.1, discussed participant selection. Two utilities will be providing [] crews each. A set of criteria will be provided to the utilities to guide selection of crew members. The criteria include successful completion of training, age range, skills and abilities range, qualifications variation, and prior experience variation. In addition, no operators participating in previous AP1000 tests will be used. This approach acceptably meets the staff's review criterion.

- (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.

Evaluation of Criterion (3)

In the ISV Plan, Section 4.1.2, "Crew Size and Number," the applicant states that the typical crew size for ISV will be []

[]. The crew size will also be varied as a complication in specific scenarios. The maximum control room staff is also specified in Section 4.1.2 and consists of [] personnel. The maximum staffing level will be addressed by []. The actual staffing level is specified for each scenario in the ISV Scenario Plan, Section A.n.3, "Scenario Participants" (for n = 1 to []). Scenario participants vary from [] to []. This reasonably addresses minimum, normal and maximum staffing levels, plus other values in between, and is acceptable.

In RAI-SRP18-COLP-26 response of July 12, 2010, the applicant committed to delete TR-52 from the DCD and replace it with APP-OCS-GJR-003, Revision 2, "AP1000 Main Control Room Staff Roles and Responsibilities" to document new staffing values. This is acceptable. The staff created **CI-SRP18-COLP-26** to verify APP-OCS-GJR-003 contains the values as described in the RAI response.

- (4) To prevent bias in the sample, the following participant characteristics and selection practices should be avoided:
- participants who are []
 - participants in []
 - participants who are selected for some specific characteristic, such as using crews that are identified as good or experienced.

Evaluation of Criterion (4)

As described in ISV Plan, Section 4.1, "Subjects"; Section 4.1.1, "Selection"; and Section 4.1.2, "Crew Size and Number", the applicant will use COL utility personnel as test participants and not design personnel. Section 4.1 states that care will be taken to ensure that the test participants do not obtain any prior knowledge of the scenarios to be used in ISV. The participants will not include subjects that participated in the HFE Tests. Section 4.1.1 states that participating utilities will be requested to assign typical crews for ISV testing based on availability. Crews will not be selected for ISV based on individual characteristics. This approach acceptably meets the staff's review criterion.

18.11.8.2.4.4 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 and consistently presented for repeated trials:
- 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.

Evaluation of Criterion (1)

The ISV Scenario Plan provides scenario descriptions for each of the [] scenarios to be part of ISV. Each scenario in the document contains the following:

- []
- []
- []
- []
- []
- []
- []
- []
- []
- []

Each scenario provides the above information in acceptable detail. At this time, only three scenarios have complete observer guides. These three provide an acceptable example of how

the remaining observer guides will be completed. This approach acceptably meets the staff's review criterion.

- (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.

Evaluation of Criterion (2)

This criterion is addressed through the use of a simulation facility for ISV that satisfies the general requirements of Sections 3 and 4 of ANSI/ANS-3.5-1988; use of COL plant operating personnel in training for operations; and use of realistic but challenging scenarios. This approach conforms to NUREG-0711 Criterion 2.

- (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).

Evaluation of Criterion (3)

The ISV Plan notes that the use of LCSs is included in the ISV scenarios and they will use simulated interactions with local operations that extend beyond the MCR. Scripted responses will be provided for the operations support staff to perform specified roles as plant personnel in applicable scenarios (e.g., local operators). This is acceptable.

There is one local control action that is a risk-important HA. This is [] and is included in an ISV scenario. The actual verification of acceptability of planned local actions associated with the hatches will need to be deferred until the plant is built. This is an acceptable approach. Therefore the RAI response proposes adding this to the HFE Design Verification at Plant Startup, APP-OCS-GEH-520. The staff reviewed APP-OCS-GEH-520, Revision B, submitted in a letter dated August 2, 2010, and found that verification of local control action has been added to the document.

18.11.8.2.4.5 Performance Measurement

The review of performance measurement covers measurement characteristics, performance measure selection, and performance criteria.

18.11.8.2.4.5.1 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):
 - Construct Validity—A measure should accurately represent the aspect of performance to be measured.

- 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.

Evaluation of Criterion (1)

The ISV Plan, Section 6, describes the performance measures to be used to evaluate integrated system performance. The characteristics of the measures are addressed in Section 6.2. Several of the measures are well-known, commonly used measures with established, acceptable measurement characteristics, such as the [

]. For others developed by Westinghouse, the basis of the measures is identified. For example, a measure of team performance will be used that is based on a []. This approach acceptably meets the staff's review criterion.

18.11.8.2.4.5.2 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.

Evaluation of Criterion (1)

The ISV Plan, Section 6.1, describes the measures to be used. The measures are hierarchal including []. Thus an acceptable hierarchal set of performance measures will be used to assess integrated system performance.

The ISV Plan, Section 6.3.1, identifies the measures to be used as pass/fail (P/F) criteria. P/F measures are measures reflecting []. This provides a reasonable set of measures to serve as P/F criteria.

Performance measures to be used as diagnostic measures are discussed in ISV Plan, Section 6.3.2. The measures are listed in Table 6.3-2 and include all measures collected during ISV trials with the exception of the P/F measures.

This approach acceptably meets the staff's review criterion.

- (2) Plant Performance Measurement—Plant performance measures representing functions, systems, components, and HSI use should be obtained.

Evaluation of Criterion (2)

The ISV Plan, Section 6, discusses ISV performance measurement. P/F plant-level measures involve applicable technical []. Plant-level diagnostic measures are also defined for each scenario so that []. For example, for the []. This approach acceptably meets the staff's review criterion.

- (3) Personnel Task Measurement—For each specific scenario, the tasks that personnel are [needed] 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 assessment, response planning, and response implementation. Secondary tasks are those personnel [need to] 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.

- 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 different from those that should be performed). Analysis of tasks performed should be used for the identification of errors of commission.
- 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

Evaluation of Criterion (3)

The ISV Plan, Section 6, discusses ISV performance measurement. Measurement of operator tasks involves both P/F and diagnostic variables. Successful performance of risk-important HAs is a P/F variable. For example, for the [

] as tasks to assess using P/F measures. For diagnostic purposes, the performance of key tasks is measured. These actions are listed in the observer guides for each scenario. This approach acceptably meets the staff's review criterion.

- (4) Situation Awareness—Personnel situation awareness should be assessed. The approach to situation awareness measurement should reflect the current state-of-the-art.

Evaluation of Criterion (4)

The ISV Plan, Section 6, discusses ISV performance measurement. Situation awareness is measured using the []. SART is a widely used and acceptable measure of situation awareness. This approach acceptably meets the staff's review criterion.

- (5) Cognitive Workload—Personnel workload should be assessed. The approach to workload measurement should reflect the current state-of-the-art.

Evaluation of Criterion (5)

The ISV Plan, Section 6, discusses ISV performance measurement. Cognitive workload is measured using the [

]. This approach acceptably meets the staff's review criterion.

- (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.

Evaluation of Criterion (6)

The ISV Plan, Section 6, discusses ISV performance measurement. Information on general aspects of anthropometrics, including control room layout and workstation configuration, have been included in the [].

An assessment of anthropometric and physiological factors will also be made during HFE Design Verification. This approach acceptably meets the staff's review criterion.

18.11.8.2.4.5.3 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.

Evaluation of Criterion (1)

The ISV Plan, Section 6.3, "Criteria," discusses the criteria to be used in evaluating performance measures. P/F performance measures are used to validate the design as was discussed in Section 4.5.2, "Performance Measure Selection, of this report. The general acceptance criteria are (1)[

].

For diagnostic measures, criteria are identified in ISV Plan, Table 6.3-2. The table provides criteria for all diagnostic measures. For example, the criteria for evaluating workload include: (1) average rating of workload across subjects from questionnaire is < 85 (range 0 to 100); (2) subjects demonstrate behavior, as specified in the scenario description for each scenario, that their workload is within a reasonable range and there are no indications of stress caused by excessive workload; and (3) No workload issues are identified through questionnaire comments, debriefing, video and audio recording review. Failure to meet the criteria is evaluated by the HED resolution process (APP-OCS-GEH-420, "AP1000 Human Engineering Discrepancy Resolution Process") to determine its priority.

This approach acceptably meets the staff's review criterion.

- (2) The basis for criteria should be defined, e.g., requirement-referenced, benchmark referenced, normative referenced, and expert-judgment referenced.

Evaluation of Criterion (2)

The ISV Plan, Section 6.3, "Criteria," discusses the criteria to be used in evaluating performance measures. The basis for criteria for P/F measures is [

]. The criteria established for diagnostic measures are based [

]. This approach acceptably meets the staff's review criterion.

18.11.8.2.4.6 Test Design

18.11.8.2.4.6.1 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.

Evaluation of Criterion (1)

The ISV Plan, Section 3.2, discussed assignment of participants to trials. A final run order will be identified after pilot testing so aspects such as scenario duration can be determined. However, an example is provided in Table 3.3-1 of a counter balanced presentation of scenarios to crews. In the example, []. Assignments are made []. The constraints and considerations are clearly identified in the ISV plan. This approach acceptably meets the staff's review criterion.

- (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.

Evaluation of Criterion (2)

The ISV Plan, Section 3.2, discussed assignment of participants to trials. As noted in the evaluation of criterion (1), the final trial orders will be determined following pilot testing. One of the principles to be followed in that determining the final run order is to balance the order to accommodate the types of concerns raised in the review criterion. For example, the Plan states that “[].” Such considerations should minimize the possibility of linear position effects. This approach acceptably meets the staff's review criterion.

18.11.8.2.4.6.2 Test Procedures

- (1) Detailed, clear, and objective procedures should be available to govern the conduct of the tests. These procedures should include:
- 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 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.
 - 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.

- Instructions regarding when and how to collect and store data. These instructions should identify which data are to be recorded by:
 - 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 questionnaires.

- 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.

Evaluation of Criterion (1)

The evaluation below is numbered to correspond to the bulleted criteria above.

1. The ISV Plan, Section 3.2, addresses crew assignment to scenarios. See the discussion of crew assignments in Section 4.6.1, "Coupling Crews and Scenario," Criterion 1 of this report above. This acceptably meets the subcriterion.

2. The ISV Plan, Section 5.2, addresses the requirements for crew briefing in general. The briefing will [

]. Detailed information on crew briefings is included in the scenario descriptions for Scenarios 1, 2 and 12 in the ISV Scenario Plan. The information provided in these three detailed scenarios is complete and consistent with the high-level guidance in the ISV Plan. For example, the briefing for Scenario 2 is:

[

].

This acceptably meets the subcriterion.

3. [

]:

- []
- []
- []

This acceptably meets the subcriterion.

4. The ISV Plan, Section 5.2.2, “Communications with ISV Personnel,” describes the general approach for communicating with ISV crews. The Plan indicates that scripted responses will be used when test personnel act as plant personnel, such as a local operator. The Plan further states that “[].” These scripted responses are included in the ISV Scenario Plan. For example, for Scenario 1, the following instruction is provided:

[]

].

This acceptably meets the subcriterion.

5. The ISV Plan, Section 5.2.3, “Unforeseen Events,” provides guidance on interacting with participants when unexpected difficulties arise. The guidance addresses events unrelated to the testing, such as fire drills, as well as related events, such as simulator anomalies. The plan outlines responsibilities for interacting with crews and guidance on resuming vs. restarting trials. This acceptably meets the subcriterion.
6. The ISV Plan, Sections 5.2.1, “General Procedures and Documentation,” and Section 5.2.4, “Storage of Data,” define the responsibilities and procedures for management of ISV data. For example, the Plan identifies the ISV coordinator as the individual responsible for data management. With regard to simulator recorded data, the Plan indicates that “The discrete event data and plant parameter data from the simulator will be stored on a server and burnt onto discs. The file names for this data will identify the scenario number, the crew, and will be dated and time-stamped.”

Further, the ISV Plan indicates that “At the end of each scenario, the ISV Coordinator will distribute and collect the completed post-trial questionnaires for the subjects, and at the end of the crews and observers participation in ISV, the ISV Coordinator will distribute and collect the final questionnaires for the subjects and observers. All of this information is hardcopy, and will be clearly marked and stored in a secure location.”

This acceptably meets the subcriterion.

7. The ISV Plan, Sections 5.2, “ISV Procedures,” provides procedures for documenting all data collected during the ISV. The guidance contained in the ISV Plan addresses all forms of data, e.g., simulator logs and questionnaires. The procedures are sufficiently explicit to ensure data is not mishandled or lost (see examples in the evaluations above). This acceptably meets the subcriterion.

In summary, the ISV Plan provides detailed, clear, and objective procedures to govern the conduct of the ISV tests. This approach acceptably meets the staff’s review criterion.

- (2) Where possible, test procedures should minimize the opportunity of tester expectancy bias or participant response bias.

Evaluation of Criterion (2)

The ISV Plan indicates that observers will be independent of the project and that their assignment to trials will be systematically varied. The use of standardized and scripted responses should also help to minimize bias. This approach acceptably meets the staff’s review criterion.

18.11.8.2.4.6.3 Test Personnel Training

- (1) Test administration personnel should receive training on:
 - 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.

Evaluation of Criterion (1)

ISV Plan, Section 4.3, addresses training of test personnel. It states that the training for the ISV staff will be sufficient to ensure effective execution of the test scenarios and data collection. This training will occur during the pilot testing of the simulator and ISV scenarios. The training will be specific for the tasks to be performed during ISV. Test conductor roles will be rehearsed prior to ISV. The training will include how and when to communicate with the participants. Scripted responses will be provided for the operations support staff to perform specified roles as plant personnel in applicable scenarios (e.g., local operators). In addition, training will be given on the importance of the ISV procedures and the possible impact of not following the ISV procedures. This will help ensure consistency of the ISV staff performance and behavior across the scenarios. This approach acceptably meets the staff’s review criterion.

18.11.8.2.4.6.4 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.

Evaluation of Criterion (1)

ISV Plan, Sections 4.1 and 4.1.3, discuss participant training. Operations personnel from the customer utilities participating in the AP1000 training program will be used for ISV. Training will include both classroom and hands-on simulator components. The training will be developed and delivered by the Westinghouse Training Group.

The training program will provide personnel with detailed AP1000 systems and plant knowledge. The program will be presented using a combination of classroom instruction, self-study, procedure walk through, and exercises. Training will include [] of AP1000 systems training and [] of procedure/simulator based training. This will include Emergency Operating Procedures (EOPs), Abnormal Operating Procedures (AOPs) and General Operating Procedures (GOPs).

This approach acceptably meets the staff's review criterion.

- (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.

Evaluation of Criterion (2)

ISV Plan, Sections 4.1 and 4.1.3, describe the training program for ISV participants. As discussed under Criterion (1), the program provides sufficient training such that the skill and knowledge levels of participants should not be significantly changing between trials. This approach acceptably meets the staff's review criterion.

18.11.8.2.4.6.5 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.

Evaluation of Criterion (1)

ISV Plan, Section 3.3, indicates pilot testing will be performed to address these aspects of the test. The objectives of simulator pilot testing are to demonstrate that the simulator responds in a manner similar to the reference unit while utilizing the plant operating procedures, to ensure simulator readiness, and to minimize the likelihood of test failures or delays. The pilot testing will be carried out in [], as described in the ISV Scenario Plan, Appendix C. In

addition to the testing of the simulator model, thorough pilot testing of all scenarios will be carried out. This approach acceptably meets the staff's review criterion.

(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:

- 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.

Evaluation of Criterion (2)

ISV Plan, Section 3.3, states that the participants for ISV will not be involved in pilot testing. Rather, the pilot testing will be performed by the Westinghouse simulator development staff, with support as needed from other Westinghouse personnel. This acceptably addresses Criterion (2). This approach acceptably meets the staff's review criterion.

18.11.8.2.4.7 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.

Evaluation of Criterion (1)

ISV Plan, Section 7, "Processing of Results," [

]. This approach acceptably meets the staff's review criterion.

(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.

Evaluation of Criterion (2)

ISV Plan, Section 7.3, indicates that each scenario is run [] times with [] different crews. If a scenario fails a P/F criterion an HED is defined and resolved. The scenario is then rerun a minimum of [] times with []. With respect to diagnostic measures, observation of a small number of HEDs will result in a [] trial being run using a []. This approach will help confirm whether an HED exists or not. The applicant indicated that, if the results of the [] trial confirm an issue, an HED will be identified and resolved. The scenario then will be re-run [] times using []. This approach acceptably meets the staff's review criterion.

- (3) The degree of convergent validity should be evaluated, i.e., the convergence or consistency of the measures of performance.

Evaluation of Criterion (3)

ISV Plan, Section 7.2, indicates that the degree of convergence of measures will be assessed in the interpretation of the results. The Plan states:

The degree to which convergent (i.e., consistent) results are observed from different measurement techniques will be [] and the results will be presented in the ISV results report. The analysis will determine if the different measurement techniques indicate the same problems. If so, it strengthens the conclusion that a problem exists and it needs to be addressed. Likewise, if none of the measurement techniques indicates that there is a problem (i.e., different measurement techniques record successful performance), then it increases the degree of certainty that a problem does not exist.

This approach acceptably meets the staff's review criterion.

- (4) The data analyses should be independently verified for correctness of analysis.

Evaluation of Criterion (4)

ISV Plan, Section 7.2, indicates that independent verification of results will be performed using applicable Westinghouse quality assurance procedures provided in APP-GW-GAP-100, "Inter-Business Unit Edition Policies & Procedures." This approach acceptably meets the staff's review criterion.

- (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.

Evaluation of Criterion (5)

ISV Plan, Section 6.3.1, "Pass/Fail Criteria," indicates that for P/F criteria, each scenario specifies that []

[]. In order to ensure margin, there are also typically acceptance criteria relating to not exceeding the []

].

Regarding the risk-important HAs, []

[]. ISV Plan, Section 6.3.1, states that "In a number of cases in the PRA, the []

[]. Therefore, the [] to perform the risk-important human actions will be closely monitored. If a case occurs where the [] is potentially insufficient to ensure reliable operator performance, this will be identified as []

].” The method of identifying and documenting the [] for performing the risk-important HAs is described in the ISV Scenario Plan, in the Scenario Specifications and in the Observer Guides for the scenarios.

RAI-SRP18-COLP46 requested more information on the mechanism for specifying and documenting the [] needed to accomplish the risk-important HAs in the ISV Scenarios. The response, provided in a letter dated August 2, 2010, the applicant stated that the “[

analyst will use [] in ISV Plan, Section 6.2, “Methods,” to complete this calculation. This approach limits the potential of results being influenced by the observer’s judgment or the observer missing a task step, event or operator action. The [] provide an objective confirmation of the observation results.

This approach acceptably meets the staff’s review criterion.

18.11.8.2.4.8 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.

Evaluation of Criterion (1)

ISV Plan, Section 7.4, provides the commitment to document the basis for validation conclusions. The ISV Plan states “The basis for concluding that the AP1000 MCR, HSI resources, procedures, and operator training are adequate (or not) will be described (i.e., that the integrated system performed acceptably during testing and can be expected to support safe operation in actual use).” This approach acceptably meets the staff’s review criterion.

- (2) Validation limitations should be considered in terms of identifying their possible effects on validation conclusions and impact on design implementation. These include:
 - 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).

Evaluation of Criterion (2)

ISV Plan, Section 7.4, provides the commitment to document test limitations. This approach acceptably meets the staff’s review criterion.

18.11.8.3 Conclusion

The staff concludes that APP-OCS-GEH-320 and APP-OCS-GEH-321 provide implementation plans that conform to the NUREG-0711 criteria associated with Integrated System Validation. The staff's review of the AP1000 ISV Plan and the ISV Scenario Plan concludes that the plans are comprehensive and thorough and provide reasonable assurance that the ISV will effectively identify any operator challenges associated with the HSI design. **OI-SRP18-COLP-03A** was created to track the completion of these documents. Based on the preceding information, the staff concludes that this open item and the corresponding element of ITAAC Design Commitment 4 (DCD, Revision 15) are complete and closed.

18.11.9 Evaluation of Tier 1 Information—Design Commitment 4, ITAAC Table 3.2-1, Tier 1, Section 3.2 (DCD Revision 15), Part 4 of 5, Issue Resolution Verification

18.11.9.1 Summary of Technical Information

ITAAC Design Commitment 4 reads as follows:

Design Commitment: An HFE program verification and validation implementation plan is develop[ed] in accordance with the programmatic level description of the AP1000 human factors verification and validation plan.

Inspection, Test, and Analysis: An inspection of the HFE verification and validation implementation plan will be performed.

Acceptance criteria (part 4): A report exists and concludes that the HFE verification and validation implementation plan was developed in accordance with the programmatic level description of the AP1000 human factors verification and validation plan and includes the ...Issue Resolution Verification activity.

In DCD Revision 17, the applicant deleted this ITAAC based on completion of the work it described.

18.11.9.2 Evaluation

NUREG-0711, Section 11.4.4.2, Criterion 1, states the following:

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. The applicant should identify unjustified discrepancies as HEDs to be addressed by the HED resolution.

Evaluation of Criterion 1

Each of the three V&V implementation plans previously referenced (APP-OCS-GEH-120, APP-OCS-GEH-220, and APP-OCS-GEH-320) contain sections directing that all discrepancies be documented on a discrepancy worksheet. The OCS product manager screens the worksheet. If the discrepancy can be directly justified, it is not considered an HED. Unjustified discrepancies are identified as HEDs, and the applicant must address them using the formal resolution process in APP-OCS-GEH-420. The staff concludes that procedures referenced in

this section provide sufficient details to satisfactorily demonstrate implementation of this NUREG criterion for HED justification.

NUREG-0711, Section 11.4.4.2, Criterion 2, states the following:

The HED analysis should include the following:

- 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, their effect on the accident analyses summarized in the safety analysis report, and their relationship to risk-significant sequences in the plant PRA.
- HED scope—The scope of the HED should consider the following:
 - Global features HEDs—These HEDs 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 HEDs 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 HEDs relate to design features that are not standardized, thus their generality has to be assessed.
 - Other—This subcategory specifically pertains to HEDs identified from integrated system validation that cannot be easily assigned to any of the three preceding categories.
- 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 that is related to the particular component.
- 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 the cumulative effect on personnel performance (e.g., degree of impairment and types of potential errors).

The applicant should also analyze HEDs with respect to the cumulative effects of multiple HEDs on plant safety and personnel performance.

In addition to addressing the specific HEDs, the analysis should treat the HEDs as indications of potentially broader problems.

Evaluation of Criterion 2

In APP-OCS-GEH-420, Section 2.2, the applicant stated that the [], which the OCS product manager approves. The assessment [] addresses the first bullet from the NUREG-0711 criterion above:

- Priority 1: []
 - []
 - []
- Priority 2: []:
 - []
 - []
 - []
- Priority 3: All others

APP-OCS-GEH-420, Section 2.3, addresses the HED scope. In this section, the applicant stated that the cumulative effects of Priority 1 and 2 HEDs are analyzed by organizing HEDs into the following categories:

- []
- []
- []
- []
- []
- []

This last category identifies [], and others using the same definitions as the NUREG criterion. By separating the []

[]. This addresses the remaining parts of the NUREG-0711 criterion above.

APP-OCS-GEH-420, Section 2.5, states that an []

to []; an evaluation is performed
described above is used to identify these generic implications.]. The categorization

The staff concludes that APP-OCS-GEH-420 provides sufficient details to satisfactorily demonstrate implementation of this NUREG criterion for HED analysis.

NUREG-0711, Section 11.4.4.2, Criterion 3, states the following:

The applicant should use a systematic evaluation to identify HEDs for correction. Priority 1 HEDs are those with direct, indirect, or potential safety consequences. Priority 2 HEDs are those that do not have significant safety consequences, but do have potential consequences to plant performance/operability, nonsafety-related personnel performance/efficiency, or other factors affecting overall plant operability. 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.

Evaluation of Criterion 3

This criterion is addressed in the previous section.

NUREG-0711, Section 11.4.4.2, Criterion 4, states the following:

The applicant should fully document each HED, 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.

Evaluation of Criterion 4

Section 2 of APP-OCS-GEH-420 includes documentation requirements. In summary, when the HFE engineer justifies an HED, he or she [

]. When an HED is resolved by a design solution, a [] is used in conjunction with a [] to identify the best solution. Solutions will be consistent with the system requirements used to design the system. Design solutions follow the design process which documents the impact on safety.

The staff concludes that APP-OCS-GEH-420 provides sufficient details to satisfactorily demonstrate implementation of this NUREG criterion for HED evaluation documentation.

NUREG-0711, Section 11.4.4.2, Criterion 5, states the following:

The applicant should identify design solutions to correct HEDs. The design solutions should be consistent with system and personnel requirements identified in the preparatory analysis (i.e., operating experience review, function and task analysis, and HSI characterization).

Evaluation of Criterion 5

APP-OCS-GEH-420, Section 2.6, states that the design solution will be consistent with the system requirements used to design the system. By comparing proposed changes to the HFE design to the original system requirements, the applicant will ensure the original design basis is maintained or adjusted as necessary.

The staff concludes that APP-OCS-GEH-420 provides sufficient details to satisfactorily demonstrate implementation of this NUREG criterion for development of HED design solutions.

NUREG-0711, Section 11.4.4.2, Criterion 6, states the following:

The applicant should evaluate designs by repeating the appropriate V&V analyses. When the problems identified by an HED cannot be fully corrected, the applicant should provide appropriate justification.

Evaluation of Criterion 6

In APP-OCS-GEH-420, Section 2.8, the applicant stated that, for design solutions associated with the HFE design verification plan or HFE task support verification plan, independent verifiers will evaluate the HSI design changes using the same standards, guidance, and methodology as described in the applicable verification plan. For design solutions associated with the integrated system validation plan, the human factors team will determine the appropriate evaluation process, using a graded approach, based on the complexity and impact of the design changes. Independent verifiers will then perform the evaluation process.

The staff concludes that APP-OCS-GEH-420 provides sufficient details to satisfactorily demonstrate implementation of this NUREG criterion for design solution evaluation.

18.11.9.3 Conclusion

The staff concludes that APP-OCS-GEH-420 provides an implementation plan that satisfactorily addresses the NUREG-0711 criteria associated with tracking and resolving HEDs. This implementation plan provides reasonable assurance that issues will be identified during all stages of the design process and that these issues will be prioritized and resolved in an efficient manner. This element of ITAAC Design Commitment 4 (DCD Revision 15) as described above is complete and closed.

18.11.10 Evaluation of Tier 1 Information—Design Commitment 4, ITAAC Table 3.2-1, Tier 1, Section 3.2 (DCD Revision 15), Part 5 of 5, Plant HFE/HSI (as Designed at the Time of Plant Startup) Verification

18.11.10.1 Summary of Technical Information

ITAAC Design Commitment 4 reads as follows:

Design Commitment: An HFE program verification and validation implementation plan is develop[ed] in accordance with the programmatic level description of the AP1000 human factors verification and validation plan.

Inspection, Test, and Analysis: An inspection of the HFE verification and validation implementation plan will be performed.

Acceptance criteria (part 5): A report exists and concludes that the HFE verification and validation implementation plan was developed in accordance with the programmatic level description of the AP1000 human factors verification and validation plan and includes the.... Plant HFE/HSI (as designed at the time of plant startup) Verification activity.

In DCD Revision 17, the applicant deleted this ITAAC based on completion of the work it described.

18.11.10.2 Evaluation

The applicant submitted APP-OCS-GEH-520 to address this part of ITAAC 4. **OI-SRP18-COLP-4A** was created to track completion of the staff's review of this document. The acceptance criteria for this implementation plan are found in NUREG-0711 section 12, Design Implementation. The staff evaluation of this plan is being provided in this section of the SER so that material applicable to ITAAC 4 closure is kept together.

NUREG-0711, Section 12.4.6, Criterion 1, states the following:

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 Control Room lighting and noise.

Evaluation of Criterion 1

In APP-OCS-GEH-520 Section 1, the applicant states that specific aspects of the OCS. HSI design that cannot be evaluated in a simulator will be evaluated via a walk down of the applicable plant area after construction. This plan applies to all control areas included in the HFE scope including the main control room, the remote shutdown room, technical support center, radioactive waste control, and local control stations. APP-OCS-GER 120 and APP-OCS-GER 220 document the results of the design and task analysis verification and are used as the basis for identifying design verifications that have not been completed. The procedure specifically identifies lighting, noise, ambient temperature and humidity, the closed circuit TV system, communication facilities, and maintainability as areas that will be evaluated. The applicant indicates that where appropriate physical measurements will be taken for key environmental features including lighting, thermal conditions, and acoustics.

The staff concludes that APP-OCS-GEH-520 provides sufficient details to satisfactorily demonstrate implementation of this NUREG criterion.

NUREG-0711, Section 12.4.6, Criterion 2, states the following:

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.

Evaluation of Criterion 2

In APP-OCS-GEH-520, the applicant states that the as-built HSIs will be verified to the same as those that resulted from the HFE program. A team is used to complete the verification. The team uses the expected design configuration and control information, including the style guide, detailed design descriptions, and guidance on evaluating maintainability, to compare the as-built design against. The adequacy of procedures and training are addressed as part of the staff's operating program inspections.

The staff concludes that APP-OCS-GEH-520 provides sufficient details to satisfactorily demonstrate implementation of this NUREG criterion.

NUREG-0711, Section 12.4.6, Criterion 3, states the following:

All HFE-related issues documented in the issue tracking system should be verified as adequately addressed.

Evaluation of criterion 3

In APP-OCS-GEH-520, the applicant states that all HEDs will be verified as being adequately addressed.

The staff concludes that APP-OCS-GEH-520 provides sufficient details to satisfactorily demonstrate implementation of this NUREG criterion.

18.11.10.3 Conclusion

The staff concludes that APP-OCS-GEH-520 provides an implementation plan that satisfactorily addresses the NUREG-0711 criteria associated with the as-built design verification. The scope and methods described provide reasonable assurance that the as-built HFE design configuration will mirror the design described in the Design Certification. This element of ITAAC Design Commitment 4 (DCD Revision 15) as described above is complete and closed. **OI-SRP18-COLP-04A** is closed.

18.16 Tier 2* Information

The staff has determined that the following information referenced in DCD Tier 2, Chapter 18, Revision 17, must be designated as Tier 2* information in the AP1000 DCD. This information is in addition to the information identified as Tier 2* for Revision 15 of the DCD as documented in section 18.16 of NUREG 1793, "AP1000 FSER."

1. APP-OCS-GEH-120, Revision B, "AP1000 Human Factors Engineering Design Verification Plan." (This report explains the applicant's method for design verification.)
2. APP-OCS-GEH-220, Revision B, "AP1000 Human Factors Engineering Task Support Verification Plan." (This report explains the applicant's method for task support verification.)

3. APP-OCS-GEH-320 Revision D, "AP1000 Human Factors Engineering Integrated System Validation Plan." (This report explains the applicant's method for performing the integrated system validation.)
4. APP-OCS-GEH-420, Revision B, "Human Factors Engineering Discrepancy Resolution Process." (This report explains the applicant's method for resolving HEDs.)
5. APP-OCS-GEH-520, Revision B, "AP1000 Plant Startup HFE Design Verification Plan." (This report explains the applicant's method for verifying the as-built design.)

Based on guidance provided in the Standard Review plan section 14.3 and Branch Technical Position HICB-16 (Guidance on the level of detail required for design certification application under 10CFR Part 52) the staff has concluded that all Tier 2* material associated with Chapter 18 will revert to Tier 2 after the plant first achieves full-power operation. This includes Tier 2* information identified in NUREG 1793. This is a change from how HFE-related Tier 2* material was addressed for the previously approved DCD Revision 15 where there was no expiration date. 10 CFR 52, Appendix D, Section VIII.B.6.b and c describe regulatory requirements associated with Tier 2* material and will be amended to reflect this change.

The additional documents were identified as Tier 2* because they describe the specific process the applicant will use to accomplish the final HFE design. The staff has verified this process conforms with regulatory guidance, in NUREG-0737, which in turn supports the staff's conclusions that the HFE design provides reasonable assurance the Control Room staff can safely control plant operations via the human-system interfaces. These documents also contain acceptance criteria that will be used when inspecting the final HFE design conforms to Table 3.2-1 ITAAC.

Westinghouse responded to RAI-SRP18-COLP-23 R3 in a letter dated August 2, 2010, revising Tier 1 and Tier 2 of the DCD to reflect these additional Tier 2* references. The staff created **CI-SRP18-COLP-23** to track this change in Revision 18 of the DCD. In addition, the introduction of the DCD addresses Tier 2* references and specifies when the * designation expires in Table 1-1. Westinghouse responded to RAI-SRP18-COLP-54 in a letter dated August 18, 2010, revising the table to include the additional references listed above and to note all human factors engineering Tier 2* references will expire when the COL holder first achieves 100% power operation. The staff created **CI-SRP18-COLP-54** to track these changes in Revision 18 of the DCD.